Lot 3 Buller Road Waroona

Level 2 Flora and Vegetation Assessment

KD.1 PTY LTD

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1 INTRODUCTION

1.1 Study and Assessment Description

The south-east corner of Lot 3 Buller Road (also known as the Jackson Block), located 8 km west of Waroona, 100 km south of Perth in the south-west of Western Australia, has been previously utilised for sand extraction. KD.1 Pty Ltd (KD1) is providing overarching environmental support into the investigation of approvals to conduct further sand extraction within other areas of Lot 3 (the Project).

A previous out of season Level 1 Flora and Vegetation Survey was conducted within the Jackson Block. To complement this survey, KD.1 have requested Woodman Environmental Consulting Pty Ltd (Woodman Environmental) conduct a Level 2 assessment of the flora and vegetation values of Lot 3 to support future environmental approvals.

1.2 Study Area Definition

The Study Area for this assessment is shown on Figure 1. The Study Area covers approximately 218.2 hectares (ha). The Study Area includes the Jackson Block (shown on Figure 1) as well as additional areas of Lot 3. The majority of the Study Area is remnant vegetation, with small cleared areas and Western Power infrastructure also present. The Study Area is located on private property.

1.3 Level of Assessment

This flora and vegetation assessment of the Study Area was undertaken at a Level 2 standard as defined by the Environmental Protection Authority's (EPA) Guidance Statement No. 51 (EPA 2004), and Position Statement No. 3 (EPA 2002). This level of survey was determined to be appropriate using Table 2 of Guidance Statement No. 51, where the Bioregion Group is defined as Group 1, and the nature of potential impacts are considered to be Low-Moderate (EPA 2004).

A Level 2 survey is defined as a background research/desktop study and reconnaissance survey, followed by a detailed or comprehensive field survey. A detailed field survey was considered appropriate (as opposed to a comprehensive survey), given that the flora and vegetation of the Swan Coastal Plain is relatively well known as a result of survey that have previously been undertaken (e.g. Gibson *et al.* 1994).

This report presents the results of both the desktop and field survey components of the Level 2 survey of the Study Area. The results of the background research/desktop study, which include a review of known information relevant to the Study Area through all sources of literature available, are presented in Section 2. The results of the reconnaissance survey and the detailed field survey of the Study Area are presented in Section 4.

1.4 Aims and Objectives

The aims of this flora and vegetation assessment were:

- Determine the flora and vegetation values of the Study Area, to provide baseline information when considering the potential impacts of the Project.

The overall objectives of the flora and vegetation assessment were to:

- Compile a list of flora taxa (native and introduced) that occur within the Study Area;
- Identify and record the locations of flora taxa that occur within the Study Area that are one of the following (hereafter referred to as significant flora taxa):
    - Listed Threatened Species under the *Environment Protection and Biodiversity Conservation Act* 1999 (Commonwealth) (EPBC Act);
    - Threatened Flora under the *Wildlife Conservation Act* 1950 (WA) (WC Act); and
    - Priority Flora taxa as classified by the Western Australian Department of Parks and Wildlife (DPaW);
    - Other significant flora taxa as defined by the EPA (2004).
- Identify and map the location of all Vegetation Types (VTs) that occur within the Study Area;
- Assess the condition of the remnant vegetation within the Study Area and identify and record locations of introduced flora taxa within remnant vegetation;
- Identify and map the location of VTs that occur within the Study Area that are listed as one of the following (hereafter referred to as significant vegetation):
    - Threatened Ecological Communities (TECs) under the EPBC Act;
    - TECs as classified by DPaW and endorsed by the WA Minister for the Environment; and
    - Priority Ecological Communities (PECs) as classified by DPaW.

The tasks undertaken to meet these objectives for the flora and vegetation survey were:

- Review all existing literature relating to flora, vegetation and other environmental factors relevant to the Study Area, including relevant state and federal databases;
- Establish flora survey quadrats throughout all discernible vegetation patterns within all areas of remnant vegetation in the Study Area;
- Undertake a classification analysis to define VTs within the Study Area;
- Map the distribution of VTs within the Study Area using a combination of aerial photograph interpretation and field observations, and discuss the composition of such VTs, including in the context of significant vegetation;
- Map and discuss the condition of the vegetation of the Study Area;
- Conduct targeted searches for significant flora taxa, including Threatened Species under the EPBC Act, Threatened Flora taxa under the WC Act, and DPaW-classified Priority Flora taxa, as well as introduced taxa, that may be present within remnant vegetation in the Study Area;
- Provide a report including maps detailing VTs, significant flora taxa, introduced taxa, significant vegetation, and the condition of vegetation within the Study Area.

2 BACKGROUND

2.1 Climate

The Study Area is located within the Swan Coastal Plain subregion in the South-West Forest Region of the Southwest Province of Western Australia (Beard 1990). The Swan Coastal Plain region is characterised by a warm Mediterranean climate with winter precipitation (Beard 1990). There are 5-6 dry months per year (where evaporation exceeds precipitation), with the region generally receiving between 600 - 1000 mm of precipitation annually. Figure 2 displays average monthly maximum and minimum temperatures, and average monthly rainfall, recorded for Wokalup (Station number: 009642), one of the nearest long-term meteorological stations (data recorded from 1951 – 2015) to the Study Area (Bureau of Meteorology 2015).

The highest average daily maximum temperature at Wokalup occurs in January (31 °C) with the lowest average minimum temperature experienced in August (7.9 °C). The average annual rainfall for this station is 943.9 mm. Average monthly rainfall peaks from late autumn to early spring (May - September), with the highest rainfall on average received in June (184.8 mm). Rainfall received at Wokalup in the months prior to survey being conducted (May-September), was below long-term average, with 429.8 mm recorded compared to the average of 731.2 mm (Bureau of Meteorology 2015).

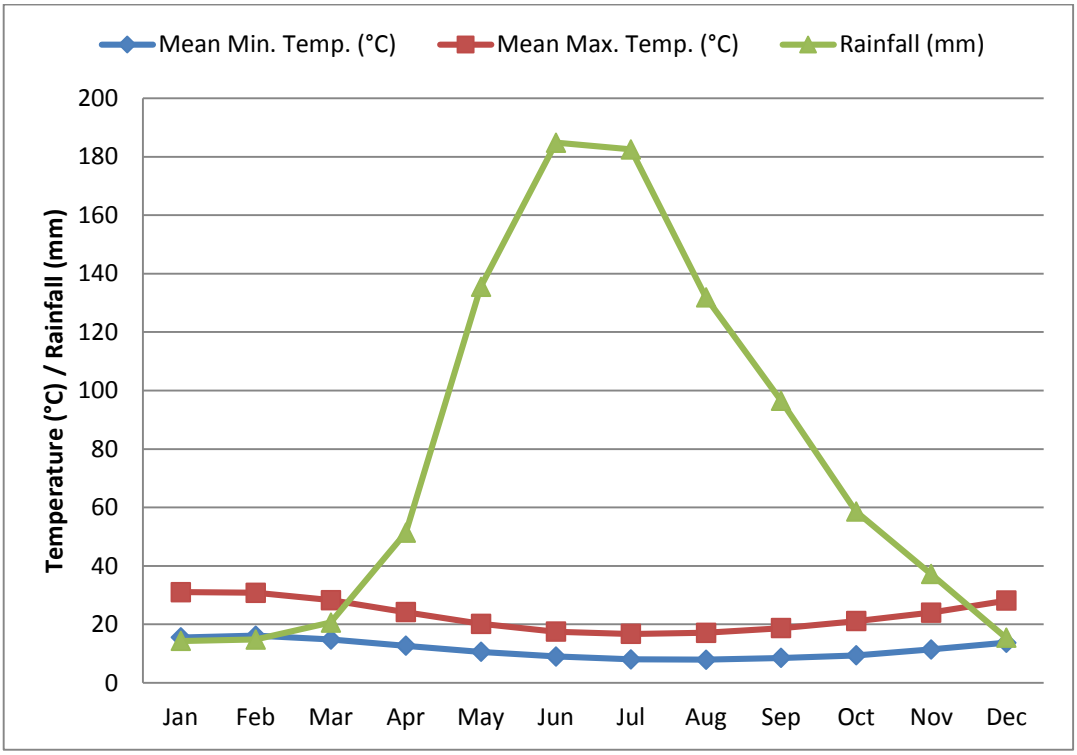


Figure 2: Mean Maximum and Minimum Temperatures (° Celsius) and Mean Rainfall (mm) for Wokalup (Bureau of Meteorology 2015)

2.2 Geology, Soils and Landforms

The Swan Coastal Plain region is a low-lying plain which is often swampy, with sandhills consisting of Mesozoic to recent sediments of the Perth Basin (Beard 1990). The majority of the Study Area has been mapped as consisting of Bassendean Sands, consisting of quartz sand (Geological Survey of Western Australia 1980). There are also mapped areas of Swamp and Lacustrine Deposits within the Study Area consisting of peat, peaty sand and clay and smaller areas of Guilford Formation consisting of clay, loam, sand and gravel alluvium (Geological Survey of Western Australia 1980).

