

Vegetation and Flora Study (BORR IPT, 2020h) Part 1: Report

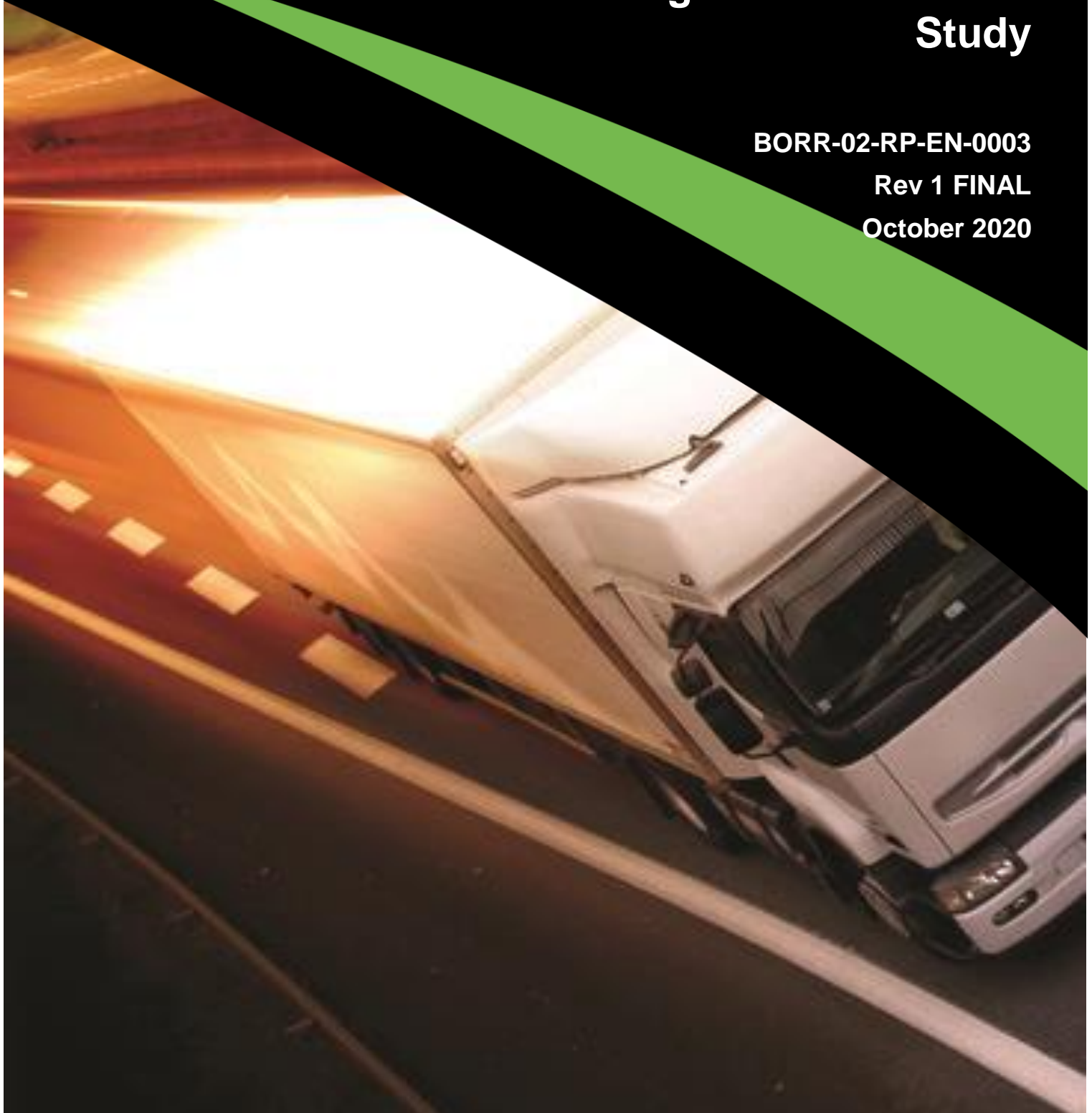


Bunbury Outer Ring Road Southern Section Vegetation and Flora Study

BORR-02-RP-EN-0003

Rev 1 FINAL

October 2020



EXECUTIVE SUMMARY

The Commissioner of Main Roads Western Australia (Main Roads) is proposing to construct and operate the Southern Section of the Bunbury Outer Ring Road (BORR) project. BORR is a planned Controlled Access Highway linking the Forrest Highway and Bussell Highway (Figure 1, Appendix A). The completed project will provide a high standard route for access to the Bunbury Port, improve road user safety and facilitate proposed development to the east of the City of Bunbury. BORR also provides an effective bypass of Bunbury for inter-regional traffic. The proposed BORR comprises three sections:

