Tonkin Highway Extension (Thomas Road to South Western Highway)

Flora and Vegetation Assessment

MAIN ROADS WESTERN AUSTRALIA

OCTOBER 2020

WOODMAN ENVIRONMENTAL

TEL. (08) 9315 4688
office@woodmanenv.com.au
PO Box 50, Applecross WA 6953
www.woodmanenv.com.au

Tonkin Highway Extension (Thomas Road to South Western Highway) Flora and Vegetation Assessment

Prepared for: Main Roads Western Australia

Job Number: MR19-32

Report Number: MR19-32-01

Cover Photograph: *Synaphea* sp. Pinjarra Plain (A.S. George 17182) (Threatened) in the Study Area, Mundijong Road Reserve, September 2019 (Woodman Environmental)

DOCUMENT REVISION AND STATUS

Revision	Status	Originator	Internal Reviewer	Internal Review Date	Client Reviewer	Client Review Date
A	Draft Report	AS/LF/DC	DC/CG/GW	4/5/2020	JT	18/8/2020
0	Final Report	AS/LF/DC	GW/AS/CG	2/10/2020		

DISCLAIMER

TABLE OF CONTENTS

FIGURES

TABLES

PLATES

APPENDICES

EXECUTIVE SUMMARY

Main Roads Western Australia (Main Roads) is proposing to extend Tonkin Highway from Thomas Road in Oakford to South Western Highway in Mundijong (The Project). The Project forms the second portion of the "Construction and use of the Tonkin Highway Extension from Mills Road West, Gosnells to South Western Highway, Mundijong" Project. Referred to the EPA and assessed at PER level, works were approved under Ministerial Statement 595 on the 12th of June 2002. Main Roads commissioned Woodman Environmental Consulting Pty Ltd (Woodman Environmental) to conduct a flora and vegetation assessment of the remaining undeveloped portion of the Project area to inform further environmental assessment and approvals applications.

Field survey was undertaken over six visits as listed below:

- 24th May 2019;
- 23rd – 26th September 2019;
- 17th October 2019;
- 23rd October 2019;
- 21st November; and
- 7th April 2020.

The initial visit involved a reconnaissance survey, with inspection of vegetated areas within the Study Area undertaken, and preliminary descriptions of the plant communities developed. The remaining visits comprised a detailed survey, as well as targeted survey for significant flora and vegetation. The detailed survey involved the survey of 11 non-permanent flora survey quadrats measuring 10 m x 10 m, with 14 relevés surveyed in areas where limited extent or condition of vegetation precluded quadrat establishment. As much of the Study Area is located in cleared or highly modified farmland, areas that were clearly highly modified were sampled via a brief inspection, either on foot or from a vehicle, with notes and photographs taken.

A total of 256 discrete vascular flora taxa were recorded in the Study Area during this survey, representing 50 families and 147 genera. Fifty of the total taxa recorded are introduced taxa. Nine significant flora were recorded in the Study Area by this survey, including three Threatened taxa, five Priority flora taxa and one taxon considered significant for other reasons. These are:

- *Acacia lasiocarpa* var. bracteolata long peduncle variant (G.J. Keighery 5026) (P1);
- *Babingtonia urbana* (P3);
- *Calectasia grandiflora* (P2);
- *Jacksonia gracillima* (P3);
- *Leucopogon* aff. sp. Busselton (D. Cooper 243) (potentially undescribed);
- *Stylidium aceratum* (P3);
- *Synaphea* sp. Pinjarra Plain (A.S. George 17182) (Threatened);
- *Synaphea* sp. Serpentine (G.R. Brand 103) (Threatened); and
- *Tetraria australiensis* (Threatened).

Eleven VTs were defined and mapped within the Study Area. Five of these were defined via floristic composition classification, using the results of a classification analysis of quadrat data from the Study Area. The remaining VTs were defined via structural vegetation classification. Additionally, a number of types of highly modified and revegetated areas were mapped.

Four significant vegetation types were identified and mapped in the Study Area by this survey, including three W.A. listed Threatened Ecological Communities (TECs) (all of which are also listed, either individually or as a component of an umbrella community, as TECs by the Commonwealth), and one Study Area VT that may represent a listed W.A. TEC, with more data required to confirm its status. These are:

- SCP3a - *Corymbia calophylla -Kingia australis* woodlands on heavy soils, Swan Coastal Plain (WA – Critically Endangered; Commonwealth - Endangered);
- SCP3c - *Corymbia calophylla -Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain (WA – Critically Endangered; Commonwealth - Endangered);
- SCP08 - Herb rich shrublands in clay pans (WA – Vulnerable; Commonwealth – Critically Endangered, as a component of the Clay Pans of the Swan Coastal Plain); and
- Study Area VT 5.

1. INTRODUCTION

1.1 Project Overview

Main Roads Western Australia (Main Roads) is proposing to extend Tonkin Highway from Thomas Road in Oakford to South Western Highway in Mundijong (The Project). This includes:

- approximately 14 kilometres (km) of four lane dual carriageway from Thomas Road to South Western Highway;
- construction/upgrades of intersections at Thomas Road, Abernethy Road, Orton Road, Mundijong Road and South Western Highway; and
- a grade separated interchange at Bishop Road catering for the Perth to Bunbury rail line and any future freight rail realignment at Mundijong.

The Project is designed to alleviate pressure on the existing transport network, to reduce travel times for private and freight traffic and improve safety and connectivity between current and future residential, business and employment precincts.

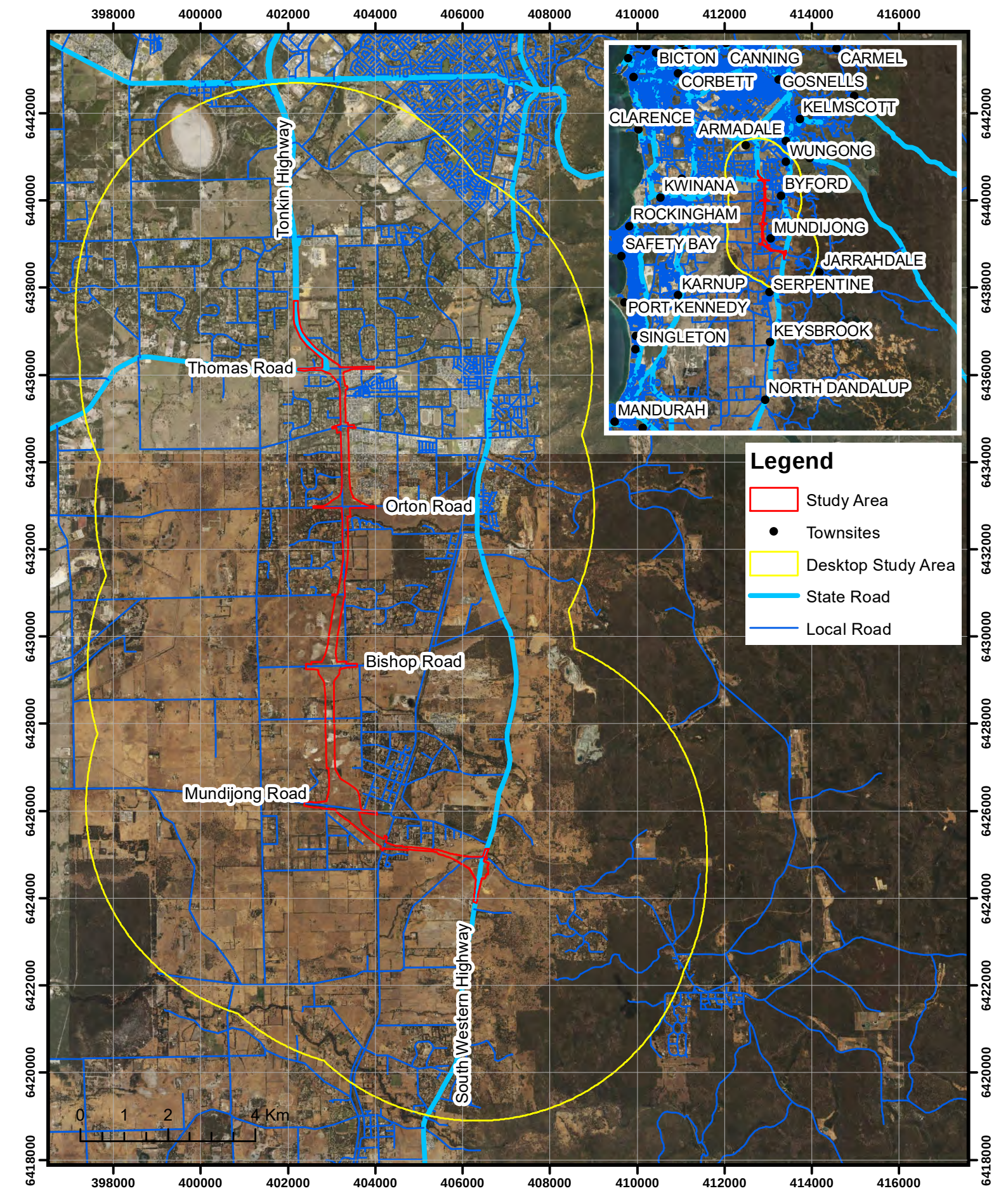
This Project forms the second portion of the "Construction and use of the Tonkin Highway Extension from Mills Road West, Gosnells to South Western Highway, Mundijong" Project. Referred to the Environmental Protection Authority (EPA) and assessed at Public Environmental Review level, works were approved under Ministerial Statement 595 on the 12th of June 2002.

Main Roads commissioned Woodman Environmental Consulting Pty Ltd (Woodman Environmental) to conduct a flora and vegetation assessment of the remaining undeveloped portion of the Project area to inform further environmental assessment and approvals applications.

1.2 Study Area Definition

Main Roads has provided the Project Study Area (the Study Area), as shown on Figure 1. The Study Area is located approximately 40 km south of Perth City, near Byford and Mundijong in the Shire of Serpentine-Jarrahdale. The Study Area is 362.3 ha in size and is located in the Perth IBRA subregion, which has been highly modified due to clearing and other associated impacts.

A Desktop Study Area, for interrogation of databases and searches for relevant literature, has been defined. As per Main Roads requirements, the Desktop Study Area includes a 5 km buffer of the Study Area, as shown on Figure 1.



Study Area and Desktop Study Area Location	Author: Alison Saligari	N
	WEC Ref: MR19-32-01	
WOODMAN ENVIRONMENTAL	Filename: MR19-32-01-f01.mxd	**Figure**
	Scale: 1:110,000 (A4)	1
	Projection: GDA 1994 MGA Zone 50	
This map should only be used in conjunction with WEC report MR19-32-01.	Revision: 0 - 25 September 2020	

1.3 Aim and Objectives

The primary aim of this assessment was to characterise the flora and vegetation values of the Study Area to the current regulatory standard.

The overall objectives of the assessment were to:

- Compile an inventory of vascular flora taxa that occur in the Study Area;
- Search for and census populations of significant flora taxa identified occurring or potentially occurring within the Study Area, with such taxa defined as one of the following (hereafter referred to as significant flora taxa), to provide context for impact assessment:
    - Listed Threatened Species (T) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Commonwealth);
    - Threatened Flora (T) under the *Biodiversity Conservation Act 2016* (BC Act) (WA);
    - Priority Flora taxa (P) as classified by the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA); and
    - Other significant flora taxa as defined by the EPA (2016a; b).
- Identify locations and determine the extent of introduced vascular flora taxa, with particular focus on those that are Weeds of National Significance (WoNS), or Declared Pests under the *Biosecurity and Agriculture Management Act 2007* (BAM Act);
- Identify, map and describe Vegetation Types (VTs) that occur within the Study Area;
- Describe and map vegetation condition within the Assessed Area as per the vegetation condition scale presented in EPA (2016a) (Appendix A);
- Identify, map and describe vegetation that occurs within the Study Area that is one of the following (hereafter referred to as significant vegetation), to provide context for impact assessment:
    - Listed Threatened Ecological Communities (TEC) under the EPBC Act;
    - TEC as classified by DBCA and endorsed by the Western Australian (WA) Minister for the Environment;
    - Priority Ecological Communities (PEC) as classified by DBCA;
    - Area of wetland or riparian vegetation that is ground or surface water-dependent; and
    - Other significant vegetation as defined by EPA (2016a; b).

The survey and reporting works comply with the following documents:

- Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016a);
- Environmental Factor Guideline – Flora and Vegetation (EPA 2016b).

Other specific guidance documents used as part of this survey are detailed in the results section of this report.

1.4 Level of Assessment

The flora and vegetation assessment of the Study Area was comprised of a Detailed Survey and Targeted Survey as defined in Section 4.3 of the 'Technical Guidance for Flora and

Vegetation Surveys for Environmental Impact Assessment' (EPA 2016a). This is considered appropriate for the Study Area, as it is likely to support a high diversity of flora and vegetation, may comprise restricted landforms or vegetation types, and is likely to support significant flora or vegetation, as outlined in Section 4.3 of the 'Technical Guidance for Flora and Vegetation Surveys for Environmental Impact Assessment' (EPA 2016a).

2. BACKGROUND

2.1 Climate

The Study Area is located within the Swan Coastal Plain (SCP) subregion (Drummond Botanical Subdistrict) of the South-West Forest region as classified by Beard (1990). The climate is classified as warm Mediterranean, with rainfall received mainly during May – September with 5 – 6 dry months per year (Beard 1990).

Figure 2 displays monthly precipitation totals and mean maximum temperature for the preceding months up until the field survey date (January - September 2019), as well as long-term average monthly maximum temperature (1965-2019) for Karnet and average monthly precipitation (1905-2019) recorded for Serpentine (all months shown), which are the nearest meteorological stations to the Study Area (Bureau of Meteorology 2020a).

The rainfall recorded from May to August, the period considered to be the most relevant in terms of promoting plant growth and flowering in the region, was well below average, with 452.2 mm recorded, compared to the long-term average of 631.7 mm. In addition, above-average daily maximum temperatures were recorded in February, March, and June to October in 2019 (Figure 2).

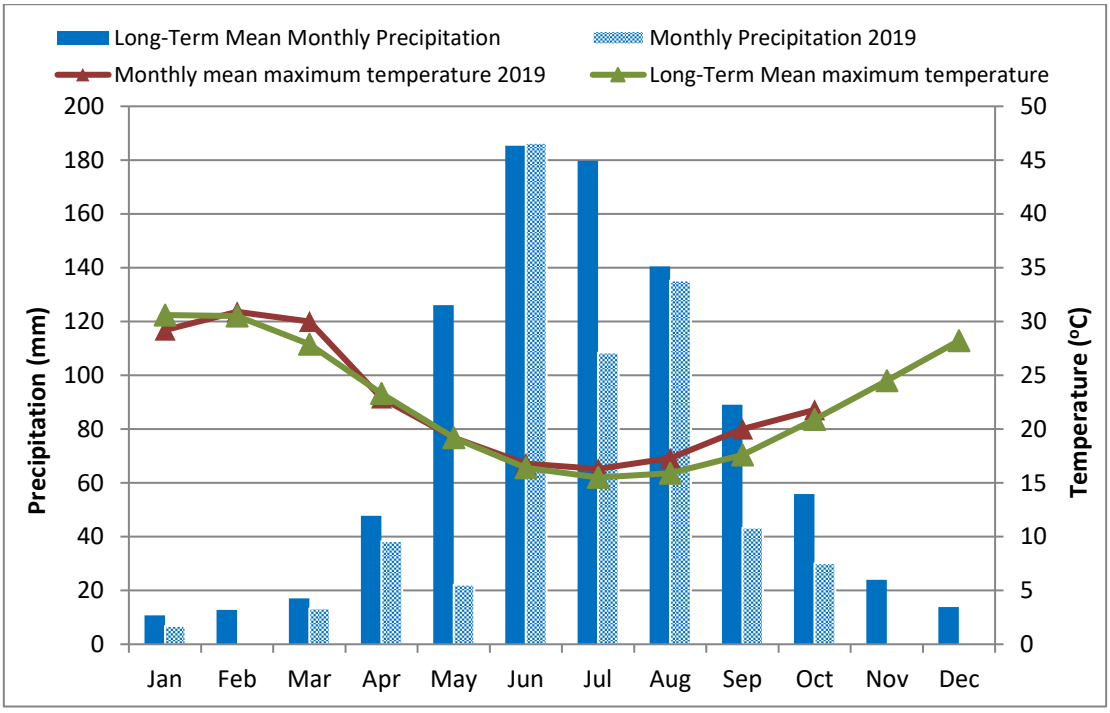


Figure 2: **Average Daily Maximum Temperature and Total Precipitation for January – September 2019, and Long-Term Average Monthly Maximum Temperature and Precipitation, for Karnet (Bureau of Meteorology 2020a)**

2.2 Geology, Landforms and Soils

The Study Area is located in the SCP subregion as defined by Beard (1981; 1990), which is equivalent to the SCP Interim Biogeographic Regionalisation for Australia (IBRA) region; it specifically occurs within the Perth (SWA-2) IBRA subregion (Commonwealth of Australia 2012). The SCP subregion consists of a coastal plain of low-lying, often swampy areas and sandhills, with soils consisting of sands or swamp deposits as well as dissected country rising to the duricrusted Dandaragan Plateau on Mesozoics consisting of mainly yellow sandy soils. The geology of the region is Mesozoic to recent sediments of the Perth Basin (Beard 1990).

The Study Area occurs within the Bassendean, Forrestfield and the Pinjarra Soil-Landscape Zones of the Swan Province. The Bassendean Zone is described as consisting of Mid-Pleistocene Bassendean sand and fixed dunes inland from the coastal dune zone, with non-calcareous sands and podsolised soils with low-lying wet areas. The Pinjarra Zone is characterised by alluvial deposits (early Pleistocene to Recent) between the Bassendean Dunes Zone and the Darling Scarp with colluvial and shelf deposits adjacent to the Darling Scarp in clayey to sandy alluvial soils with wet areas (Purdie *et al.* 2004).

A total of 27 soil-landscape units are mapped within the Study Area as summarised in Table 1 and presented in Figure 3 (Department of Primary Industries and Development (DPIRD) (2019a)).

Table 1: Soil Landscape Units of the Study Area (DPIRD 2019a)

Unit Name	Unit Symbol	Description
Bassendean B1 Phase	212Bs__B1	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m; banksia dominant.
Bassendean B1a Phase	212Bs__B1a	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands with an intensely coloured yellow B horizon occurring within 1 m of the surface; marri and jarrah dominant.
Bassendean B2 Phase	212Bs__B2	Flat to very gently undulating sandplain with well to moderately well drained deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.
Bassendean B3 Phase	212Bs__B3	Closed depressions and poorly defined stream channels with moderately deep, poorly to very poorly drained bleached sands with an iron-organic pan, or clay subsoil. Surfaces are dark grey sand or sandy loam.
Bassendean B4 Phase	212Bs__B4	Broad poorly drained sandplain with deep grey siliceous sands or bleached sands, underlain at depths generally greater than 1.5 m by clay or less frequently a strong iron-organic hardpan.
Bassendean B6 Phase	212Bs__B6	Sandplain and broad extremely low rises with imperfectly drained deep or very deep grey siliceous sands.
Forrestfield F1c Phase	213Fo_F1c	1-15% lower slopes with well drained deep uniform yellowish brown sands which are generally free of laterite or gravel.
Forrestfield F2b Phase	213Fo__F2b	Low slopes and foot slopes up to 5-10% with well drained moderately deep to deep, gravelly acidic yellow duplex soils and rare laterite.
Forrestfield F3 Phase	213Fo__F3	1-3% foot slopes with deep, imperfectly drained yellow and, less commonly, acidic grey duplex soils.
Forrestfield F4 Phase	213Fo__F4	Incised stream channels within gentle slopes with deep acidic yellow duplex soils and sandy alluvial gradational brown earths.
Forrestfield (D Range) F1 Phase	213Fo_Ff1	Foot and low slopes < 10% with deep rapidly drained siliceous yellow brown sands, and pale or bleached sands with yellow-brown subsoil. Shrubland of unidentified species.
Forrestfield (D Range) F3 Phase	213Fo__Ff3	Foot and low slopes <10%. Well drained gravelly yellow or red duplex soils with sandy loam to loam topsoil. Woodland of E. wandoo and E. marginata.
Forrestfield (D Range) F10 Phase	213Fo_Ff10	Alluvial fans on lower slopes <5-10% with variable poorly drained soils.
Pinjarra, B1 Phase	213Pj__B1	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m; banksia dominant.
Pinjarra, B2 Phase	213Pj__B2	Flat to very gently undulating sandplain with well to moderately well drained deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.
Pinjarra, B2a Phase	213Pj__B2a	Flat to very gently undulating sandplain with well to moderately well drained deep bleached grey sands with an intensely coloured yellow B horizon usually well within 1 m of the surface.
Pinjarra, B4 Phase	213Pj_B4	Broad poorly drained sandplain with deep grey siliceous sands or bleached sands, underlain at depths generally greater than 1.5 m by clay or less frequently a strong iron-organic hardpan.

Unit Name	Unit Symbol	Description
Pinjarra, P1b Phase	213Pj__P1b	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or ineffective duplex) soils. Moderately deep pale sand to loamy sand over clay: imperfectly drained and moderately susceptible to salinity in limited areas.
Pinjarra, P1c Phase	213Pj__P1c	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or ineffective duplex) soils. Deep pale brown to yellowish sand to sandy loam over clay; imperfectly drained and moderately susceptible to salinity in limited areas.
Pinjarra, P1d Phase	213Pj__P1d	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or ineffective duplex) soils. Shallow pale sand to sandy loam over clay; imperfect to poorly drained and moderately susceptible to salinity.
Pinjarra, P1e Phase	213Pj__P1e	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or ineffective duplex) soils. Shallow pale sand to sandy loam over very gravelly clay; moderately well drained.
Pinjarra, P2 Phase	213Pj__P2	Flat to very gently undulating plain with deep alkaline mottled yellow duplex soils which generally consist of shallow pale sand to sandy loam over clay.
Pinjarra, P3 Phase	213Pj__P3	Flat to very gently undulating plain with deep, imperfect to poorly drained acidic gradational yellow or grey-brown earths and mottled yellow duplex soils, with loam to clay loam surface horizons.
Pinjarra P7 Phase	213Pj_P7	Seasonally inundated swamps and depressions with very poorly drained variable acidic mottled yellow and gley sandy duplex and effective duplex soils.
Pinjarra P8 Phase	213Pj_P8	Broad poorly drained flats and poorly defined stream channels with moderately deep to deep sands over mottled clays; acidic or less commonly alkaline gley and yellow duplex soils to uniform bleached or pale brown sands over clay.
Pinjarra, P9 Phase	213Pj__P9	Shallowly incised stream channels of minor creeks and rivers with deep acidic mottled yellow duplex soils.
Pinjarra P11 Phase	213Pj_P11	Shallow brown loamy soils or less commonly, very shallow sands over ironstone pavement which is a clear barrier to drainage.

Soil Landscape Units of the Desktop Study Area	Author: Alison Saligari	
	WEC Ref: MR19-32-01	
WOODMAN ENVIRONMENTAL	Filename: MR19-32-01-f03.mxd	**Figure**
	Scale: 1:70,000 (A4)	3
	Projection: GDA 1994 MGA Zone 50	
This map should only be used in conjunction with WEC report MR19-32-01.	Revision: 0 - 25 September 2020	

Legend

- Study Area
- Desktop Study Area

Soil Landscape Units

- 212BsW_SWAMP, Sw - Swamp (Bassendean)
- 212Bs__B1, Bassendean B1 Phase
- 212Bs__B1a, Bassendean B1a Phase
- 212Bs__B2, Bassendean B2 Phase
- 212Bs__B2a, Bassendean B2a Phase
- 212Bs__B3, Bassendean B3 Phase
- 212Bs__B4, Bassendean B4 Phase
- 212Bs__B6, Bassendean B6 Phase
- 213Fo__F1c, Forrestfield F1c Phase
- 213Fo__F2a, Forrestfield F2a Phase
- 213Fo__F2b, Forrestfield F2b Phase
- 213Fo__F2c, Forrestfield F2c Phase
- 213Fo__F3, Forrestfield F3 Phase
- 213Fo__F4, Forrestfield F4 Phase
- 213Fo__F5, Forrestfield F5 Phase
- 213Fo__Ff1, Forrestfield (D Range) F1 Phase
- 213Fo__Ff10, Forrestfield (D Range) F10 Phase
- 213Fo__Ff2, Forrestfield (D Range) F2 Phase
- 213Fo__Ff3, Forrestfield (D Range) F3 Phase
- 213Fo__Ff7, Forrestfield (D Range) F7 Phase
- 213Fo__Ff8, Forrestfield (D Range) F8 Phase
- 213PjSWP10, Pinjarra P10 Phase
- 213PjSWP6a, Pinjarra P6a Phase
- 213PjSWP6b, Pinjarra P6b Phase
- 213PjSWP6c, Pinjarra P6c Phase
- 213Pj__Cs, EnvGeol Cs Phase
- 213Pj__P11, Pinjarra P11 Phase
- 213Pj__P11a, Pinjarra P11a Phase
- 213Pj__P1a, Pinjarra P1a Phase
- 213Pj__P1b, Pinjarra P1b Phase
- 213Pj__P1c, Pinjarra P1c Phase
- 213Pj__P1d, Pinjarra P1d Phase
- 213Pj__P1e, Pinjarra P1e Phase
- 213Pj__P2, Pinjarra P2 Phase
- 213Pj__P2a, Pinjarra P2a Phase
- 213Pj__P3, Pinjarra P3 Phase
- 213Pj__P4, Pinjarra P4 Phase
- 213Pj__P5, Pinjarra P5 Phase
- 213Pj__P7, Pinjarra P7 Phase
- 213Pj__P8, Pinjarra P8 Phase
- 213Pj__P9, Pinjarra P9 Phase
- 213Pj__S10, EnvGeol S10 Phase
- 255DpDW2, Dwellingup 2 Phase
- 255DpYG, Yarragil Subsystem
- 255DpYG1, Yarragil 1 Phase
- 255DpYG4, Yarragil 4 Phase
- 255Mv, Murray Valleys System
- 255MvBG1, Balgobin 1 Phase
- 255MvBG2, Balgobin 2 Phase
- 255MvDS1, Darling Scarp 1 Phase
- 255MvDS2, Darling Scarp 2 Phase
- 255MvHE, Helena Subsystem
- 255MvHE1, Helena 1 Phase
- 255MvHE2, Helena 2 Phase
- 255MvMA, Myara Subsystem
- 255MvMA1, Myara 1 Phase
- 255MvMA2, Myara 2 Phase
- 255MvMM1, Mambup 1 Phase
- 255MvMM2, Mambup 2 Phase
- 255MvMY, Murray Subsystem
- 255MvMY1, Murray 1 Phase
- 255MvMY2, Murray 2 Phase
- 255MvMY3, Murray 3 Phase
- 255MvMY4, Murray 4 Phase

Soil Landscape Units of the Desktop Study Area	Author: Alison Saligari	N
	WEC Ref: MR19-32-01	
WOODMAN ENVIRONMENTAL	Filename: MR19-32-01-f03-1.mxd	**Figure**
	Scale: 1:70,000 (A4)	3.1
	Projection: GDA 1994 MGA Zone 50	
This map should only be used in conjunction with WEC report MR19-32-01.	Revision: 0 - 25 September 2020	

2.3 Groundwater and Surface Water Values

The wetlands on the SCP have been mapped, evaluated and assigned a management category which provides guidance on how they should be managed and protected. Wetlands are classified by combining hydrological attributes and landform types as described in the methodology for the evaluation of wetlands on the SCP (DBCA 2017a). There are two types of wetlands within the Estate as listed below:

- Palusplain: seasonally waterlogged flat; and
- Creek: seasonally inundated channel.

In addition, wetlands have been evaluated and classified into three management categories including Conservation wetlands (Highest priority wetlands), Resource Enhancement wetlands (Priority wetlands) and Multiple Use wetlands (DBCA 2017a).

Development or clearing of Conservation category wetlands is not considered appropriate, as these wetlands are regarded as the most valuable wetlands and any activity that may lead to further loss or degradation is therefore inappropriate. Resource Enhancement category wetlands are viewed as having the potential to be managed, restored and protected with the objective of improving their conservation value and hydrological/hydrogeological regime. The use, development and management of Multiple Use wetlands should be considered in the context of ecologically sustainable development and best management practice catchment planning with their role in managing the natural hydrological and hydrogeological regime of the general area maintained (DBCA 2017a).

Figure 4 presents the geomorphic wetlands mapped within the Study Area (DBCA 2020a). There are several small areas of Conservation category palusplains in the Study Area, however, the largest wetland areas are Multiple Use palusplains. The single creek in the Study Area is listed as Resource Enhancement.