2.3 Regional Vegetation

The Study Area is located in the Swan Coastal Plain Interim Biogeographic Regionalisation for Australia (IBRA) region (Commonwealth of Australia 2012). The vegetation of the Swan Coastal Plain IBRA region is characterised by mainly *Banksia* woodland on leached sands with *Melaleuca* swamps where ill-drained, with woodland of tuart (*Eucalyptus gomphocephala*), jarrah (*E. marginata*) and marri (*Corymbia calophylla*) on less leached soils (Beard 1990).

Within this IBRA region, the Study Area is located within the Perth subregion (Commonwealth of Australia 2012). The vegetation of the Perth subregion consists of heath and/or Tuart woodlands on limestone, *Banksia* and Jarrah-*Banksia* woodlands on Quaternary marine dunes of various ages, Marri on colluvial and alluvials, and includes a complex series of seasonal wetlands (Mitchell *et al* 2002).

Beard (1979) mapped vegetation of the Swan Coastal Plain within the Pinjarra area at a scale of 1:250,000 (Beard 1979). The vegetation mapping by Beard (1979) was used by Shepherd *et al.* (2002) to describe vegetation system associations, also at a scale of 1:250,000. Two vegetation system associations occur in the Study Area, as summarised in Table 1 and presented on Figure 3. Table 1 also presents the current extent of each vegetation system association in relation to its pre-European extent (Government of Western Australia 2013), and the percentage of the current extent of each vegetation system association currently protected for conservation (in DPaW-managed land). The two vegetation system associations present in the Study Area have less than 30 % of the pre-European extent remaining. Bassendean_126 is relatively well protected with 51 % of its current extent within reserves. However, Bassendean_1000 is not well protected with less than 17 % of its current extent within reserves.

Table 1: Extent of Vegetation System Associations within the Study Area (Government of Western Australia 2013)

Vegetation System Association	Description	Current Extent (ha)	Percentage of Pre-European Extent Remaining	Percentage of Current Extent Protected for Conservation
Bassendean_126	Bare areas; freshwater lakes	413	28.65	51.38
Bassendean_1000	Mosaic: Medium forest; jarrah-marri / Low woodland; banksia / Low forest; teatree (*Melaleuca* spp.)	23,696	26.90	16.82

A search of the Commonwealth Department of the Environment (DoE) database with regard to environmental matters of national significance listed under the EPBC Act was performed for an area encompassing the Study Area with a 10 km buffer (search area) (DoE 2015). The results of this search indicate that 2 TECs listed under the EPBC Act are likely to occur within the search area. These are:

- Claypans of the Swan Coastal Plain (Critically Endangered) and;
- *Corymbia calophylla – Kingia australis* woodlands of heavy soils of the Swan Coastal Plain (Endangered).

In addition, the search also returned one Wetland of International Importance, being the Peel-Yalgorup system. This was noted as being within 10 km of the search area. The results of this search are presented in Appendix A.

A search of DPaW's TEC and PEC database was undertaken for an area encompassing the Study Area with a buffer of 10 km, to identify the presence of any DPaW-classified TECs and DPaW-classified PECs that coincide with the search area (DPaW 2015a). A total of five TECs were returned by the search, being:

- Clifton-microbialite: Stromatolite like freshwater microbialite community of coastal brackish lakes (Critically Endangered);
- SCP3b: *Eucalyptus calophylla - Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain (Vulnerable);
- SCP3a: *Eucalyptus calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain (Critically Endangered);
- SCP10a: Shrublands on dry clay flats (Endangered); and
- SCP08: Herb rich shrublands in clay pans (Vulnerable)

In addition, three DPaW-classified PECs were returned by the search, being:

- Elongate Fluviatile Delta System: Peel-Harvey inlet (Priority 1);
- SCP21c: Low lying *Banksia attenuata* woodlands or shrublands (Priority 3); and
- SCP25: Southern *Eucalyptus gomphocephala-Agonis flexuosa* woodlands (Priority 3).

No occurrences of these TECs or PECs are currently known from within the Study Area, however there is an occurrence of SCP21c (Priority 3) located in close proximity (within

approximately 1 km) to the Study Area (Figure 4). Appendix B presents definitions, categories and criteria for TECs and PECs (DPaW 2010).

Wetlands of the SCP were originally mapped and classified by Hill *et al* (1996). The Geomorphic Wetlands Swan Coastal Plain dataset (DPaW 2013) was digitised from this report and is maintained and updated by DPaW. A number of Geomorphic Wetlands have been mapped within the Study Area including a number of Sumplands and Damplands and one Palusplain (DPaW 2013). Sumplands are described as seasonally inundated basins, Damplands are described as seasonally waterlogged basins and Palusplains are described as seasonally waterlogged flats (Hill *et al* 1996). Of these wetlands, there are three catergorised as 'Conservation', four categorised as 'Resource Enhancement', three categorised as 'Multiple Use' and one which is not assessed (DPaW 2013). These categories are described by DPaW (2014a) as outlined below:

- **Conservation (Highest priority wetlands):** Wetlands which support a high level of attributes and functions. Objective is to preserve and protect the existing conservation values of the wetlands through various mechanisms. No development or clearing is considered appropriate. These are the most valuable wetlands and any activity that may lead to further loss or degradation is inappropriate.
- **Resource Enhancement (Priority wetlands):** Wetlands which may have been partially modified but still support substantial ecological attributes and functions. Ultimate objective is to manage, restore and protect towards improving their conservation value. These wetlands have the potential to be restored to Conservation category. This can be achieved by restoring wetland function, structure and biodiversity. Protection is recommended through a number of mechanisms.
- **Multiple Use:** Wetlands with few remaining important attributes and functions. Use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through landcare.

2.4 Regional Flora

DPaW's threatened flora databases, including the Western Australian Herbarium (WAHerb) specimen database, Threatened and Priority Flora database, and Threatened and Priority Flora List, were searched for information regarding listed significant flora taxa known from within or in the immediate vicinity of the Study Area (DPaW 2015c). The search was requested for the Study Area with a 10 km buffer.

A total of 56 taxa were returned from the database search. Of these, seven taxa listed as Threatened under the WC Act were returned, with the remainder (49) being DPaW-classified Priority flora taxa. These taxa are presented in Appendix C. Appendix D presents conservation codes for Western Australia flora (DPaW 2014b). *Melaleuca viminalis* (P2) was returned from the database search from WAHerb records. This taxon is native to the Kimberley region of Western Australia, with WAHerb records lodged from the south-west of Western Australia listed as naturalised (not native to the area). Therefore, as the conservation status of this taxon is not relevant for the south-west of Western Australia (including the Study Area), this taxon is not considered further.

No occurrences of significant flora taxa are currently known from within the Study Area. However, there are records of three significant flora taxa located in close proximity to the Study Area including:

- One record of *Caladenia huegelii* (Threatened) 1.5 km to the south of the Study Area;
- Four records of *Caladenia speciosa* (P4) to the north and east of the Study Area with the closest record approximately 0.15 km to north of the Study Area;
- Three records *Boronia capitata* subsp. *gracilis* (P3) 2 km to the south of the Study Area;
- One record of *Isopogon drummondii* (P3) approximately 1.5 km to the east of the Study Area.

Significant flora locations and ecological communities located in close proximity to the Study Area are presented on Figure 4. Of these records, the most eastern record of *Caladenia speciosa* and the record of *Isopogon drummondii* are likely to be erroneous given they are located in cleared paddocks.

The search of the DoE database (DoE 2015) with regard to environmental matters of national significance listed under the EPBC Act (Appendix A) returned 12 flora taxa listed as Threatened Species. These taxa are listed in Table 2 and Appendix A. Four of these taxa are not considered relevant to this assessment; as they are not known from the vicinity of the Study Area (as described in Table 2), and are considered extremely unlikely to occur in the vicinity of the Study Area. These taxa are not considered further in this assessment.

Table 2: Threatened Flora Taxa Returned From the Interrogation of the DoE Database (DoE 2015)

Taxon	Status	Nearest Location to Study Area	Comments
Andersonia gracilis	Endangered	Approximately 75 km to north-east	Not known from area – not relevant to assessment
Caladenia huegelii	Endangered	Approximately 1 km to south	
Darwinia foetida	Critically Endangered	Approximately 120 km to north	Not known from area – not relevant to assessment
Diuris micrantha	Vulnerable	Approximately 14 km to south-east	
Diuris purdiei	Endangered	Approximately 14 km to south-west	
Drakaea elastica	Endangered	Approximately 11 km to south-east	
Drakaea micrantha	Vulnerable	Approximately 12 km to south-east	
Eleocharis keigheryi	Vulnerable	Approximately 9 km to east	
Eucalyptus balanites	Endangered	Approximately 75 km to north	Not known from area – not relevant to assessment
Lambertia echinata subsp. *occidentalis*	Endangered	Approximately 95 km to south	Not known from area – not relevant to assessment
Synaphea sp. Fairbridge Farm (D.Papenfus 696)	Critically Endangered	Approximately 14 km to north-west	
Synaphea stenoloba	Endangered	Approximately 8 km to south-east	

The search of the DoE database with regard to environmental matters of national significance listed under the EPBC Act identified that 10 significant invasive flora taxa, or habitat for the taxa, may occur within the Study Area and surrounds, as listed in Table 3. Five of these taxa are listed as Declared Pests in Western Australia under the Biosecurity and Agriculture Management Act 2007 (BAM Act) (Department of Agriculture and Food 2015), and are Weeds of National Significance (WoNS) (Australian Weeds Committee 2015), with an additional taxon also listed as a WoNS.