- 'BORR Northern Section' – Forrest Highway to Boyanup-Picton Road
- 'BORR Central Section' – Boyanup-Picton Road to South Western Highway
- 'BORR Southern Section' – South Western Highway (near Bunbury Airport) to Bussell Highway.

Main Roads commissioned the BORR IPT to undertake a vegetation and flora study during the 2018 spring season, for BORR Southern Section (the Project). The purpose of the assessment was to delineate key flora and vegetation values within the survey area.

The 2018 assessment encompassed a survey area that was planned to include and extend beyond the proposed alignment of the BORR Southern Section. Subsequent refinement of the alignment resulted in some areas being included in the proposed alignment that were not contained within the 2018 survey area. In addition to this, in 2019, the Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain ecological community (Tuart TEC) was listed as a threatened ecological community (TEC) (at the level of critically endangered) by the then Department of the Environment and Energy (DotEE). The Approved Conservation Advice (DotEE, 2019a) specified criteria and thresholds for determining occurrences of the TEC that had not been considered in the 2018 survey methodology. Separate to this, targeted surveys for vegetation representing the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) listed Clay Pans of the Swan Coastal Plain TEC (Claypan TEC) (and associated State-listed TECs and floristic community types), and Threatened flora taxa listed under the EPBC Act were deemed necessary to provide a comprehensive and complete assessment.

In response to the factors listed above, the following additional surveys were conducted:

- Detailed and targeted assessment over previously unsurveyed gaps (September 2019)
- Targeted survey for occurrences of TECs and Priority ecological communities (PECs), including the Tuart TEC (September 2019)
- Targeted survey for occurrences of Claypan TEC within and surrounding the revised proposed alignment (September 2019)
- Targeted surveys for the Threatened orchid species *Diuris drummondii* (30 November 2019) and *Drakaea* spp (August and September 2019)
- Targeted surveys for other Threatened orchid species, including *Caladenia huegelii*, *Diuris micrantha* and *Caladenia speciosa*, was undertaken in suitable Jarrah / Banksia and wetland habitat. Listed Threatened species *Eleocharis keigheryi*, *Austrostipa jacobiana* and *Austrostipa bronwenae* were also searched for in wetland / dampland habitat (August and September 2019)

This report presents the results of the initial 2018 survey and additional surveys as listed above. Also included is an analysis of survey (quadrat) data from GHD (2014; GHD, 2015) and Biota (2016; Biota, 2018) where these surveys overlap with the 2018 survey area.

This report is subject to, and must be read in conjunction with, the limitations and assumptions contained throughout the report.

Key findings

Vegetation

The survey area contains a combination of native vegetation and highly disturbed areas, including roads, road reserve and paddocks. A total of ten vegetation types comprising remnant native vegetation were identified and described from the survey area. A further three types, comprising highly disturbed areas, revegetation and planted vegetation were also identified and described.

The survey area occurs on the Bassendean and Spearwood Dunes and Pinjarra Plain. The sandy low dunes and plains that characterise the survey area were dominated by *Eucalyptus* / *Banksia* forests, in particular *Eucalyptus* / *Agonis* and *Banksia* woodlands / forests. Creek lines, swamps and low relief / seasonally inundated areas were dominated by *Eucalyptus rudis* / *Melaleuca preissiana* / *Melaleuca raphiophylla* woodlands. These were generally disturbed and dominated by introduced grasses and herbs in the ground-layer. In the agricultural areas and some road reserves, native vegetation occurred as scattered remnant trees or stands over introduced grasses. The survey area included approximately 163.8 ha (53.2%) of native vegetation.

The vegetation condition of the survey area ranged from Excellent to Completely Degraded. Over half of the survey area was cleared/highly modified (186.1 ha or 53.2 %). Historical clearing and aggressive weed species have influenced the structure and composition of the remaining native vegetation. There was 43.5 ha of vegetation in Good or better condition (approximately 12.4 % of the survey area) and 119.7 ha in Good to Degraded or worse condition (approximately 34.2 % of the survey area).