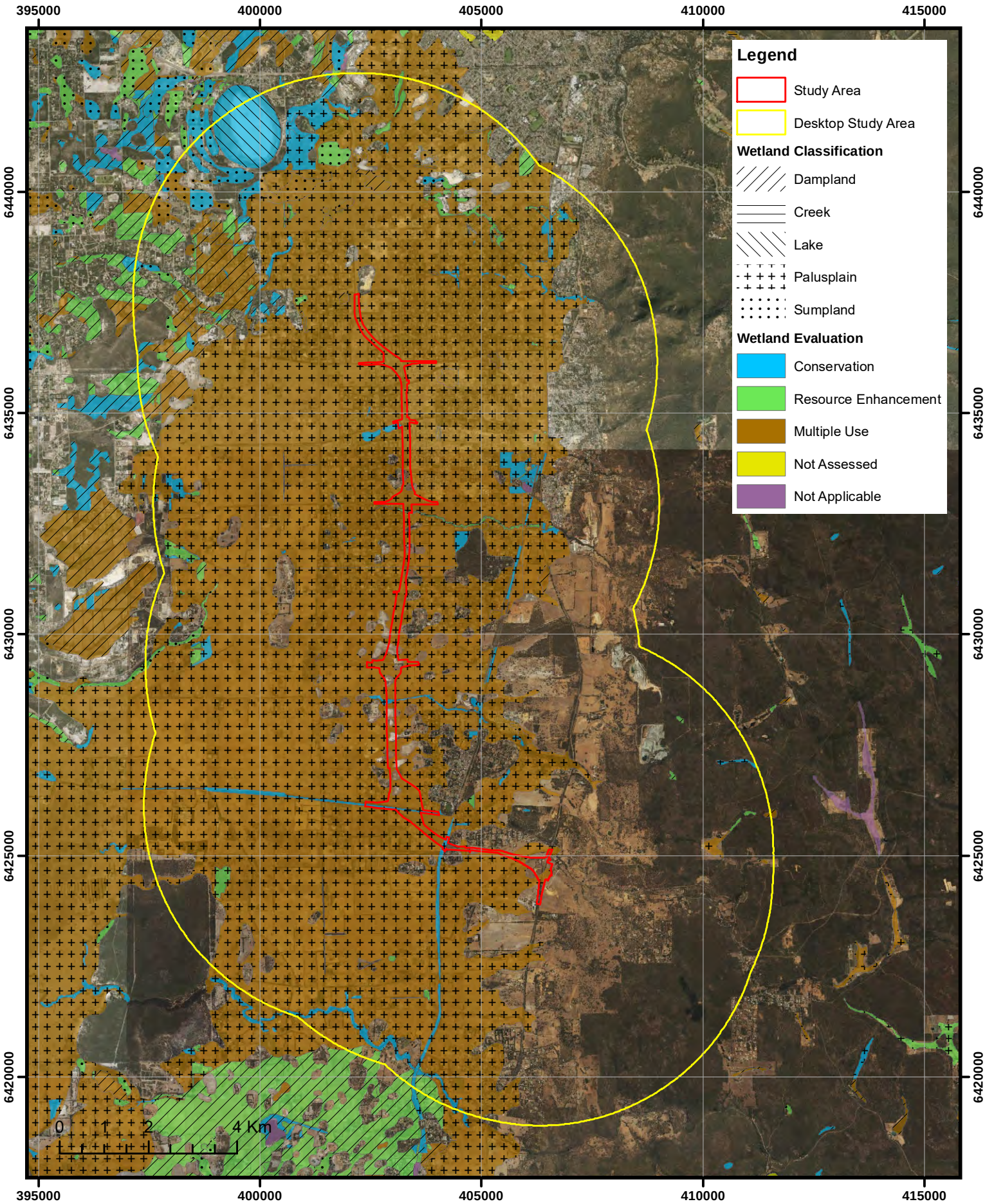
In a local groundwater context, according to the Bureau of Meteorology's 'Groundwater Dependent Ecosystem (GDE) Atlas' (Bureau of Meteorology 2020b) the majority of the Study Area is located in Moderate Potential GDE (national assessment) (Aquatic GDE). Aquatic GDEs are described as 'ecosystems that rely on the surface expression of groundwater–this includes surface water ecosystems which may have a groundwater component, such as rivers, wetlands and springs' (Bureau of Meteorology 2020b).

The search of the Department of Agriculture, Water and the Environment (DAWE) Species Profile and Threats (SPRAT) Database (DAWE 2020) with regard to Matters of National Environmental Significance (MNES) listed under the EPBC Act identified two Wetlands of International Importance (Ramsar), being the Forrestdale and Thomsons Lakes and the Peel-Yalgorup system. The former site occurs approximately 3 km north north-east of the Study Area itself, while the latter occurs 30 – 40 km downstream from the Study Area; the Serpentine River drains into this system, with the nearest point of the river being 5 km south-west from the Study Area. However, a minor tributary of the river intersects the Study Area near South Western Highway.

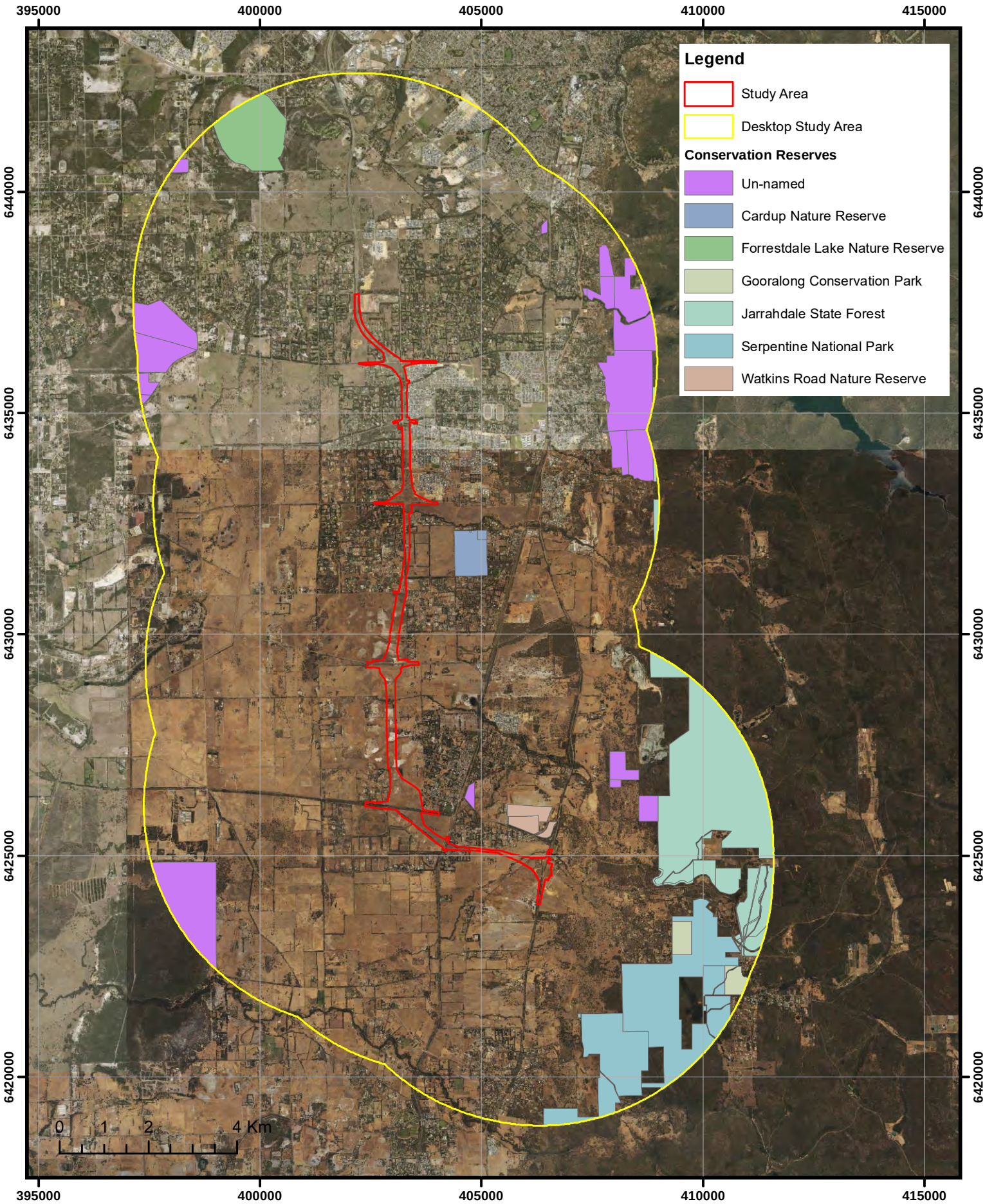
2.4 Land Tenure

The majority of the Study Area is comprised of freehold land, with smaller areas of unallocated crown land, rail reserves, road reserves and other easements.

There are a number of conservation reserves in the Desktop Study Area including Cardup Nature Reserve, Forrestdale Lake Nature Reserve, Gooralong Conservation Park, Jarrahdale State Forest, Serpentine National Park and Watkins Road Nature Reserve. None of these conservation reserves are located within, or adjacent to the Study Area (Figure 5).



Geomorphic Wetlands Mapping of the Desktop Study Area	Author: Alison Saligari	N
	WEC Ref: MR19-32-01	
WOODMAN ENVIRONMENTAL	Filename: MR19-32-01-f04.mxd	**Figure**
	Scale: 1:110,000 (A4)	4
	Projection: GDA 1994 MGA Zone 50	
This map should only be used in conjunction with WEC report MR19-32-01.	Revision: 0 - 25 September 2020	



Conservation Reserves in the Desktop Study Area	Author: Alison Saligari	N
	WEC Ref: MR19-32-01	
WOODMAN ENVIRONMENTAL	Filename: MR19-32-01-f05.mxd	**Figure**
	Scale: 1:110,000 (A4)	5
	Projection: GDA 1994 MGA Zone 50	
This map should only be used in conjunction with WEC report MR19-32-01.	Revision: 0 - 25 September 2020	

3. METHODS

3.1 Desktop Study

Prior to commencement of the field survey, a review of all publicly available flora and vegetation data relevant to the Study Area was undertaken. This included obtaining and reviewing copies of reports of previous biological surveys carried out within the vicinity of the Study Area (where available) and interrogation of relevant databases and other sources as listed in Table 2.

Table 2: Searches Undertaken for the Desktop Study Area

Source	Search Attributes	Search Purpose
DBCA Threatened and Priority Ecological Communities Database (data provided by Main Roads)	Database interrogated using Desktop Study Area boundary	Obtain records of WA TECs and/or DBCA-classified PECs within the Desktop Study Area
DBCA TEC and PEC lists	Review of current DBCA TEC and PEC lists (DBCA 2018a, 2020b)	Identify whether there are any additional DBCA listed TECs or PECs which could occur within the Desktop Study Area
DBCA Significant Flora Databases (WA Herbarium specimen database and Threatened and Priority Flora (TPFL) database) (data provided by Main Roads)	Database interrogated using Desktop Study Area boundary	Obtain records of listed significant flora within the Desktop Study Area
DAWE SPRAT Database (interrogated using the Protected Matters Search Tool (DAWE 2020))	Database interrogated using approximate Desktop Study Area boundary (exact boundary cannot be used); search performed prior to survey, updated 13/1/20	Identify MNES, including Threatened flora and TECs, listed under the EPBC Act, that occur or have the potential to occur within the Desktop Study Area
DBCA NatureMap (WA Herbarium and TPFL records) (DBCA 2007-)	Database interrogated using approximate Desktop Study Area boundary (exact boundary cannot be used); search performed prior to survey, updated 20/1/20	Obtain records of listed significant flora and introduced flora within the Desktop Study Area
2019 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Government of Western Australia 2019)	Study Area Vegetation Associations – current extent, data current March 2019 (report 2a)	Identify extent of Vegetation Associations within the Study Area

3.2 Personnel and Licensing

Table 3 lists the personnel involved in both fieldwork and plant identifications for the survey. The Project Manager (David Coultas) has had extensive experience (> 10 years) in conducting similar flora surveys in the SCP bioregion as well as extensive experience in undertaking plant identifications of flora from the SCP. All plant material was collected under the *Flora Taking (Biological Assessment) licences* and *Authorisation to Take or Disturb Threatened Species* pursuant to the *Biodiversity Conservation Act* 2016, sections 40, 274 and 275, as listed in Table 3.

Table 3: Personnel and Licensing Information

Personnel	Flora Collecting Permit (BC Act/WC Act)	Experience in the SCP bioregion	Role
David Coultas BSc (Environmental Biology) (Hons)	FB62000051 TFL23-1819	>10 years	Project Manager/ Field Manager / Plant identifications
Emalyn Loudon BAg (Hons)	--	>3 years	Field survey
Greg Woodman BSc (Environmental Science) (Hons)	FB62000053 TFL19-1819	>20 years	Field survey
Leah Firth BSc (Conservation Biology)	FB62000055	< 1 year	Field survey Plant identifications
Marlee Starcevich BSc (Environmental Science) (Hons)	FB62000056 TFL26-1819	>2 years	Field survey

3.3 Field Survey Methods

Field survey was undertaken over six visits as listed below, with survey aspects detailed in parentheses:

- 24th May 2019 (reconnaissance survey (2 person days));
- 23rd – 26th September 2019 (detailed survey – quadrats and relevés; targeted survey (16 person days));
- 17th October 2019 (detailed survey – quadrats and relevés; targeted survey (4 person days));
- 23rd October 2019 (targeted survey; re-score of quadrats (2 person days));
- 21st November (re-score of quadrats (2 person days)); and
- 7th April 2020 (targeted significant flora survey for specific perennial taxa only (2 person days)).

The reconnaissance survey involved on–ground inspection of vegetated areas (as defined through initial aerial photography interpretation) within the Study Area, with data being collected to allow for preliminary descriptions of the plant communities to be developed. This information formed the basis of a detailed survey plan (including targeted survey), the implementation of which is described below.

The detailed survey involved the survey of 11 non-permanent flora survey quadrats within intact vegetation within the Study Area in 2019. All quadrats measured 10 m x 10 m covering an area of 100 m^2. The quadrat size used is the indicative size for flora and vegetation surveys in the SCP Bioregion, as outlined in Table 1 of the Technical Guidance for Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016a). Quadrats were only established in vegetation that was spatially large enough, and was generally in at least Very Good condition (see Section 3.7).

All vascular flora taxa that were visually identifiable within each quadrat were recorded. At least one reference specimen of most taxa encountered (excluding common, distinctive taxa)

was collected for verification and identification purposes. The following information was recorded at each quadrat:

- Personnel;
- Unique quadrat number;
- Date of survey;
- Size and shape of quadrat;
- GPS (Global Positioning System) coordinates at start corner of quadrat;
- Site photograph, taken diagonally into quadrat from start corner;
- Compass bearing for two sides of quadrat that commence at start corner of quadrat;
- Topography (including landform type and aspect);
- Soil colour and type (including the presence of any rock outcropping and surface stones);
- Vegetation condition (EPA 2016a; scale presented in Appendix A);
- Approximate time since fire;
- Presence and type of disturbance (if any);
- Percentage foliage cover (for each vascular plant taxon, including cover within the quadrat of individuals rooted outside of the quadrat);
- Height (m) (average for each taxon, excluding climbers/aerial shrubs); and
- Additional flora taxa present immediately outside of the quadrat.

In line with the methods used by the SCP study (Gibson *et al.* 1994) (see Section 5.1.1), any quadrats established in seasonally inundated areas were re-sampled during subsequent visits (see above), as such areas often contain suites of annual taxa that grow and flower as the water level recedes and the soil dries.

A number of areas of vegetation in the Study Area are on narrow road and rail reserves that are not spatially large enough to allow for quadrats to be established. Such areas were also often in Good or poorer condition (see Section 3.7). These cases necessitated the establishment and survey of relevés rather than quadrats. Relevés surveyed an area approximately within a radius of 10 m around a central point, however, this was modified to approximately 15 m either side of a central point for narrow areas of vegetation. All data recorded for quadrats (as listed above) was also recorded for relevés, however, only dominant taxa were generally recorded, as well as taxa not previously observed elsewhere. A total of 14 relevés were established and surveyed in the Study Area.

As much of the Study Area is located in cleared or highly modified farmland, areas that were clearly highly modified were sampled via a brief inspection, either on foot or from a vehicle, with notes and photographs taken.

Notes on vegetation pattern boundaries and distribution were also taken while traversing the Study Area, including a GPS location at the point where the notes were taken, a brief description of the vegetation including dominant and characteristic taxa, and a photograph. These notes were used to aid in the mapping of polygons of vegetation patterns that were not allocated quadrats. Not all vegetation pattern polygons received quadrats due to condition of vegetation; however, many polygons could be confidently allocated to a final VT using a combination of mapping notes and aerial photograph interpretation. Additional flora

taxa were also recorded opportunistically in the Study Area during traverses on foot between quadrats and relevés, with GPS locations of such taxa recorded. Locations of any significant flora and introduced flora taxa encountered opportunistically while traversing between quadrats and relevés were also recorded.

Targeted survey for significant flora taxa was undertaken as part of the survey, with a list of significant flora taxa likely to be encountered compiled as part of the desktop study. Such survey was undertaken primarily during the September and October 2019 visits outlined above, to coincide with the flowering period of most of the target taxa, including several wetland annual taxa known to flower in October. Supplementary survey was conducted in April 2020, following the completion of quadrat surveys in 2019, for specific perennial taxa that can be identified outside of their flowering periods. Appropriate habitat for such taxa in the Study Area was specifically transected on foot at spacings of 10 m. If populations of known significant flora taxa were identified, a representative collection of material was made, and the abundance and spatial distribution of individuals within each population was recorded using a DGPS for listed Threatened taxa, and a standard Garmin GPS for all other taxa.

Locations of any introduced flora taxa encountered while traversing between quadrats and relevés, and while conducting targeted searching for significant flora taxa, were also recorded using the same method as for significant flora taxa.

Traverses in the Study Area between quadrat and relevé locations, as well as transects are mapped as track logs in Appendix B.

3.4 Plant Collection and Identification

Specimens of any unknown taxa were collected and were pressed for later identification at the WA Herbarium. External experts of particular families or genera were consulted for any specimens considered to be difficult to identify or of taxonomic interest.

Taxon nomenclature generally follows *FloraBase* (WA Herbarium 1998-) with all names checked against the current DBCA Max database to ensure their validity. However, in cases where names of plant taxa have been published recently in scientific literature but have not yet been adopted on *FloraBase* due to time and/or resource constraints, nomenclature in the published literature is followed. The conservation status of each taxon was checked against *FloraBase*, which provides the most up-to-date information regarding the conservation status of flora taxa in Western Australia.

Specimens of interest, including significant flora taxa, range extensions of taxa and potential new taxa, will be sent to the WA Herbarium for consideration for vouchering as soon as practicable. However, this process is via donation, and the WA Herbarium may not voucher all specimens, in accordance with its own requirements. The specimen vouchering will be supported by completed Threatened and Priority Flora Report Forms submitted to DBCA (Species and Communities Branch) in the case of listed significant flora (e.g. Threatened and Priority flora taxa).

3.5 Floristic Analysis

Classification analysis of floristic data from the Study Area was conducted using 11 quadrats established in the Study Area by Woodman Environmental. Classification analysis methods generally followed those presented in Gibson *et al.* (1994). As per Gibson *et al.* (1994), singletons (i.e. any taxon occurring only once in the quadrat dataset) were removed from the dataset prior to analysis; a preliminary analysis undertaken with singletons included found that their inclusion had little effect on the analysis results. In contrast to Gibson *et al.* (1994), introduced taxa were also removed from the dataset prior to analysis. It is considered that the distribution of introduced taxa is generally most strongly influenced by the disturbance history of site rather than other natural ecological drivers, and therefore their inclusion in such an analysis is not considered to be desirable. Hybrids were also excluded, as well as taxa whose identification was unclear because of poor available material, except when such a taxon (with multiple records in the dataset) was known to be unique in the dataset (i.e. although not identifiable to species level, there was enough material to indicate a unique taxon). The final dataset contained 64 taxa following the removal of the above-noted taxa, with only a single taxon being removed where the identification was unclear (*Haemodorum* sp.)

As per Gibson *et al.* (1994), a single-layer data matrix (i.e. presence/absence data only) was used in the classification analysis, with PATN (V3.12) (Belbin and Collins 2009) utilised to perform the classification and ordination analysis of the data matrix. Also as per Gibson *et al.* (1994), the Bray-Curtis coefficient was used to generate an association matrix for the classification analysis. This association matrix consisted of pairwise coefficients of similarities between quadrats based on floristic data. Agglomerative hierarchical clustering, using flexible Unweighted Pair Group Method with Arithmetic Mean (UPGMA) (ß=-0.1), was used to generate a quadrat classification dendrogram (Sneath and Sokal 1973).

The above classification analysis aggregated quadrats into a group classification. The resulting dendrogram and taxon group matrix were initially examined at a group level determined by PATN as potentially appropriate for the dataset, to determine the plausibility of groups with regard to taxon groups, in combination with field observations.

In addition to the above classification analysis, additional classification analyses were conducted using Woodman Environmental quadrats and DBCA's amended SCP floristic quadrat dataset ('amended SCP dataset') (Keighery *et al.* 2012), as well as Woodman Environmental quadrats and DBCA's original SCP dataset (Gibson *et al.* 1994). The amended SCP dataset contains those quadrats established by Gibson *et al.* (1994), as well as over 500 additional sites (quadrats and relevés) established by the DBCA subsequent to that survey. This analysis was conducted with the aim of examining the relationship of Woodman Environmental quadrats to those in the SCP quadrat datasets, and therefore their relationships to the vegetation of the wider southern SCP, as opposed to the local vegetation relationships examined by the first classification analysis. As for the first analysis, the resultant dendrogram and taxon group matrices were examined; of particular focus was whether the quadrat groups produced by the first classification analysis were maintained in the subsequent classification analysis dendrograms. It was assumed that dissolution of groups of quadrats from the first classification analysis likely indicated that the vegetation represented

by such quadrats was relatively dissimilar in a regional context; this may not have been obviously evident in the local context of the first classification analysis because of the comparatively limited size of the dataset being analyzed.

For the additional classification analyses, methods and parameters were as for the first analysis; however, as per Gibson *et al.* (1994), introduced taxa were included in the dataset.

3.6 Vegetation Unit Definition, Mapping and Description

As outlined in Section 3.3, survey of vegetation in the Study Area used both quadrats and relevés, because the size of some areas of vegetation did not allow for the establishment of quadrats. Therefore, VTs were defined using a combination of floristic composition classification (i.e. via a floristic classification analysis as outlined in Section 3.5), and structural vegetation classification, as defined in the technical guidance for flora and vegetation surveys (EPA 2016a).

The classification analysis of Study Area floristic data (see Section 3.7) aggregated quadrats into a group classification. The resulting dendrogram and taxon group matrix were initially examined at a group level determined by PATN as potentially appropriate for the dataset, to determine the plausibility of groups with regard to taxon groups, in combination with field observations. This process determined a final number of clusters, which were considered to represent VTs.

Following this process, floristic and structural data recorded at relevés was examined to determine whether vegetation sampled by the relevé was analogous to any of the VTs defined by floristic composition classification. Any such vegetation that was not considered to be analogous with any of the VTs defined by floristic composition classification was considered to represent a discrete VT.

VT descriptions have been adapted from the National Vegetation Information System (NVIS) Australian Vegetation Attribute Manual Version 6.0 (Executive Steering Committee for Australian Vegetation Information (ESCAVI) 2003), as stipulated by EPA (2016a). This model follows nationally-agreed guidelines to describe and represent VTs, so that comparable and consistent data are produced nation-wide. It should be noted that the NVIS system utilises vegetation descriptions derived from structural characteristics of the individual community units, while a number of the VTs presented in this report are defined based on the results of a floristic classification analysis, excluding any structural data. Such VTs therefore may include multiple structural types. Considering the effect of disturbance factors such as fire on vegetation structure, this approach is designed to provide a map of VTs that reflect taxon composition and the influences of the physical and chemical environment rather than disturbance history.

It should also be noted that this report describes VTs at the NVIS Sub-Association level, rather than the Association level as stipulated by EPA (2016a). This level is considered more appropriate for the vegetation of the Survey Area, as often the vegetation possessed one or more additional strata to the traditional three-stratum classification system used at the Association level.

For VTs defined via floristic composition classification, indicator taxa are often defined via indicator taxon analysis; indicator taxa are those that have high fidelity to a given VT. However, because of the limited number of quadrats established within the Study Area, it is considered that there is insufficient data available to undertake a meaningful indicator taxon analysis. Indicator taxon analysis was therefore not undertaken.

The locations of quadrats and/or relevés within each VT were used in conjunction with aerial photograph interpretation and field notes taken during survey to develop VT mapping polygon boundaries. These VT mapping polygon boundaries were then digitised using Geographic Information System (GIS) software.

3.7 Vegetation Condition Mapping

Vegetation condition was described using the vegetation condition scale presented in EPA (2016a) (see Appendix A). Notes on vegetation condition were taken during the field survey via vehicle traverses and during foot traverses undertaken within the Study Area. Vegetation condition was also recorded at all quadrats. Vegetation condition category polygon boundaries were developed using this information and were digitised using GIS software as for VT polygon boundaries.

3.8 Significant Flora and Vegetation

3.8.1 Significant Flora

As per EPA (2016b), flora taxa may be significant for a range of reasons, including, but not limited to the following:

- Being identified as a Threatened or Priority species (formally listed significant taxa – includes taxa listed under both State and Commonwealth legislation, and classified as Priority by DBCA);
- Locally endemic or associated with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems);
- New species or species with anomalous features that indicate a potential new species;
- Representative of the range of a species (particularly at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- Unusual species, including restricted subspecies, varieties or naturally occurring hybrids; and
- Relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

Significant taxa recorded within the Study Area are discussed in Section 5.2.2 with reference to the above categories. In this section, point locations, individuals and populations known from the Study Area are discussed. It is worthy of note that a population in the context of this survey is defined as a discrete group of individuals of a taxon separated by more than 500 m from the nearest discrete group of individuals (DBCA 2017b). However, this definition can only be tentatively applied if the intervening 500 m has not been surveyed.

3.8.2 Significant Vegetation

As per EPA (2016b), vegetation may be significant for a range of reasons, including, but not limited to the following:

- Being identified as a TEC or PEC (formally listed significant vegetation – includes vegetation listed under Commonwealth legislation, endorsed as a TEC by the Western Australian Government, or classified as a PEC by DBCA);
- Having restricted distribution;
- Degree of historical impact from threatened processes;
- A role as a refuge; and
- Providing an important function required to maintain ecological integrity of a significant ecosystem.

The vegetation described by the study of the southern SCP by Gibson *et al.* (1994), together with supplementary vegetation description to this study published in Government of Western Australia (2000), is the current baseline used when assessing the significance of vegetation on the southern SCP. The vast majority of terrestrial TECs and PECs that occur on the southern SCP are Floristic Community Types (FCTs) described by this Study; the Study also provides information on the distribution of all FCTs described, as well as their conservation status.

Consequently, further floristic analyses were undertaken to determine relationships between VTs from the Study Area that were defined via floristic composition classification and SCP FCTs defined by Gibson *et al.* (1994), with the aim of aligning VTs with SCP FCTs. As there is no formal guidance available on the most appropriate way to undertake this process, several different analytical approaches were employed, and all results reviewed, in an attempt to build supporting evidence for aligning VTs with SCP FCTs. These were:

- Analysis of the Woodman Environmental quadrat dataset from the Study Area with the original SCP dataset (Gibson *et al.* 1994);
- Analysis of the Woodman Environmental quadrat dataset from the Study Area with the amended SCP dataset (Keighery *et al.* 2012), which includes more than 500 additional survey sites;
- Single site insertion analysis of representative quadrats of VTs described in the Study Area, with the original SCP dataset (Gibson *et al.* 1994) (at least two representative quadrats from each VT analysed, excluding those represented by a single quadrat only); and
- Single site insertion analysis of representative quadrats of VTs described in the Study Area, with the amended SCP dataset (Keighery *et al.* 2012) (at least two representative quadrats from each vegetation type analysed, excluding those represented by a single quadrat only).

It should be noted that the metadata for the amended SCP dataset explicitly states that it is not suitable for FCT analysis due to "inconsistencies in the grouping and splitting of some species compared to that used in the Gibson *et al.* (1994) analysis". However, the exact dataset that DBCA used which included the more than 500 additional sites established on the SCP subsequent to the Gibson *et al.* (1994) study, which is referred to in the aforementioned metadata, does not appear to be publicly available. Therefore, the amended SCP dataset was

used for analysis by this assessment, as the alternative of not using this dataset, and hence not considering a significant volume of data, was considered inappropriate in the absence of formal guidance on analysis methods. The argument that "inconsistencies in the grouping and splitting of some species compared to that used in the Gibson *et al.* (1994) analysis" is not considered to be reason enough to discount the dataset in this context; such issues are likely to frequently arise when a historical dataset is only periodically updated to reflect current taxonomic concepts. However, it considered unlikely that such issues would have a significant bearing on analysis results in this current context.

Further to this, as noted above, a dataset similar to the amended SCP dataset has been re-analysed by the DBCA on behalf of the former Department of Environmental Protection (Government of Western Australia 2000), with supplementary SCP FCT descriptions published as a result; however, the methods of this analysis are not documented in Government of Western Australia (2000), and apparently were never fully documented (V. English *pers. comm.* 2015). It is apparent that DBCA used the ALOC non-hierarchical classification technique, whereby the groups of quadrats that formed the basis of the original SCP FCTs were 'locked' in place, and additional quadrats were allocated to these groups or to new groups via analysis (V. English *pers. comm.* 2015). It is assumed, although there is no documented evidence, that the single site insertion approach was then used, whereby quadrats were added singly to the locked dataset. FCTs were then assigned to the additional survey sites contained in the amended SCP dataset based on the results of the analyses (Keighery *et al.* 2012). It is assumed that these methods were used as re-analysis of the entire amended SCP dataset would have caused significant disruption (based on previous unpublished analyses conducted by Woodman Environmental) to the original quadrat groupings that were used to define FCTs in Gibson *et al.* (1994), given such a large volume of data was added. The original FCTs described by Gibson *et al.* (1994) could not have been maintained using this approach. The ALOC analysis approach does not appear to be widely used; the DBCA does not appear to have published any studies that have used this method, with recent studies published by the DBCA using the classification methods outlined in Section 3.5.

Analysis methods and parameters were the same used as for the analysis of the Woodman Environmental quadrat dataset as outlined in Section 3.5; as noted in Section 3.5, these are the same methods utilised by Gibson *et al.* (1994).

The resultant analysis dendrograms were then reviewed to determine the position of Woodman Environmental quadrats in relation to quadrats from the SCP quadrat datasets; from this, VT and FCT relationships were inferred. It is important to note that all of the analytical approaches outlined above do not maintain the original quadrat groupings that formed the basis of the original FCTs defined by Gibson *et al.* (1994) in the resultant dendrograms. As a result, there is inherent ambiguity in inferences made from examination of the dendrograms alone. To provide further support for the inferences made, taxon lists of Woodman Environmental quadrats were also compared to the typical species lists for SCP FCTs presented in Gibson *et al.* (1994). As well as quadrat taxon lists, other information such as vegetation structure, soils, topography and geographical distribution data from this study were also reviewed against that of relevant published data. Note that quadrats from the amended SCP dataset were not considered as part of this process.

For VTs from the Study Area defined via structural vegetation classification, only the similarity in dominant taxa, soils, topography and geographical distribution between these VTs and SCP FCTs can be considered when attempting to align VTs with SCP FCTs. Therefore, taxon lists of Woodman Environmental relevés were compared to the typical species lists for SCP FCTs presented in Gibson *et al.* (1994), as well as quadrat taxon lists from this study, with VTs aligned with SCP FCTs if possible, where there appeared to be relatively high similarity.