Table 3: Invasive Flora Taxa Returned From the Interrogation of the DoE Database (DoE 2015)

Taxon	Common Name	Nearest Location to Study Area	Comments
Asparagus asparagoides	Bridal Creeper	Approximately 20 km to south	Declared Pest, WoNS
Cenchrus ciliaris	Buffel-grass	Approximately 98 km to north	
Chrysanthemoides monilifera	Bitou Bush	Approximately 70 km to north	Declared Pest, WoNS
Eichhornia crassipes	Water Hyacinth	Approximately 18 km to north-east	Declared Pest, WoNS
Genista sp. X *Genista monspessulana*	Broom	Approximately 75 km to north	WoNS
Lantana camara	Common Lantana	Approximately 7 km to south-east	Declared Pest, WoNS
Olea europaea	Olive	Approximately 23 km to south	
Pinus radiata	Radiata Pine Monterey Pine	Approximately 76 km to north	
Rubus fruticosus aggregate	Blackberry	Approximately 8 km to east	Declared Pest, WoNS
Urochloa mutica	Para Grass	Approximately 145 km to north	

A search of the WAHerb specimen database for records of introduced taxa within the Study Area and surrounds was performed using the online tool NatureMap (DPaW 2015d). A total of 97 introduced taxa were returned from the search. These taxa are presented in Appendix E. Of these taxa, *Lantana camara* (Capitate Rush), *Rubus laudatus* and *Salix matsudana* are Declared Pests in Western Australia under the BAM Act (Department of Agriculture and Food 2015), and are WoNS (Australian Weeds Committee 2015).

2.5 Local Flora and Vegetation

There is limited publicly available information in regards to previous flora and vegetation surveys undertaken within or in close proximity to the Study Area.

A number of quadrats were established and assessed in close proximity to the Study area as part of the DPaW floristic survey of the southern Swan Coastal Plain (Gibson *et al.* 1994). A total of three quadrats measuring 10 x 10 m were assessed in Buller Road Nature Reserve, located immediately adjacent to the Study Area. Two community types were mapped within the reserve including:

- 21a – Central *Banksia attenuata – Eucalyptus marginata* woodlands
- 21c – Low lying *Banksia attenuata* woodlands or shrublands

Of these, community 21c is listed as a Priority Ecological Community (DPaW 2015b).

MBS Environmental (2015) undertook a Level 1 flora and vegetation survey of the Jackson Block, which is located within the south-east corner of the Study Area. The survey included a reconnaissance site survey and the assessment of five 10 m x 10 m quadrats. A total of two vegetation units were identified within the 36.8 ha survey area as described below:

Vegetation Unit 1: Low Woodland of *Corymbia calophylla*, *Eucalyptus marginata*, *Banksia* spp. and *Allocasuarina fraseriana* over a Low Open Shrubland dominated by *Hibbertia hypericoides* over a Grassland of native and introduced species on very low relief sand dunes.

Vegetation Unit 2: Thicket of *Kunzea ericifolia*, *Melaleuca preissiana* and *Melaleuca rhaphiophylla*, over Open Low Shrubland of *Astartea* ?*scoparia* and *Adenanthos meisneri* over bare ground in lower ground associated with a sumpland.

These vegetation units were not identified to be representative of any listed TECs or PECs. The vegetation condition (assessed using the Keighery (1994) Bushland Condition Scale) varied from Completely Degraded to Very Good, with Very Good – Good condition assigned to the majority of the survey area (19.8 ha) (MBS Environmental 2015).

A total of 83 vascular plant taxa, representing 32 plant families and 60 genera. were recorded by MBS Environmental (2015) within the Jackson Block. No Threatened or Priority flora taxa were recorded during the survey. A total of 17 introduced taxa were recorded as listed in Appendix E. There were three introduced taxa recorded not listed in Appendix E as they were identified to genus level only (*Lupinus* sp., *Trifolium* sp. and *Watsonia* sp.). Of the 17 introduced taxa recorded, *Gomphocarpus fruticosus* and *Zantedeschia aethiopica* are listed as Declared Pests in Western Australia under the BAM Act (Department of Agriculture and Food 2015) and are WoNS (Australian Weeds Committee 2015).

2.6 Summary of Environmental Factors

The desktop review of flora and vegetation within the Study Area identified the following key issues:

- A total of five DPaW-classified TECs and three PECs within the vicinity of the Study Area, one of which is located within approximately 1 km of the Study Area - SCP21c (Priority 3);
- A total of 58 significant flora taxa are known from within or in the vicinity of the Study Area, including 10 taxa listed as Threatened and 48 DPaW-classified Priority Flora taxa (Appendix C);
- A total of 116 introduced taxa are known to occur or have the potential to occur within or in the vicinity of the Study Area, including eight taxa listed as Declared Pests in Western Australia under the BAM Act (Department of Agriculture and Food 2015), and nine taxa listed as WoNS (Australian Weeds Committee 2015).

3 METHODS

3.1 Personnel and Licensing

Table 4 lists the personnel involved in both fieldwork and plant identifications for the survey of the Study Area. Personnel involved in fieldwork and plant identifications have previous experience with the flora of the south-west botanical province. All plant material was collected under the scientific licences pursuant to the WC Act Section 23C and Section 23F as listed in Table 3.

Table 4: Field Team Personnel and Licensing Information

Personnel	Role	Flora Collecting Permit Number	DRF Collecting Permit Number
David Coultas	Fieldwork / Plant Identifications	SL011384	147-1415
Samuel Coultas	Plant Identifications	SL011383	150-1415
Kim Kershaw	Fieldwork	SL011379	146-1415
Bethea Loudon	Plant Identifications	SL011382	149-1415
Alison Saligari	Fieldwork / Plant Identifications	SL011380	148-1415
Greg Woodman	Fieldwork	SL011378	143-1415

3.2 Initial Aerial Photography Interpretation

Initial interpretation of ortho-rectified aerial photography at a scale of 1:6,500 was conducted to determine preliminary vegetation patterns present within the Study Area, with quadrats allocated based on these patterns. A minimum of three quadrats were allocated to each discernible vegetation pattern where possible; such replication is required for meaningful results to be produced following classification analysis of quadrat data, and to provide local context for VT distribution.

3.3 Field Survey Methods

3.3.1 Reconnaissance Survey

An initial reconnaissance visit to the Study Area was conducted by experienced botanists Greg Woodman and David Coultas on the 2nd of September 2015. The reconnaissance survey served 2 main purposes, the first being targeted searching for the orchid taxon *Drakaea elastica* (Threatened). This was considered necessary, as the desktop review detailed in Section 2, and the review of aerial photography detailed in Section 3.2, indicated that this taxon was known from relatively close proximity to the Study Area, and that appropriate habitat was likely to be present in the Study Area. DPaW advise that survey for *Drakaea elastica* should be undertaken in July / August when the orchid leaves are visible. While survey could not be undertaken in these months due to the approval timing of this assessment, it is considered that survey in very early September still remains appropriate for survey for this taxon, as its leaves are still likely to be visible.

Searching was conducted on foot by two botanists experienced in the identification of *Drakaea* taxa. All areas of appropriate habitat, particularly grey sand areas adjacent to winter-wet areas, and thickets of *Kunzea glabrescens* (Spearwood), were inspected via

wandering transects. GPS coordinates (using hand held Garmin GPS units) were recorded for each individual or clump of individuals, with abundance recorded for the latter.

The second main purpose of the reconnaissance survey was to identify vehicular access within the Study Area in preparation for the detailed survey, record notes on preliminary vegetation types, as well as any other significant features (wetlands, unusual vegetation types) and record opportunistic locations of other known significant flora taxa and introduced taxa. All tracks traversable by vehicle were driven, with additional foot traverses conducted to inspect specific areas of interest (e.g. unusual vegetation, wetlands etc.). Any locations of significant flora taxa or introduced taxa identified were recorded as for *Drakaea elastica* above.

Track logs for the reconnaissance survey are presented in Figure 5.

3.3.2 Detailed Survey

The detailed field survey was conducted over one visit in Spring, from the 22nd – 25th of September 2015. It is considered that this visit was conducted in the most appropriate time to survey in the Swan Coastal Plain Bioregion, as the majority of taxa in this region are in flower at this time. Access to the Study Area was achieved on foot and by vehicle using existing tracks.