Five conservation significant ecological communities were identified (based on results of desktop and field assessments) within the survey area:

- Banksia Woodlands of the Swan Coastal Plain – listed as a Threatened Ecological Community (TEC) at the level of Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Also listed as a Priority 3 Ecological Community (PEC) by Department of Biodiversity, Conservation and Attractions (DBCA)
- Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain (SCP) - listed as a TEC at the level of Critically Endangered under the EPBC Act. Also listed as a Priority 3 Ecological Community (PEC) by DBCA
- Southern SCP *Eucalyptus gomphocephala* – *Agonis flexuosa* woodlands (floristic community type 25) – listed as Priority 3 by DBCA.

Flora

The floristic diversity of the survey area has been assessed by combining survey data from GHD (2014 and 2015), Biota (2016 and 2018) and the current survey (Appendix E). A total of 428 species have been recorded across these surveys including 119 introduced or planted species (28 %).

During the 2018 survey, 289 plant species (including subspecies and varieties) representing 227 genera and 71 plant families were recorded within the survey area. This total included 198 (68.5 %) native species and 91 introduced (exotic / planted) (31.5 %) species.

The likelihood of occurrence assessment post-field survey concluded that three species are known to occur, 11 species may possibly occur and the remaining 40 species are unlikely or highly unlikely to occur within the survey area. Three DBCA Priority-listed flora species were recorded within the survey area during the various field surveys; *Lasiopetalum membranaceum* (P3) (2018 and 2019 surveys), *Caladenia speciosa* (P4) (GHD, 2015) and *Acacia semitrullata* (P4) (GHD, 2014).

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- Appendix I Flora Likelihood of Occurrence Assessment

Document Control					
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1 INTRODUCTION

1.1 Project background

The Commissioner of Main Roads Western Australia (Main Roads) is proposing to construct and operate the Southern Section of the Bunbury Outer Ring Road (BORR) project. BORR is a planned Controlled Access Highway linking the Forrest Highway and Bussell Highway (Figure 1, Appendix A). The completed project will provide a high standard route for access to the Bunbury Port, improve road user safety and facilitate proposed development to the east of the City of Bunbury. BORR also provides an effective bypass of Bunbury for inter-regional traffic. The proposed BORR comprises three sections:

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- ‘BORR Southern Section’ – South Western Highway (near Bunbury Airport) to Bussell Highway.

This document refers to BORR Southern Section only.

Main Roads commissioned the BORR IPT to undertake a vegetation and flora study during the 2018 spring season, for BORR Southern Section (the Project). The purpose of the assessment was to delineate key flora and vegetation values within the survey area.

The 2018 assessment encompassed a survey area that was planned to include and extend beyond the proposed alignment of the BORR Southern Section. Subsequent refinement of the alignment resulted in some areas being included in the proposed alignment that were not contained within the 2018 survey area. In addition to this, in 2019, the Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain ecological community (Tuart TEC) was listed as a threatened ecological community (TEC) (at the level of critically endangered) by the then Department of the Environment and Energy (DotEE). The Approved Conservation Advice (DotEE, 2019a) specified criteria and thresholds for determining occurrences of the TEC that had not been considered in the 2018 survey methodology. Separate to this, targeted surveys for vegetation representing the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) listed Clay Pans of the Swan Coastal Plain TEC (Claypan TEC) (and associated State-listed TECs and floristic community types), and Threatened flora taxa listed under the EPBC Act were deemed necessary to provide a comprehensive and complete assessment.

In response to the factors listed above, the following additional surveys were conducted:

- Detailed and targeted assessment over previously unsurveyed gaps (September 2019)
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- Targeted surveys for the Threatened orchid species *Diuris drummondii* (30 November 2019) and *Drakaea* spp (August and September 2019)
- Targeted surveys for other Threatened orchid species, including *Caladenia huegelii*, *Diuris micrantha* and *Caladenia speciosa*, was undertaken in suitable Jarrah / Banksia and wetland habitat. Listed Threatened species *Eleocharis keigheryi*, *Austrostipa jacobiana* and *Austrostipa bronwenae* were also searched for in wetland / dampland habitat (August and September 2019)

This report presents the results of the initial 2018 survey and additional surveys as listed above. Also included is an analysis of survey (quadrat) data from GHD (2014; GHD, 2015) and Biota (2016; Biota, 2018) where these surveys overlap with the 2018 survey area.