With regard to other TECs and PECs listed in Western Australia that were not described in the Gibson *et al.* (1994) study, only broad descriptions generally are provided in the respective TEC and PEC lists published by the DBCA to allow for diagnosis. The vegetation of the Study Area was therefore manually compared to such descriptions to determine whether any vegetation may represent such a TEC or PEC. A similar process was followed for TECs listed under the EPBC Act, with the vegetation of the Study Area assessed against the appropriate listing and conservation advice for any TECs likely to occur in the Study Area.

4. ADEQUACY AND LIMITATIONS OF SURVEY

4.1 Adequacy of Survey

The Study Area covers approximately 362 ha, the majority of which (94.8 %) is either cleared or highly modified. Within the remaining 5.2 % of the Study Area, 11 quadrats and 13 relevés were established in all preliminary vegetation patterns discernible by initial aerial photograph interpretation, both to adequately sample variation in vegetation throughout the Study Area and to ensure adequacy of sampling for vascular plant taxa. The number of quadrats and relevés established in the Study Area is considered to be an acceptable number given the limited amount of intact vegetation present.

To provide an indication of the adequacy of this survey, a taxon accumulation curve was produced using PC-Ord (McCune and Mefford 2011). Taxon accumulation curves represent a theoretical model of the relationship between sampling intensity and taxon accumulation; when sampling intensity is increased, taxon accumulation is reduced, and a taxon accumulation curve becomes asymptotic.

The taxon accumulation curve for quadrat data from the Study Area was generated using all native taxa (both annual and perennial) recorded within each quadrat. Taxon accumulation calculations for the Study Area were then undertaken utilising the Chao-2 estimator for species richness (Chao 1987) and compared to the actual number of taxa recorded in the Study Area. This provides some indication as to whether sufficient quadrats were surveyed to adequately sample the species richness in the Study Area. As the generation of species accumulation curves includes quadrat data only, and not taxa recorded during targeted searching or otherwise opportunistically recorded, the indication of adequacy of survey provided is considered to be conservative.

Figure 6 presents the species accumulation curve generated from quadrat data from the Study Area. As the curve is asymptotic in this case, the recorded number of taxa within quadrats equals the estimated taxon richness in the Study Area. Based on this, the analysis indicates that the Survey Area was relatively well-sampled despite that fact that only a small area of vegetation was sampled via quadrats.

Another adequacy of survey measure is that developed by Mueller-Dombois and Ellenberg (1974), who suggest that an adequacy cut-off point might be when a 10 % increase in quadrats surveyed results in a 5 % (or less) increase in taxa recorded. This measure was also calculated using all native taxa recorded within each quadrat. The number of quadrats established in the Study Area satisfies this adequacy measure suggested by Mueller-Dombois and Ellenberg (1974), with the final taxon increase value of 0 % recorded following the final 10 % increase in quadrats.

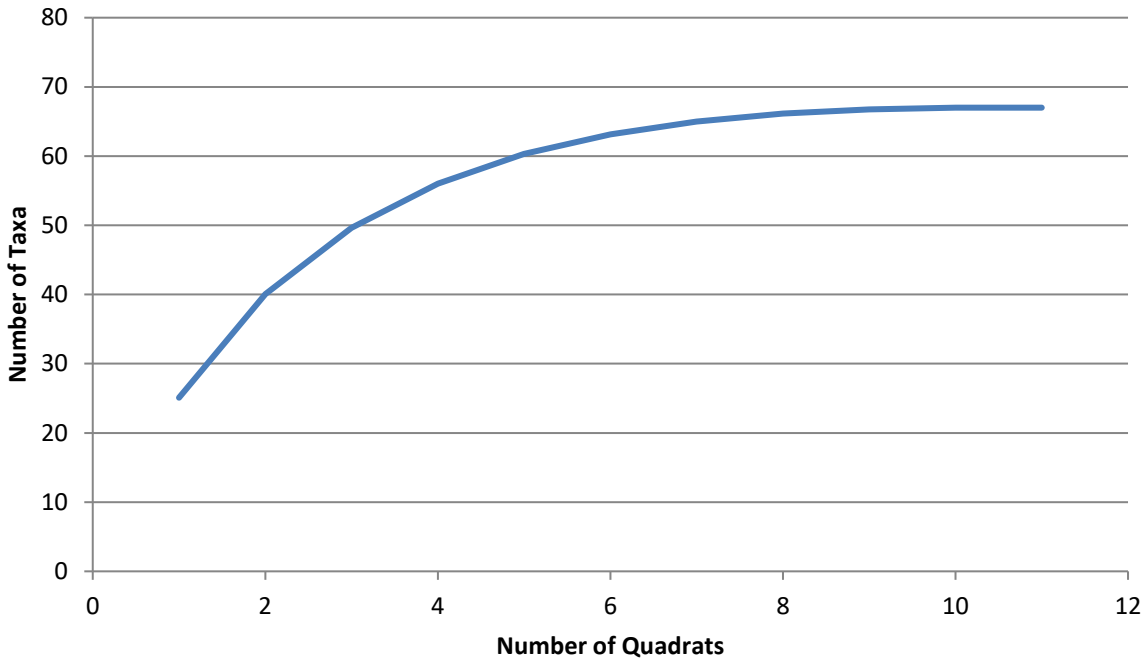


Figure 6: Study Area Quadrat Data Species Accumulation Curve

4.2 Limitations of Survey

Table 4 presents the limitations of the flora and vegetation survey of the Survey Area in accordance with EPA (2016a). Overall, there were no constraints associated with effort and extent, competency / experience of the team carrying out the survey, sources of information and remoteness and/or access which affected the results of the survey of the Study Area. However, the below average rainfall recorded prior to the survey and level of historical clearing and disturbance has affected the reliability of vegetation mapping and proportion of flora identified as discussed in Table 4.

Table 4: Limitations of the Flora and Vegetation Survey of the Study Area

Limitation	Limitation of Survey	Comment
Effort and Extent	No	Detailed survey undertaken across entire Study Area. Multiple quadrats and/or relevés were established in each vegetation pattern identified in the Study Area. No constraints prevented appropriate sampling techniques (quadrat establishment, foot transects) being employed. Relative ease of access within the Study Area enabled detailed vegetation type and condition mapping to be undertaken throughout the Study Area via foot and vehicle transects. Mapping reliability is therefore considered to be high. During the Targeted Survey for significant taxa areas were searched on foot in their entirety, with transects generally undertaken at 10 m intervals. A 10 m interval was considered to be adequate to provide appropriate data on the distribution of significant flora taxa within the survey area. Due to the intensity of survey method used the numbers of individuals presented are considered to be an accurate estimate of the numbers of individuals actually present.
Competency / experience of the team carrying out the survey	No	Project Managers have had extensive experience (> 10 years) in conducting similar assessments on the SCP. Personnel conducting and overseeing plant identifications have had > 10 years' experience in identification of the SCP flora. Senior personnel provided guidance to less experienced botanists throughout the survey where necessary. Relevant experts at the WA Herbarium were consulted regarding taxonomic identifications where required. The experience and competency of personnel is therefore not considered to be a limitation of the survey.
Proportion of flora identified, recorded and/or collected.	Possible minor	All vascular groups that were present in the Study Area were sampled. A high proportion of perennial vascular taxa were recorded based on the intensity and method of survey, and almost all could be positively identified. Of all the specimens collected, 99% were identified to species (or subspecies / variant) level. Specimens with incomplete identifications were sterile and were likely to be representative of other identified taxa. A high proportion of annual vascular taxa were recorded based on the intensity and method of survey; however, detection and identification of some annual taxa may have been limited by below average rainfall recorded prior to the survey (during July – October 2019; see timing/weather/season/cycle below). Unknown vascular taxa were collected, with specimens identified at the WA Herbarium.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data	No	Good contextual information for the Study Area was available prior to the survey. Sources of information used included government databases (DBCA, DAWE), previous unpublished reports and data from the vicinity of the Study Area (Eco Logical 2019; Spectrum 2018; 360 Environmental 2014; GHD 2012; Woodman Environmental 2006) as well as numerous general sources pertaining to the climate, geomorphology, flora and vegetation of the SCP.
Timing/weather/season/cycle	Possible minor	The majority of the survey was conducted within what is considered to be the appropriate season for survey in the SCP bioregion (Spring). However, the lower than average rainfall in July – October 2019, in combination with higher than average temperatures in July – October 2019, may potentially have resulted in the abundance of annual taxa being affected, as well as sooner than expected senescence of such taxa. It is not known if the rainfall received was insufficient for germination of any taxa. Some targeted survey was conducted in April 2020, however, this survey targeted perennial taxa that are distinct at any time of year only.

Limitation	Limitation of Survey	Comment
Disturbances (e.g. fire, flood, accidental human intervention etc.), which affected results of survey	Possible minor	There was no evidence of fires having burnt the vegetation in recent years, or evidence of any other non-clearing related significant disturbances. All vegetation was subject to some level of prior disturbance, as all vegetation occurred in road or rail verges or immediately adjacent to areas cleared for agriculture or other purposes. This level of disturbance has likely influenced species composition of the remaining vegetation to varying amounts which has resulted in some uncertainty when both defining communities and mapping community boundaries. However, such disturbance is a factor which is common throughout the Swan Coastal Plain and associated datasets from the SCP.
Remoteness and/or access problems	No	The Study Area was accessed either via the roads, tracks or on foot and there were no access issues which hindered the survey extent.

5. RESULTS AND DISCUSSION

5.1 Desktop Study

5.1.1 Regional Vegetation

The vegetation of Western Australia as it was presumed to have existed prior to European settlement has been mapped at a scale of 1:250,000 as vegetation associations, with the Pre-European Vegetation spatial database created (Beard *et al.* 2013). Two vegetation associations occur in the Study Area, as summarised in Table 5 and presented on Figure 7. Table 5 also presents the current extent of each vegetation association in relation to its pre-European extent (Government of Western Australia 2019), and the percentage of the current extent protected for conservation at IBRA bioregion level. The 968 and 3 vegetation associations have 6.6 % and 18.1 % of their pre-European extent remaining respectively, both with a very small proportion (1.2 %) of the remaining extant area protected for conservation.

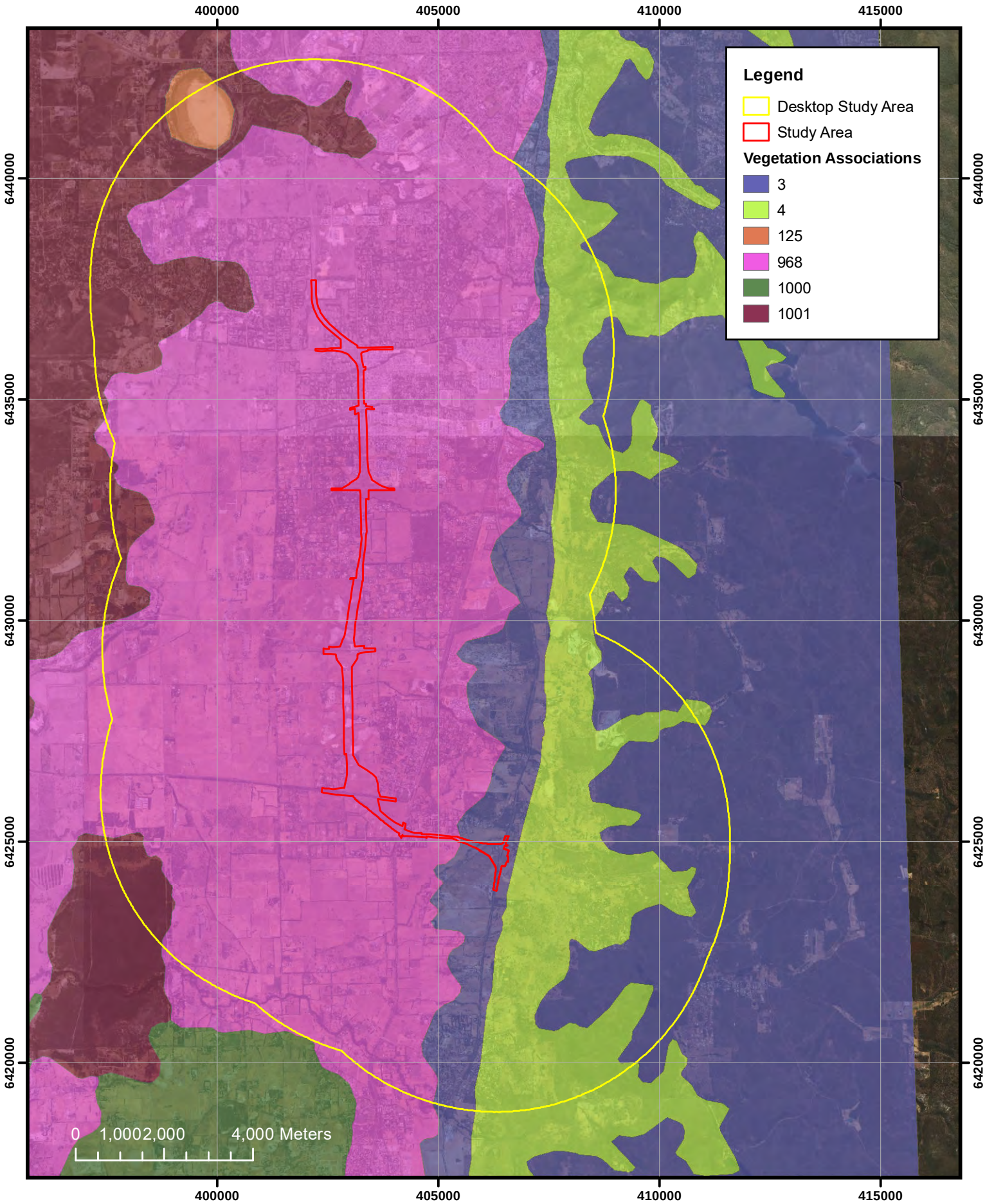
Table 5: Vegetation Associations Occurring in the Study Area (Government of Western Australia 2019a)

Vegetation Association	Description	Current Extent (ha)	Percentage of Pre-European Extent Remaining	Percentage of Current Extent Protected for Conservation
968	Medium woodland; jarrah, marri & wandoo	9,017	6.6	1.2
3	Medium forest; jarrah-marri	3,151	18.1	1.2

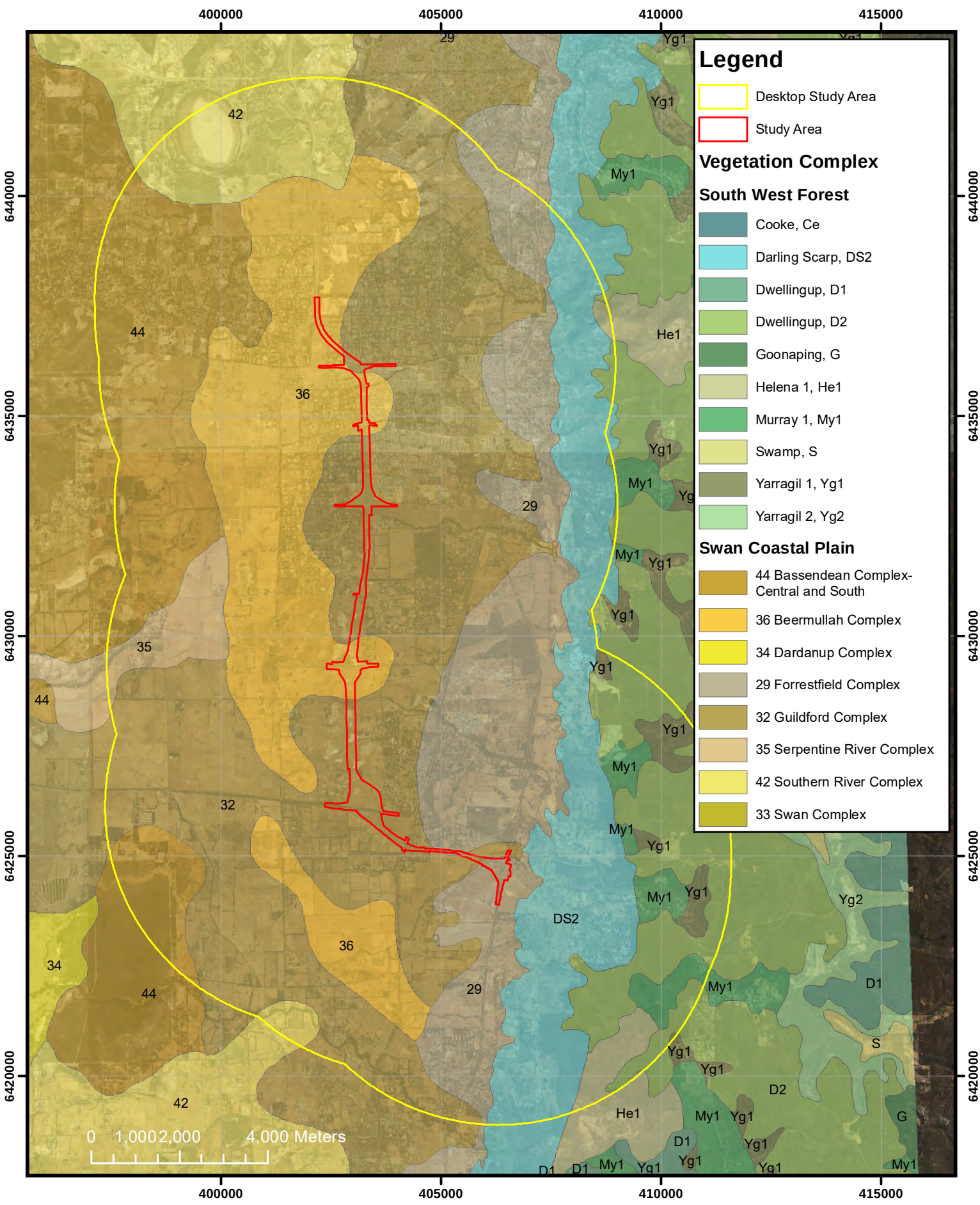
Heddle *et al.* (1980) mapped and described the vegetation complexes of the Swan Coastal Plain, which were subsequently refined and presented by the DBCA (Government of Western Australia 2019b). Three vegetation complexes occur in the Study Area, as summarised in Table 6 and presented on Figure 8. Table 6 also presents the current extent of each vegetation complex in relation to its pre-European extent (Government of Western Australia 2019b), and the percentage of the current extent of each vegetation system association currently protected for conservation, as a function of the extent of mapping of vegetation complexes over the Swan Coastal Plain. The Guildford, Beermullah and Forrestfield vegetation complexes have less than 13 % of their pre-European extent remaining on the Swan Coastal Plain, with a very small proportion (0.3 %, 2.1 % and 1.4 % respectively) of the remaining extent protected for conservation.

Table 6: Vegetation Complexes Occurring in the Study Area (Government of Western Australia 2019b)

Vegetation Complex	Description	Current Extent (ha)	Percentage of Pre-European Extent Remaining	Percentage of Current Extent Protected for Conservation
Guildford Complex (32)	A mixture of open forest to tall open forest of *Corymbia calophylla* (Marri) - *Eucalyptus wandoo* (Wandoo) - *Eucalyptus marginata* (Jarrah) and woodland of *Eucalyptus wandoo* (Wandoo) (with rare occurrences of *Eucalyptus lane-poolei* (Salmon White Gum)). Minor components include *Eucalyptus rudis* (Flooded Gum) - *Melaleuca rhaphiophylla* (Swamp Paperbark).	4,607	5.1	0.3
Beermullah Complex (36)	Mixture of low open forest of *Casuarina obesa* (Swamp Sheoak) and open woodland of *Corymbia calophylla* (Marri) - *Eucalyptus wandoo* (Wandoo) - *Eucalyptus marginata* (Jarrah). Minor components include closed scrub of Melaleuca species and occurrence of *Actinostrobus pyramidalis* (Swamp Cypress).	447	6.7	2.1
Forrestfield Complex (29)	Vegetation ranges from open forest of *Corymbia calophylla* (Marri) - *Eucalyptus wandoo* (Wandoo) - *Eucalyptus marginata* (Jarrah) to open forest of *Eucalyptus marginata* (Jarrah) - *Corymbia calophylla* (Marri) - *Allocasuarina fraseriana* (Sheoak) - Banksia species. Fringing woodland of *Eucalyptus rudis* (Flooded Gum) in the gullies that dissect this landform.	2,803	12.3	1.4



Vegetation Associations of the Desktop Study Area	Author: Alison Saligari	N
	WEC Ref: MR19-32-01	
WOODMAN ENVIRONMENTAL	Filename: MR19-32-01-f07.mxd	**Figure**
	Scale: 1:110,000 (A4)	7
	Projection: GDA 1994 MGA Zone 50	
This map should only be used in conjunction with WEC report MR19-32-01.	Revision: 0 - 25 September 2020	

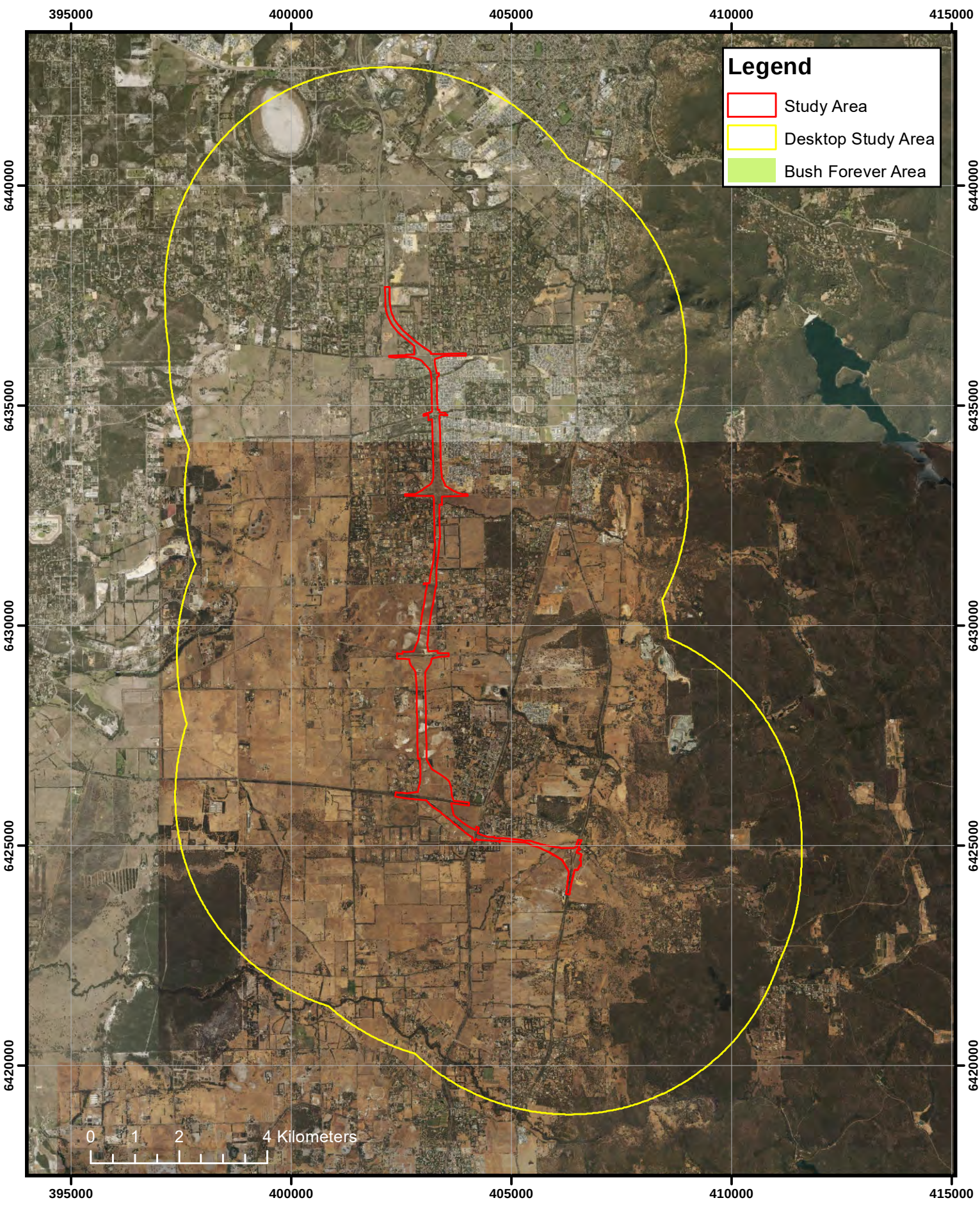


Vegetation Complexes of the Desktop Study Area	Author: Leah Firth	
	WEC Ref: MR19-32-01	
WOODMAN ENVIRONMENTAL	Filename: MR19-32-01-f08.mxd	**Figure**
	Scale: 1:110,000 (A4)	8
	Projection: GDA 1994 MGA Zone 50	
This map should only be used in conjunction with WEC report MR19-32-01.	Revision: 0 - 25 September 2020	

The patterning of plant communities on the southern SCP was the subject of a detailed floristic survey by DBCA (as the Department of Conservation and Land Management) and the Conservation Council (Gibson *et al.* 1994). This survey established quadrats across the SCP, with subsequent classification analysis defining FCTs. One quadrat (MUD-4) was established within the Study Area, within the Mundijong Road reserve, with a further two quadrats (MUD-5 and MUD-9) established just to the west (within 150 m) of the Study Area within the Mundijong Road reserve (Figure 9). MUD-4 and MUD-5 are considered to represent FCT 3a, which is a community found on heavy soils of the eastern SCP, while MUD-9 was considered to represent FCT 8, a seasonally wet claypan community. (Gibson *et al.* 1994). Both correspond to listed TECs, as outlined in Section 5.1.4.

Several areas of remnant vegetation intersected by the Study Area have previously been identified as areas of regionally significant bushland, through the Government of Western Australia's Bush Forever project (Government of Western Australia 2000) (Figure 9). The vegetation present within these areas was also described in the context of SCP FCTs. The Bush Forever sites intersected by the Study Area are:

- Cardup Brook Bushland (Site No. 351) (vegetation on and adjacent to Hopkins Road reserve south of Orton Road);
- Abernethy Road Bushland (Site No. 65) (vegetation adjacent to Abernethy and Hopkins Road intersection);
- Mundijong and Watkins Roads Bushland (Site No. 360) (vegetation along Mundijong Road reserve);
- Byford to Serpentine Rail/Road Reserves and Adjacent Bushland (Site No. 365) (vegetation along Wright Road and adjacent railway easement); and
- Transit Road Bushland (Site No. 71) (vegetation along South Western Highway).



Bush Forever Sites within the Desktop Study Area	Author: Alison Saligari WEC Ref: MR19-32-01	N
WOODMAN ENVIRONMENTAL This map should only be used in conjunction with WEC report MR19-32-01.	Filename: MR19-32-01-f09.mxd Scale: 1:110,000 (A4) Projection: GDA 1994 MGA Zone 50 Revision: 0 - 25 September 2020	**Figure** 9

5.1.2 Local Flora and Vegetation Surveys

A number of flora and vegetation surveys which are publicly available, have been undertaken within 5 km of the Desktop Study Area as outlined in Table 7.

Six TECs, two currently listed Threatened taxa and four Priority taxa have been recorded during the surveys as presented in Table 6. Of these, the Threatened taxa *Synaphea* sp. Serpentine (G.R. Brand 103) and *Synaphea* sp. Pinjarra Plain (A. S. George 17182) and the P3 taxon *Babingtonia urbana* were recorded in the Study Area itself, with the TECs 'Clay Pans of the Swan Coastal Plain', 'Herb rich shrublands in clay pans' and *Corymbia calophylla – Kingia australis* woodlands on heavy soils, Swan Coastal Plain' identified as possibly occurring within the Study Area.

Surveys conducted prior to 2014 were undertaken to meet the requirements of a Level 2 Survey, which consisted of background research/desktop study and reconnaissance survey, followed by either a detailed or comprehensive survey. The level of survey required was determined from Table 2 of the Environmental Protection Authority's Guidance Statement No. 51 (EPA 2004). Since 2014 the Environmental Protection Authority have released new advice ('Technical Guidance for Flora and Vegetation Surveys for Environmental Impact Assessment' (EPA 2016a)), which supersedes Guidance Statement No 51. The original Level 2 Survey has been replaced by a Detailed Survey.

Table 7: Summary of Flora and Vegetation Surveys Previously Conducted in the Local Area

Report Title and Author	Location and Scope	Key Findings (Flora and Vegetation only)
Mundijong Road Spring Flora Survey – Main Roads WA (Eco Logical 2019)	Located within Study Area Detailed and Targeted Survey – 8.9 hectares of road reserve.	• Recorded 97 taxa from 34 families and 78 genera. • Eight quadrats (10 x 10 m) and transects (5-20 m apart). • Field survey was conducted in spring. • Two EPBC Act listed threatened species were recorded; *Synaphea* sp. Serpentine (G.R. Brand 103) and *Synaphea* sp. Pinjarra Plain (A. S. George 17182) • No priority taxa recorded. • Recorded 27 introduced taxa. • Four vegetation communities mapped within survey area. • Relationship to TECs and PECs was inconclusive due to degraded condition of vegetation. However, there was some similarity with the 'Clay Pans of the Swan Coastal Plain' TEC.
Bungendore Park Targeted Flora Survey – City of Armadale (Spectrum Ecology 2018)	Located just to east of Desktop Study Area Targeted Survey – 84 x 5m^2 sites.	• No Threatened or Priority taxa recorded. • All 84 sites inspected. No quadrats due to the small size of sites. • Field survey was conducted in spring.
Abernethy Road, Byford Flora, Vegetation and Fauna Report – Shire of Serpentine Jarrahdale (360 Environmental 2014)	Partly overlaps Study Area Level 2 Flora and Vegetation Assessment – 20.5 hectares.	• Recorded 58 taxa from 26 families and 50 genera. • Three relevés completed. No quadrats were done due to highly disturbed condition of vegetation. • Field survey was conducted in spring. • No threatened or priority taxa were formally reported; however, *Babingtonia urbana* (P3) (as *Baeckea* sp. Perth Region (R.J. Cranfield 444)) was recorded at one site, but was apparently ignored in the main report. • Recorded 20 introduced taxa. • Four floristic community types recorded. However statistical analysis was not undertaken as quadrats were not done due to the highly disturbed state of the vegetation. • Two potential TECs were recorded; Herb rich shrublands in clay pans (SCP 8) and *Corymbia calophylla-Kingia australis* woodlands on heavy soils (SCP 3a).