Subsequent visits to re-sample quadrats, particularly those established in wetland areas, were initially proposed in line with advice from DPaW, and methods used by DPaW in their survey of the southern Swan Coastal Plain (Gibson *et al*. 1994). This allows for the capture of additional suites of annual taxa and geophyte perennial taxa that may develop and flower over the course of Spring and early Summer. However, no such visits were conducted, as it was determined during the first visit that all wetland areas in the Study Area were already dry at the time of the visit, and would be unlikely to hold a significant amount of water even in wetter than average years. Therefore, it is unlikely that additional sampling later in Spring and early Summer would record a significant number of additional taxa.

A total of 16 permanently marked flora survey quadrats were established by this survey. Quadrats were marked with a single fence dropper at the recorded GPS coordinate for the quadrat. All quadrats covered an area of 100 m^2 for sampling, with all quadrats measuring 10 m x 10 m. This quadrat size corresponds to that used during the floristic survey of the southern Swan Coastal Plain (Gibson *et al.* 1994). The quadrats were orientated north-south/east-west where possible, with the bearings of each side recorded for any quadrats that could not be established in this fashion.

All vascular flora taxa that were visually identifiable within each quadrat were recorded. At least one reference specimen of most taxa (excluding common, distinctive taxa) encountered was collected for verification and identification purposes (see Section 3.4).

The following information was recorded at each quadrat:

- Personnel;
- Unique quadrat number;

- Date of survey;
- GPS coordinates (GDA94);
- Site photograph;
- Topography (including landform type and aspect);
- Soil colour and type (including the presence of any rock outcropping and surface stones);
- Vegetation condition (Keighery (1994), displayed in Table 5);
- Approximate time since fire;
- Presence of disturbance (if any);
- Percentage foliage cover (for each taxon); and
- Height (m) (for each taxon, excluding climbers/aerial shrubs).

A single detailed recording site was also established, within an area that was not suitable for a quadrat because the vegetation was partially degraded and very narrow. The detailed recording site was sampled from a central point to a radius of 10 m. All data recorded for quadrats was also recorded for the detailed recording site, however only dominant and common taxa were recorded. The detailed recording site was not permanently marked.

Locations of quadrats and detailed recording sites are presented on Figure 5.

Additional flora taxa, as well as any locations of known significant flora taxa and introduced taxa, were also recorded opportunistically in the Study Area via a search around the general vicinity of each quadrat or detailed recording site, and during searches on foot between quadrats or detailed recording sites.

Mapping notes of vegetation pattern boundaries and distribution were also taken while traversing the Study Area on foot and by vehicle. This was to aid in mapping polygons of vegetation patterns that were not allocated quadrats. Not all vegetation pattern polygons received quadrats or detailed recording sites because of time constraints, however many polygons could be confidently allocated to a final VT using a combination of mapping notes and aerial photograph interpretation.

In addition to searches conducted around and between quadrats, specific, targeted searching for significant flora taxa in the Study Area was undertaken as part of this survey for such taxa that could be positively identified in the field. In particular, this included the threatened orchid taxon *Caladenia huegelii*, which is known to occur in close (< 1 km) proximity to the Study Area. Transects at 20 m intervals were traversed through appropriate habitat, with appropriate habitat determined following consideration of the known habitat for *Caladenia huegelii*, as well as the condition of the vegetation in the Study Area (this is discussed further in Section 5.2). GPS coordinates (using hand held Garmin GPS units) were recorded for each individual or clump of individuals, with abundance recorded for the latter.

All track logs from the detailed survey in the Study Area are presented in Figure 5.

3.4 Plant Specimen Collection and Identification

Specimens of unknown taxa were collected and pressed for later identification at the WAHerb. Identifications were undertaken by experienced botanists David Coultas, Samuel Coultas, Bethea Loudon and Alison Saligari. 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* (DPaW 2015e) with all names checked against the current DPaW Max database to ensure their validity. However, in cases where names of plant taxa have been published recently in scientific literature but have not been adopted on *Florabase* (DPaW 2015e), 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 WAHerb for consideration for vouchering as soon as practicable. However as this process is via donation, the WAHerb may not voucher all such specimens, in accordance with its own requirements. The specimen vouchering will be supported by completed Threatened and Priority Flora Report Forms (TPRFs) submitted to DPaW (Species and Communities Branch) in the case of listed significant flora (e.g. Threatened and Priority flora taxa).

All other specimens are kept in-house for reference for a period of 1 year after finalisation of Study.

3.5 Classification Analysis

Classification analysis of quadrat data from the Study Area was conducted on 16 quadrats established within the Study Area. Three analyses were undertaken for this Study. One analysis was undertaken using only the 16 quadrats established for the Study which excluded introduced and opportunistic taxa. Two analyses were undertaken using the 16 quadrats from the Study together with the 1098 quadrats from the updated version of the Swan Coastal Plain (SCP) dataset (Keighery *et al.* 2012) (compared to 509 quadrats from the original SCP dataset (Gibson *et al*. 1994)). One of the SCP dataset analyses excluded opportunistic taxa, and the other excluded both opportunistic and introduced taxa.

The updated version of the SCP dataset, sourced through *NatureMap* (DPaW 2015d), contains weed and native flora quadrat data compiled between 1990 through to 1996 for the southern SCP. This dataset is derived from a database that has been compiled and maintained over many years, combining the results of a number of floristic studies conducted on plant communities of the IBRA (Interim Biogeographic Regionalisation for Australia) SCP Bioregion, south of the Moore River. It includes sampling site details, the native and introduced (weed) flora collected at these sampling sites and the floristic community type (FCT) assigned to these sampling sites. The taxonomy of the flora in the database has been updated regularly as determined by Greg and Bronwen Keighery. This

dataset lists the taxonomy (including family names) which was current in this database on 23 June 2005 when the dataset was compiled (DPaW 2015d).

A total of 95, 1708 and 1506 vascular taxa entities were included in the analyses of the 16 quadrats (introduced taxa were removed), the combined SCP dataset analysis with introduced taxa included and the combined SCP dataset analysis with introduced taxa removed respectively. In terms of the two SCP dataset analyses, taxa belonging to several categories were removed or altered prior to analysis, as listed below:

- Taxa that are now an excluded name – such taxa were removed from the analysis due to the inability to determine their current name.
- Taxa where their names are not valid and a current name could not be determined.
- Taxa that are not known from the South West land division.
- Supplementary names where the genus is a known weed species were changed to reflect this status (so as not to be assessed as a native taxon).

Some taxa and infra-taxa were amalgamated where taxonomy was unclear or could not be determined in all cases. In addition, genus/species entities were combined with entities that went to subspecies or varietal level. All taxa removed and amalgamated from the classification analysis (including the Study quadrats and the SCP dataset) are presented in Appendix F.

OptimClass (Tichý et al. 2010) analysis was utilised in order to determine the most suitable approach to classification based on the available data. OptimClass evaluates the quality of a set of different partitions of the same dataset, based on the number of taxa that are faithful to clusters of that partition. Faithful taxa are identified using the Fisher's exact test for the right-tailed hypothesis, which is a suitable measure of statistical fidelity of taxa to clusters of quadrats (Sokal & Rohlf 1995; Chytrý *et al*. 2002). However as OptimClass runs off percent foliage cover data, this analysis was used on the Study 16 quadrats only. OptimClass analysis was unable to be undertaken on the SCP dataset as it only contains presence/absence data.

Following OptimClass analysis the standard classification analysis using PATN (V3.1.2) (Belbin & Collins 2009) as used in the previous analysis by Gibson *et al.* (2012) was undertaken to analyse the various datasets. Classification results of the analysis were produced as dendrograms. In reviewing the regional significance of vegetation types, the placement of the Study Area quadrats within the dendrograms developed for the larger combined datasets were then reviewed, along with their relationship to quadrats from the SCP dataset. Two separate analyses were run, one containing introduced and one with introduced excluded, to see how the absence of weeds affected the placement of quadrats within the dendrograms.

Indicator taxon analysis (INDVAL) was then conducted using PC-Ord (McCune & Mefford 2011) using the method of Dufrene & Legendre (1997), to determine the indicator taxa for the FCT(s) of the 2015 quadrats and SCP20a. A Monte Carlo permutation test was used to test for the significance of the indicator taxa. Indicator taxon analysis identifies faithful taxa i.e. those species that consistently represent the FCT.

3.6 Vegetation Type Definition, Description and Mapping

VT descriptions have been adapted from the National Vegetation Information System (NVIS) Australian Vegetation Attribute Manual Version 6.0 (ESCAVI 2003). This model follows nationally-agreed guidelines to describe and represent VTs, so that comparable and consistent data is produced nation-wide. It must be noted that the NVIS system utilises vegetation descriptions derived from structural characteristics of the individual community units, while the VTs presented in this report have been derived from analysis of quadrat floristics, excluding any structural component. 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.