1.2 Purpose of this report

The purpose of this study is to identify the vegetation and flora within the survey area in order to inform project design and environmental approvals.

The aim of the study was to:

- Identify, map and describe vegetation types
- Assess and map the condition of vegetation
- Identify and map the location of Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs)
- Identify areas of high floristic value including those that provide habitat for conservation significant flora, wetland / riparian vegetation, vegetation types that are poorly represented and those with high diversity
- Identify and map the location of conservation significant flora species.

1.3 Project location

1.3.1 Survey area

The survey area assessed in this flora and vegetation study covers approximately 349.91 hectares (ha) and includes existing road reserves, agricultural land and native vegetation. The Proposal Area is approximately 200 ha and entirely contained within the survey area.

As described in Section 1.1, the study commenced with a vegetation and flora study conducted during the 2018 spring season. In 2019, additional targeted surveys were completed within the Proposal Area for TECs and PECs as well as Threatened flora. This included those areas contained within the 2018 survey area and additional areas not previously surveyed.

The survey area is mapped in Figure 2, Appendix A. Combined survey effort, including the past, 2018 and additional survey areas is shown in Figure 3, Appendix A.

1.3.2 Study area

A study area was defined for the desktop based searches of the assessment and includes a 5 kilometre (km) buffer of the survey area for the purpose of flora and vegetation database searches.

1.4 Scope of works

The scope of works for the flora and vegetation survey included:

- A desktop review of publically available information and relevant reports to determine the environmental values of the survey area
- A biological survey to identify:
 - Vegetation community types present, including the presence of any TECs or PECs or other significant vegetation
 - Vegetation condition, including the location of any Weeds of National Significance (WONS) or Declared Weeds

- Flora species present including introduced species
- The presence or potential presence of any Threatened or Priority flora
- Preparation of a biological survey report (this document) that:
 - Documents the results of the desktop assessment and field survey, including mapping
 - Identifies and discusses potentially occurring significant flora and vegetation communities
- Provision of spatial files in GIS format.

1.5 Relevant legislation

In Western Australia (WA), significant communities and flora are protected under both Federal and State Government legislation. In addition, regulatory bodies provide a range of guidance and information on expected standards and protocols for environmental surveys.

An overview of key legislation and guidelines, conservation codes and background information relevant to this project are provided in Appendix B.

1.6 Limitations and assumptions

This report has been prepared by BORR IPT for Main Roads and may only be used and relied on by Main Roads for the purpose agreed between BORR IPT and the Main Roads as set out in section 1.2 of this report.

BORR IPT otherwise disclaims responsibility to any person other than Main Roads arising in connection with this report. BORR IPT also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by BORR IPT in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. BORR IPT has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by BORR IPT described in this report. BORR IPT disclaims liability arising from any of the assumptions being incorrect.

BORR IPT has prepared this report on the basis of information provided by Main Roads and others who provided information to BORR IPT (including Government authorities), which BORR IPT has not independently verified or checked beyond the agreed scope of work. BORR IPT does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of infrastructure, services and vegetation, and access. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions may change after the date of this Report. BORR IPT does not accept responsibility arising from, or in connection with, any change to the site conditions. BORR IPT is also not responsible for updating this report if the site conditions change.

This report has assessed the flora values within the survey area, as shown in Figure 1, Appendix A.

2 METHODOLOGY

2.1 Desktop assessment

Prior to the commencement of the field survey, a desktop assessment was undertaken to identify relevant environmental information pertaining to both the survey area and study area and to assist in survey design. The desktop assessment involved a review of:

- GHD (2014) – Lot 1 Ducane Road Environmental Values Assessment
- GHD (2015) – Vegetation and Flora survey of the BORR South Alignment
- Biota (2016) – Bunbury Outer Ring Road Southern Section – Reassessment of Floristic Communities
- Biota (2018) – Bunbury Outer Ring Road Southern Section – Banksia Woodlands TEC Assessment
- Ecoedge (2017) – Report of a Targeted Rare Flora Survey for *Diuris drummondii* along four sections of the Bunbury Outer Ring Road proposed alignment