Report Title and Author	Location and Scope	Key Findings (Flora and Vegetation only)
Report for Rail Reserves in the Shire of Serpentine Jarrahdale: Spring Flora and Vegetation Survey and Fauna and Habitat Assessment – Public Transport Authority (GHD 2012)	Partly overlaps Study Area Level 2 Flora and Vegetation Assessment – 230 hectares.	• Recorded 394 taxa from 65 families and 197 genera • 16 quadrats (10 x 10 m) and six relevés. • Field survey was conducted in spring. • One threatened taxa recorded but identification not confirmed; *Synaphea stenoloba* or possibly *Synaphea* sp. Serpentine. • Four priority taxa recorded; *Grevillea bipinnatifida* subsp. *pagna* (P1), *Synaphea odocoileops* (P1), *Johnsonia pubescens* subsp. *cygnorum* (P2) and *Calothamnus rupestris* (P4) – delisted since 2012. • Recorded 58 introduced taxa. • 13 vegetation types mapped. • Five TECs or vegetation closely associated with a TEC were identified; Communities of Tumulus Springs (Organic Mound Springs, SCP), *Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain (SCP 20b), *Corymbia calophylla – Kingia australis* woodlands on heavy soils Swan Coastal Plain (SCP 3a), *Corymbia calophylla – Xanthorrhoea preissii* woodlands on heavy soils Swan Coastal Plain (SCP 3c) and Shrublands on dry clay flats (SCP 10a).
Provision of Domestic Supply King Rd/Mundijong Rd Environmental Assessment – Western Power (Woodman Environmental 2006)	Located 5km east of the Study Area Inspection of area to be impacted by installation of private power pole and associated trench.	• No native taxa recorded at the site. • Site dominated by pasture and introduced taxa.

5.1.3 Significant Flora

The search of the DBCA WA Herbarium specimen Database and TPFL Database (data provided by Main Roads as per Section 3.1) returned a total of 28 significant vascular flora taxa that have records in the Desktop Study Area.

A search of these databases using NatureMap (DBCA 2007-) was also undertaken as part of the Desktop Study, to check for any recently added records and confirm the records returned from the DBCA WA Herbarium specimen Database and TPFL Database search (Appendix C). No additional taxa were returned.

The search of the DAWE SPRAT Database (DAWE 2020) with regard to MNES listed under the EPBC Act identified 18 flora taxa listed as Threatened species, or habitat for such species, that may occur in the Desktop Study Area (Table 8). The full results of the DAWE Database search are presented in Appendix D.

A list of significant flora taxa known from within the Desktop Study Area is presented in Table 8 and on Figure 10. This list has been compiled from the results of searches of DBCA's Threatened Flora Databases and DAWE's SPRAT Database. Four of these taxa are known to occur in the Study Area: *Tetraria australiensis* (T); *Synaphea* sp. Serpentine (G.R. Brand 103) (T), *Synaphea* sp. Pinjarra Plain (A.S. George 17182) (T) and *Babingtonia urbana* (P3). Appendix E presents conservation codes for Western Australia flora (DBCA 2019a).

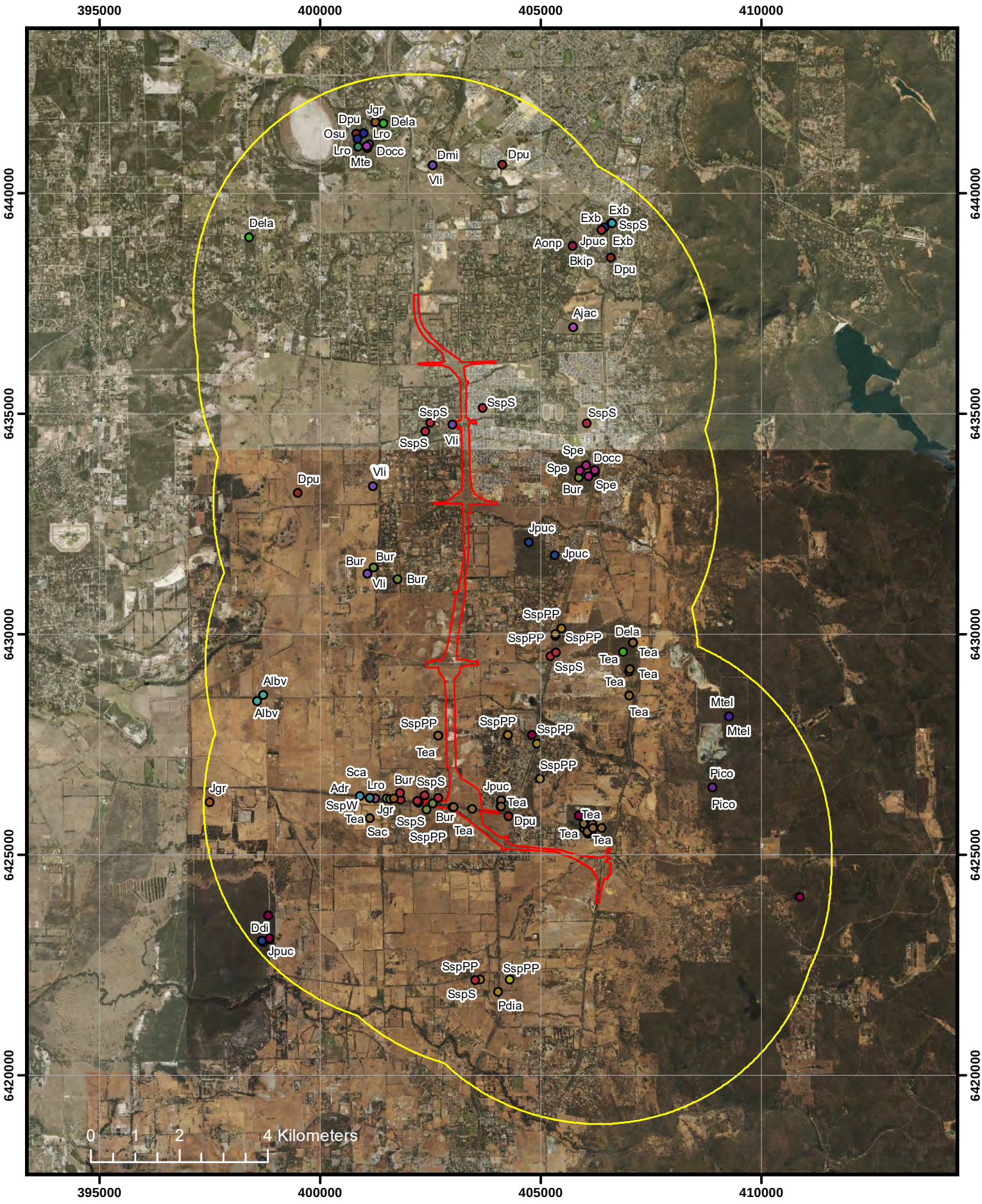
Table 8: Significant Flora Taxa Known from Within the Desktop Study Area

Taxon	Status	Source *	Flowering Period (WA Herbarium 1998-)	Habitat (WA Herbarium 1998-)
Acacia lasiocarpa var. *bracteolata* long peduncle variant (G.J. Keighery 5026)	P1	DBCA	May or August	Grey or black sand over clay. Swampy areas, winter wet lowlands.
Acacia oncinophylla subsp. *patulifolia*	P4	DBCA	March to April or September to December	Granite, occasionally on laterite. Brown loam.
Andersonia gracilis	Threatened	DAWE	August to November	White/grey sand, sandy clay, gravelly loam. Winter-wet areas, near swamps.
Angianthus drummondii	P3	DBCA	October to December	Grey or brown clay soils, ironstone. Seasonally wet flats.
Anthocercis gracilis	Threatened	DAWE	September to October	Sandy or loamy soils. Granite outcrops.
Austrostipa jacobsiana	Threatened	DBCA	November	Grey/white sand.
Babingtonia urbana	P3	DBCA	October to March	Wetlands
Banksia kippistiana var. *paenepeccata*	P3	DBCA	September to November	Lateritic gravelly soils.
Caladenia huegelii	Threatened	DAWE	August to October	Grey or brown sand, clay loam.

Taxon	Status	Source *	Flowering Period (WA Herbarium 1998-)	Habitat (WA Herbarium 1998-)
Diuris micrantha	Threatened	DAWE	September to October	Brown loamy clay. Winter-wet swamps, in shallow water.
Diuris purdiei	Threatened	DBCA, DAWE	September to October	Grey-black sand, moist. Winter-wet swamps.
Dillwynia dillwynioides	P3	DBCA	August - December	Sandy soils. Winter-wet depressions.
Drakaea elastica	Threatened	DBCA, DAWE	October to November	White or grey sand. Low-lying situations adjoining winter-wet swamps.
Drakaea micrantha	Threatened	DBCA, DAWE	September to November	White-grey sand.
Drosera occidentalis	P4	DBCA	October to November	Swampy or damp flats, sandy floodplain.
Eleocharis keigheryi	Threatened	DAWE	August to November	Clay, sandy loam. Emergent in freshwater: creeks, claypans.
Eucalyptus x balanites	Threatened	DBCA, DAWE	October to December or January to February	Sandy soils with lateritic gravel.
Grevillea curviloba subsp. *incurva*	Threatened	DAWE	August to October	Grey/white or brown sand, sandy loam. Winter-wet heath.
Jacksonia gracillima	P3	DBCA	September to November	Grey sand, winter-wet areas.
Johnsonia pubescens subsp. *cygnorum*	P2	DBCA	September-October	Grey-white-yellow sand. Flats, seasonally-wet sites.
Lasiopetalum pterocarpum	Threatened	DAWE	September to November	Dark red-brown loam or clayey sand over granite. On sloping banks near creeklines.
Lepidosperma rostratum	Threatened	DBCA, DAWE	June to July, September to December	Peaty sand, clay. Seasonally wet swamps.
Meionectes tenuifolia	P3	DBCA	October to December	Wetlands, swamps.
Millotia tenuifolia var. laevis	P2	DBCA	September to October	Granite or laterite soils, yellow sand.
Ornduffia submersa	P4	DBCA	September to November	Wetlands
Parsonsia diaphanophleba	P4	DBCA	April to June	Alluvial soils. Along rivers.
Pithocarpa corymbulosa	P3	DBCA	January to April	Gravelly or sandy loam. Amongst granite outcrops.
Schoenus capillifolius	P3	DBCA	October to November	Brown mud. Claypans.

Taxon	Status	Source *	Flowering Period (WA Herbarium 1998-)	Habitat (WA Herbarium 1998-)
Schoenus pennisetis	P3	DBCA	August to November	Grey or peaty sand, sandy clay. Swamps, winter-wet depressions.
Schoenus sp. Waroona (G.J. Keighery 12235)	P3	DBCA	October to November	Clay or sandy clay. Winter-wet flats.
Stylidium aceratum	P3	DBCA	October to November	Sandy soils. Swamp heathland.
Synaphea sp. Fairbridge Farm (D. Papenfus 696)	Threatened	DAWE	September to October	Grey clayey sand or sandy with lateritic pebbles. Near winter-wet flats.
Synaphea sp. Pinjarra Plain (A.S. George 17182)	T	DBCA	September to November	Grey sandy loam or brown clayey loam, laterite. Flats, seasonally wet areas, wet depressions or drains.
Synaphea sp. Serpentine (G.R. Brand 103)	Threatened	DBCA, DAWE	September to October	Brown loam or sand. Seasonally wet areas.
Tetraria australiensis	Threatened	DBCA, DAWE	September to December	Brown sandy loam or grey sand. Winter damp areas.
Thelymitra dedmaniarum	Threatened	DAWE	November to January	Grey loam. Granite.
Thelymitra stellata	Threatened	DAWE	October to November	Sand, gravel, lateritic loam.
Verticordia lindleyi subsp. *lindleyi*	P4	DBCA	October to May	Sand, sandy clay. Winter-wet depressions.
Verticordia plumosa var. *ananeotes*	Threatened	DAWE	November to January	White/grey sand or sandy clay. Winter-wet flats.

*Sources are:
DBCA – DBCA's Significant Flora Databases, data provided by Main Roads and NatureMap (see Section 3.1);
DAWE – SPRAT Database Search



Existing Significant Flora Records of the Desktop Study Area	Author: Alison Saligari	
	WEC Ref: MR19-32-01	
WOODMAN ENVIRONMENTAL	Filename: MR19-32-01-f10.mxd	**Figure**
	Scale: 1:110,000 (A4)	10
	Projection: GDA 1994 MGA Zone 50	
This map should only be used in conjunction with WEC report MR19-32-01.	Revision: 0 - 25 September 2020	

Legend

Study Area

Desktop Study Area

Significant Flora

Adr	*Angianthus drummondii* (P3)
Ajac	*Austrostipa jacobsiana* (T)
Albv	*Acacia lasiocarpa* var. bracteolata long peduncle variant (G.J. Keighery 5026) (P1)
Aonp	*Acacia oncinophylla* subsp. *patulifolia* (P4)
Bkip	*Banksia kippistiana* var. *paenepeccata* (P3)
Bur	*Babingtonia urbana* (P3)
Ddi	*Dillwynia dillwynioides* (P3)
Dela	*Drakaea elastica* (T)
Dmi	*Drakaea micrantha* (T)
Docc	*Drosera occidentalis* (P4)
Dpu	*Diuris purdiei* (T)
Exb	*Eucalyptus x balanites* (T)
Jgr	*Jacksonia gracillima* (P3)
Jpuc	*Johnsonia pubescens* subsp. *cygnorum* (P2)
Lro	*Lepidosperma rostratum* (T)
Mte	*Meionectes tenuifolia* (P3)
Mtel	*Millotia tenuifolia* var. *laevis* (P2)
Osu	*Ornduffia submersa* (P4)
Pdia	*Parsonsia diaphanophleba* (P4)
Pico	*Pithocarpa corymbulosa* (P3)
Sac	*Stylidium aceratum* (P3)
Sca	*Schoenus capillifolius* (P3)
Spe	*Schoenus pennisetis* (P3)
SspPP	*Synaphea* sp. Pinjarra Plain (A.S. George 17182) (T)
SspS	*Synaphea* sp. Serpentine (G.R. Brand 103) (T)
SspW	*Schoenus* sp. Waroona (G.J. Keighery 12235) (P3)
Tea	*Tetraria australiensis* (T)
Vli	*Verticordia lindleyi* subsp. *lindleyi* (P4)

Existing Significant Flora Records of the Desktop Study Area

Author: Alison Saligari

WEC Ref: MR19-32-01

WOODMAN ENVIRONMENTAL

Filename: MR19-32-01-f10-1.mxd

Scale: 1:110,000 (A4)

Projection: GDA 1994 MGA Zone 50

Revision: 0 - 25 September 2020

Figure 10.1

This map should only be used in conjunction with WEC report MR19-32-01.

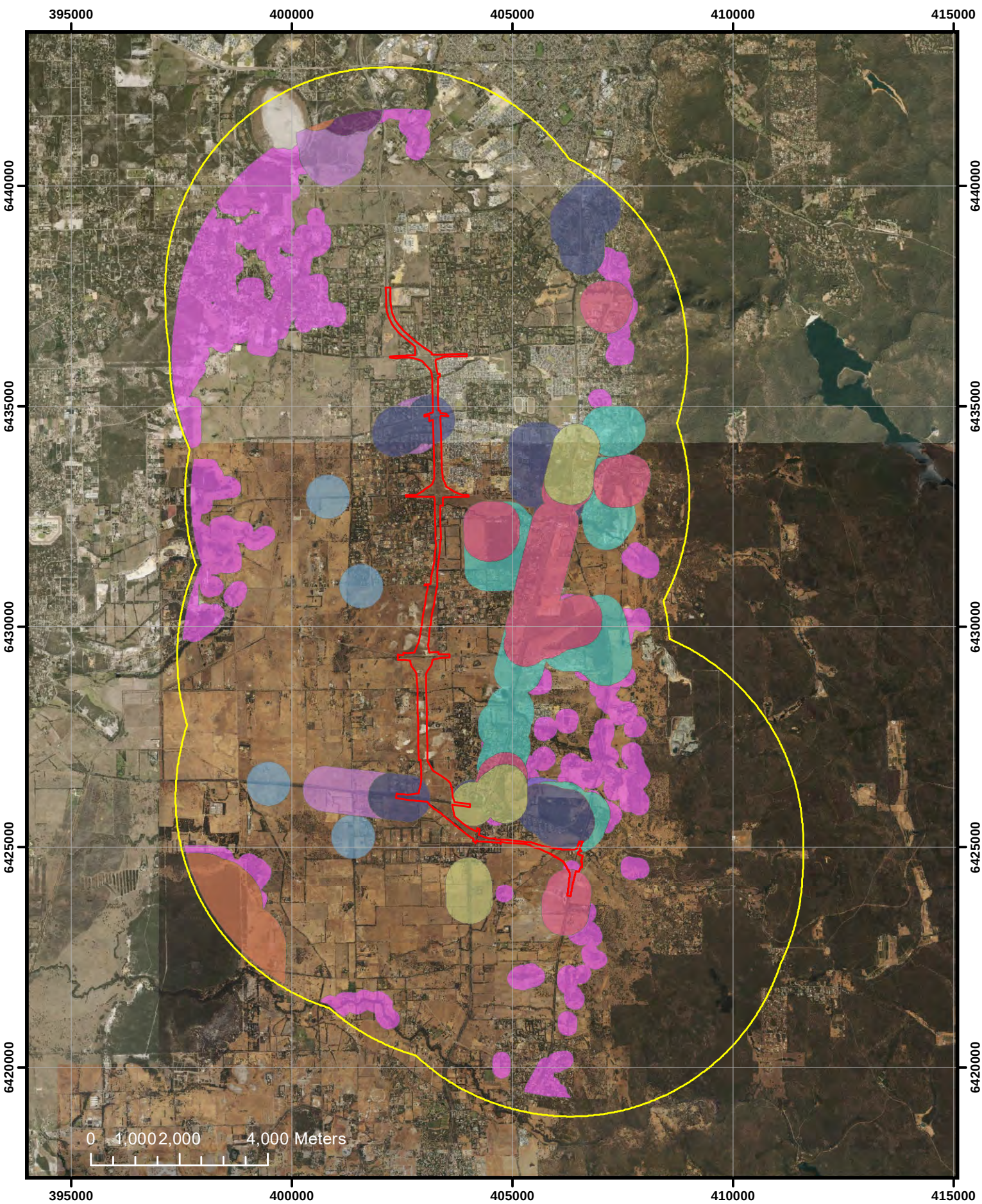
5.1.4 Significant Vegetation

The interrogation of the DBCA TEC and PEC Database (data provided by Main Roads as per Section 3.1) and DAWE's SPRAT Database returned a total of 13 significant communities that have records in the Desktop Study Area (Table 9). The names of the communities in Table 9 are as presented in WA lists (DBCA 2018a; 2020b) unless otherwise noted. As outlined in Table 9, many of the significant communities are listed by both WA and the Commonwealth, often under slightly different names, or the WA community is listed as a component of a Commonwealth community. Two of the communities are listed as PECs in Western Australia with the remaining communities listed as TECs under either state and/or federal legislation. Six of these communities have buffer polygon that intersect the Study Area itself, highlighted in pink in Table 9. The locations of significant vegetation are presented on Figure 11. Appendix F presents definitions, categories and criteria for TECs and PECs (DBCA 2013).

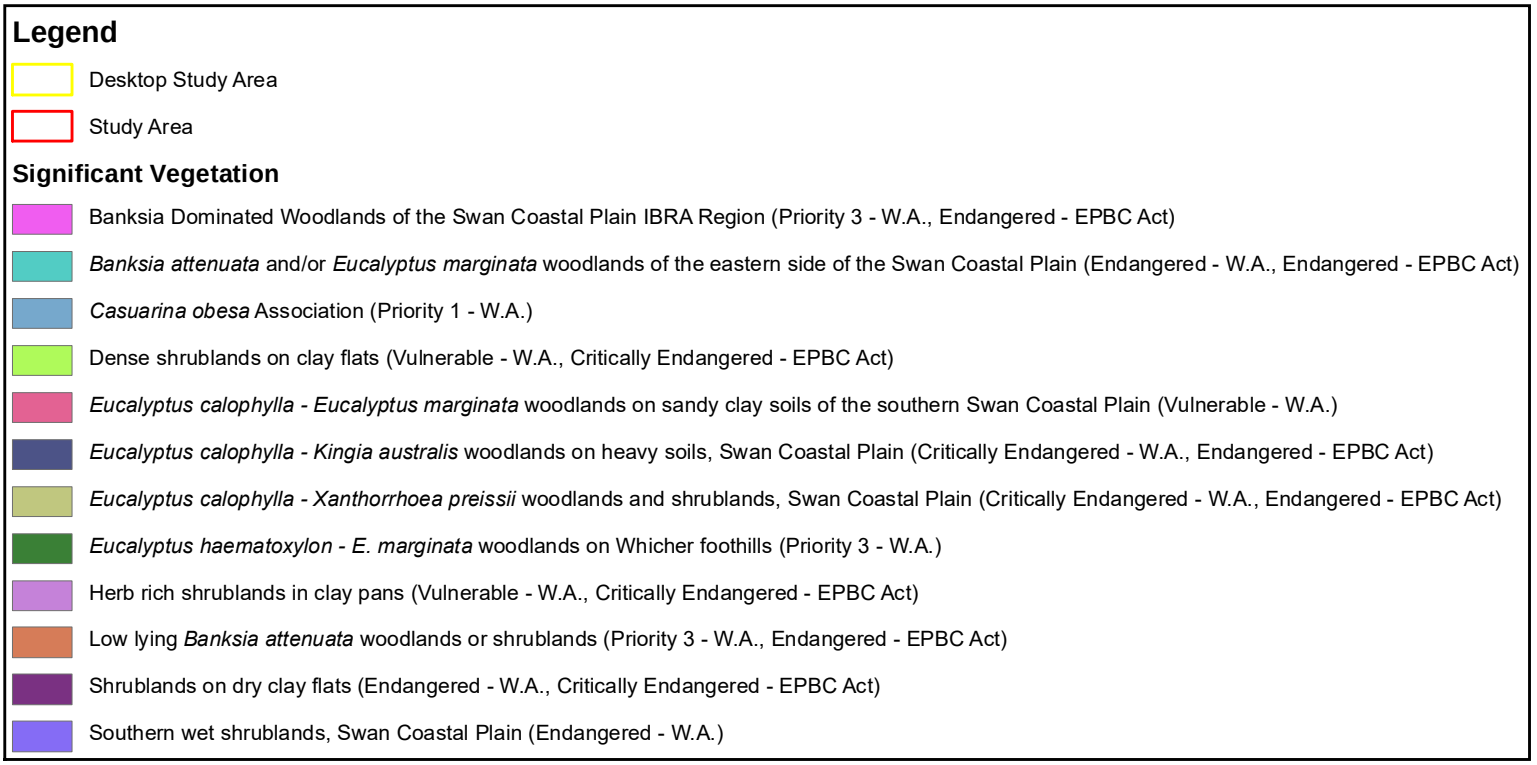
Table 9: Significant Vegetation Known from Within the Desktop Study Area

Community	Conservation Status (W.A.)	EPBC Act Ranking	Source
SCP20b - *Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain	TEC (Endangered)	Endangered*	DBCA
Banksia dominated woodlands of the Swan Coastal Plain IBRA region (WA); Banksia Woodlands of the Swan Coastal Plain (Commonwealth)	PEC (P3)	Endangered	DAWE, DBCA
Casuarina obesa association	PEC (P1)	-	DBCA
SCP3a - *Corymbia calophylla -Kingia australis* woodlands on heavy soils, Swan Coastal Plain (WA); *Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain (Commonwealth)	TEC (Critically Endangered)	Endangered	DAWE, DBCA
SCP3b - *Corymbia calophylla – Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain	TEC (Vulnerable)	-	DBCA
SCP3c - *Corymbia calophylla -Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain; *Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands of the Swan Coastal Plain (Commonwealth)	TEC (Critically Endangered)	Endangered	DAWE, DBCA
SCP09 - Dense shrublands on clay flats (WA); Clay Pans of the Swan Coastal Plain (Commonwealth)	TEC (Vulnerable)	Critically Endangered	DBCA
Eucalyptus haematoxylon - Eucalyptus marginata woodlands on Whicher foothills ('floristic community type 1a')	PEC (P3)	-	DBCA
SCP08 - Herb rich shrublands in clay pans (WA); Clay Pans of the Swan Coastal Plain (Commonwealth)	TEC (Vulnerable)	Critically Endangered	DBCA; DAWE
Low lying *Banksia attenuata* woodlands or shrublands ('floristic community type 21c')	PEC (P3)	Endangered*	DBCA
SCP10a - Shrublands on dry clay flats (WA); Clay Pans of the Swan Coastal Plain (Commonwealth)	TEC (Endangered)	Critically Endangered	DBCA
SCP02 - Southern wet shrublands, Swan Coastal Plain	TEC (Endangered)	-	DBCA
Tuart (*Eucalyptus gomphocephala*) woodlands of the Swan Coastal Plain (WA); Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain (Commonwealth)	PEC (P3)	Critically Endangered	DAWE

Sources are:
*Note: can be a component of the EPBC listed TEC 'Banksia Woodlands of the Swan Coastal Plain'
DBCA – DBCA's TEC and PEC Database, data provided by Main Roads and NatureMap (see Section 3.1)
DAWE – SPRAT Database Search



Existing Significant Vegetation Records of the Desktop Study Area	Author: Alison Saligari	N
	WEC Ref: MR19-32-01	
WOODMAN ENVIRONMENTAL	Filename: MR19-32-01-f11.mxd	**Figure**
	Scale: 1:110,000 (A4)	11
	Projection: GDA 1994 MGA Zone 50	
This map should only be used in conjunction with WEC report MR19-32-01.	Revision: 0 - 25 September 2020	



Existing Significant Vegetation Records of the Desktop Study Area	Author: Alison Saligari	N
	WEC Ref: MR19-32-01	
WOODMAN ENVIRONMENTAL	Filename: MR19-32-01-f11-1.mxd	**Figure**
	Scale: 1:110,000 (A4)	11.1
	Projection: GDA 1994 MGA Zone 50	
This map should only be used in conjunction with WEC report MR19-32-01.	Revision: 0 - 25 September 2020	

5.1.5 Introduced Flora

A list of introduced flora taxa known from within the Desktop Study Area is presented in Table 10. This has been compiled from WA Herbarium specimen data and the results of the search of DAWE's SPRAT Database. A total of 148 introduced taxa or habitat for such taxa are known from the Desktop Study Area. Of these, 18 taxa /taxon complexes are Declared Pests (DPIRD 2020) under the BAM Act and/or listed WoNS (AWC 2020).