For the purposes of this report, it is considered that a VT is equivalent to a NVIS sub-association as described in ESCAVI (2003). Common taxa within each stratum were generally defined as taxa that occurred in greater than one-third of quadrats established within a particular VT (however this varied slightly depending on the number of quadrats); these may include taxa not in the VT description, as the VT description is based on dominance within each stratum, as well as the frequency that a taxon was recorded within each VT.

The locations of quadrats within each VT (as indicated on the dendrogram generated using the Study Area quadrats only) were used in conjunction with aerial photography 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

Vegetation condition was recorded at all quadrats, and also opportunistically within the Study Area where areas of disturbance to vegetation were noted (e.g. weed infestations, historical clearing). Vegetation condition was described using a vegetation condition scale from Keighery (1994). The Keighery (1994) scale is presented in Table 5. Vegetation condition polygon boundaries for the Study Area were developed using this information in conjunction with aerial photography interpretation, and were digitised as for VT polygon boundaries.

Table 5: Vegetation Condition Scale for the South-West Botanical Province (Keighery 1994)

Condition Ranking	Description	Example
1 Pristine	Pristine or nearly so; no obvious signs of disturbance.	
2 Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.	Damage to trees caused by fire, the presence of non-aggressive weeds and occasional vehicle tracks.
3 Very Good	Vegetation structure altered, obvious signs of disturbance.	Disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
4 Good	Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it.	Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
5 Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management.	Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds at high density, partial clearing, dieback and grazing.
6 Completely Degraded	The structure of the vegetation is no longer intact, and the area is completely or almost completely without native species.	These areas are often described as 'parkland cleared' with the flora composing of weed or crop species with isolated native trees and shrubs.

3.8 Significant Flora and Vegetation

3.8.1 Significant Flora

EPA Guidance Statement No. 51 (EPA 2004) considers that any taxon listed as Threatened under relevant legislation (WC Act, EPBC Act), or classified by DPaW as Priority flora, is considered to be significant. Such taxa are therefore addressed in this report. Guidance Statement No. 51 also notes that a flora taxon may also be considered as significant if it meets one of the following criteria:

- It has a keystone role in a particular habitat for threatened species, or supporting large populations representing a significant proportion of the local regional population of a species;
- It is of relic status;
- It has anomalous features that indicate a potential new discovery;
- It is representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- It is a restricted subspecies, variety, or naturally occurring hybrid;
- It displays local endemism/has a restricted distribution;
- It is poorly reserved.

It is considered that the criterion of level of reservation (i.e. presence in conservation reserves such as national parks or nature reserves) is difficult to apply in the context of this

assessment, as the lack of comprehensive surveys of reserves in the region surrounding the Study Area makes accurate determination of the reservation status of a particular taxon difficult. However, level of reservation may be relevant in the context of addressing the significance of a taxon that meets one of the other criteria listed above, particularly listed Threatened or Priority flora taxa, as taxa meeting these criteria may be of higher significance if they are known to be not or poorly reserved.

Significant flora taxa are discussed in Section 5.1.1.

3.8.2 Significant Vegetation

EPA Guidance Statement No. 51 (EPA 2004) considers that vegetation listed as a TEC under the EPBC Act, or classified as a TEC or PEC by DPaW, is considered to be significant. Such vegetation is therefore addressed in this report. Guidance Statement No. 51 also notes that vegetation may also be considered as significant if it meets one of the following criteria:

- It is uncommon or scarce;
- It contains unusual species;
- It has a novel combinations of species;
- It plays a role as a refuge;
- It plays a role as a key habitat for threatened species or large populations representing a significant proportion of the local to regional total population of a species;
- It is representative of the range of a unit (particularly, a good local and/or regional example of a unit in 'prime' habitat, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- It has a restricted distribution.

The updated version of the SCP dataset (Keighery *et al.* 2012) was used when assessing the regional significance of VTs. As mentioned in Section 3.5, classification analyses were conducted using data from Keighery *et al.* (2012), to determine the similarity between quadrats from the Study Area and quadrats from Keighery *et al.* (2012). The results of this analysis are therefore considered when determining the potential regional significance of VTs described in the Study Area. The occurrence of potential suitable habitat for VTs outside the Study Area was also considered; potential suitable habitat was determined by reviewing landform and soil patterns observable on aerial photography over areas in the immediate vicinity of the Study Area.

Significant vegetation is discussed in Sections 5.2.

4 ADEQUACY AND LIMITATIONS OF SURVEY

4.1 Adequacy of Survey

The Study Area covers 218.6 ha, with 16 quadrats established within it. Quadrats were established in all preliminary vegetation patterns discernable by initial aerial photograph interpretation (see Section 3.2 and 3.3), 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 established in the Study Area is considered to be an acceptable number given the diversity of topography and soil types noted in the Study Area.

To provide an indication of the adequacy of this survey, a taxon accumulation curve was produced using PC-Ord (V 6) (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 via PC-Ord, utilising the Chao-2 estimator for species richness (Chao 1987), and compared to the actual number of taxa recorded in the Study Area. This gives some indication as to whether sufficient quadrats have been surveyed to adequately sample the species richness in the Study Area. As the generation of species accumulation curves includes quadrat data only, and not opportunistically-recorded taxa, 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. Using the Chao-2 estimator, the recorded number of taxa within quadrats is equivalent to 82.8 % of the estimated taxon richness in the Study Area. Sampling was therefore considered to be adequate using this estimation measure. It is of interest that the estimated number of taxa in the Study Area from quadrats only using Chao-2 was 115; when opportunistic records of taxa are included, 144 native taxa were recorded in the Study Area (see Section 5.1), indicating that the Study Area was relatively well-sampled.

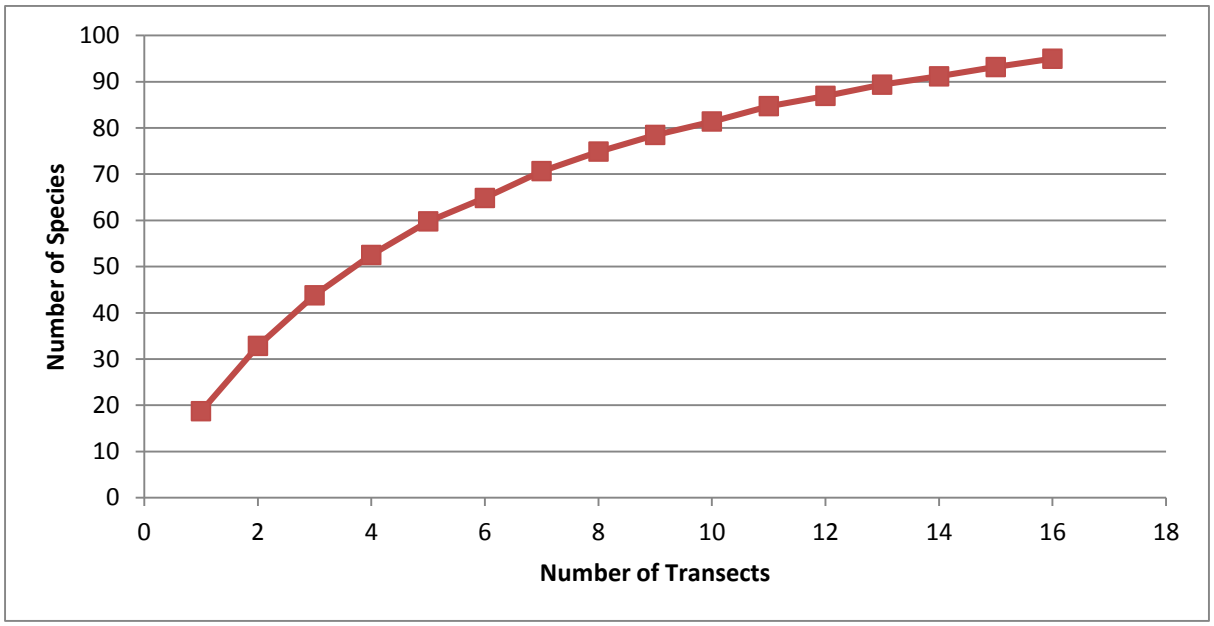


Figure 6: Study Area Species Accumulation Curve

Another adequacy of survey measure is that developed by Mueller-Dombois and Ellenberg (1974), who suggest that a 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 2.9 % recorded following a 10 % increase in quadrats.

4.2 Limitations of Survey

Table 6 presents the limitations of the flora and vegetation survey of the Study Area in accordance with EPA Guidance Statement No. 51 (EPA 2004).