The desktop assessment also involved a review of:

- The Department of the Environment and Energy (DotEE) Protected Matters Search Tool (PMST) to identify communities and species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) potentially occurring within the study area (DotEE, 2019b) (Appendix C)
- The Department of Biodiversity, Conservation and Attractions (DBCA) TEC and PEC database to determine the potential for significant ecological communities to be present within the study area (provided by Main Roads)
- The DBCA NatureMap database for flora species previously recorded within the study area (DBCA, 2007-)(Appendix C)
- The DBCA Threatened (Declared Rare) and Priority Flora database (TPFL) and the WA Herbarium database (WAHERB) for Threatened and Priority flora species listed under the *Biodiversity Conservation Act 2016* (BC Act) (which replaced the *Wildlife Conservation Act 1950*) and listed as Priority by DBCA, previously recorded within the study area (provided by Main Roads) (DBCA, 2019c)
- Existing datasets including previous vegetation mapping of the survey area, aerial photography, geology/soils and hydrology information to provide background information on the variability of the environment, likely vegetation units and to identify areas with potential to contain TECs, PECs, and Threatened and Priority listed flora species
- Consultation with DBCA flora officer also identified additional conservation significant flora taxa not identified in desktop searches that are potentially present / have been recorded near the survey area.

Data from previous flora and vegetation investigations completed within the survey area were considered in the desktop assessment and included in the flora inventory. As shown in Table 2-2, flora assessments have been carried out within the survey area in September 2011, June 2013, June 2014, October 2016, November 2016, November 2017 and November 2019. These surveys include 34 quadrats / releves within the the survey area that were additional to those sampled in the 2018 and 2019 surveys. Data from these quadrats / releves have also been used to describe the vegetation types and / or included in the floristic community type (FCT) analysis for this report.

The location of the previous survey areas is shown in Figure 3, Appendix A.

Table 2-1 Data collected from previous and related field surveys

SOURCE	MEASUREMENT
GHD (2014)	Survey of Lot 1 Ducane Road. GHD completed a flora and vegetation assessment of Lot 1 Ducane Road on the 13 June 2013. This included nine quadrats, all of which are within the current survey area.
GHD (2015)	The survey was considered to be a level 2 assessment (as per the now superseded EPA guidelines). Phase 1 was carried out on the 21 to 23 September 2011 and Phase 2 from the 16 to 18 June 2014. A total of 21 quadrats (20 within the current survey area) were assessed and the vegetation types / condition described.
Biota (2016)	Survey from the 25 to 26 October 2016 by two Biota botanists targeting areas identified in GHD (2015) as likely to correspond with FCT 8 and FCT21b. Seven sites were sampled, of which five quadrats (three of which were re-sampled from GHD 2015) are within the current survey area.
Biota (2018)	The survey was carried out from the 4 to 6 November 2017 by two Biota botanists. Twenty-four target areas were sampled, using either quadrats (10 x 10 m) or mapping notes. Five quadrats and one relevé were sampled (two quadrats and one relevé within the current survey area).
Ecoedge (2017; 2019a)	Ecoedge completed a targeted assessment on the 19 and 30 November 2016 and 30 November 2019 of portions of the BORR South proposed alignment that provide suitable habitat for <i>Diuris drummondii</i> and adjacent areas. Three areas were searched as part of these assessments.
Ecoedge (2019b)	Ecoedge completed a desktop review for the location of potential claypan wetlands, which identified one potential claypan wetland. A field survey determined that the wetland was not to be a claypan community.

2.2 Field assessment

BORR IPT botanists with assistance from Ecoedge botanists completed a detailed vegetation and flora assessment of the survey area in August (late winter/ early spring) and September 2018 (spring). A targeted orchid survey of selected sites was completed in August and September 2019. A targeted *Diuris drummondii* (Tall Donkey Orchid) survey was also completed on 19 November and 30 November 2016 and 30 November 2019. In addition, a targeted survey for TECs/PECs and confirmation of vegetation types in previously unsurveyed gaps in the survey area was undertaken in September 2019. A review of potential conservation listed claypan occurrences was also undertaken. A summary of the field assessments undertaken is presented in Table 2-2.