Table 10: Introduced Flora Taxa Known from Within the Desktop Study Area or Habitat Likely to Occur Within the Area

Taxon	Common Name	Source*	Comments
Aira caryophyllea	Silvery Hairgrass	DBCA	
Aira cupaniana	Silvery Hairgrass	DBCA	
Aira praecox	Early Hairgrass	DBCA	
Aizoon pubescens		DBCA	
Anthoxanthum odoratum	Sweet Vernal Grass	DBCA	
Anredera cordifolia	Madeira Vine	DAWE	WoNS
Arctotheca calendula	Cape Weed	DBCA	
Asclepias curassavica	Redhead Cottonbush	DBCA	
Asparagus asparagoides	Bridal Creeper	DBCA, DAWE	Declared Pest, WoNS
Avellinia michelii		DBCA	
Avena barbata	Bearded Oat	DBCA	
Avena sativa	Common Oat	DBCA	
Babiana angustifolia		DBCA	
Bellardia trixago	Bellardia	DBCA	
Bellardia viscosa		DBCA	
Brachychiton populneus	Kurrajong	DBCA	
Brachypodium distachyon	False Brome	DBCA	
Briza maxima	Blowfly Grass	DBCA	
Briza minor	Shivery Grass	DBCA	
Bromus diandrus	Great Brome	DBCA	
Bromus hordeaceus	Soft Brome	DBCA	
Callitriche stagnalis	Common Starwort	DBCA	
Casuarina glauca	Swamp Sheoak	DBCA	
Cenchrus ciliaris	Buffel Grass	DAWE	
Centaurium erythraea	Common Centaury	DBCA	
Cerastium glomeratum	Mouse Ear Chickweed	DBCA	
Chamaecytisus palmensis	Tagasaste	DBCA	
Chloris gayana	Rhodes Grass	DBCA	
Chrysanthemoides monilifera subsp. *monilifera*	Boneseed	DBCA, DAWE	Declared Pest, WoNS
Cicendia filiformis	Slender Cicendia	DBCA	
Cichorium intybus	Chicory	DBCA	
Cirsium vulgare	Spear Thistle	DBCA	
Conyza bonariensis	Flaxleaf Fleabane	DBCA	
Conyza parva		DBCA	
Conyza sumatrensis		DBCA	
Cotula coronopifolia	Waterbuttons	DBCA	
Crassula alata		DBCA	
Crassula natans var. *minus*	Floating Pigmyweed	DBCA	
Crepis foetida subsp. *foetida*	Stinking Hawksbeard	DBCA	
Cuscuta epithymum	Lesser Dodder	DBCA	

Taxon	Common Name	Source*	Comments
Cynodon dactylon	Couch	DBCA	
Cyperus congestus	Dense Flat-sedge	DBCA	
Cyperus tenellus	Tiny Flatsedge	DBCA	
Disa bracteata	South African Orchid	DBCA	
Dischisma capitatum	Woolly-headed Dischisma	DBCA	
Dittrichia graveolens	Stinkwort	DBCA	
Ehrharta calycina	Perennial Veldt Grass	DBCA	
Ehrharta longiflora	Annual Veldt Grass	DBCA	
Eragrostis curvula	African Lovegrass	DBCA	
Erodium botrys	Long Storksbill	DBCA	
Euphorbia maculata	Spotted Spurge	DBCA	
Euphorbia prostrata	Prostrate Sandmat	DBCA	
Freesia alba x leichtlinii	Freesia	DBCA	
Fumaria capreolata	Whiteflower Fumitory	DBCA	
Galium divaricatum	Lamarck's bedstraw	DBCA	
Gastridium phleoides	Nitgrass	DBCA	
Genista sp. X Genista monspessulana	Broom	DAWE	WoNS
Gladiolus angustus	Long Tubed Painted Lady	DBCA	
Gladiolus caryophyllaceus	Wild Gladiolus	DBCA	
Gomphocarpus fruticosus	Narrowleaf Cottonbush	DBCA	Declared Pest
Hainardia cylindrica	Common Barbgrass	DBCA	
Holcus lanatus	Yorkshire Fog	DBCA	
Holcus setiger	Annual Fog	DBCA	
Hordeum marinum	Sea Barley	DBCA	
Hypochaeris glabra	Smooth Catsear	DBCA	
Hypochaeris radicata	Flat Weed	DBCA	
Isolepis hystrix		DBCA	
Juncus articulatus	Jointed Rush	DBCA	
Juncus bufonius	Toad Rush	DBCA	
Juncus capitatus	Capitate Rush	DBCA	
Juncus microcephalus		DBCA	
Lachenalia aloides	Cape Cowslip	DBCA	
Lantana camara	Lantana	DAWE	Declared Pest, WoNS
Linum trigynum	French Flax	DBCA	
Logfia gallica	Daggerleaf cottonrose	DBCA	
Lolium perenne	Perennial Ryegrass	DBCA	
Lolium rigidum	Wimmera Ryegrass	DBCA	
Lotus angustissimus	Narrowleaf Trefoil	DBCA	
Lotus subbiflorus	Hairy Bird's-foot Trefoil	DBCA	
Lycium ferocissimum	African Boxthorn	DAWE	WoNS
Lysimachia arvensis	Pimpernel	DBCA	
Lysimachia minima	Chaffweed	DBCA	
Melaleuca armillaris subsp. *armillaris*	Giant Honey-Myrtle	DBCA	
Melinis repens	Natal Grass	DBCA	
Misopates orontium	Lesser Snapdragon	DBCA	
Monopsis debilis var. *depressa*		DBCA	
Moraea flaccida	One-leaf Cape Tulip	DBCA	Declared Pest
Oenothera affinis	Longflower Evening Primrose	DBCA	

Taxon	Common Name	Source*	Comments
Oenothera mollissima	Primrose	DBCA	
Oenothera stricta subsp. *stricta*	Primrose	DBCA	
Olea europaea	Olive	DAWE	
Ornithopus compressus	Yellow Serradella	DBCA	
Ornithopus pinnatus	Slender Serradella	DBCA	
Oxalis glabra	Finger Leaf	DBCA	
Oxalis pes-caprae	Soursob	DBCA	
Panicum capillare	Witchgrass	DBCA	
Parentucellia latifolia	Common Bartsia	DBCA	
Pentameris airoides subsp. *airoides*	False Hairgrass	DBCA	
Phleum pratense	Timothy Grass	DBCA	
Phyllopodium cordatum		DBCA	
Pinus radiata	Radiata Pine	DAWE	
Poa annua	Winter Grass	DBCA	
Polygala virgata		DBCA	
Polygonum aviculare	Wireweed	DBCA	
Polypogon monspeliensis	Annual Beardgrass	DBCA	
Ranunculus trilobus	Buttercup	DBCA	
Romulea rosea	Guildford Grass	DBCA	
Rubus fruticosus aggregate	Blackberry	DAWE	WoNS
Rubus ulmifolius	Blackberry	DBCA	Declared Pest
Rumex acetosella	Sorrel	DBCA	Declared Pest
Salix sp.	Willows	DAWE	Declared Pest, WoNS
Salvinia molesta	Salvinia	DAWE	WoNS
Schinus molle	Chilean Pepper Tree	DBCA	
Setaria verticillata	Whorled Pigeon Grass	DBCA	
Silene gallica	French Catchfly	DBCA	
Solanum elaeagnifolium	Silver Nightshade	DAWE	Declared Pest, WoNS
Solanum linnaeanum	Apple of Sodom	DBCA	Declared Pest
Solanum nigrum	Black Berry Nightshade	DBCA	
Sonchus asper	Rough Sowthistle	DBCA	
Sonchus oleraceus	Common Sowthistle	DBCA	
Sparaxis bulbifera	Harlequin Flower	DBCA	
Spergula arvensis	Corn Spurry	DBCA	
Stellaria media	Chickweed	DBCA	
Symphyotrichum squamatum	Bushy Starwort	DBCA	
Tagetes erecta	Marigold	DBCA	
Tamarix aphylla	Athel Pine	DAWE	Declared Pest, WoNS
Trifolium angustifolium	Narrowleaf Clover	DBCA	
Trifolium arvense	Hare's Foot Clover	DBCA	
Trifolium campestre var. *campestre*	Hop Clover	DBCA	
Trifolium cernuum	Drooping Flower Clover	DBCA	
Trifolium dubium	Suckling Clover	DBCA	
Trifolium incarnatum var. *incarnatum*	Crimson Clover	DBCA	
Trifolium subterraneum	Subterranean Clover	DBCA	
Urochloa mutica	Para Grass	DAWE	
Ursinia anthemoides subsp. *anthemoides*	Ursinia	DBCA	
Vellereophyton dealbatum	White Cudweed	DBCA	

Taxon	Common Name	Source*	Comments
Verbascum virgatum	Twiggy Mullein	DBCA	
Vicia hirsuta	Hairy Vetch	DBCA	
Vicia sativa subsp. *sativa*	Garden Vetch	DBCA	
Vulpia bromoides	Squirrel Tail Fescue	DBCA	
Vulpia myuros forma *myuros*	Rat's Tail Fescue	DBCA	
Wahlenbergia capensis	Cape Bluebell	DBCA	
Washingtonia filifera	California Palm	DBCA	
Watsonia borbonica	Cape Bugle-Lily	DBCA	
Watsonia marginata	Fragrant Bugle-Lily	DBCA	
Watsonia meriana var. *bulbillifera*	Bulbil Watsonia	DBCA	
Watsonia meriana var. *meriana*	Bulbil Watsonia	DBCA	
Zantedeschia aethiopica	Arum Lily	DBCA	Declared Pest

*Sources are:
DBCA – WA Herbarium Specimen Database, data provided by NatureMap (see Section 3.1);
DAWE – SPRAT Database Search (see Section 3.1)

5.2 Field Survey Results

5.2.1 Vascular Flora Census

A total of 256 discrete vascular flora taxa were recorded in the Study Area during this survey, representing 50 families and 147 genera. The most well-represented families are Myrtaceae (32 taxa), Proteaceae (28 taxa), Fabaceae (24 taxa) and Cyperaceae (23 taxa). Forty-seven taxa are annual taxa. Fifty of the total taxa recorded are introduced taxa (see Section 5.2.5). Given the very small area of intact vegetation in the Study Area and history of disturbance of this vegetation (most areas are in narrow road reserves), the floristic diversity is considered to be relatively high.

Average taxon (excluding hybrids) richness per quadrat was 40.27 (± 13.94), with the greatest number of taxa recorded in a single quadrat being 58, and the lowest number being 19. A full list of taxa is presented in Appendix G, with raw quadrat data and parameters presented in Appendix H.

5.2.2 Significant Flora Taxa

5.2.2.1 Summary of Significant Flora Taxa

Table 11 presents a summary of data relating to significant flora taxa recorded in the Study Area during this survey. A total of nine significant flora taxa were recorded in the Study Area during this survey, including three Threatened taxa, five Priority flora taxa (discussed in Section 5.2.2.2) and one taxon considered significant for other reasons as per EPA (2016a; 2016b) (discussed in Section 5.2.2.3). Appendix E presents conservation codes for Western Australia flora (DBCA 2019b). It should be noted that the data presented in Table 11 is considered to supersede data previously recorded in the Study Area by Eco Logical (2019).

One additional taxon, *Melaleuca viminalis*, was recorded in the Study Area. This taxon is indigenous to the Kimberley Region of Western Australia, and is known from very few locations; it is therefore listed as P2 based on this limited natural distribution (it is also indigenous to the Northern Territory, Queensland and New South Wales) (Craven *et al.* 2010). However, this taxon is widely cultivated as a street and garden tree and has become

naturalised in some areas of the south-west of WA including the Perth Metropolitan area. It is therefore considered to be an introduced taxon in the Study Area (see Section 5.2.5); it is not included in Table 11, and is not discussed further in the context of significant flora.

Locations of significant flora taxa recorded in the Study Area are presented in Appendix I and J. Completed TPFRFs for significant flora taxa recorded during the survey are presented in Appendix K.

Table 11: Summary of Significant Flora Taxa Recorded within the Study Area

Taxon	Status	No. of Locations Recorded			No. of Individuals Recorded			Vegetation Types^
		Inside Study Area	Outside Study Area	Total	Inside Study Area	Outside Study Area	Total	
Acacia lasiocarpa var. bracteolata long peduncle variant (G.J. Keighery 5026)	P1	1	0	1	1	0	1	11^
Babingtonia urbana	P3	56	40	96	430	1071	1501	3^, 4, 7, 9, 11^
Calectasia grandiflora	P2	17	1	18	75	1	76	3^
Jacksonia gracillima	P3	41	5	46	104	8	112	3^, 4, 7, 11^
Leucopogon aff. sp. Busselton (D. Cooper 243)	Potentially undescribed	2	0	2	4	0	4	3^
Stylidium aceratum	P3	2	0	2	13	0	13	2
Synaphea sp. Pinjarra Plain (A.S. George 17182)	T	23	15	38	26	43	69	3^
Synaphea sp. Serpentine (G.R. Brand 103)	T	268	0	268	551	0	551	1, 2^, 3^, 7
Tetraria australiensis	T	290	1	291	1208	6	1214	2^, 4^

^Designates preferred habitat, based on proportional quadrat representation and landforms/soils.
Note: all data collected by Woodman Environmental, 2019-2020.

5.2.2.2 Listed Significant Flora Taxa

***Acacia lasiocarpa* var. *bracteolata* long peduncle variant (G.J. Keighery 5026) (P1)**

Acacia lasiocarpa var. *bracteolata* long peduncle variant (G.J. Keighery 5026) (P1) is a shrub growing up to 1.5 m high in swampy areas and winter wet lowlands (WA Herbarium 1998-) (Plate 1). This taxon is endemic to Western Australia (ALA 2020), occurring over a range of approximately 51 km from Huntingdale (Perth) in the north to west of North Dandalup in the south (DBCA 2007-), with the Study Area occurring in this range. There are nine location records of this taxon representing approximately five populations throughout its range, none of which occur in conservation tenure (DBCA 2007-).

This species was searched for as part of targeted survey within the Study Area, with one individual at one point location recorded, within the Bishop Road reserve (Appendix J, Sheet 4). Targeted searching was conducted outside the Study Area to determine if the population extended outside the Study Area (Appendix B), however, no further individuals could be located. This location is within VT 11, which appears to represent the preferred habitat for this taxon (Appendix I and J, Sheet 4). This represents a new population of this taxon, which had not previously been recorded in the Study Area (see Section 5.1.3). It is considered unlikely that any further locations of this taxon occur in the Study Area.

It is worth noting that a collection from the Mundijong Road reserve initially thought to be this taxon was later identified as typical *Acacia lasiocarpa* var. *bracteolata*. Further investigation revealed that this taxon was already known from Mundijong Road just west of the Study Area, with a collection from SCP quadrat MUD-9 identified as this taxon (WA Herbarium 1998-). Confusingly, however, in the amended SCP dataset (Keighery *et al.* 2012), *Acacia lasiocarpa* var. *bracteolata* long peduncle variant (G.J. Keighery 5026) (P1) is recorded for MUD-9, while in the original SCP dataset (Gibson *et al.* 1994), as well as the 2013 Claypans dataset, which re-scored MUD-9 (DBCA 2007-), typical *Acacia lasiocarpa* var. *bracteolata* is recorded for MUD-9. Typical *Acacia lasiocarpa* var. *bracteolata* is easily distinguishable from the long peduncle variant based on characters provided on the World Wide Wattle website (WWW 2020); it is clear that the entity present in the Mundijong Road reserve is typical *Acacia lasiocarpa* var. *bracteolata*. The record of *Acacia lasiocarpa* var. *bracteolata* long peduncle variant (G.J. Keighery 5026) (P1) for MUD-9 in the amended SCP dataset (Keighery *et al.* 2012) is therefore considered erroneous.

Plate 1: ***Acacia lasiocarpa* var. *bracteolata* long peduncle variant (G.J. Keighery 5026) (P1) scanned specimen**

***Babingtonia urbana* (P3)**

Babingtonia urbana (P3) is an erect shrub growing up to 1.2 m high occurring on flats and winter-wet depressions with clay loam or sand (WA Herbarium 1998-) (Plate 2). This taxon is endemic to Western Australia (ALA 2020), occurring over a range of approximately 200 km from Cooljarloo in the north to west of Mundijong in the south; however, records are from three disjunct areas, being the Perth area, Cooljarloo area and near Moora (DBCA 2007-). The Study Area is within the range of the locations known in the Perth area. There are 28 location records of this taxon representing approximately 12 verifiable populations throughout it range, one of which occurs partly in Wongonderrah Nature Reserve (DBCA 2007-).

This species was searched for as part of targeted survey within the Study Area. This species was recorded at 56 locations in the Study Area with a total of 430 individuals recorded; these represent three discrete populations, occurring along Mundijong Road, Bishop Road and Abernethy Road (Appendix J, Sheet 4). Targeted searching was conducted outside the Study Area to determine if the populations extended outside the Study Area; the Mundijong Road and Abernethy Road populations were found to extend outside the Study Area, with an additional population located further west of the Study Area along Mundijong Road (Appendix I and J). A total of 40 point locations and 1,071 individuals recorded outside the Study Area. Both populations in the Mundijong Road reserve, including the one in the Study Area, are known populations represented by WA Herbarium records. Eco Logical (2019) did not record the Mundijong Road reserve population in the Study Area and erroneously stated that this taxon was unlikely to occur there. Although there are no existing records that correspond to the Abernethy Road population based on coordinates, a 1981 WA Herbarium

record from Abernethy Road, Oakford, probably represents this population, with the coordinates of this record being erroneous (Kargotich Road south of Orton Road). This population was also recorded in site data, but not reported, by 360 Environmental (2014). The population adjacent to Bishop Road appears to be a new population. It is considered unlikely that any further locations of this taxon occur in the Study Area.

In the Study Area, the locations of this taxon occur within VTs 3, 4, 7, 9 and 11, with VT 3 and 11 apparently representing the preferred habitat for this taxon.

Plate 2: *Babingtonia urbana* (P3) (Woodman Environmental)

***Calectasia grandiflora* (P2)**

Calectasia grandiflora (P2) is a rhizomatous, perennial herb growing up to 0.65 m high occurring in winter-damp areas (WA Herbarium 1998-) (Plate 3). This taxon is endemic to Western Australia (ALA 2020), occurring over a range of approximately 37 km from near Beckenham in the north to Serpentine in the south (DBCA 2007-). The Study Area is located within the range of this taxon. There are only 11 location records of this taxon representing approximately 5 populations throughout its range, one of which occurs in conservation tenure (Kenwick Wetlands Nature Reserve) (DBCA 2007-).

Calectasia grandiflora was listed as a priority taxon subsequent to this current survey being conducted. However, it was searched for as part of targeted survey within the Study Area because it was known by Woodman Environmental personnel to be a potentially significant taxon through previous survey in the SCP bioregion. This species was recorded at 17 locations in the Study Area with a total of 75 individuals recorded; all locations were in the Mundijong Road reserve and represent one population (Appendix I and J, Sheet 4). This taxon has previously been recorded in the Mundijong Road Reserve in the Study Area (Gibson *et al.* 1994). It is considered unlikely that any further locations of this taxon occur in the Study Area. Targeted searching was conducted outside the Study Area to determine if the population extended outside the Study Area; this population just extends outside the Study Area, with

only a single individual recorded. All locations in the Study Area were recorded within VT 3, which appears to represent the preferred habitat for this taxon.

Plate 3: *Calectasia grandiflora* (P2) (Woodman Environmental)

***Jacksonia gracillima* (P3)**

Jacksonia gracillima (P3) is a spreading shrub growing up to 1 m wide and 1.5 m high occurring in shrublands on the edges of winter wet swamps on peaty sand over clay (WA Herbarium 1998-; Chappill *et al.* 2007) (Plate 4). This taxon is endemic to Western Australia (ALA 2020), occurring over a range of approximately 200 km from Forrestfield in the north to near Busselton in the south (DBCA 2007-). The Study Area is located within this known range. There are 30 location records of this taxon representing approximately 21 populations, four of which occur in conservation tenure throughout its range (Tom Bateman Reserve Bushland, Piara Nature Reserve, Modong Nature Reserve and Forrestdale Lake Nature Reserve) (DBCA 2007-).

This species was searched for as part of targeted survey within the Study Area. This species was recorded at 41 locations in the Study Area with a total of 104 individuals recorded; these represent three discrete populations, occurring along Mundijong Road, Bishop Road and Abernethy Road (Appendix J, Sheet 4). Targeted searching was conducted outside the Study Area to determine if the populations extended outside the Study Area; the Mundijong Road and Abernethy Road populations were found to extend outside the Study Area (Appendix I and J), with a total of 5 point locations and 8 individuals recorded outside the Study Area. Although not previously recorded in the Study Area, this species has been recorded in the Mundijong Road reserve further west of the Study Area (separate population); the populations adjacent to Abernethy Road and Bishop Road also appear to be new populations. It is considered unlikely that any further locations of this taxon occur in the Study Area.

In the Study Area, this species occurs within VT 3, 4, 7 and 11, with VTs 3 and 11 representing the preferred habitat for this taxon

Plate 4: *Jacksonia gracillima* (P3) (Woodman Environmental)

***Stylidium aceratum* (P3)**

Stylidium aceratum (P3) is a fibrous rooted annual herb growing to 0.09 m high, occurring on sandy soils within swamp heathland (WA Herbarium 1998-) (Plate 5). This taxon is endemic to Western Australia (ALA 2020), occurring over a range of approximately 285 km from Badgingarra in the north to Wagerup in the south (DBCA 2007-). The Study Area is located within this range. There are 24 location records of this taxon representing approximately 18 populations throughout its range, five of which occur in conservation tenure (Bullsbrook Nature Reserve, Badgingarra National Park, Black Swamp Nature Reserve, Austin Bay Nature Reserve and Yule Brook Reserve DBCA 2007-).

This species was searched for as part of targeted survey within the Study Area. This species was recorded at two locations in the Study Area with a total of 13 individuals recorded; both locations were in the Mundijong Road reserve and represent one population. The population was in a waterlogged area at the interface of VTs 1 and 2 (Appendix I and J, Sheet 4). Given that this is an annual taxon, the numbers of individuals are likely to vary depending on seasonal conditions. Although this survey was undertaken during a season where well below average rainfall was received, this species was restricted to a small area of suitable habitat in the Study Area and is not likely to be especially more abundant even in a good season. This population does not extend outside the Study Area. Although not previously recorded in the Study Area, it has been recorded in the Mundijong Road reserve further west of the Study Area. It is considered unlikely that any further locations of this taxon occur in the Study Area.

Plate 5: ***Stylidium aceratum*** **(P3) (Woodman Environmental)**

Synaphea **sp. Pinjarra Plain (A.S. George 17182) (Threatened)**

Synaphea sp. Pinjarra Plain (A.S. George 17182) (Threatened) is an erect clumped shrub growing up to 0.8 m high occurring on flats and seasonally wet areas and depressions (WA Herbarium 1998-) (Plate 6). This taxon is listed as Endangered under both the BC Act and EPBC Act (DBCA 2018b, DAWE 2020). It is endemic to Western Australia (ALA 2020), found in a linear band from just north of Mundijong to West Coolup, growing predominantly in grey-brown sandy loams but also less often in heavier brown clay-sand overlain by laterite pebbles (DPaW 2016). The Study Area is located within the known range of this taxon.

According to the Interim Recovery Plan for this taxon, *Synaphea* sp. Pinjarra Plain (A.S. George 17182) is known from 12 populations comprising 707 mature plants (DPaW 2016). Most populations are on disturbed road and rail reserves; part of one population occurs in conservation tenure.

This species was searched for as part of targeted survey within the Study Area. This species was recorded at 23 locations in the Study Area with a total of 26 individuals recorded; all locations were within the Mundijong Road reserve and represent one population. Targeted searching was conducted outside the Study Area to determine if the population extended outside the Study Area; a further 15 point locations and 43 individuals were recorded outside the Study Area (Appendix I and J, Sheet 1). It is considered unlikely that any further locations of this species occur in the Study Area. This population has previously been recorded by DBCA; it represents TPFL Population 10, with three individuals recorded by the last survey (DBCA 2019b). Eco Logical (2019) also recorded this population, however, only recorded two individuals. Both are significantly lower than the 69 individuals recorded by this current survey. The results of this current survey increase the total known number of individuals for the species to 773 mature plants. All records in the Study Area were within VT 3, which represents the preferred habitat for this taxon.

Plate 6: ***Synaphea*** **sp. Pinjarra Plain (A.S. George 17182) (Threatened) (Woodman Environmental)**

Synaphea **sp. Serpentine (G.R. Brand 103) (Threatened)**

Synaphea sp. Serpentine (G.R. Brand 103) (Threatened) is an erect clumped shrub growing up to 0.6 m high occurring in seasonally wet areas (WA Herbarium 1998-) (Plate 7). This species is listed as Critically Endangered under both the BC Act and EPBC Act (DBCA 2018c, DAWE 2020). It is endemic to Western Australia (ALA 2020), occurring over a narrow geographic range from west of Byford to south of Serpentine, growing predominantly in grey-brown sandy-loam or clay (DPaW 2017). The Study Area is located within the known range of this taxon.

According to the Interim Recovery Plan *Synaphea* sp. Serpentine (G.R. Brand 103) is known from six highly fragmented populations comprising 1,331 mature individuals. The majority of plants are found on weedy road and rail reserves that are threatened by further habitat degradation and ongoing maintenance activities (DPaW 2017). Part of one population occurs in conservation tenure.

This species was searched for as part of targeted survey within the Study Area. This species was recorded at 268 locations in the Study Area with a total of 551 individuals recorded; all locations were within the Mundijong Road reserve and represent one population. Targeted searching was conducted outside the Study Area to determine if the population extended outside the Study Area; however, no further locations were recorded (Appendix I and J, Sheet 2). It is considered unlikely that any further locations of this species occur in the Study Area. This population has previously been recorded by DBCA; it represents TPFL Population 5, with 48 mature individuals and 53 juvenile individuals recorded by the last survey (DBCA 2019b). Eco Logical (2019) also recorded 180 individuals in this this population. Both estimates are

significantly lower than the 551 individuals recorded by this current survey. The results of this current survey increase the total known number of individuals for the species to 1,834 mature plants. Records in the Study Area were within VTs 1,2, 3 and 7, with VTs 2 and 3 representing the preferred habitat for this species.

Plate 7: ***Synaphea*** **sp. Serpentine (G.R. Brand 103) (Threatened) (Woodman Environmental)**

Tetraria australiensis **(Threatened)**

Tetraria australiensis (Threatened) is a rhizomatous tufted perennial herb growing to 1 m high occurring on sand over clay flats (WA Herbarium 1998-) (Plate 8). This taxon is listed as Vulnerable under both the BC Act and EPBC Act (DBCA 2018c, DAWE 2020). It is endemic to Western Australia (ALA 2020), occurring over a range of approximately 197 km from Ferndale (Perth) in the north to near Busselton in the south (DBCA 2007-). The Study Area is located within the known range of this taxon. There is currently no Interim Recovery Plan for this taxon and the Approved Conservation Advice is out of date (DAWE 2008); therefore, there is no accurate population and abundance estimate publicly available for the taxon. However, there are 66 location records of this taxon in DBCA's databases; it is currently unknown how many populations these represent, but it appears to be at least 20, with several new populations found recently by Woodman Environmental (field observations). At least three occur in conservation tenure (Watkins Road Nature Reserve, Lambkin Nature Reserve, Ruabon Nature Reserve) (DBCA 2007-).

This species was searched for as part of targeted survey within the Study Area. This species was recorded at 290 locations in the Study Area with a total of 1,208 individuals recorded. Of these, 288 locations and 1,205 individuals were recorded in the Mundijong Road reserve, all of which represent one population. A second, small population (two locations, three

individuals) was recorded along the rail reserve adjacent to Wright Road (Appendix I and J, Sheet 3). It is considered unlikely that any further locations of this species occur in the Study Area.

The Mundijong Road population has previously been recorded by DBCA; it represents TPFL Population 10, with a similar number of 1,054 mature individuals recorded by the last survey (DBCA 2019b). Eco Logical (2019) did not record this species in the Study Area but noted that insufficient material was available for identification due to dry conditions; however, it is a perennial species that can be identified at any time of year. Targeted survey was conducted outside the Study Area adjacent to where this population occurs, with no further locations recorded. It is known that TPFL population 8 occurs immediately north of the eastern end of the Study Area along Mundijong Road near the Mundijong sports complex, therefore TPFL populations 8 and 10 should be considered sub-populations of a single population. TPFL population 8 was not assessed due to access constraints; the last DBCA survey recorded 483 individuals, and it is likely that this number is still accurate. A new population of this species was opportunistically recorded well to the west of the Study Area and the population discussed above in the Mundijong Road reserve, while conducting targeted survey for *Leucopogon* aff. sp. Busselton (D. Cooper 243) (see Section 5.2.2.3). Six individuals were recorded at the single location observed.

The Wright Road population appears to represent a new population. Targeted survey outside the Study Area in suitable habitat did not extend this population outside the Study Area; however, much of the rail reserve in this area is highly degraded. Records in the Study Area were within VTs 2, and 4, which represent the preferred habitat for this species.

Plate 8: ***Tetraria australiensis*** **(T) (Woodman Environmental)**

5.2.2.3 Other Significant Flora Taxa

***Leucopogon* aff. sp. Busselton (D. Cooper 243)**

A collection from the Study Area was identified by *Leucopogon* expert Mike Hislop from the WA Herbarium as *Leucopogon* aff. sp. Busselton (D. Cooper 243) (Plate 9). Further research is required to ascertain the taxonomic status of this entity as currently it cannot be reliably distinguished from *Leucopogon* sp. Busselton (D. Cooper 243) (P2). However, it is possible that reliable discriminatory characters may be found, and therefore it may represent a separate distinct taxon (M. Hislop *pers. comm.*). This entity is currently known from four populations, including the Study Area (where it has previously been recorded), over a range of 60 km, from near Cannington to North Dandalup (M. Hislop *pers. comm.*). If considered synonymous with *Leucopogon* sp. Busselton (D. Cooper 243) (P2), it would be known from two disjunct areas, including the area noted above and to the south between Bunbury and Vasse, and would be represented by around 15 populations. *Leucopogon* aff. sp. Busselton (D. Cooper 243) is considered to be a significant taxon as per EPA (2016a; b).

This taxon was searched for as part of targeted survey within the Study Area. This taxon was recorded at two locations in the Study Area with a total of four individuals recorded, all within the Mundijong Road reserve; these represent one population (Appendix I and J, Sheet 4). These locations were in areas mapped as VT 3, which represents the preferred habitat for this taxon. Targeted searching was conducted outside the Study Area to determine if the population extended outside the Study Area, however no individuals could be found. It has been previously recorded just outside the Study Area in SCP quadrat MUD-9, however, a search of this quadrat during this survey failed to find this taxon; this confirms the results of the re-score of MUD-9 for the 2013 Claypans dataset (DBCA 2007-), which did not record this taxon. All individuals appear to have senesced at this location, however, soil-stored seed may still be present.

Plate 9: *Leucopogon* aff. sp. Busselton (D. Cooper 243) scanned specimen

5.2.3 Distribution Extensions and Distribution Gaps

Table 12 presents taxa where the collections of flora taxa from the Study Area represent extensions to the known distribution of such taxa or otherwise fill gaps within the known distribution of such taxa according to *NatureMap* (DBCA 2007-).

Table 12: Taxa Where Collections Represent Range Extensions to the Known Ranges of these Taxa or Fill Distribution Gaps (DBCA 2007-)

Taxon	Description
Schoenus andrewsii	Range extension to the south (nearest record approximately 30 km to the north)

5.2.4 Likelihood of Occurrence of Further Significant Flora Taxa

As detailed in Section 5.1.3, a total of 39 significant flora taxa were identified as occurring within the Desktop Study Area prior to survey. Of these, seven were recorded within the Study Area by this survey, as detailed in Section 5.2.2. Table 13 presents an assessment of the likelihood of the remaining 32 taxa being present within the Study Area. Of these 32 taxa, none are considered likely to occur in the Study Area.

Table 13: Likelihood of Significant Flora Taxa Occurring Within the Study Area

Taxon	Status	Flowering Period (WA Herbarium 1998-)	Habitat (WA Herbarium 1998-)	Identifiable During Survey?	Likelihood of Occurrence
Acacia oncinophylla subsp. *patulifolia*	P4	March to April or September to December	Granite, occasionally on laterite. Brown loam.	Yes	Unlikely: habitat not considered to be present.
Andersonia gracilis	Threatened	August to November	White/grey sand, sandy clay, gravelly loam. Winter-wet areas, near swamps.	Yes	Unlikely: habitat present, however all potential habitat inspected during survey.
Angianthus drummondii	P3	October to December	Grey or brown clay soils, ironstone. Seasonally wet flats.	Yes	Unlikely: habitat not considered to be present.
Anthocercis gracilis	Threatened	September to October	Sandy or loamy soils. Granite outcrops.	Yes	Unlikely: habitat not considered to be present.
Austrostipa jacobsiana	Threatened	November	Grey/white sand.	Yes	Unlikely: habitat not considered to be present.
Banksia kippistiana var. *paenepeccata*	P3	September to November	Lateritic gravelly soils.	Yes	Unlikely: habitat not considered to be present.
Caladenia huegelii	Threatened	August to October	Grey or brown sand, clay loam.	Yes	Unlikely: habitat present, however all potential habitat inspected during survey.
Diuris micrantha	Threatened	September to October	Brown loamy clay. Winter-wet swamps, in shallow water.	Yes	Unlikely: habitat not considered to be present.
Diuris purdiei	Threatened)	September to October	Grey-black sand, moist. Winter-wet swamps.	Yes	Unlikely: habitat not considered to be present.
Dillwynia dillwynioides	P3	August - December	Sandy soils. Winter-wet depressions.	Yes	Unlikely: habitat present, however all potential habitat inspected during survey.
Drakaea elastica	Threatened	October to November	White or grey sand. Low-lying situations adjoining winter-wet swamps.	Yes	Unlikely: habitat not considered to be present.
Drakaea micrantha	Threatened	September to November	White-grey sand.	Yes	Unlikely: habitat not considered to be present.