Table 6: Limitations of the Flora and Vegetation Survey of the Study Area

Limitation	Limitation of Survey	Comment
Level of survey.	No	Level 2 Detailed Survey: The field component of the detailed survey was undertaken in September 2015, within the usual peak flowering season for the Swan Coastal Plain region. Replicated quadrats were established in each vegetation pattern identified in the Study Area. EPA (2004) indicates that survey should also be undertaken in other seasons, and it is noted that some perennial taxa expected to occur in the Study Area flower in other seasons (e.g. Winter). However, it is considered that survey in the peak flowering season only is adequate in this case, as it is likely that most taxa that flower outside the peak flowering season could be identified during the survey period.
Competency/experience of the consultant(s) carrying out the survey.	No	Senior personnel undertaking the survey have had extensive experience in conducting similar assessments, including assessments in the Swan Coastal Plain bioregion. Senior personnel provided guidance to less experienced botanists throughout the survey where necessary.
Scope (What floral groups were sampled and were some sampling methods not able to be employed because of constraints?)	Potential minor	All vascular groups that were present in the Study Area were sampled. No constraints prevented appropriate sampling techniques (quadrat establishment, foot transects) being employed. DPaW advises that sampling of quadrats on multiple occasions, as opposed to a single visit, is the appropriate sampling scope for surveys in the Swan Coastal Plain bioregion, particularly for quadrats located within wetland areas such as swamps and clay pans, where different suites of annual taxa develop and flower over the course of Spring and Summer. This sampling scope is line with the methods used by DPaW for the survey of the Southern Swan Coastal Plain (Gibson *et al.* 1994). This scope was initially proposed to be adopted for this current survey; however it was determined during the detailed survey visit (Section 3.3.2) that all wetland areas in the Study Area were already dry at the time of the visit, and would be unlikely to hold a significant amount of water even in wetter than average years. Therefore, no further visits to sample quadrats were conducted, as it was considered unlikely that a significant number of additional taxa would be recorded by further visits.
Proportion of flora identified, recorded and/or collected.	No	A high proportion of perennial vascular taxa were recorded based on the intensity and method of survey. A high proportion of annual vascular taxa were recorded based on the intensity and method of survey. Although rainfall was below-average prior to survey (see timing/weather/season/cycle below), this was unlikely to have affected the presence of annual vascular taxa or the ability to identify plant taxa. Unknown vascular taxa were collected, with specimens identified at the WAHerb. Adequacy of survey measures indicate a high percentage (82.8) of taxa expected to occur in the Study Area was recorded (Chao-2 estimator), and the number of quadrats established in the Study Area satisfies the criterion suggested by Mueller-Dombois and Ellenberg (1974), with an increase of 2.9 % in species recorded per increase of 10 % of quadrats.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	No	Sources of information used included government databases (DPaW, DoE) including the SCP dataset (Keighery *et al*. 2012) and one reports from within the Study Area. Good contextual information for the Study Area was available prior to the survey.

Limitation	Limitation of Survey	Comment
The proportion of the task achieved and further work which might be needed.	Potential minor	The Level 2 survey was completed, with the survey including searching for significant Threatened flora taxa likely to be present in the Study Area. One incomplete identification of a *Caladenia* species is required to be further investigated. A complete census for *Acacia semitrullata* (P4) has not been undertaken (this may not be required). No further vegetation survey within the Study Area is considered necessary.
Timing/weather/season /cycle.	No	The field survey was conducted in Spring, corresponding with the optimum flowering period for the Swan Coastal Plain region. The flowering period was considered by Woodman Environmental to be adequate. Although rainfall was below-average prior to survey (see section 2.1), this was unlikely to have affected the presence of annual vascular taxa or the ability to identify plant taxa.
Disturbances (e.g. fire, flood, accidental human intervention etc.), which affected results of survey.	Potential Minor	Previous fire history was recorded in parts of the Study Area. However, this did not influence patterns discernible from aerial photography given the time since fire was greater than five years. Disturbance in the form of lower native species richness and presence of weed species may have resulted in grouping of quadrats with those in the regional dataset with a lower species richness and presence of similar weed species. Mapping boundaries in some instances were difficult to determine from aerial photography due to disturbance.
Intensity (In retrospect, was the intensity adequate?)	No	The survey intensity was considered adequate to identify floristic groupings of terrestrial flora and expected taxon richness as required by a Level 2 survey, with replication of quadrats in VTs and foot searching undertaken throughout the Study Area, and targeted searching for significant flora taxa.
Completeness and mapping reliability (e.g. was relevant area fully surveyed).	Potential Minor	The survey of the Study Area is considered complete in terms of mapping of VTs. Specific searching for significant flora taxa was undertaken for in suitable habitat. Mapping reliability was considered good as high resolution aerial photography was used, with 16 quadrats established in the Study Area; however in some instances mapping boundaries were difficult to determine from aerial photography. Both foot and vehicle transects were employed. Delineation of VTs via PATN analysis required some manual dissection of the dendrogram due to variable vegetation condition.
Resources and experience of personnel.	No	Adequate resources including experienced field personnel and taxonomists with appropriate expertise in the flora of the South-West Botanical Province were utilised.
Remoteness and/or access problems.	No	Access to the Study Area was considered adequate, with a number of tracks utilised, and relatively short distances between such tracks requiring foot access.

5 RESULTS

5.1 Flora of the Study Area

A total of 192 discrete vascular flora taxa, including 144 native taxa, were recorded within the Study Area during the current survey. These taxa represent 53 families and 134 genera. The most well-represented families were Fabaceae (22 taxa), Myrtaceae (21 taxa) and Orchidaceae (18 taxa). An additional 11 taxa were recorded by MBS Environmental (2015), with five of these being recorded only in the revegetation area. A total of 152 native species have been recorded to occur within the study Area (combined results from current survey and MBS Environmental (2015) results). A full list of taxa is presented in Appendix G, with raw quadrat and detailed recording site data and parameters presented in Appendix H.

5.1.1 Significant Flora Taxa

One significant flora taxon was recorded in the Study Area; *Acacia semitrullata* (P4). No taxa listed as Threatened under the EPBC Act were recorded within the Study Area. Locations of significant flora taxa from this survey of the Study Area are presented in Appendix I, and displayed on Figure 7.

Acacia semitrullata (P4) is a slender, erect, pungent shrub to 0.7 m high (Plate 1) that occurs on white/grey sand or clay on sandplains and in swampy areas (DPaW 2015e). This taxon occurs over a range of approximately 265 km in the south-west of Western Australia, from near Walpole in the south-east to west of Coolup in the north. Waroona is near the northern-most edge of its known distribution (DPaW 2015d). There are 122 DPaW records of this taxon in Western Australia, with numerous localities within conservation reserves (DPaW 2015d). A total of 11 individuals of *Acacia semitrullata* were recorded at five point locations within the Study Area (Figure 7).

Plate 1: *Acacia semitrullata* (P4) (Photos: S.D. Hopper, from Florabase (DPaW 2015e))

The Threatened orchid taxon *Drakaea elastica* was not recorded in the Study Area, despite targeted searches in appropriate habitat, with the common taxon *Drakaea livida* being the only *Drakaea* taxon recorded in the Study Area.

The Threatened orchid taxon *Caladenia huegelii* was also not recorded in the Study Area, despite targeted searches in suitable habitat. A single sterile individual of a *Caladenia* taxon was recorded; this individual could potentially represent *Caladenia huegelii*, however it could also represent several other common *Caladenia* taxa. This is discussed further in Section 6.1. The location of this individual is also presented in Appendix I.

No other taxa that meet any of the remaining significant flora criteria as outlined by EPA (2004) and Section 3.8.1 of this report were recorded.

5.1.2 Introduced Taxa

A total of 46 introduced flora taxa were recorded by this survey of the Study Area, with an additional 4 introduced flora taxa recorded by MBS Environmental (2015). Table 7 presents a list of the introduced flora taxa recorded in the Study Area during the current survey, together with location information, and ratings for each introduced taxon under the Environmental Weed Strategy for Western Australia (CALM 1999).

Of the introduced taxa recorded in the Study Area, *Gomphocarpus fruticosus* and *Zantedeschia aethiopica* are Declared Pests under the BAM Act (Department of Agriculture and Food 2015). *Gomphocarpus fruticosus* was recorded at one location in the Study Area, while *Zantedeschia aethiopica* was common throughout the Study Area with occurrences at numerous locations, particularly in the northern part of the Study Area. Locations of introduced taxa recorded within quadrats and opportunistically are presented in Appendix I, with Declared plant locations presented on Figure 8.