Table 2-2 Flora and vegetation survey timing and effort

DATE	SURVEY EFFORT	FIELD TEAM AND EXPERIENCE
21 August 2018	Late winter / early spring assessment of wetland areas within the survey area / reconnaissance survey. 16 person hours were spent on these surveys.	Two GHD senior botanists, one with over 13 years' experience undertaking surveys in the South-West of Western Australia, including the Swan Coastal Plain, and one with ten years' experience undertaking flora surveys on the Swan Coastal Plain.
22 October, 30 October – 1 November 2018	Spring detailed survey within the survey area. 64 person hours were spent on these surveys.	One GHD senior botanist with over 12 years' experience undertaking flora surveys on the Swan Coastal Plain, and one GHD graduate ecologist with one year's experience undertaking flora and vegetation surveys.
23 – 30 August 2019	<i>Drakaea</i> targeted search of two locations. 130 person hours were spent on these surveys.	One BORR IPT senior botanist with over 16 years' experience in undertaking flora surveys and assessments on the Swan Coastal Plain, and one Ecoedge botanist with 10 years' experience undertaking flora surveys, in particular in the Bunbury region.
23 September – 9 October 2019	<i>Drakaea</i> targeted search of two locations. Targeted surveys for orchids and TECs across suitable habitats. Confirm vegetation types in previously unsurveyed gaps in the survey area. 300 person hours were spent on these surveys.	One BORR IPT senior botanist with over 16 years' experience in undertaking flora surveys and assessments on the Swan Coastal Plain, and one Ecoedge botanist with 10 years' experience undertaking flora surveys, in particular in the Bunbury region.
19 and 30 November 2016 and 30 November 2019	<i>Diuris drummondii</i> targeted search of three locations (Ecoedge, 2019a). 16 person hours were spent on these surveys. In addition four surveys areas were targeted in 2016 (Ecoedge, 2017). 32 person hours were spent on these surveys.	One Ecoedge senior botanist over 25 years' experience undertaking flora surveys in the South West of Western Australia, including the Swan Coastal Plain, and one Ecoedge botanist with 10 years' experience undertaking flora surveys, in particular in the Bunbury region.
1 August 2019	Review of potential conservation listed claypan occurrences (Ecoedge, 2019b). 16 person hours were spent on these surveys.	One Ecoedge senior botanist over 25 years' experience undertaking flora surveys in the South West of Western Australia, including the Swan Coastal Plain, and one Ecoedge botanist with 10 years' experience undertaking flora surveys, in particular in the Bunbury region, and one DBCA Senior Botanist (Andrew Webb).

The field surveys listed above were undertaken to verify the results of the desktop assessment, identify and describe the dominant vegetation units, assess vegetation condition, and identify and record vascular flora species present at the time of survey. Searches for significant ecological communities and flora species were also undertaken during the field survey. The survey personnel, survey timing and survey effort were appropriate to record the environmental values present within the survey area, and consistent with the standard required for environmental assessment of the Proposal.

The survey methodology employed by BORR IPT was undertaken with reference to the Environmental Protection Authority (EPA) *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA, 2016).

2.2.1 Data collection

Field survey methods involved a combination of sampling quadrats, relevés and photographic reference points located in identified vegetation units and traversing the survey area by foot / vehicle. In total, 20 non-permanent quadrats, three relevés and 109 photographic reference points (PPs) were described throughout the survey area (Figure 2, Appendix A). Copies of the quadrat and relevé data and PPs are provided in Appendix D.

Quadrats (measuring 10 m x 10 m – area of 100 m²) were located within each identified vegetation unit. A minimum of three quadrats were located within each identified vegetation unit, except for those that were largely in a Degraded to Completely Degraded condition / represented by scattered trees over introduced understorey species. Relevés were used to supplement quadrat data. At each PP, the vegetation type / condition was noted and searches for native flora via walking traverses were undertaken.

Field data at each quadrat were recorded on a pro-forma data sheet and included the parameters detailed in Table 2-3.