Taxon	Status	Flowering Period (WA Herbarium 1998-)	Habitat (WA Herbarium 1998-)	Identifiable During Survey?	Likelihood of Occurrence
Drosera occidentalis	P4	October to November	Swampy or damp flats, sandy floodplain.	Yes	Unlikely: habitat present, however all potential habitat inspected during survey.
Eleocharis keigheryi	Threatened	August to November	Clay, sandy loam. Emergent in freshwater: creeks, claypans.	Yes	Unlikely: habitat not considered to be present.
Eucalyptus x balanites	Threatened	October to December or January to February	Sandy soils with lateritic gravel.	Yes	Unlikely: habitat not considered to be present.
Grevillea curviloba subsp. *incurva*	Threatened	August to October	Grey/white or brown sand, sandy loam. Winter-wet heath.	Yes	Unlikely: habitat not considered to be present.
Johnsonia pubescens subsp. *cygnorum*	P2	September-October	Grey-white-yellow sand. Flats, seasonally-wet sites.	Yes	Unlikely: habitat present, however all potential habitat inspected during survey.
Lasiopetalum pterocarpum	Threatened	September to November	Dark red-brown loam or clayey sand over granite. On sloping banks near creeklines.	Yes	Unlikely: habitat not considered to be present.
Lepidosperma rostratum	Threatened	June to July, September to December	Peaty sand, clay. Seasonally wet swamps.	Yes	Unlikely: habitat present, however all potential habitat inspected during survey.
Meionectes tenuifolia	P3	October to December	Wetlands, swamps.	Yes	Unlikely: habitat present, however all potential habitat inspected during survey.
Millotia tenuifolia var. laevis	P2	September to October	Granite or laterite soils, yellow sand.	Yes	Unlikely: habitat present, however all potential habitat inspected during survey.
Ornduffia submersa	P4	September to November	Wetlands	Yes	Unlikely: habitat not considered to be present.
Parsonsia diaphanophleba	P4	April to June	Alluvial soils. Along rivers.	Yes	Unlikely: habitat not considered to be present.
Pithocarpa corymbulosa	P3	January to April	Gravelly or sandy loam. Amongst granite outcrops.	Yes	Unlikely: habitat not considered to be present.

Taxon	Status	Flowering Period (WA Herbarium 1998-)	Habitat (WA Herbarium 1998-)	Identifiable During Survey?	Likelihood of Occurrence
Schoenus capillifolius	P3	October to November	Brown mud. Claypans.	Yes	Unlikely: habitat not considered to be present.
Schoenus pennisetis	P3	August to November	Grey or peaty sand, sandy clay. Swamps, winter-wet depressions.	Yes	Unlikely: habitat present, however all potential habitat inspected during survey.
Schoenus sp. Waroona (G.J. Keighery 12235)	P3	October to November	Clay or sandy clay. Winter-wet flats.	Yes	Unlikely: habitat present, however all potential habitat inspected during survey.
Synaphea sp. Fairbridge Farm (D. Papenfus 696)	Threatened	September to October	Grey clayey sand or sandy with lateritic pebbles. Near winter-wet flats.	Yes	Unlikely: habitat present, however all potential habitat inspected during survey.
Thelymitra dedmaniarum	Threatened	November to January	Grey loam. Granite.	Yes	Unlikely: habitat not considered to be present.
Thelymitra stellata	Threatened	October to November	Sand, gravel, lateritic loam.	Yes	Unlikely: habitat not considered to be present.
Verticordia lindleyi subsp. *lindleyi*	P4	October to May	Sand, sandy clay. Winter-wet depressions.	Yes	Unlikely: habitat present, however all potential habitat inspected during survey.
Verticordia plumosa var. *ananeotes*	Threatened	November to January	White/grey sand or sandy clay. Winter-wet flats.	Yes	Unlikely: habitat present, however all potential habitat inspected during survey.

5.2.5 Introduced Taxa

Fifty introduced taxa were recorded within the Study Area during the 2019 survey. Table 14 lists location information and comments regarding the significance of these taxa, including ecological impact and invasiveness ratings for each introduced taxon under the *Invasive Plant Prioritization Process for the DBCA* for the Swan Region (DBCA 2014). Five of the recorded taxa, highlighted in yellow in Table 14, are Declared Pests under the BAM Act (DPIRD 2019). One WoNS, *Asparagus asparagoides* (Bridal Creeper), were recorded in the Study Area. Locations of introduced taxa are presented in Appendix I and L.

Table 14: Summary of Introduced Taxa Recorded within the Study Area

Taxon	Common Name	Number of Locations Recorded	Comments
**Acacia podalyriifolia*	Queensland Silver Wattle	1	High ecological impact and moderate invasiveness - DBCA
**Arctotheca calendula*	Cape Weed	1	High ecological impact and rapid invasiveness - DBCA
**Arundo donax*	Bamboo	1	High ecological impact and slow invasiveness - DBCA
**Asparagus asparagoides*	Bridal Creeper	8	Declared Pest - s22(2); WoNS High ecological impact and rapid invasiveness - DBCA
**Avena barbata*	Bearded Oat	4	High ecological impact and rapid invasiveness - DBCA
**Babiana angustifolia*	Baboonflower	1	High ecological impact and rapid invasiveness - DBCA
**Briza maxima*	Blowfly Grass	10	Unknown ecological impact and rapid invasiveness - DBCA
**Briza minor*	Shivery Grass	7	Unknown ecological impact and rapid invasiveness - DBCA
**Centaurium tenuiflorum*	Slender Centaury	1	Unknown ecological impact and rapid invasiveness - DBCA
**Cicendia filiformis*	Slender Cicendia	1	Low ecological impact and rapid invasiveness - DBCA
**Conyza sumatrensis*	Fleabane	1	Medium ecological impact and rapid invasiveness - DBCA
**Cotula turbinata*	Funnel Weed	1	Low ecological impact and moderate invasiveness - DBCA
**Cyperus tenellus*	Tiny Flat Sedge	1	Low ecological impact and unknown invasiveness - DBCA
**Disa bracteata*	South African Orchid	2	Unknown ecological impact and rapid invasiveness - DBCA
**Echium plantagineum*	Paterson's Curse	1	Declared Pest - s22(2) High ecological impact and moderate invasiveness - DBCA
**Ehrharta calycina*	Perennial Veldtgrass	13	High ecological impact and rapid invasiveness - DBCA
**Ehrharta longiflora*	Annual Veldtgrass	7	Medium ecological impact and rapid invasiveness - DBCA
**Eragrostis curvula*	African Lovegrass	3	High ecological impact and rapid invasiveness - DBCA
**Euphorbia terracina*	Geraldton Carnation Weed	1	High ecological impact and rapid invasiveness - DBCA

Taxon	Common Name	Number of Locations Recorded	Comments
**Fumaria capreolata*	Climbing Fumitory	1	High ecological impact and rapid invasiveness - DBCA
**Gladiolus caryophyllaceus*	Pink Gladiolus	4	High ecological impact and rapid invasiveness - DBCA
**Gladiolus undulatus*	Wavy Gladiolus	2	High ecological impact and rapid invasiveness - DBCA
**Gomphocarpus fruticosus*	Narrow leaf cotton bush	6	Declared Pest - s22(2) High ecological impact and rapid invasiveness - DBCA
**Hypochaeris glabra*	Flatweed	10	High ecological impact and rapid invasiveness – DBCA
**Juncus capitatus*	Capitate Rush	1	Unknown ecological impact and rapid invasiveness - DBCA
**Juncus usitatus*	Common Rush	1	Not rated - DBCA
**Logfia gallica*	Slender Cudweed	1	Low ecological impact and rapid invasiveness - DBCA
**Lolium perenne*	Perennial Ryegrass	1	High ecological impact and rapid invasiveness - DBCA
**Lolium rigidum*	Wimmera Ryegrass	1	High ecological impact and rapid invasiveness - DBCA
**Lupinus angustifolius*	Narrowleaf Lupin	1	High ecological impact and moderate invasiveness - DBCA
**Lysimachia arvensis*	Scarlet Pimpernel	1	Unknown ecological impact and rapid invasiveness - DBCA
Melaleuca viminalis	Weeping bottlebrush	1	Not rated - DBCA
**Melia azedarach*	Cape Lilac	1	Low ecological impact and moderate invasiveness - DBCA
**Melinis repens*	Natal Red Top	1	Unknown ecological impact and moderate invasiveness - DBCA
**Monopsis debilis*	Monopsis	1	Moderate ecological impact and rapid invasiveness - DBCA
**Moraea flaccida*	One leaf cape tulip	4	Declared Pest - s22(2) High ecological impact and rapid invasiveness - DBCA
**Olea europaea* subsp. *europaea*	Olive	2	High ecological impact and rapid invasiveness - DBCA
**Osteospermum ecklonis*	Veldt Daisy	1	Unknown ecological impact and moderate invasiveness - DBCA
**Oxalis pes-caprae*	Soursob	3	High ecological impact and slow invasiveness - DBCA
**Parentucellia latifolia*	Red Bartsia	1	Unknown ecological impact and rapid invasiveness - DBCA
**Romulea rosea*	Guildford Grass	3	Unknown ecological impact and rapid invasiveness - DBCA
**Solanum nigrum*	Black Berry Nightshade	3	Medium ecological impact and rapid invasiveness - DBCA
**Sonchus oleraceus*	Common Sowthistle	5	Unknown ecological impact and rapid invasiveness - DBCA
**Sparaxis bulbifera*	Sparaxis	2	High ecological impact and rapid invasiveness - DBCA
**Ursinia anthemoides*	Ursinia	3	Unknown ecological impact and rapid invasiveness - DBCA

Taxon	Common Name	Number of Locations Recorded	Comments
**Vellereophyton dealbatum*	White Cudweed	1	Unknown ecological impact and rapid invasiveness - DBCA
**Vulpia myuros*	Rat's Tail Fescue	1	High ecological impact and rapid invasiveness - DBCA
**Wahlenbergia capensis*	Cape Bluebell	2	Unknown ecological impact and rapid invasiveness - DBCA
**Watsonia meriana* var. *bulbillifera*	Bubil Watsonia	10	High ecological impact and rapid invasiveness - DBCA
**Zantedeschia aethiopica*	Arum Lily	1	Declared Pest - s22(2) High ecological impact and rapid invasiveness - DBCA

5.2.6 Floristic Classification Results

The PATN software package (Belbin and Collins 2009) initially suggested that a four-group classification of quadrats may be appropriate for the data analysed. The resulting dendrogram (see Appendix M) and taxon group matrix (Appendix N) were therefore initially examined at this level, to determine the plausibility of groups with regard to taxon groups and also field observations. This process identified that one of the groups could feasibly be divided further into two plausible groups. Additionally, review of the resulting dendrogram of the further classification analyses using Woodman Environmental quadrats and DBCA's SCP quadrat datasets (as detailed in Section 3.5) also supported this division. This process ultimately determined that there were five plausible groups which are considered to represent VTs; these groups were resolved at differing levels of similarity. The groups are ordered from 1 to 5 from top to bottom in the dendrogram in Appendix M. The initial four clusters are also indicated on the dendrogram by the colour of each individual quadrat stem.

5.2.7 Vegetation Units

As noted above, five VTs were defined via floristic composition classification. A further six VTs were defined via structural vegetation classification, following review of relevé data, and comparison of such data with quadrat data. A total of 11 VTs were therefore defined and mapped in the Study Area. Table 15 presents a description of each of the VTs mapped in the Study Area, including location, area mapped, sampling regime, significant flora recorded, average taxon richness and a description of variation found within the VT. The method of definition (structural or floristic composition) is also denoted under each VT.

Appendix O presents a taxon-VT matrix. Appendix P presents the detailed vegetation type mapping.

Table 15: Description of Vegetation Types Mapped in the Study Area

VT	Summary	Photograph
1	**Description:** Mid sparse shrubland dominated by *Xanthorrhoea preissii* and *Kingia australis* over low open shrubland dominated by *Verticordia densiflora* var. *densiflora* over low sparse sedgeland and grassland of mixed species dominated by *Schoenus rigens, Mesomelaena tetragona, Cyathochaeta avenacea*,**Ehrharta calycina* and *Neurachne alopecuroidea* over low sparse forbland of mixed species including *Drosera menziesii*, *Drosera heterophylla*, *Thelymitra antennifera*, *Burchardia multiflora* and *Stylidium pulchellum* on brown sandy clay with occasional laterite pebbles on seasonally inundated flats. **Definition method:** floristic composition classification **Area mapped (Proportion of the Study Area):** 0.23 ha (0.06 %) **Sampling:** One quadrat (TE-01) **Significant Taxa:** *Synaphea* sp. Serpentine (G.R. Brand 103) (Threatened) **Average taxon richness per quadrat:** 58 **Similar VTs:** Similar to VT 2, but differs most obviously in possessing a taxon-rich forbland stratum that is absent from the latter VT **Variation:** the degraded portion of the single polygon of this VT had scattered *Melaleuca rhaphiophylla* individuals, however, it is unclear if these are remnant or recent colonisers.	 **Plate 10: VT 1 (Quadrat TE-01)**

VT	Summary	Photograph
2	**Description:** Tall sparse shrubland dominated by *Jacksonia sternbergiana*, *Kingia australis* and *Xanthorrhoea preissii* over low sparse shrubland dominated by *Hypocalymma angustifolium* subsp. Swan Coastal Plain (G.J. Keighery 16777), *Stirlingia latifolia* and *Hakea prostrata* over low open sedgeland and grassland of mixed species including *Cyathochaeta avenacea*, *Amphipogon turbinatus*, *Tetraria australiensis*, *Mesomelaena tetragona* and *Tetraria octandra* over low sparse shrubland of mixed species including *Dampiera linearis* and *Banksia dallanneyi* subsp. *dallanneyi* var. *dallanneyi* on brown sandy loam on seasonally moist flats. **Definition method:** floristic composition classification **Area mapped (Proportion of the Study Area):** 0.51 ha (0.14 %) **Sampling:** One quadrat (TE-03) **Significant Taxa:** *Synaphea* sp. Serpentine (G.R. Brand 103) (Threatened), *Stylidium aceratum* (P3), *Tetraria australiensis* (Threatened) **Average taxon richness per quadrat:** 37 **Similar VTs:** Similar to VT 1 – see under that VT for notes. Also similar to VT 3, however, that VT possess a much more taxon-rich low shrubland stratum. **Variation:** none observed – one polygon mapped.	 **Plate 11: VT 2 (Quadrat TE-03)**

VT	Summary	Photograph
3	**Description:** Tall to mid sparse shrubland dominated by *Jacksonia sternbergiana*, *Kingia australis* and *Xanthorrhoea preissii* over mid sparse shrubland of mixed species dominated by *Hakea varia* over shrubland to open shrubland of mixed species including *Hypocalymma angustifolium* subsp. Swan Coastal Plain (G.J. Keighery 16777), *Hakea incrassata*, *Allocasuarina microstachya*, *Grevillea pilulifera* and *Kunzea micrantha* subsp. *micrantha* over low open rushland and sedgeland of mixed species including *Desmocladus lateriflorus*, *Mesomelaena tetragona*, *Tetraria octandra* and *Schoenus subflavus* subsp. *subflavus* on brown sandy clay on seasonally moist flats **Definition method:** floristic composition classification **Area mapped (Proportion of the Study Area):** 1.57 ha (0.43 %) **Sampling:** Four quadrats (TE-04, TE-05, TE-06, TE-07) **Significant Taxa:** *Babingtonia urbana* (P3*), Calectasia grandiflora* (P2), *Jacksonia gracillima* (P3), *Leucopogon* aff. sp. Busselton (D. Cooper 243), *Synaphea* sp. Pinjarra Plain (A.S. George 17182) (Threatened), *Synaphea* sp. Serpentine (G.R. Brand 103) (Threatened) Average taxon richness per quadrat: 50.3 ± 8.4 **Similar VTs:** Similar to VT 2 – see under that VT for notes. **Variation:** none observed – only two polygons mapped.	 **Plate 12: VT 3 (Quadrat TE-05)**

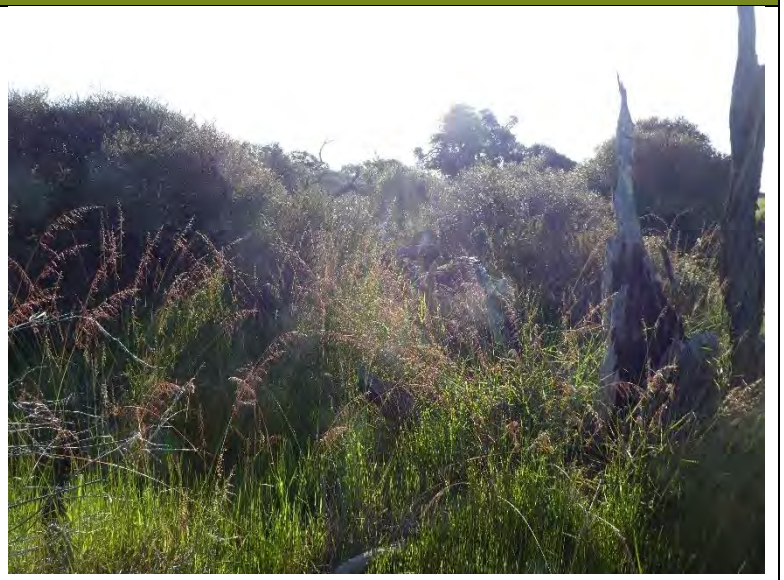
VT	Summary	Photograph
4	**Description:** Mid open forest of *Corymbia calophylla* over tall to mid sparse shrubland dominated by *Xanthorrhoea preissii* and *Kingia australis* over low sedgeland to open sedgeland dominated by *Cyathochaeta avenacea*, *Tetraria octandra*, *Lepidosperma* cf. *oldhamii* and *Mesomelaena tetragona* over low sparse forbland of mixed species dominated by *Dasypogon bromeliifolius*, *Sowerbaea laxiflora*, *Conostylis aculeata* subsp. *preissii, Caesia micrantha* and *Burchardia congesta* on grey or brown sand or sandy loam on dry flats. **Definition method:** floristic composition classification **Area mapped (Proportion of the Study Area):** 8.10 ha (2.24 %) **Sampling:** Four quadrats (TE-02, TE-08, TE-09, TE-10) and one relevé (R14) **Significant Taxa:** *Babingtonia urbana* (P3*), Jacksonia gracillima* (P3), *Tetraria australiensis* (T) **Average taxon richness per quadrat:** 46.3 ± 3.2 **Similar VTs**: similar to VT 6, however, VT 6 contains a number of understorey species more common to the nearby Darling Scarp. **Variation**: in several occurrences, *Melaleuca preissiana* was relatively common as a low tree, and there were other species including *Astartea fascicularis* that are more typical of wetlands. However, these were usually in occurrences that had been historically disturbed, and it is possible that these species have colonised areas where soil has been dug out and the area has become unnaturally wet.	 **Plate 13: VT 4 (Quadrat TE-02)**

VT	Summary	Photograph
5	**Description:** Mid open forest dominated by *Eucalyptus marginata* subsp. *marginata*, *Allocasuarina fraseriana* and occasionally *Corymbia calophylla* over tall sparse shrubland dominated by *Xanthorrhoea preissii* and occasionally *Banksia grandis* over low open shrubland of mixed species including *Labichea punctata*, *Phyllanthus calycinus*, *Hakea stenocarpa*, *Hakea lissocarpha* and *Babingtonia camphorosmae* over low open sedgeland of mixed species including *Tetraria* sp. Jarrah Forest (R. Davis 7391), *Mesomelaena pseudostygia* and *Tetraria octandra* on grey-brown sand on foothills. **Definition method:** floristic composition classification **Area mapped (Proportion of the Study Area):** 0.82 ha (0.23 %) **Sampling:** One quadrat (TE-11) **Significant Taxa:** None **Average taxon richness per quadrat:** 46 **Similar VTs:** Not especially similar to any other VTs **Variation:** none observed – only one polygon mapped.	 **Plate 14: VT 5 (Quadrat TE-11)**

VT	Summary	Photograph
6	**Description:** Mid open forest of *Corymbia calophylla* over mid sparse shrubland of *Xanthorrhoea preissii* and *Kingia australis* over low sparse shrubland of mixed species including *Hypocalymma angustifolium*, *Hakea lissocarpha* and *Hibbertia hypericoides* over low open sedgeland of mixed species including *Cyathochaeta avenacea*, *Lepidosperma apricola*, *Tetraria octandra* and *Mesomelaena tetragona* over low open introduced grassland of mixed species including **Ehrharta calycina*, **Ehrharta longiflora*, **Avena barbata* and **Briza maxima* over low open shrubland and forbland of mixed species including *Dampiera linearis*, *Lechenaultia biloba*, *Tricoryne elatior*, *Caesia micrantha* and *Watsonia meriana* var. *bulbillifera* on brown sandy loam on mid to lower slopes of foothills. **Definition method:** structural vegetation classification **Area mapped (Proportion of the Study Area):** 0.73 ha (0.20 %) **Sampling:** One relevé (R06) **Significant Taxa:** None **Average taxon richness per quadrat:** N/A **Similar VTs:** similar to VT 4 – see under that VT for notes **Variation:** none observed – only one polygon mapped.	 **Plate 15: VT 6 (Relevé R06)**

VT	Summary	Photograph
7	**Description:** Tall shrubland of mixed species dominated by *Melaleuca osullivanii*, *Melaleuca viminea* subsp. *viminea*, and occasionally *Hakea varia* and *Acacia saligna* subsp. *saligna* ms over mid sparse shrubland to isolated shrubs of mixed species including *Calothamnus hirsutus*, *Kingia australis* and *Xanthorrhoea preissii* over low sparse sedgeland and rushland to isolated sedges and rushes of mixed species including *Lepidosperma longitudinale*, *Leptocarpus canus* and *Schoenus rigens* over low introduced grassland of mixed species dominated by **Ehrharta calycina*, **Ehrharta longiflora*, **Briza maxima* and **Briza minima* over open forbland of mixed species (primarily introduced) including **Oxalis purpurea*, **Hypochaeris glabra*, **Sparaxis bulbifera*, **Moraea flaccida* and **Aphelia cyperoides* on brown sandy clay on flats. **Definition method:** structural vegetation classification **Area mapped (Proportion of the Study Area):** 1.20 ha (0.33 %) **Sampling:** Three relevés (R07, R08, R09) **Significant Taxa:** *Babingtonia urbana* (P3*), Jacksonia gracillima* (P3), *Synaphea* sp. Serpentine (G.R. Brand 103) (T) **Average taxon richness per quadrat:** N/A **Similar VTs:** not especially similar to any other VTs **Variation**: in one area, *Calothamnus hirsutus* formed a shrubland, and sedges and rushes were apparently absent.	 **Plate 16: VT 7 (Relevé R08)**

VT	Summary	Photograph
8	**Description:** Mid open to closed forest of *Eucalyptus rudis*, *Melaleuca rhaphiophylla* and *Melaleuca preissiana* over isolated mid shrubs of mixed species including *Xanthorrhoea preissii* over low grassland and forbland of introduced species including **Ehrharta longiflora*, **Watsonia meriana* var. *bulbillifera*, **Oxalis pes-caprae, *Juncus usitatus* and **Zantedeschia aethiopica* on brown loam in drainage lines and on adjacent floodplains. **Definition method:** structural vegetation classification **Area mapped (Proportion of the Study Area):** 3.61 ha (1.0 %) **Sampling:** Two relevés (R02, R05) **Significant Taxa:** None **Average taxon richness per quadrat:** N/A **Similar VTs:** not especially similar to any other VTs **Variation:** no notable variation observed	 **Plate 17: VT 8 (Relevé R05)**

VT	Summary	Photograph
9	**Description:** Tall open shrubland of mixed species including *Melaleuca viminea* subsp. *viminea*, *Melaleuca preissiana*, *Melaleuca rhaphiophylla* and *Acacia saligna* subsp. *saligna* ms over low grassland and forbland of introduced species including **Ehrharta calycina*, **Ehrharta longiflora, *Eragrostis curvula* and **Lolium perenne* and **Moraea flaccida* on brown sandy loam on flats. **Definition method:** structural vegetation classification **Area mapped (Proportion of the Study Area):** 0.81 ha (0.22 %) **Sampling:** One relevé (R10) **Significant Taxa:** *Babingtonia urbana* (P3*)* **Average taxon richness per quadrat:** N/A **Similar VTs:** not especially similar to any other VTs **Variation:** no notable variation observed	 **Plate 18: VT 9 (Relevé R10)**

VT	Summary	Photograph
10	**Description:** Low open woodland of *Banksia attenuata* and *Banksia menziesii* over tall sparse shrubland of *Jacksonia furcellata* and *Kunzea glabrescens* over low sparse shrubland of mixed species including *Eremaea pauciflora* var. *pauciflora*, *Melaleuca trichophylla*, *Melaleuca seriata*, *Hypocalymma robustum* and *Hibbertia hypericoides* subsp. *hypericoides* over low sparse rushland, shrubland and forbland of mixed species including *Conostylis aculeata* subsp. *preissii*, *Dasypogon bromeliifolius*, *Lyginia imberbis, Banksia dallanneyi* subsp. *dallanneyi* var. *dallanneyi* and *Desmocladus flexuosus* over low open grassland of introduced species dominated by **Ehrharta calycina*, **Ehrharta longiflora* and **Bromus diandrus* on grey sand on low dunes. **Definition method:** structural vegetation classification **Area mapped (Proportion of the Study Area):** 0.35 ha (0.10 %) **Sampling:** One relevé (R11) **Significant Taxa:** None **Average taxon richness per quadrat:** N/A **Similar VTs:** not especially similar to any other VTs **Variation:** none observed – only one polygon mapped	 **Plate 19: VT 10 (Relevé R11)**

VT	Summary	Photograph
11	**Description:** Isolated low trees of *Melaleuca preissiana* over isolated tall shrubs of *Viminaria juncea* and *Callitris pyramidalis* over mid to low shrubland to low shrubland of mixed species dominated by *Regelia ciliata*, *Hakea varia*, *Pericalymma ellipticum, Calothamnus lateralis* var. *lateralis* and occasionally *Verticordia densiflora* over low sparse rushland and forbland of mixed species including *Hypolaena pubescens, Conostylis aculeata* subsp. *preissii* and *Cytogonidium leptocarpoides* over low open grassland of introduced species dominated by **Eragrostis curvula* and **Ehrharta calycina* on brown sandy loam on flats. **Definition method:** structural vegetation classification **Area mapped (Proportion of the Study Area):** 0.84 ha (0.23 %) **Sampling:** Two relevés (R12, R13) **Significant Taxa:** *Acacia lasiocarpa* var. *bracteolata* long peduncle variant (G.J. Keighery 5026) (P1), *Babingtonia urbana* (P3*), Jacksonia gracillima* (P3) **Average taxon richness per quadrat:** N/A **Similar VTs:** not especially similar to any other VTs **Variation:** none observed – only one polygon mapped	 **Plate 20: VT 11 (Relevé R12)**

5.2.8 Other Areas Described

Areas where natural vegetation has been completely and apparently permanently removed, with no native taxa remaining, have been mapped as 'Cleared' (C). This includes roads (and associated infrastructure including culverts), tracks and areas cleared for farming activities. A total of 301.5 ha of 'Cleared' land was mapped, representing 83.2 % of the Study Area (Appendix P).

Because of the long history of disturbance within the Study Area, there are many areas that still possess tree or large shrub taxa, but are highly modified otherwise, with understoreys usually completely comprised of introduced taxa. In many cases the trees or large shrubs are native species and are probably remnant, however, in other cases these taxa have likely colonised the area following disturbance (e.g. in drains). Occasionally, some areas contained a mixture of native trees and non-native trees that have presumably been planted or have escaped from nearby plantings. All of the above-described areas have therefore been mapped as 'Highly Modified Areas', and no attempt has been made to align any such areas with VTs. A total of 15.6 ha of 'Highly Modified Areas' were mapped, representing 4.3 % of the Study Area. Table 16 outlines the different types of 'Highly Modified Areas' mapped in the Study Area.

Table 16: Description of Highly Modified Areas Mapped in the Study Area

Code	Description	Area (ha) mapped	Proportion (%) of Study Area
AS	Individual or stands of *Acacia saligna* over pasture weeds on grey sands on cleared palusplains	0.39	0.11
BI	Individual or stands of *Banksia ilicifolia* over pasture weeds on grey sandy soils on low rises	0.02	0.005
CC	Individual or stands of *Corymbia calophylla* over pasture weeds on various soils and topographical positions	8.27	2.29
CO	Individual or stands of *Casuarina obesa* over pasture weeds on grey sands on cleared palusplains and in roadside drains	2.04	0.56
EG	Individual or stands of planted *Eucalyptus gomphocephala* over pasture weeds on grey sands on cleared palusplains and in roadside drains	0.01	0.003
EM	Individual or stands of *Eucalyptus marginata* over pasture weeds on grey sandy soils on low rises	0.21	0.06
ER	Individual or stands of *Eucalyptus rudis* over pasture weeds on grey sands on cleared palusplains and in roadside drains	0.51	0.14
ER/CC	Mixed stand of *Eucalyptus rudis* and *Corymbia calophylla* over pasture weeds on grey sands on cleared palusplains and in roadside drains	0.17	0.05
ER/EC	Mixed stand of *Eucalyptus rudis* and planted *E. camaldulensis* over pasture weeds on grey sands on cleared palusplains and in roadside drains	0.30	0.08
ER/MP	Mixed stand of *Eucalyptus rudis* and *Melaleuca preissiana* over pasture weeds on grey sands on cleared palusplains and in roadside drains	0.41	0.11

Code	Description	Area (ha) mapped	Proportion (%) of Study Area
ER/MR	Mixed stand of *Eucalyptus rudis* and *Melaleuca rhaphiophylla* over pasture weeds on grey sands on cleared palusplains and in roadside drains	0.70	0.19
ER/CO/MP/MR	Mixed stand of *Eucalyptus rudis, Casuarina obesa, Melaleuca preissiana* and *Melaleuca rhaphiophylla* over pasture weeds on grey sands on cleared palusplains and in roadside drains	0.47	0.13
EW	Individual or stands of *Eucalyptus wandoo* over pasture weeds on grey sands on cleared land	0.06	0.02
MP	Individual or stands of *Melaleuca preissiana* over pasture weeds on grey sands on cleared palusplains and in roadside drains	2.00	0.55
TO	Dense rushland of **Typha orientalis* growing in a minor creek	0.03	0.01

Additionally, there are several areas where tree and shrub species have clearly been planted for the purposes of revegetation. This includes a number of sections of roadside revegetation along Tonkin Highway. These areas often possessed native taxa, however these taxa had clearly been planted, and the resulting taxon combinations did not resemble remnant vegetation. However, in some cases, the majority of taxa present were not native to the area. These areas were mapped as 'Revegetated Areas'. A total of 26.3 ha of 'Revegetated Areas' were mapped, representing 7.3 % of the Study Area.