Table 7: Summary of Introduced Taxa Known Within the Study Area

Taxon	Common Name	Number of Locations Recorded in the Study Area	Vegetation Types	Rating (CALM 1999)
**Acacia longifolia*	Sallow Wattle			Not rated
**Acetosella vulgaris*	Sorrel			Low
**Arctotheca calendula*	Cape Weed			Moderate
**Arundo donax*	Giant Reed			Low
**Avena barbata*	Bearded Oat			Moderate
**Briza maxima*	Blowfly Grass			Moderate
**Briza minor*	Shivery Grass			Moderate
**Cenchrus clandestinus*	Kikuyu Grass			Moderate
**Chamaecytisus palmensis*	Tagasaste			Mild
**Cotula coronopifolia*	Waterbuttons			Not rated
**Cynodon dactylon*	Couch			Moderate
**Disa bracteata*	South African Orchid			Moderate
**Ehrharta calycina*	Perennial Veldt Grass			High

Taxon	Common Name	Number of Locations Recorded in the Study Area	Vegetation Types	Rating (CALM 1999)
**Ehrharta longiflora*	Annual Veldt Grass			Moderate
**Eragrostis curvula*	African Love Grass			High
**Erodium botrys*	Long Storksbill			Low
**Euphorbia terracina*	Geraldton Carnation Weed			High
**Fumaria capreolata*	Whiteflower Fumitory			Mild
**Geranium molle*	Dove's Foot Cranesbill			Low
**Gomphocarpus fruticosus*	Narrowleaf Cottonbush			Moderate
**Hypochaeris glabra*	Smooth Catsear			Moderate
**Lavandula stoechas*	Italian Lavender			Low
**Lolium rigidum*	Wimmera Ryegrass			Moderate
**Lotus subbiflorus*	Lotus			Low
**Lupinus cosentinii*	Sandplain Lupin			High
**Lupinus luteus*	Yellow Lupin			Low
**Lysimachia arvensis*	Pimpernel			Moderate
**Ornithopus pinnatus*	Slender Serradella			Low
**Orobanche minor*	Lesser Broomrape			Moderate
**Oxalis pes-caprae*	Soursob			Not rated
**Petrorhagia dubia*	Velvety Pink			Mild
**Phytolacca octandra*	Red Ink Plant			Mild
**Poa annua*	Winter Grass			Mild
**Ranunculus muricatus*	Sharp Buttercup			Low
**Raphanus raphanistrum*	Wild Radish			Low
**Romulea rosea*	Guildford Grass			High
**Solanum nigrum*	Black Berry Nightshade			Moderate
**Sonchus oleraceus*	Common Sowthistle			Moderate
**Stellaria media*	Chickweed			Low
**Symphyotrichum squamatum*	Bushy Starwort			Not rated
**Trachyandra divaricata*	Onion Weed			Mild
**Trifolium ?subterraneum*	Subterranean Clover			Moderate
**Trifolium dubium*	Suckling Clover			Moderate
**Typha orientalis*	Bulrush			High
**Ursinia anthemoides*	Ursinia			Moderate
**Vulpia bromoides*	Squirrel Tail Fescue			Moderate
**Watsonia meriana*	Bulbil Watsonia			Moderate
**Zantedeschia aethiopica*	Arum Lily			High

5.2 Vegetation of the Study Area

5.2.1 Vegetation Types

Examination of the Study Area quadrat classification dendrogram, identified five VTs. Although this subdivision of clusters results in the VTs being resolved at differing levels of similarity, the recognition of five VTs is supported by field observations. Appendix J presents the dendrogram of the Study Area quadrats only. Appendix K and L present the dendrograms of the analyses showing the Study Area quadrats with the SCP dataset (Gibson *et al*. 2012) with introduced taxa included and introduced excluded respectively. Appendix M presents the results of the indicator taxon analysis.

The analysis undertaken with the SCP dataset resulted in some quadrats grouping differently. Quadrats 15 and 16 were grouped with VT1 despite them having a lower level of similarity in the Study Area quadrat analysis (Appendix J). Quadrat 15 grouped with VT1 quadrats in all dendrograms which is why this was grouped into VT 1. Quadrat 16 grouped with quadrat 02 in the SCP analysis which included introduced taxa. However, this area was Degraded which resulted in the quadrat grouping with wetland VT 2. Analyses undertaken with introduced taxa removed grouped it closer to VT 1. Quadrat 03 grouped with SCP wetland quadrats in the two SCP analyses (Appendix K and L), however it was grouped with quadrat 02 based on common native taxa and the results of the Study Area quadrat analysis (Appendix J). This was also related to the lower condition ranking of this vegetation.

At a higher level in the classification dendrogram, the five VTs were arranged into two broad groups, as outlined below:

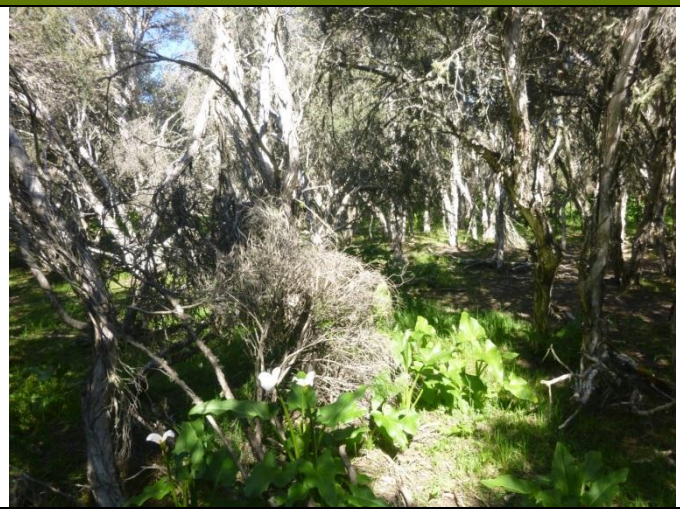
- Group 1 (VT 1) corresponds to vegetation generally consisting of *Allocasuarina fraseriana, Eucalyptus marginata* and *Corymbia calophylla* woodland over *Banksia* woodland over taxon-rich shrubland on variable landforms from upperslopes to flats.
- Group 2 (VTs 2 - 5) corresponds to vegetation associated with wetlands on low-lying areas including depressions and flats.

The VTs described in the Study Area are summarised in Table 8 below, including a description of the VT (as per Section 3.6), total area mapped in the Study Area, and number of quadrats established in each VT. A map of the VTs described in the Study Area is presented in Figure 7. Appendix N presents detailed information on VTs described in the Study Area, including indicator and common taxa. Appendix O presents a taxon-VT matrix (quadrat data only).

Table 8: Summary of Vegetation Types Defined in the Study Area

VT	Description	Extent (ha) (Percentage)*	Number of Quadrats	Presence of Significant Flora Taxa	Photograph
1	Mid open woodland to open forest of *Allocasuarina fraseriana, Eucalyptus marginata* and *Corymbia calophylla* over low open woodland to woodland dominated by *Banksia attenuata, Banksia grandis* and *Banksia ilicifolia* over mid sparse to open shrubland dominated by *Xanthorrhoea preissii* over low to mid sparse shrubland to shrubland dominated by *Hibbertia hypericoides* over low sparse to open forbland dominated by *Dasypogon bromeliifolius* and *Desmocladus flexuosus* on grey sand on lower to upper slopes and flats.	136.9 (62.7)	9	*Acacia semitrullata* (P4)	
2	Low to mid closed forest of *Melaleuca preissiana* over mid sparse to open shrubland dominated by *Astartea scoparia* over low grassland of introduced species on grey sand on closed depressions and flats.	36.7 (16.8)	2	*Acacia semitrullata* (P4)	

VT	Description	Extent (ha) (Percentage)*	Number of Quadrats	Presence of Significant Flora Taxa	Photograph
3	Mid sparse woodland to open forest of *Eucalyptus rudis* over low open forest *Melaleuca preissiana* over tall open shrubland dominated by *Astartea scoparia* occasionally with *Melaleuca teretifolia* over low grassland and forbland of introduced species on grey sand on flats.	2.7 (1.2)	2	-	
4	Low open forest of *Melaleuca teretifolia* over tall sedgeland dominated by *Lepidosperma longitudinale* and tall open rushland dominated by *Meeboldina roycei* on brown sandy loam on open depressions fringed by low open forest of *Melaleuca preissiana* over tall shrubland dominated by *Astartea scoparia,* and *Taxandria linearifolia* over mid open shrubland dominated by *Aotus gracillima* and *Pteridium esculentum* subsp. *esculentum* over mid sparse sedgeland dominated by *Lepidosperma longitudinale* on black sandy loam on open depressions.	7.2 (3.3)	2	-	

VT	Description	Extent (ha) (Percentage)*	Number of Quadrats	Presence of Significant Flora Taxa	Photograph
5	Low closed forest of *Melaleuca cuticularis* over low grassland and forbland of introduced species on brown clay loam on closed depressions.	4.8 (2.2)	1	-	

5.2.2 Other Areas Described

Significant areas where no vegetation occurred because of human disturbance were mapped as 'Cleared Land' (C). This included a previously cleared area in the south-east corner and paddocks in the north-west corner of the block (Figure 8). A total of 29.9 ha of 'Cleared Land' have been mapped, representing 13.7 % of the Study Area. Smaller tracks were not mapped as 'Cleared Land' because of their complexity and small size.

5.2.3 Significant Vegetation

The analyses undertaken with the SCP dataset did not indicate that any of the quadrats within the Study Area represented any TECs as identified in the SCP dataset (Gibson *et al*. 2012). However, the VT1 quadrats grouped closely with quadrats forming part of SCP21a, SCP21c and SCP23a in both dendrograms. Of these, SCP21c is a listed PEC as described below.

- Low lying *Banksia attenuata* woodlands or shrublands (community type 21c) (Priority 3): This type occurs sporadically between Gingin and Bunbury, and is largely restricted to the Bassendean system. The type tends to occupy lower lying wetter sites and is variously dominated by *Melaleuca preissiana*, *Banksia attenuata, B. menziesii, Regelia ciliata, Eucalyptus marginata* or *Corymbia calophylla*. Structurally, this community type may be either a woodland or occasionally shrubland.

VT1 does appear to be related to and have similarities to SCP21c, however the description of the SCP21 subgroups provided in the floristic survey of the SCP (Gibson *et al* 1994) indicates that VT1 more closely resembles SCP21a than SCP21c. The quadrats established in lower-lying damp areas of VT1 which recorded some taxa preferring damp areas potentially contributed to the grouping of VT1 with SCP21c quadrats. In addition, SCP21c is described as having a lower average species richness than SCP21a (54.6 taxa per quadrat compared to 40.5) which may have contributed to the Study Area quadrats (VT1 quadrats recorded an average species richness of 26 taxa per quadrat – Appendix N) grouping with SCP21c.

Quadrat 2 and 16 (VT2) grouped with SCP05 quadrats as well as one SCP22 quadrat and one SCP04 quadrat in the dendrogram including introduced taxa. SCP22 is a listed PEC as described below:

- *Banksia ilicifolia* woodlands, southern Swan Coastal Plain (community type 22) (Priority 3): Low lying sites generally consisting of *Banksia ilicifolia – B. attenuata* woodlands, but *Melaleuca preissiana* woodlands and scrubs are also recorded. Occurs on Bassendean and Spearwood systems in the central Swan Coastal Plain north of Rockingham. Typically has very open understorey, and sites are likely to be seasonally waterlogged.

The VT2 has affinities with community type 22, although *Banksia ilicifolia* and *B. attenuata* were not generally recorded within VT2. In addition, the dendrogram excluding introduced taxa grouped quadrat 16 with the VT1 quadrats and quadrat 2 with SCP05 quadrats and SCP04 quadrats indicating that generally poor vegetation condition within the Study Area has had a significant impact on how the quadrats have grouped.

The remaining quadrats of the Study Area did not group with quadrats representing any PECs. Quadrat 3 (VT2) and quadrats from VT3, VT4 and VT5 grouped with SCP11 quadrats in the analysis including introduced taxa (Appendix K).

The VTs were also compared with the current TEC and PEC descriptions. There were no VTs mapped within the Study Area which were representative of any TECs as described in the current TEC list (DPaW 2015f). In assessing the VTs within the Study Area against the current PEC list (DPaW 2015b), VT1 was found to represent one PEC which is described below:

- *Banksia* dominated woodlands of the Swan Coastal Plain IBRA region (Priority 3): The main feature of these *Banksia* woodlands is the presence of *Banksia attenuata* and/or *B. menziesii* occurring on deep sands. The species commonly co-occur. The community occurs on the Quindalup, Spearwood and Bassendean dunes and rarely on the Pinjarra Plain landforms that comprise the dominant landforms of the Swan Coastal Plain.

5.2.4 Vegetation Condition

Vegetation condition mapping polygons are displayed on Figure 8. The Study Area was highly impacted by various disturbances including weeds, previous clearing and grazing. There was obvious evidence of Dieback (*Phytophthora cinnamomi*) noted throughout the Study Area, however Dieback can only be confirmed by soil sample analysis, which is beyond the scope of this report.

The condition scale providing descriptions of vegetation condition is presented in Section 3.7. There was no vegetation which was considered to be in 'Pristine' or 'Excellent' condition. The majority of vegetation was considered to be 'Degraded' (37.6% of the Study Area), with areas mapped as 'Very Good' (21.7 % of the Study Area), and Good' (20.6 % of the Study Area) also mapped). There were also smaller areas mapped as a combination of 'Degraded' / 'Completely Degraded', 'Completely Degraded' and 'Cleared Land' (13.7% of the Study Area) (Figure 8). The areas in the Study Area mapped as 'Cleared Land' (see Section 5.2.2) were not allocated condition scores, as they are essentially completely cleared.

6 DISCUSSION AND CONCLUSIONS

6.1 Flora of the Study Area

A total of 144 discrete native vascular flora taxa with an additional 48 introduced taxa were recorded within the Study Area (including opportunistic records). The total number of taxa is above the estimate made using the Chao-2 estimator for taxon richness for the Study Area (115), indicating that the Study Area was relatively well-sampled. In comparison, the study undertaken by MBS Environmental (2015) identified 83 taxa in the smaller south-east Jackson Block.

There was one significant flora taxon recorded within the Study Area; *Acacia semitrullata* (P4). This taxon is not considered to have been comprehensively surveyed for in the Study Area and it is considered likely that further locations of this taxon would be found in the Study Area if targeted survey was undertaken. *Acacia semitrullata* has a wide distribution (approximately 265 km) and is known from 122 DPaW records, with numerous localities within conservation reserves (DPaW 2015d); Waroona is near the northern-most edge of its known distribution.

No Threatened flora taxa were recorded within the Study Area. The Threatened orchid taxa *Drakaea elastica* and *Caladenia huegelii* were not recorded in the Study Area, despite targeted searches in suitable habitat. It is considered that the Study Area has been adequately surveyed for these taxa, and it is therefore unlikely that these taxa occur in the Study Area. However, as mentioned in Section 5.1.1, a single sterile individual of a *Caladenia* taxon was recorded that could potentially represent *Caladenia huegelii*, or several other common *Caladenia* taxa. Flowering material is required to confirm the identity of this individual.

A total of 48 introduced flora taxa were recorded by this survey of the Study Area. Of these, there were two Declared Pests under the BAM Act (Department of Agriculture and Food 2015) including *Gomphocarpus fruticosus* and *Zantedeschia aethiopica.* *Zantedeschia aethiopica* was found to be common throughout the Study Area, particularly in northern part of the Study Area. Despite this, it is important that proposed Project impacts employ appropriate hygiene procedures, including post-impact inspections, to manage the potential introduction and spread of introduced taxa.

6.2 Vegetation of the Study Area

Classification analysis of quadrat data from the Study Area arranged quadrats into five clusters which were used to define VTs in the Study Area. In comparison, the study undertaken by MBS Environmental (2015) identified two vegetation units in the smaller Jackson Block.

The parameters used for the classification analysis in this assessment are considered to have produced a robust classification with ecologically plausible clusters of quadrats that were used to define VTs. Although VTs were defined using limited data (a number of clusters contained only one or two quadrats), the use of the SCP dataset provides further data in

terms of vegetation sampling from a wider geographical area. However, the high level of disturbance recorded throughout the Study Area (discussed further in Section 6.3) has potentially impacted on the grouping of the Study Area quadrats within the larger analyses. Overall the VTs described in the Study Area are considered to be a relatively accurate reflection of the floristic, geological and topographical variability of the Study Area. It is considered that the VT mapping polygons presented in this assessment are relatively accurate, and reliable for the purposes of the environmental impact assessment process in Western Australia.

The Priority 3 PEC '*Banksia* dominated woodlands of the Swan Coastal Plain IBRA region' is considered to occur within the Study Area which is represented by VT1. The dendrogram indicated that VT1 also had similarities to the Priority 3 PEC SCP21c (section 5.2.3), although the vegetation of VT1 is generally more similar to SCP21a (not a listed PEC). Likewise, while one dendrogram grouped two quadrats with the Priority 3 PEC SCP22, the vegetation descriptions as supported by the second regional analysis excluding introduced taxa indicate that this PEC is not present in the Study Area.

A number of Geomorphic Wetlands categorised as 'Conservation' and 'Resource Enhancement' have been mapped within the Study Area (DPaW 2013). No development or clearing is considered appropriate for wetlands categorised as 'Conservation' and protection is recommended for wetlands categorised as 'Resource Enhancement' (DPaW 2014b). This should be considered in light of any future development proposals in the Study Area.

6.3 Vegetation Condition of the Study Area

The vegetation of the Study Area has been impacted by various disturbance vectors including weeds, previous clearing, grazing and evidence of Dieback, with the condition of the vegetation ranging from 'Very Good' to 'Completely Degraded'. Approximately 42 % of the Study Area was mapped as 'Good' or above indicating that under half of the vegetation retains its basic vegetation structure or ability to regenerate it (Keighery 1994). Approximately 44 % of the Study Area was mapped as 'Degraded' or 'Completely Degraded' indicating the vegetation structure has been severely impacted by disturbance. Despite this, areas mapped as 'Degraded' or 'Completely Degraded' may still provide habitat for cockatoos and other fauna due to the presence of large trees.

Although Glevan Consulting confirmed that some areas are Dieback infested within the Jackson Block (Glevan Consulting 2015), additional survey for Dieback would be required to identify its presence in the wider Study Area.

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