Table 17: Description of Revegetated Areas Mapped in the Study Area

Code	Description	Area (ha) mapped	Proportion (%) of Study Area
IE:	Areas planted with Non-indigenous *Eucalyptus* species over pasture weeds	9.64	2.67
RV1:	Revegetated road reserve with *Casuarina obesa*, introduced *Eucalyptus* species and the occasional *Corymbia calophylla* and *Eucalyptus rudis* over *Melaleuca rhaphiophylla* and *M. teretifolia* over pasture weeds	8.52	2.36
RV2:	Revegetated land with *Corymbia calophylla* and *Eucalyptus rudis* over *Melaleuca rhaphiophylla* and mixed shrub species over pasture weeds	0.33	0.09
RV3:	Revegetated road reserve dominated by *Corymbia calophylla* with occasional *Eucalyptus marginata*, *E. wandoo*, *E. rudis*, *E. accedens* and *E. lane poolei* over *Acacia saligna*, *A. pulchella*, *Xanthorrhoea preissii* and various indigenous and non-indigenous shrub species over pasture weeds	3.11	0.86
Mixed Plantation:	Shelter belt plantings composed of introduced *Eucalyptus* species along with *E. rudis*, *E. gomphocephala*, *E. wandoo*, *Corymbia calophylla*, *Melaleuca rhaphiophylla*, *M. preissiana*, *M. teretifolia*, *Allocasuarina fraseriana*, *Acacia saligna* and *Callistemon phoeniceus*.	4.69	1.29
PR?:	Individual or stands of *Pinus ?radiata* over pasture weeds on grey sands on cleared land	0.02	0.04

5.2.9 Relationships of VTs to SCP FCTs

As described in Section 3.8.2, further floristic analysis was undertaken to determine relationships between VTs the Study Area defined by floristic composition classification and SCP FCTs defined by Gibson *et al.* (1994), with the aim of aligning VTs with SCP FCTs. Several different analytical approaches were employed, to build supporting evidence for aligning VTs with SCP FCTs. Additionally, taxon lists of Woodman Environmental quadrats were also compared to the typical species lists for SCP FCTs presented in Gibson *et al.* (1994), as well as quadrat taxon lists, soils, topography and geographical distribution data from this study. Table 18 presents a summary of the results of this process.

As outlined in Table 18, all of the VTs of the Study Area defined by floristic composition have been aligned with SCP FCTs except for one (VT 5). Based on the limited data available (one quadrat established in a very small area of vegetation), it is considered possible that VT 5 represents a community not sampled by quadrats in the SCP datasets analysed. This is discussed further in Section 5.2.10. Two of the VTs (VT 2 and 3) have been aligned with the same SCP FCT (FCT 3a), and therefore are considered to represent local forms of this FCT. Excerpts from classification analysis dendrograms are presented in appendices as follows:

- Analysis of the Woodman Environmental quadrat dataset from the Estate with the original SCP dataset (Gibson *et al.* 1994) – Appendix Q;
- Analysis of the Woodman Environmental quadrat dataset from the Estate with the amended SCP dataset (Keighery *et al.* 2012) – Appendix R;
- Single site insertion analysis of representative quadrats of VTs described in the Estate, with the original SCP dataset (Gibson *et al.* 1994) – Appendix S; and
- Single site insertion analysis of representative quadrats of VTs described in the Estate, with the amended SCP dataset (Keighery *et al.* 2012) – Appendix T.

In contrast to the VTs defined by floristic composition classification, only one of the six VTs defined via structural vegetation classification could be aligned with confidence, being VT 6 (Table 18). Although the occurrence of this VT is on a narrow road reserve, it was rated as being in Good condition, with a reasonable number of native understorey taxa present, along with a relatively intact overstorey. Comparison of data from the occurrence of this VT with typical species lists for SCP FCTs presented in Gibson *et al.* (1994), as well as quadrat taxon lists, soils, topography and geographical distribution data, indicates that this VT represents SCP FCT 3c. Of the remaining VTs defined via structural vegetation classification, four may represent SCP FCTs, however, these determinations are at best tentative. The occurrences of VTs 8 and 9 are too degraded for firm conclusions to be drawn, with the taxa remaining suggesting some affinity to FCT 11. In the case of VTs 10 and 11, there are several FCTs that are similar to these VTs. Separation of these FCTs is difficult outside of a floristic analysis, as there is much overlap between typical and common taxa. A floristic analysis is not possible because the size of the occurrence prevented the establishment of quadrats in the occurrences of these VTs. The remaining VT, VT 7, is strongly suspected to be a product of historical disturbance, as the dominant taxa are not similar to any SCP FCTs in the context of typical or common taxa, and there was evidence of historical physical disturbance (soil excavation) at the occurrences of this VT.

As discussed in Section 3.8.2, because of the lack of formal guidance regarding the appropriate methodology for aligning vegetation with SCP FCTs, and also the lack of information regarding how new quadrats contained in the amended SCP dataset were assigned to SCP FCTs, the VT-FCT alignment determinations presented in Table 18 cannot be considered absolutely conclusive. However, the determinations were generally supported by the results of multiple analyses, including analyses that follow DBCA's standard analysis methods. Comparisons of quadrat taxon lists also supported the determinations in all cases.

There were a few cases where the results of one or a few of the analyses did not entirely support the final determination made. Such cases involved one specific quadrat that represents VT 4 (TE-10). This was not unexpected as TE-10 was established adjacent to a sandy wetland and appears to have partially sampled transitional vegetation. However, based on examination of taxon lists, this quadrat appears to be most similar to FCT 3c, as for all other quadrats in VT 4.

Table 18: Summary of Analyses and Comparisons to Determine Relationships of VTs to SCP FCTs

VT	Analysis with all Study Area and amended SCP dataset	Analysis with all Study Area and original SCP dataset	Single insertion – amended SCP dataset	Single insertion – original SCP dataset	Final determination
1	**FCT 8** Quadrat classified within a large group of SCP quadrats that all represent FCT 8, except for a single quadrat that represents FCT 13. Quadrat nested within this large group.	**FCT 8** Quadrat classified within a large group of SCP quadrats that all represent FCT 8, except for single quadrats that represent FCTs 7 and 13, and 2 quadrats that represent FCT 9. Quadrat nested within this large group.	**FCT 8** Quadrat TE-01 singly inserted – classified within a large group of SCP quadrats that all represent FCT 8, except for a single quadrat that represents FCT 13. Quadrat nested within this large group.	**FCT 8** Quadrat TE-01 singly inserted – classified within a large group of SCP quadrats that all represent FCT 8, except for single quadrats that represent FCTs 7 and 13, and 2 quadrats that represent FCT 9. Quadrat nested within this large group.	**FCT 8** Comparison of FCT description also supports this determination, as does species richness (particularly annual and geophytic herbs), the topography, hydrology and presence of clay soil.
2	**FCT 3a** Quadrat classified within a group of SCP quadrats that all represent FCT 3a (group also includes Study Area quadrats that represent VT 3). Quadrat nested within this group.	**FCT 3a** Quadrat classified within a group of SCP quadrats that all represent FCT 3a, except for a single quadrat that represents FCT 1b (group also includes Study Area quadrats that represent VT 3). Quadrat nested within this group.	**FCT 3a** Quadrat TE-03 singly inserted – classified within a group of SCP quadrats that all represent FCT 3a. Quadrat nested within this group.	**FCT 3a** Quadrat TE-03 singly inserted – classified within a group of SCP quadrats that all represent FCT 3a. Quadrat nested within this group.	**FCT 3a** Comparison of FCT description also supports this determination, as does species richness compared to most closely related quadrats, the topography, hydrology and presence of relatively heavy soil.
3	**FCT 3a** Quadrats classified within a group of SCP quadrats that all represent FCT 3a (group also includes Study Area quadrat that represents VT 2). Quadrats form a subgroup with 2 SCP quadrats from Mundijong Road (MUD-4 and MUD-5), however, are nested within subgroup.	**FCT 3a** Quadrat classified within a group of SCP quadrats that all represent FCT 3a, except for a single quadrat that represents FCT 1b (group also includes Study Area quadrat that represents VT 2). Quadrats form a subgroup with a single SCP quadrat from Mundijong Road (MUD-4).	**FCT 3a** All quadrats singly inserted – TE-04 classified within a group of SCP quadrats that all represent FCT 3a, except for single quadrats that represent FCTs 1b, 2 and 3c. TE-04 forms a peripheral subgroup with a single SCP quadrat from Mundijong Road (MUD-4). TE-05 and TE-06 classified within a group of SCP quadrats that all represent FCT 3a, except for single quadrats that represent FCTs 1b and 2. TE-05 and TE-06 nested within this group. TE-07 classified within a group of SCP quadrats that all represent FCT 3a; quadrat nested within this group.	**FCT 3a** All quadrats singly inserted – TE-04 and TE-05 classified within a group of SCP quadrats that all represent FCT 3a. TE-04 and TE-05 form a peripheral subgroup with a single SCP quadrat from Mundijong Road (MUD-4). TE-06 classified within a group of SCP quadrats that all represent FCT 3a. TE-06 forms a peripheral subgroup with two SCP quadrats from Mundijong Road (MUD-4 and MUD-5). TE-07 classified within a group of SCP quadrats that all represent FCT 3a; quadrat nested within this group.	**FCT 3a** Comparison of FCT description also supports this determination, as does species richness compared to most closely related quadrats, the topography, hydrology and presence of relatively heavy soil.

VT	Analysis with all Study Area and amended SCP dataset	Analysis with all Study Area and original SCP dataset	Single insertion – amended SCP dataset	Single insertion – original SCP dataset	Final determination
4	**3c** Quadrats classified within a small group of SCP quadrats that mostly represent FCT 3c, with two quadrats that represent FCT 6 (group also includes Study Area quadrat that represents VT 5). Quadrats contained within two peripheral sub-groups. Quadrats in adjacent group represent FCTs 2 and 3a.	**3c** Three quadrats (TE-02, TE-08, TE-09) classified within a group of SCP quadrats that all represent FCT 3c (group also includes Study Area quadrat that represents VT 5). Quadrats form discrete subgroup within group. One quadrat (TE-10) classified within a group of SCP quadrats that predominantly represent FCT 21c, with two quadrats that represent FCT 6. TE-10 forms a peripheral group with the two quadrats that represent FCT 6.	**Inconclusive – possibly 3c** All quadrats singly inserted – TE-02 and TE-09 classified within a group of SCP quadrats that contains five quadrats that represent FCT 3c; however, this group also contains two quadrats from FCTs 24 and 25, and one each from FCTs S08 and 18. TE-02 and TE-09 are nested within this group. TE-08 classified within a small group of SCP quadrats that all represent FCT 3c; TE-08 is nested within this group. TE-10 classified within a large group of SCP quadrats that contains numerous quadrats that represent FCT 6, plus smaller numbers of quadrats that represent FCTs S01, S02, 3c, 4, 5, 7 and 28. TE-10 forms a peripheral subgroup with 3 quadrats that represent FCT 6.	**3c** All quadrats singly inserted – TE-02, TE-08 and TE-09 classified within a group of SCP quadrats that all represent FCT 3c. TE-02, TE-08 and TE-09 are all nested within this group. TE-10 classified within a group of SCP quadrats that predominantly represent FCT 21c, with two quadrats that represent FCT6. TE-10 forms a peripheral subgroup with the two quadrats that represent FCT 6.	**3c** Comparison of FCT description also supports this determination, as does species richness compared to most closely related quadrats, the topography, hydrology and presence of relatively heavy soil. Quadrat TE-10 was established at the interface of a sandy wetland, and likely sampled vegetation that is somewhat transitional between that in the wetland and that considered to represent FCT 3c; this likely explains its inconclusive classification in a number of the analyses conducted.

VT	Analysis with all Study Area and amended SCP dataset	Analysis with all Study Area and original SCP dataset	Single insertion – amended SCP dataset	Single insertion – original SCP dataset	Final determination
5	**3c** Quadrat classified within a small group of SCP quadrats that mostly represent FCT 3c, with two quadrats that represent FCT 6 (group also includes Study Area quadrats that represent VT 4). Quadrat nested within group.	**3c** Quadrat classified within a group of SCP quadrats that all represent FCT 3c (group also includes Study Area quadrats that represent VT 4). Quadrat forms discrete subgroup within group.	**3c** Quadrat TE-11 singly inserted – classified within a group of SCP quadrats that contains five quadrats that represent FCT 3c; however, this group also contains two quadrats from FCTs 24 and 25, and one each from FCTs S08 and 18. Quadrat forms subgroup that is most closely related to a subgroup of 3c quadrats.	**3c** Quadrat classified within a group of SCP quadrats that all represent FCT 3c. Quadrat forms discrete subgroup within group.	**Potentially undescribed (aff. FCT 3b/3c)** Comparison of FCT description and taxon lists does not strongly support analysis results, particularly in the dominance of *Eucalyptus marginata* subsp. *marginata* and *Allocasuarina fraseriana* (absent in other occurrences of FCT 3c), the absence of many typical and common taxa for FCT 3c and the presence of a number of taxa that are uncommon on the SCP and apparently are not present in other occurrences of FCT 3. Comparison of typical and common taxa indicates affinity to FCT 3b, however, a number of taxa recorded (e.g. *Allocasuarina fraseriana*, *Conostylis setosa*) are absent from occurrences of this FCT. The topography and soils also appear to be at variance to those present at occurrences of FCTs 3b and 3c. Quadrat is on the very eastern margin of the Swan Coastal Plain on a relatively highly elevated, sandy section of the Ridge Hill Shelf; this landform was noted as being under-sampled by the SCP study. It is possible that this site may represent an FCT/FCT subtype not sampled by the SCP study. The composition of the vegetation appears similar to Jarrah Forest bioregion vegetation.
6	**NA**	**NA**	**NA**	**NA**	**FCT 3c** Comparison of taxon lists supports this determination, with many of the typical and common taxa for this FCT present. Topography, geographical location, soil type and hydrology also support this determination.

VT	Analysis with all Study Area and amended SCP dataset	Analysis with all Study Area and original SCP dataset	Single insertion – amended SCP dataset	Single insertion – original SCP dataset	Final determination
7	**NA**	**NA**	**NA**	**NA**	**Inconclusive – probably not natural vegetation** The combination of the taxa present within areas of this VT, and obvious signs of historical disturbance (excavation), indicates that this VT is an artefact of disturbance. It appears to contain common elements of FCTs 8 (i.e. the presence of *Melaleuca osullivanii* and *Melaleuca viminea* subsp. *viminea*) and 3a (i.e the presence of *Xanthorrhoea preissii* and *Kingia australis*), both of which occur either adjacent or in very close proximity to areas of this VT . However, it lacks the suite of ephemerals and geophytes, and the species-rich low shrubland, present in nearby occurrences of FCTs 8 and 3a respectively. The almost-completely introduced grassland and forbland layer also suggests significant historical disturbance.
8	**NA**	**NA**	**NA**	**NA**	**Possibly FCT 11** The presence of *Eucalyptus rudis* and *Melaleuca rhaphiophylla* indicate that this VT may represent FCT 11; there are also a number of locations of this FCT in the general vicinity of the Study Area (Lowlands property). However, the removal of the majority of the understorey through agricultural processes does not allow for a conclusive determination.

VT	Analysis with all Study Area and amended SCP dataset	Analysis with all Study Area and original SCP dataset	Single insertion – amended SCP dataset	Single insertion – original SCP dataset	Final determination
9	**NA**	**NA**	**NA**	**NA**	**Possibly FCT 11** The presence of *Eucalyptus rudis* and *Melaleuca rhaphiophylla* indicate that this VT may represent FCT 11; there are also locations of this FCT in the general vicinity of the Study Area (Lowlands property). However, the removal of most of the understorey through agricultural processes did not allow for sampling via quadrats.
10	**NA**	**NA**	**NA**	**NA**	**Possibly 23a** The presence of *Banksia menziesii* together with *Banksia attenuata* indicates that this VT may represent VT 23a. There are a number of locations of this VT in the general vicinity of the Study Area (Lowlands, Banksia Road Nature Reserve, Modong Nature Reserve). However, *Banksia menziesii* occasionally occurs in areas of FCT 21a, and there are numerous locations of this FCT in the general vicinity of the Study Area (Lowlands, Cardup Nature Reserve). The condition of this VT and its small spatial extent did not allow for sampling via quadrats.
11	**NA**	**NA**	**NA**	**NA**	**Possibly FCT 5** The presence of *Pericalymma ellipticum*, the sandy soil profile and the absence of a species-rich herb layer indicate that this VT could represent FCT 5, rather than the claypan FCT 10a, which also frequently contains *Pericalymma ellipticum*. However, *Pericalymma ellipticum* also often occurs within areas of FCT 4. There are several locations of both FCTs in the general vicinity of the Study Area (Modong Nature Reserve, Lowlands).

5.2.10 Significant Vegetation

A total of four significant communities have been identified by this assessment as occurring within the Study Area, as listed in Table 19. The significant communities are represented by one or more VTs defined and mapped within the Study Area (Table 19). Each significant community is discussed further below. Three of the significant communities are listed as TECs in WA, and are also listed as TECs under the EPBC Act, although they are listed under different names (Table 19). One Study Area VT is considered to be significant but is not considered to be equivalent to any listed significant communities. Photographs of the significant communities are presented in Appendix U. The locations of significant communities are presented in Appendix V.

Table 19: Significant Vegetation Occurring within the Study Area

Community	Conservation Status (W.A.)	Conservation Status (Commonwealth)	VTs	No. of Patches / Occurrences	Total Area Mapped (ha)
SCP3a - *Corymbia calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain (WA); *Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain (Commonwealth)	Critically Endangered	Endangered	2, 3	1 occurrence	2.08
SCP3c - *Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain (WA); *Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands of the Swan Coastal Plain (Commonwealth)	Critically Endangered	Endangered	4, 6	8 occurrences	8.83
SCP08 - Herb rich shrublands in clay pans (WA); Clay Pans of the Swan Coastal Plain (Commonwealth)	Vulnerable	Critically Endangered	1	1 occurrence	0.23
Study Area VT 5	-	-	5	1	0.8

Additionally, Study Area VT 10 partially satisfies the criteria for the 'Banksia Woodlands of the Swan Coastal Plain' TEC (Commonwealth) (listed as the PEC Banksia dominated woodlands of the Swan Coastal Plain IBRA region (P3)) in WA), however, is not considered to represent this TEC. This is discussed further below.

As presented in Section 5.1.4, the buffer polygons of six significant communities intersect the Study Area. Although the actual occurrence of a significant community may not be within the Study Area, according to the metadata information for the DBCA TEC and PEC Database, buffers are placed around occurrences of TECs and PECs to ensure that impacts in the vicinity of TECs or PECs to surface water or groundwater, which the TEC or PEC may depend on, are

identified. Table 20 presents a summary of the status of these significant communties following survey of the Study Area.

Three of the six above-noted significant communities (SCP3a, SCP3c and SCP08) are considered to occur in the Study Area (Table 19), however, two (SCP3a and SCP08) have buffer polygons that intersect the Study Area in locations where these significant communities are not considered to occur in the Study Area. Of these, the occurrence of SCP3a is considered erroneous, while the occurrence location of SCP08 is outside the Study Area. These are discussed further below. The polygons of the 'Banksia Woodlands of the Swan Coastal Plain' TEC (Commonwealth) are indicative only, as the polygons were determined by overlaying broad-scale vegetation mapping over remnant vegetation polygons; ground-truthing has not been undertaken to confirm occurrences in this dataset in most cases (TSSC 2016). No vegetation representing this TEC was found within the intersected polygons in the Study Area (discussed further below). The buffer polygon for the TEC SCP20b clearly corresponds to vegetation that is located outside the Study Area and is upslope and well-separated from the Study Area by cleared paddocks and roads (Appendix V); this community is not discussed further. The buffer polygon of the TEC SCP 3b appears to correspond to vegetation mapped as VT 5 in the Study Area; this is discussed further below.

None of the other significant communities known to or potentially occurring within the Desktop Study Area (as presented in Section 5.1.4) are considered to occur in the Study Area.

Table 20: Status of Significant Vegetation Types with Buffer Polygons Intersecting the Study Area

Community	Conservation Status	
SCP20b - *Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain	Endangered (WA and Commonwealth*)	One buffer polygon intersected (South Western Highway – Appendix V, Sheet 8); actual occurrence outside Study Area, up slope from Study Area, separated by cleared paddocks and roads. Therefore, no occurrences in the Study Area.
Banksia dominated woodlands of the Swan Coastal Plain IBRA region (WA); Banksia Woodlands of the Swan Coastal Plain (Commonwealth)	P3 (WA); Endangered (Commonwealth)	Three buffer polygons intersected (South Western Highway – Appendix V, Sheet 8); buffer polygons are indicative occurrences only; no vegetation representing this community found within buffer polygons in Study Area; vegetation representing this community in buffer polygon outside of Study Area (if any) is upslope and separated by cleared paddocks and roads.

Community	Conservation Status	
SCP3a - *Corymbia calophylla -Kingia australis* woodlands on heavy soils, Swan Coastal Plain (WA); *Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain (Commonwealth)	Critically Endangered (WA); Endangered (Commonwealth).	Four buffer polygons intersected (two – Mundijong Road – Appendix V Sheet 6, one – Abernethy Road – Appendix V Sheet 2, one – South Western Highway – Appendix V, Sheet 8). Mundijong Road – equivalent vegetation mapped in Study Area within western buffer polygon, with further equivalent vegetation located west of Study Area; eastern buffer polygon actual occurrence outside Study Area, but immediately north-east of Study Area. Abernethy Road – actual occurrence inside Study Area, however, occurrence considered erroneous, with vegetation considered to represent SCP3c TEC (see discussion below). South Western Highway - actual occurrence outside Study Area, up slope from Study Area, separated by cleared paddocks and roads
SCP3b - *Corymbia calophylla – Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable (WA)	One buffer polygon intersected (South Western Highway – Appendix V, Sheet 8); actual occurrence potentially extends inside Study Area. However, occurrence may be erroneous – vegetation in Study Area mapped as VT 5, which has affinities to SCP FCTs 3b and 3c, but appears to be at variance to these FCTs, and may represent an unsampled sub-type of SCP FCT 3, or a distinct FCT (see discussion below).
SCP3c - *Corymbia calophylla -Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain; *Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands of the Swan Coastal Plain (Commonwealth)	Critically Endangered (WA); Endangered (Commonwealth).	One buffer polygon intersected (Mundijong Road – Appendix V Sheet 6). Equivalent vegetation mapped in Study Area within buffer polygon, with further equivalent vegetation extending east and north-east outside Study Area.
SCP08 - Herb rich shrublands in clay pans (WA); Clay Pans of the Swan Coastal Plain (Commonwealth)	Vulnerable (WA); Endangered (Commonwealth).	Two buffer polygons intersected (one – Mundijong Road – Appendix V Sheet 6, one – Abernethy Road – Appendix V Sheet 2). Mundijong Road – equivalent vegetation mapped in Study Area just east of polygon, with actual occurrence located immediately west of Study Area. Abernethy Road – actual occurrence outside Study Area, but immediately west of Study Area.

*Note: can be a component of the EPBC listed TEC 'Banksia Woodlands of the Swan Coastal Plain

SCP3a – *Corymbia calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain TEC

The TEC '*Corymbia calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain' (Critically Endangered – W.A.), which is listed under the EPBC Act with the similar name '*Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain' (Endangered), is equivalent to the SCP FCT 3a, as described by Gibson *et al.* (1994). Originally, this TEC was represented by 13 quadrats from the Gibson *et al.* (1994) study, which represented five occurrences distributed from Cannington in the north to Waroona in the south. Subsequent analysis of the amended SCP dataset resulted in a further four quadrats

being assigned to this FCT (Government of Western Australia 2000); these represent three additional occurrences at Forrestfield, Serpentine and Pinjarra, within the known range of this TEC. There are further occurrences in the DBCA's database that are not represented by quadrats in publicly available datasets (DBCA 2007-); a total of 41 occurrences are known as of April 2017 (DAWE 2017a), with this TEC's distribution now known to extend to Guildford in the north and Ruabon in the south. There are no patch size or condition thresholds for occurrences of this TEC, with all occurrences considered to be important, or areas critical to its survival (DAWE 2017a).

This TEC is considered to be represented by VTs 2 and 3 within the Study Area. As outlined in Table 18, all analyses conducted indicated that quadrats from these VTs represented FCT 3a. This was also supported by comparison of quadrat taxon lists, species richness, topography, soils and hydrology. In addition, most analyses indicated that the quadrats from these VTs were most closely related to SCP FCT 3a quadrat MUD-4, which is also located within the Study Area in very close proximity to these quadrats, and SCP FCT 3a quadrat MUD-5, located just outside the Study Area (Appendix V, Sheet 6).

VTs 2 and 3 were mapped in several small polygons along the Mundijong Road reserve; these are considered to represent one occurrence of this TEC (Appendix V, Sheet 6). These polygons are considered to be part of a known occurrence, as indicated by a DBCA buffer polygon (Table 20). A total of 2.1 ha of this TEC have been mapped in the Study Area; almost two-thirds of this area (1.3 ha) was mapped as being in Very Good condition, with just over one-third (0.8 ha) mapped as Degraded.

As mentioned in Table 20, a DBCA buffer polygon for this TEC intersects the Study Area near Abernethy Road, with the actual occurrence apparently inside the Study Area (Appendix V, Sheet 2). However, the field survey and subsequent classification analyses do not support FCT 3a occurring at this location. Although the results of most analyses were inconclusive with regard to the relationship of the Woodman Environmental quadrat established at this location (TE-10), likely because of the quadrat's placement in somewhat transitional vegetation, no analysis results indicated that this quadrat was similar to any FCT 3a. One analysis indicated that this quadrat was most similar to quadrats from FCT 3c; comparison of the FCT description, species richness, topography and hydrology also supported this determination. In particular, FCT 3a is the wettest of the three subtypes of FCT 3, occurring in low-lying situations, and is generally referred to as a wetland community (DAWE 2017a). This is reflected in the common taxa of this FCT, with taxa such as *Pericalymma ellipticum* and *Hakea ceratophylla* frequently occurring. However, the aforementioned occurrence is a dryland site on well-drained, relatively sandy soil, in common with occurrences of FCT 3c, which is the driest of the FCT 3 subtypes (DAWE 2017b). Neither *Pericalymma ellipticum, Borya scirpoidea* or *Hakea ceratophylla* occur at this location (either within the quadrat or elsewhere); additionally, the typical taxon *Kingia australis* is also absent.

According to Government of Western Australia (2000), the vegetation at this location was not sampled, with the occurrence of FCT 3a at this location inferred. Therefore, it is assumed that an appropriate classification analysis of data collected from a quadrat was not undertaken. The process of inferring occurrences of SCP FCTs is not known, and therefore the rationale behind the determination of an occurrence of FCT 3a at this location is unclear. It is possible

that the vegetation may have been in better condition when the original assessment was undertaken, and therefore there may have been additional species present that are no longer extant at the site. However, given the absence of the typical and common taxa outlined above, as well the topography and soils outlined above, it seems unlikely that the common wetland taxa from FCT 3a, as well as the typical taxon *Kingia australis*, were ever present at this site. It is therefore considered that this occurrence of FCT 3a is erroneous; this vegetation should be considered an occurrence of FCT 3c.

SCP3c – *Corymbia calophylla* - *Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain TEC

The TEC '*Corymbia calophylla -Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain' (Critically Endangered – W.A.), which is listed under the EPBC Act with the similar name '*Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands of the Swan Coastal Plain' (Endangered), is equivalent to the SCP FCT 3c, as described by Gibson *et al.* (1994). This TEC was represented by 10 quadrats from the Gibson *et al.* (1994) study, which represented six occurrences distributed from Bullsbrook in the north to Bunbury in the south. No additional quadrats in the amended SCP dataset were assigned to this FCT (Government of Western Australia 2000). There are further occurrences in the DBCA's database that are not represented by quadrats in publicly available datasets (DBCA 2007-). A total of 29 occurrences are known as of April 2017 (DAWE 2017b), with this TEC's distribution now known to extend to Capel in the south. There are no patch size or condition thresholds for occurrences of this TEC, with all occurrences considered to be important, or areas critical to its survival (DAWE 2017b).

This TEC is considered to be represented by VTs 4 and 6 within the Study Area. As outlined in Table 18, the majority of analyses conducted indicated that quadrats from VT 4 represented FCT 3c. This was also supported by comparison of quadrat taxon lists, species richness, topography, soils and hydrology; comparison of these characteristics also supported the alignment of the single relevé surveyed in VT 6 with FCT 3c. As previously mentioned, quadrat TE-10 appears to have been placed in transitional vegetation; this was unfortunately necessary because of the very small area of vegetation present that was in suitable condition for a quadrat. This likely explains the inconclusive results of several of the analyses conducted; however, it is still considered appropriate to align this quadrat with FCT 3c based on comparison of quadrat taxon lists, species richness, topography and hydrology.

VTs 4 and 6 were mapped in a number of small polygons across the Study Area, with a single larger polygon mapped along the Mundijong Road reserve (Appendix V, Sheets 2-4, 6-8); these are considered to represent eight occurrences of this TEC. The polygon on Mundijong Road is considered to be part of a known occurrence, as indicated by a DBCA buffer polygon (Table 20). The remaining polygons would apparently be new occurrences. As discussed above, the polygon of this TEC mapped on Abernethy Road in the Study Area (Appendix V, Sheet 2) is considered by the DBCA to be an occurrence of FCT 3a, however, this is considered to be erroneous. A total of 9.0 ha of this TEC have been mapped in the Study Area; more than half of this area was mapped as Degraded or Completely Degraded condition (approximately 46 % and 9 % respectively); 23 % and 22 % was mapped as Very Good and Good respectively.

SCP08 – Herb rich shrublands in clay pans / Clay Pans of the Swan Coastal Plain TEC

The TEC 'Herb rich shrublands in clay pans' is listed as Vulnerable in WA, and is equivalent to the SCP FCT 8, as described by Gibson *et al.* (1994). This TEC was represented by 21 quadrats from the Gibson *et al.* (1994) study, which represented eight occurrences distributed from Upper Swan in the north to Bunbury in the south. Subsequent analysis of the amended SCP dataset resulted in a further six quadrats being assigned to this FCT (Government of Western Australia 2000). These represent four additional occurrences at Gingin, Bullsbrook, Langford and Bunbury, extending the known range of this TEC north and south. There are further occurrences in the DBCA's database that are not represented by quadrats in publicly available datasets (DBCA 2007-). The total number of occurrences and its total distribution is not available, however, a total of 298.1 ha of this TEC has been mapped as of September 2015 (DBCA 2015).

The 'Herb rich shrublands in clay pans' TEC is considered to be a component of the Commonwealth TEC 'Clay Pans of the Swan Coastal Plain', which is listed as Critically Endangered under the EPBC Act (DAWE 2012). This TEC is distributed primarily within the Swan Coastal Plain bioregion, with some occurrences also within the adjacent Jarrah Forest bioregion (DAWE 2012). As of September 2015, a total of 114 occurrences are known across 50 locations, with about 909 ha mapped (DBCA 2015). There is no patch size threshold for this TEC, however, to be considered an occurrence under the EPBC Act, a patch must meet at least the Good condition rating, as per EPA (2016a) (TSSC 2012).

The 'Herb rich shrublands in clay pans' TEC is considered to be represented by VT 1 within the Study Area. As outlined in Table 18, all analyses conducted indicated that the quadrat from VT 1 represented FCT 8. This was also supported by comparison of quadrat taxon lists, species richness, topography, soils and hydrology. In addition, most analyses indicated that the quadrat from this VT was most closely related to SCP FCT 8 quadrat MUD-9, which is located just outside the Study Area on Mundijong Road (Appendix V, Sheet 6), and SCP FCT 8 quadrats MUD-2, MUD-3, MUD-6 and MUD-7, which are located approximately 1 km west of the Study Area on Mundijong Road.

VT 1 was mapped in one small polygon in the Mundijong Road reserve (Appendix V, Sheet 6), representing one occurrence of the 'Herb rich shrublands in clay pans' TEC. The polygon on Mundijong Road is considered to be a new occurrence, as it occurs outside a DBCA buffer polygon that intersects the Study Area on Mundijong Road (Table 20), which relates to SCP quadrat MUD-9. A total of 0.2 ha of the 'Herb rich shrublands in clay pans' TEC have been mapped in the Study Area; three-quarters of this area was mapped as Degraded condition, with the remainder mapped as Very Good. Because a proportion of the polygon of the 'Herb rich shrublands in clay pans' TEC was mapped as Very Good condition, it therefore represents an occurrence of the 'Clay Pans of the Swan Coastal Plain' TEC under the EPBC Act. It is considered that the entire mapped polygon, including the portion mapped as Degraded, should be considered to represent the 'Clay Pans of the Swan Coastal Plain', as the Degraded portion is still important in the context of the overall functionality of the occurrence. As this occurrence is within a Bush Forever site (Site No. 360), it is considered to be an important occurrence (DBCA 2015).

As mentioned in Table 20, a DBCA buffer polygon for the 'Herb rich shrublands in clay pans' TEC intersects the Study Area near Abernethy Road (Appendix V, Sheet 2). However, the field survey confirmed that no vegetation similar to this TEC occurs within the Study Area itself. As the actual occurrence location is outside the Study Area, it is not currently known exactly how close to the Study Area it extends to, however, it is assumed it is less than 250 m west of the Study Area based on the buffer polygon location. It should be noted, however, that according to Government of Western Australia (2000), the occurrence of this TEC has been inferred at this location; given that the inference of SCP 3a in the same block of vegetation appears to be erroneous (see discussion above), sampling via quadrats and classification analyses with the SCP datasets should be undertaken to verify the accuracy of this inference.

Study Area VT 5

As outlined in Table 18, Study Area VT 5, which was mapped in one small polygon adjacent to South Western Highway (Appendix V, Sheet 8) has affinities to SCP FCT 3b and 3c. Although all analyses conclusively indicated that the quadrat established within this VT is similar to FCT 3c quadrats, it is not especially closely related to any SCP quadrat. As noted in Table 18, comparison of quadrat taxon lists did not strongly support the results of the analyses. This comparison appeared to indicate a greater similarity to SCP FCT 3b, however, it is probable that this similarity was only superficial, given that none of the analyses conducted suggested a close relationship to FCT 3b quadrats. The topography and soils of the VT 5 quadrat also appear to be at variance to those present at occurrences of FCTs 3b and 3c.

It is therefore considered possible that this site may represent an FCT or FCT subtype not sampled by quadrats within the amended SCP dataset. As noted in Table 18, the occurrence of VT 5 is on the very eastern margin of the Swan Coastal Plain on a relatively highly elevated, sandy section of the Ridge Hill Shelf; this landform was noted as being under-sampled by the SCP study (Gibson *et al.* 1994), with no quadrats from the amended SCP dataset established within the general vicinity of the occurrence of VT 5. Because of the very small size of the area of vegetation mapped as VT 5 that is present in the Study Area, only a single quadrat could be established; however, this vegetation continues along the road reserve of South Western Highway to the south. It is considered that further sampling in this adjacent vegetation outside the Study Area would be required to provide greater certainty as to the affinities of this vegetation to SCP FCTs. It is possible that the single quadrat may have been established in an unusual or transitional area, and that further sampling may indicate stronger similarity to described SCP FCTs. However, it appears that regardless of the outcome of further sampling, the vegetation mapped as VT 5 would be significant vegetation, as per EPA (2016a). The composition of the VT 5 appears to be more similar to Jarrah Forest bioregion vegetation than vegetation on the Swan Coastal Plain, with many typical Jarrah Forest species present; it is possible that VT 5 occurs in nearby areas of this bioregion.

As noted in Table 20 it appears, based on the location of a DBCA buffer polygon, that the vegetation mapped as VT 5 is considered to be part of an occurrence of the TEC '*Corymbia calophylla – Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain', which is equivalent to SCP FCT 3b. Although the vegetation mapped as VT 5 does appear to have at least some superficial affinity to this FCT, as noted above, further sampling via quadrats would be required to ascertain whether it is closely similar. According

to Government of Western Australia (2000), the vegetation at this location was not sampled, with the occurrence of FCT 3a at this location inferred. Therefore, it is assumed that an appropriate classification analysis of data collected from a quadrat was not undertaken. As previously mentioned, the process of inferring occurrences of SCP FCTs is not known, and therefore the rationale behind the determination of an occurrence of FCT 3b at this location is unclear. As for the inferred occurrence of FCT 3a in the Study Area near Abernethy Road, it is possible that the inferred determination of SCP 3b at the location of the polygon of VT 5 is also erroneous, and is based on the superficial similarities observed during this current survey.

Banksia Woodlands of the Swan Coastal Plain TEC

As noted above, the single occurrence of mapped along Bishop Road and the adjacent rail reserve partially satisfies the criteria for the 'Banksia Woodlands of the Swan Coastal Plain' TEC (Commonwealth) (listed as the PEC Banksia dominated woodlands of the Swan Coastal Plain IBRA region (P3)) in WA), however, is not considered to represent this TEC.

The Approved Conservation Advice (TSSC 2016) for this community stipulates a four-step process for identifying this community. These steps are followed in the context of identifying whether vegetation of the Estate represents this TEC, as outlined below. The first step involves key diagnostic characteristics (location and physical environment, soils and landform, structure, and composition). The occurrence of VT 10 (referred to as a patch in the Approved Conservation Advice) satisfies all four key diagnostic characteristics, as it occurs within the Swan Coastal Plain IBRA bioregion, occurs on well drained, low nutrient soils on a sandplain landform (low dune), and has a basic structure of a low woodland dominated by *Banksia attenuata* and *Banksia menziesii*, over a relatively diverse understorey. The second step is the condition threshold of a patch of a TEC; The Approved Conservation Advice for this TEC then specifies that a patch of the TEC must meet the Good vegetation condition category as per EPA (2016a) to be considered a patch of the TEC under the EPBC Act. As the patch of VT 10, was mapped as Degraded, it therefore does not satisfy the condition threshold, and therefore is not considered to be a patch of the TEC under the EPBC Act.

It is worthy of note that there is a reasonable degree of subjectivity involved in applying condition ratings to vegetation. However, in this context, even if the patch of VT 10 were to be allocated a condition rating of Good or better, it would still not satisfy Step 3 of the identification process, being the patch size threshold. The size of the patch is 0.35 ha; even a patch rated as Excellent must be a minimum of 0.5 ha to be considered the TEC under the EPBC Act.

Note that as the patch of VT 10 is not an occurrence of the 'Banksia Woodlands of the Swan Coastal Plain' TEC, it is also not an occurrence of the 'Banksia dominated woodlands of the Swan Coastal Plain IBRA region PEC (P3)'. These communities are considered equivalent and the description, area and condition thresholds that apply to the EPBC-listed TEC also apply to this Priority ecological community (DBCA 2020b).

5.2.11 Vegetation Condition

Table 19 presents the area (ha) of each VT and corresponding condition rating mapped in the Study Area. More than half (60.3 %) of VT areas mapped in the Study Area (the total area of VTs mapped equated to 5.2% of the entire Study Area) was mapped as Degraded or Completely Degraded (EPA 2016a; Appendix A) with significant evidence of impact to vegetation composition and structure as a result of human activities, including rubbish dumping and very high levels of introduced (weed) taxa. The remainder of the intact vegetation (39.7%) was rated as 'Good' or 'Very Good'.

Table 21: Vegetation Condition Ratings for each Vegetation Type Mapped within the Study Area

VT	Completely Degraded	Degraded	Good	Very Good	Excellent	Pristine	Total (ha)
1	0	**0.17**	0	**0.05**	0	0	**0.23**
2	0	**0.15**	0	**0.36**	0	0	**0.51**
3	0	**0.61**	0	**0.96**	0	0	**1.57**
4	**0.35**	**3.66**	**1.99**	**2.10**	0	0	**8.10**
5	0	**0.64**	0	**0.18**	0	0	**0.82**
6	**0.37**	**0.36**	0	0	0	0	**0.73**
7	0	0	**1.20**	0	0	0	**1.20**
8	**0.75**	**2.86**	0	0	0	0	**3.61**
9	0	**0.81**	0	0	0	0	**0.81**
10	0	**0.35**	0	0	0	0	**0.35**
11	0	**0.23**	**0.61**	0	0	0	**0.84**
Total	**1.47**	**9.84**	**3.8**	**3.65**	**0**	**0**	**18.77**

Areas that are currently cleared were mapped as Cleared Land (vegetation condition rated as Cleared Land) and make up 83.2 % (301.49 ha) of the entire Study Area. The condition of areas mapped as Highly Modified and Revegetated Areas were mapped as Completely Degraded and make up 11.6 % (41.9 ha) of the entire Study Area.

Detailed vegetation condition mapping presented in Appendix L.

6. CONCLUSION

The floristic diversity of the Study Area (256 discrete vascular flora taxa recorded by this survey) is considered to be relatively high given the limited area of intact vegetation in the Study Area, with most areas of intact vegetation located in narrow road reserves. The below-average rainfall experienced during the winter and spring months leading up to survey however has potentially reduced the number of annual taxa recorded.

Nine significant flora taxa, including three listed as Threatened under both the EPBC Act and BC Act, were recorded in the Study Area by this survey including:

- *Acacia lasiocarpa* var. *bracteolata* long peduncle variant (G.J. Keighery 5026) (P1) – one individual recorded, located within the Study Area representing one new population;
- *Babingtonia urbana* (P3) – 1501 individuals recorded, 430 of which are inside the Study Area, representing three populations in the Study Area, one of which is a new population;
- *Calectasia grandiflora* (P2) - 76 individuals recorded, 75 of which are inside the Study Area, representing one population (previously recorded population);
- *Jacksonia gracillima* (P3) - 112 individuals recorded, 104 of which are inside the Study Area, representing three new populations;
- *Leucopogon* aff. sp. Busselton (D. Cooper 243) (potentially undescribed) - four individuals recorded, all within the Study Area (representing a previously recorded population);
- *Stylidium aceratum* (P3) - 13 individuals recorded, all within the Study Area, representing one new population;
- *Synaphea* sp. Pinjarra Plain (A.S. George 17182) (Threatened – Endangered under both EPBC Act and BC Act) - 69 individuals recorded, 26 of which are inside the Study Area, representing one population (previously recorded population);
- *Synaphea* sp. Serpentine (G.R. Brand 103) (Threatened – Critically Endangered under both EPBC Act and BC Act) - 551 individuals recorded, all within the Study Area, representing one population (previously recorded population); and
- *Tetraria australiensis* (Threatened – Vulnerable under both EPBC Act and BC Act) - 1214 individuals recorded, 1208 of which are inside the Study Area, representing two populations; one of which is a new population.

The majority of locations of significant flora taxa are associated with areas of intact vegetation associated with road reserves intersecting the Tonkin Hwy road reserve, including Mundijong Road (majority of Threatened flora locations), and Abernethy and Bishop Roads. The majority of records of significant flora taxa were taken within the Study Area, however some populations were recorded as extending in intact vegetation outside of the Study Area, predominantly *Babingtonia urbana* (P3) and *Synaphea* sp. Pinjarra Plain (A.S. George 17182) (Threatened).

As a result of the methods used to conduct the targeted survey, including survey intensity and timing, it is considered unlikely that any further locations of any of these significant flora taxa occur in the Study Area. In addition, it is considered unlikely that any additional significant

flora taxa that were identified during the desktop assessment would occur within the Study Area, based on both extent of survey and habitat types present.

As noted above, there was little intact native vegetation in the Study Area, with the majority of the Study Area mapped as Cleared, Highly Modified or Revegetated. The condition of all these areas was mapped as Cleared or Completely Degraded (total 343.4 ha, 94.8% of the Study Area).

A total of 11 VTs were otherwise mapped in the Study Area (18.9 ha; 5.2% of the Study Area). The condition of more than half (60.1%) of mapped VTs in the Study Area was mapped as Degraded or Completely Degraded, with significant evidence of historical impact to vegetation composition and structure as a result of human activities. The condition of the remainder of the intact vegetation (7.5 ha; 2.1% of the Study Area) was rated as 'Good' or 'Very Good', with no areas mapped as 'Excellent' or 'Pristine', which is typical of the location of the Study Area within a region which has experienced historically high levels of clearing and weed invasion.

A total of four significant communities were identified and mapped in the Study Area as presented below.

SCP3a - *Corymbia calophylla -Kingia australis* woodlands on heavy soils, Swan Coastal Plain (WA – Critically Endangered; Commonwealth - Endangered) is considered to be represented by VTs 2 and 3 within the Study Area. All analyses conducted indicated that quadrats from these VTs represented FCT 3a, and this was further supported by comparison of quadrat taxon lists, species richness, topography, soils and hydrology. One occurrence of this TEC was mapped over approximately 2.1 ha within the Study Area, on the Mundijong Road reserve, with the vegetation condition mapped as either Very Good or Degraded (Appendix V Sheet 6). As no condition thresholds have been applied to this EPBC-listed TEC (DAWE 2017a), all areas meeting the description of the TEC are considered habitat critical to its survival.

SCP3c - *Corymbia calophylla -Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain (WA – Critically Endangered; Commonwealth - Endangered) is considered to be represented by VTs 4 and 6 within the Study Area. The majority of analyses conducted indicated that quadrats from VT 4 represented SCP FCT 3c, and this was also supported by comparison of quadrat/relevé taxon lists, species richness, topography, soils and hydrology to the species composition and habitat characteristics of this community. Eight occurrences of this TEC were mapped over approximately 8.8 ha within the Study Area, with the vegetation condition ranging from Very Good to Completely Degraded. Areas where the SCP3c vegetation was mapped as either Very Good or Good included representation just south of the Thomas Road intersection, south-west of the Abernethy Road intersection, and on Mundijong Road Reserve; otherwise, all other occurrences were either in Degraded or Completely Degraded condition. However, as no condition thresholds have been applied to this EPBC-listed TEC (DAWE 2017b), all areas meeting the description of the TEC are considered habitat critical to its survival.

SCP08 - Herb rich shrublands in clay pans (WA – Vulnerable; Commonwealth – Critically Endangered, as a component of the Clay Pans of the Swan Coastal Plain) is considered to be

represented by VT 1 within the Study Area. All analyses conducted indicated that the quadrat from VT 1 represented FCT 8, and this was also supported by comparison of quadrat taxon lists, species richness and vegetation structure, topography, soils and hydrology with relevant lists and habitat descriptions. One occurrence of this TEC was mapped over approximately 0.2 ha within the Study Area, with an area of 0.05ha mapped as being in Very Good condition, with the remaining 0.2 ha mapped as Degraded.

The listing advice for the EPBC-listed 'Clay Pans of the Swan Coastal Plain', which includes SCP08 (Herb rich shrublands in claypans [Community Type 8 (SCP08)]) provides advice with regards to condition and patch size thresholds for this TEC (TSSC 2012), with no minimum patch sizes, and vegetation to be in 'Good' condition or better. However, it is considered that areas of the TEC which have vegetation condition less than Good may still retain important natural values and they should not be excluded from recovery and other management actions. As such, it is considered that the entire mapped polygon, including the portion mapped as Degraded, should be considered to represent the 'Clay Pans of the Swan Coastal Plain', as the Degraded portion is still important in the context of the overall functionality of the occurrence, including maintenance of the hydrology of the site. This occurrence is also considered to be an important occurrence due to its inclusion within a Bush Forever site (Site No. 360) (DBCA 2015).

Study Area VT 5 has affinities to SCP FCT 3b (based on comparison of quadrat taxon lists) and FCT 3c (based on the results of the analyses), however, it is not especially closely related to any SCP quadrat. The occurrence of VT 5 is on the very eastern margin of the Swan Coastal Plain, an area which was noted as being under-sampled by the SCP study (Gibson *et al.* 1994); in addition, no quadrats from the amended SCP dataset were established within the general vicinity of the occurrence of VT 5. It is therefore considered possible that this site either may represent an FCT not sampled by quadrats within the amended SCP dataset, or that the single quadrat may have been established in an unusual or transitional area.

One occurrence of Study Area VT 5 was mapped over approximately 0.8 ha within the Study Area, with this vegetation continuing to the south along the road reserve of South Western Highway. Further sampling in the adjacent vegetation outside the Study Area would be required to provide greater certainty as to the affinities of this vegetation to SCP FCTs. However, regardless of the outcome of further sampling, the vegetation mapped as VT 5 would be significant vegetation, as per EPA (2016a). The composition of the VT 5 appears to be more similar to Jarrah Forest bioregion vegetation than vegetation on the Swan Coastal Plain, with many typical Jarrah Forest species present; it is possible that VT 5 occurs in nearby areas of this bioregion.

Although the vegetation of the Study Area has been widely cleared and otherwise disturbed, Threatened flora and ecological communities listed under both the BC Act and EPBC Act are present within the Study Area.

7. REFERENCES

Atlas of Living Australia (ALA) (2020)
The Australasian Virtual Herbarium. Council of Heads of Australasian Herbaria. Available: http://avh.chah.org.au. Accessed January, 2020.

Australian Weeds Committee (2020)
Weeds Australia - Weeds of National Significance. Available: http://www.weeds.org.au/WoNS/. Accessed January 2020.

Beard, J. S. (1981)
Vegetation Survey of Western Australia, Swan 1:1 000 000. Map and Explanatory Notes to Sheet 7. Published by University of Western Australia Press, Perth.

Beard, J.S. (1990)
Plant Life of Western Australia. Kangaroo Press, Perth.

Belbin, L. and Collins, A. (2009)
PATN. Version 3.12, Blatant Fabrications Pty Ltd.

Bureau of Meteorology (2020a)
Climate Statistics for Australian Locations – Serpentine and Karnet. Available: http://www.bom.gov.au/climate/data/. Sourced January 2020.

Bureau of Meteorology (2020b)
Groundwater Dependent Ecosystems Atlas. Available: http://www.bom.gov.au/water/groundwater/gde/map.shtml. Accessed April 2020.

Chao, A. (1987)
Estimating the population size for capture-recapture data with unequal catchability. *Biometrics* 43:783-791.

Chappill, J.A., Wilkins, C.F., Crisp, M.D. (2007)
Taxonomic revision of Jacksonia (Leguminosae: Mirbelieae). Australian Systematic Botany 20: 618-620

Commonwealth of Australia (2012)
Interim Biogeographic Regionalisation for Australia, Version 7. Department of Sustainability, Environment, Water, Population and Communities. Available: http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html#ibra

Craven, L.A., Lepschi, B.J. and Cowley, K.J. (2010)
Melaleuca (Myrtaceae) of Western Australia: five new species, three new combinations, one new name and a new state record. *Nuytsia* 20: 27-36.

Department of Agriculture, Water and the Environment (DAWE) (as Department of the Environment, Water, Heritage and the Arts) (2008)
Approved Conservation Advice for Tetraria australiensis (Southern Tetraria). Canberra: Department of the Environment, Water, Heritage and the Arts. Available from http://www.environment.gov.au/biodiversity/threatened/species/pubs/10137-conservation-advice.pdf.

Department of Agriculture, Water and the Environment (DAWE) (as Department of Sustainability, Environment, Water, Population and Communities) (2012)
Approved Conservation Advice for Clay Pans of the Swan Coastal Plain. Available: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/121-conservation-advice.pdf.

Department of Agriculture, Water and the Environment (DAWE) (as Department of the Environment and Energy) (2017a)
Approved Conservation Advice for *Corymbia calophylla - Kingia australis* woodlands on heavy soils of the Swan Coastal Plain. Available: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/17-conservation-advice.pdf.

Department of Agriculture, Water and the Environment (DAWE) (as Department of the Environment and Energy) (2017b)
Approved Conservation Advice for *Corymbia calophylla – Xanthorrhoea preissii* woodlands and shrublands of the Swan Coastal Plain. Available: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/18-conservation-advice.pdf.

Department of Agriculture, Water and the Environment (DAWE) (as Department of the Environment and Energy) (2020)
Interrogation of Species Profile and Threats (SPRAT) Database using Protected Matters Search Tool. Queried 13/1/20, report reference YTB32G. Available: https://www.environment.gov.au/epbc/protected-matters-search-tool.

Department of Biodiversity, Conservation and Attractions (DBCA) (2007-)
NatureMap: Mapping Western Australia's Biodiversity. Available: https://naturemap.dpaw.wa.gov.au/. Accessed January 2020.

Department of Biodiversity, Conservation and Attractions (DBCA) (as Department of Environment and Conservation) (2013)
Definitions, Categories and Criteria for Threatened and Priority Ecological Communities. Current January 2013. Available: https://www.dpaw.wa.gov.au/images/plants-animals/threatened-species/definitions_categories_and_criteria_for_threatened_and_priority_ecological_communities.pdf

Department of Biodiversity, Conservation and Attractions (DBCA) (as Department of Parks and Wildlife) (2014)

Invasive Plant Prioritization Process – Impact and Invasiveness Ratings – Swan Region. Available: https://www.dpaw.wa.gov.au/plants-and-animals/plants/weeds/156-how-does-dpaw-manage-weeds

Department of Biodiversity, Conservation and Attractions (DBCA) (as Department of Parks and Wildlife) (2015)

Interim Recovery Plan No. 354 – Claypans 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), 2015-202. October 2015.

Department of Biodiversity, Conservation and Attractions (DBCA) (2017a)

A methodology for the evaluation of wetlands on the Swan Coastal Plain, draft prepared by the Wetlands Section of the Department of Biodiversity, Conservation and Attractions and the Urban Water Branch of the Department of Water and Environmental Regulation, Perth, December 2017.

Department of Biodiversity, Conservation and Attractions (DBCA) (2017b)

Threatened and Priority Flora Report Form – Field Manual. Version 1.3, August 2017. Available: https://www.dpaw.wa.gov.au/images/documents/plants-animals/monitoring/forms/threatened-priority-flora-field-manual.pdf

Department of Biodiversity, Conservation and Attractions (DBCA) (2018a)

List of Threatened Ecological Communities (TECs) endorsed by the Western Australian Minister for Environment. Species and Communities Branch, 28th June 2018

Department of Biodiversity, Conservation and Attractions (DBCA) (2018b)

Threatened and Priority Flora List – December 2018. Available: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-plants. Species and Communities Branch, Department of Parks and Wildlife.

Department of Biodiversity, Conservation and Attractions (DBCA) (2019a)

Conservation Codes for Western Australian Flora and Fauna. Current 3rd January 2019. Available: https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities

Department of Biodiversity, Conservation and Attractions (DBCA) (2019b)

Interrogation of the DBCA Western Australian Herbarium specimen database, Threatened and Priority Flora database and Threatened and Priority Flora List, search performed and data supplied by Main Roads.

Department of Biodiversity, Conservation and Attractions (DBCA) (2020a)

Geomorphic Wetlands, Swan Coastal Plain Dataset. Available: https://catalogue.data.wa.gov.au/dataset/geomorphic-wetlands-swan-coastal-plain. Accessed January 2020.

Department of Biodiversity, Conservation and Attractions (DBCA) (2020b)
Priority Ecological Communities for Western Australia, Version 30. Species and Communities Program, Department of Biodiversity, Conservation and Attractions, 28th July 2020.

Department of Parks and Wildlife (2016)
Synaphea sp. Pinjarra Plain (A.S. George 17182) Interim Recovery Plan 2016–2021. Interim Recovery Plan No. 363. Department of Parks and Wildlife, Western Australia.

Department of Parks and Wildlife (2017)
Serpentine Synaphea (*Synaphea* sp. Serpentine (G.R. Brand 103)) Interim Recovery Plan 2017–2022. Interim Recovery Plan No. 380. Department of Parks and Wildlife, Western Australia.

Department of Primary Industries and Regional Development (DPIRD) (2019a)
Soil-landscape zones Western Australia. Zones derived from soil-landscape mapping (best available) Version April 2018.

Department of Primary Industries and Regional Development (DPIRD) (2020)
Declared Organism Search. Available: http://www.agric.wa.gov.au/organisms. Accessed January 2020.

Eco Logical (2019)
Mundijong Road Spring Flora Survey. Unpublished report prepared for Main Roads WA

Environmental Protection Authority (2004)
Guidance for the Assessment of Environmental Factors – Terrestrial Flora and Vegetation surveys for Environmental Impact Assessment in Western Australia, No. 51, June 2004. Unpublished report produced by the Environmental Protection Authority, Western Australia.

Environmental Protection Authority (EPA) (2016a)
Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment. EPA, Western Australia, December 2016.

Environmental Protection Authority (EPA) (2016b)
Environmental Factor Guideline – Flora and Vegetation. Published 13th December 2016 (www.epa.wa.gov.au/).

Executive Steering Committee for Australian Vegetation Information (ESCAVI) (2003)
Australian Vegetation Attribute Manual: National Vegetation Information System, Version 6.0. Department of the Environment and Heritage, Canberra.

GHD (2012)
Report for Rail Reserves in the Shire of Serpentine Jarrahdale, Spring Flora and Vegetation Survey and Fauna and Habitat Assessment. Unpublished report prepared for the Public Transport Authority.

Gibson, N., Keighery, B., Keighery, G., Burbidge, A., and Lyons, M. (1994)
A Floristic Survey of the southern Swan Coastal Plain. Unpublished report for the Australian Heritage Commission prepared by the Department of Conservation and Land Management and the Conservation Council of Western Australia (Inc.), July 1994.

Government of Western Australia (2000)
Bush Forever Volume 2. Directory of Bush Forever Sites. Published by the Department of Environmental Protection, Perth, WA.

Government of Western Australia (2019a)
2018 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of March 2019. WA Department of Biodiversity, Conservation and Attractions. Available:
https://catalogue.data.wa.gov.au/dataset/dbca-statewide-vegetation-statistics

Government of Western Australia (2019b)
2018 South West Vegetation Complex Statistics. Current as of March 2019. WA Department of Biodiversity, Conservation and Attractions, Perth, https://catalogue.data.wa.gov.au/dataset/dbca

Keighery, B.J., Keighery, G.J., Longman, V.M. and Clarke, K.A. (2012)
Native and Weed Flora of the Southern Swan Coastal Plain: 2005 Dataset. Department of Environment and Conservation, Kensington, Western Australia.

McCune, B. and Mefford, M.J. (2011)
PC-Ord. Multivariate Analysis of Ecological Data, Version 6.08. MjM Software, Gleneden Beach, Oregon U.S.A.

Mueller-Dombois, D. and Ellenberg, H. (1974)
Aims and Methods of Vegetation Ecology. Wiley and Sons, Canada.

Purdie, B R, Tille, P J, and Schoknecht, N R. (2004)
Soil-landscape mapping in south-Western Australia: an overview of methodology and outputs. Department of Agriculture and Food, Western Australia. Report 280, 160p.

Rye, B. L (2015)
A revision of the south-western Australian genus Babingtonia (Mrytaceae: Chamelauiceae). Nuytsia 25: 219-250

Shepherd, D., Beeston, G. and Hopkins, A. (2002)
Native Vegetation in Western Australia. Extent, Type and Status. Resource Management Technical Report 249. Department of Agriculture.

Sneath, P.H.A, and Sokal, R.R. (1973)
Numerical Taxonomy: The Principles and Practice of Numerical Classification. Published by Freeman, San Francisco.

Spectrum Ecology (2018)
Bungendore Park Targeted Flora Survey. Unpublished report prepared for the City of Armadale.

Threatened Species Scientific Community (TSSC) (2012)
Commonwealth Listing Advice on Claypans of the Swan Coastal Plain. Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/121-listing-advice.pdf.

Threatened Species Scientific Community (TSSC) (2016)
Approved Conservation Advice (including listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community. Department of the Environment and Energy, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/131-conservation-advice.pdf.

WA Herbarium (1998-)
Florabase. Available: https://florabase.dpaw.wa.gov.au/. Accessed January, 2020.

Woodman Environmental (2006)
Provision of Domestic Supply King Rd/Mundijong Rd Environmental Assessment. Unpublished report prepared for Western Power Corporation.

WWW (2020)
WorldWideWattle ver. 2. Published on the Internet at: www.worldwidewattle.com [Accessed April 2020].

360 Environmental (2014)
Abernethy Road, Byford Flora, Vegetation and Fauna Report. Unpublished report prepared for the Shire of Serpentine Jarrahdale.