Table 2-3 Data collected during the field survey

ASPECT	MEASUREMENT
Collection attributes	Site code, personnel/recorder; date, quadrat dimensions, photograph of the quadrat
Physical features	Aspect, slope, landform, soil attributes, ground surface cover, leaf and wood litter
Location	Coordinates recorded in GDA94 datum using a hand-held Global Positioning System (GPS) tool to accuracy approximately ± 5 metres (m)
Vegetation condition	Vegetation condition was assessed using the condition rating scale adapted by EPA (2016) for the South West Botanical Province
Disturbance	Level and nature of disturbances (e.g. weed presence, fire and time since last fire, impacts from grazing, exploration activities)
Flora	List of dominant flora from each structural layer. List of all species within the quadrat including stratum, average height and cover (using National Vegetation Information System (NVIS)).

A flora inventory was compiled from species listed in described quadrats, relevés, PPs and from opportunistic floristic records throughout the survey area.

2.2.2 Vegetation units

Vegetation units were identified and boundaries delineated in GHD (2015). During the 2018 and 2019 surveys, the previous mapping was ground-truthed to detect any changes since the previous surveys. Areas not previously surveyed were mapped using a combination of aerial photography, topographical features, field data/observations and statistical analyses.

Vegetation units were described based on structure, dominant species and cover characteristics as defined by quadrat data and field observations. Vegetation unit descriptions follow NVIS and are consistent with

NVIS Level V (Association). At Level V up to three species per stratum are used to describe the association (ESCAVI, 2003).

2.2.3 Statistical analyses

PRIMER v6 (Clarke, K.R. and Gorley, R.N., 2006) was used to examine the similarity between sites using collected data. A presence / absence matrix was created of all species (including perennials and annuals) present in BORR IPT quadrats and quadrats from GHD (2014; GHD, 2015) and Biota (2016; Biota, 2018) that are within the current survey area. The dissimilarity between quadrats was determined using the Bray-Curtis measure and the Resemblance function in PRIMER. A Cluster analysis (using Agglomerative Hierarchical Clustering technique) based on group average was undertaken using the Bray-Curtis similarity matrix and results presented as a dendrogram. In addition, a nonmetric multi-dimensional scaling analysis (MDS) was undertaken using the Bray-Curtis similarity matrix and results presented as a two dimensional scatter plot. Analysis was run using two scenarios:

- All species (base quadrat data)
- Native species only (weed species removed from each quadrat).

The outputs of the PRIMER analysis were used to inform decisions on vegetation units.

2.2.4 Comparison of vegetation units with regional datasets

Statistical analysis

The Swan Coastal Plain dataset (SWA) (accessed through *NatureMap*) is derived from a database compiled and maintained over many years, combining the results of a number of floristic studies (conducted between 1990 and 1996) on plant communities of the SWA bioregion, south of Moore River. The SWA dataset includes sampling site details, the flora collected at these sampling sites and the FCT assigned to these sampling sites. The taxonomy of the flora in the SWA dataset used is current as of December 2018 updated by BORR IPT.

PRIMER v6 (Clarke, K.R. and Gorley, R.N., 2006) was used to compare the BORR IPT quadrats to existing data (where available) for FCTs described on the SWA. SWA site locations within a 5 km buffer of the survey area were located and the FCTs represented by these sites were identified. All site locations for these FCTs from the SWA dataset were extracted, along with those identified in the desktop searches (e.g. TEC and PEC searches). Representative quadrats from each FCT selected for the analysis are shown in Table 2-4.

The BORR IPT and SWA dataset quadrat data was combined, reconciled to align nomenclature and a presence/absence matrix created of all species (including perennials and annuals). Singleton species (those occurring in only one quadrat) were removed from the matrix as well as species that were only identified to family or genus level. The dissimilarity between quadrats was determined using the Bray-Curtis measure and the Resemblance function in PRIMER. A Cluster analysis (using Agglomerative Hierarchical Clustering technique) based on group average was undertaken using the Bray-Curtis similarity matrix and results presented as a dendrogram. In addition, a nonmetric multi-dimensional analysis (MDS) was undertaken using the Bray-Curtis similarity matrix and results presented as a two dimensional scatter plot. A factor was added to the output to define sample groups by FCT. The outputs of the PRIMER analysis were used to inform decisions on vegetation units.

It is noted that PRIMER can be limited in use for this purpose as analysis is based on all species recorded in quadrats and does not take into account dominance of species. Further interpretation of statistical results, coupled with multiple field surveys and desktop information is needed to determine whether the vegetation units are representative of a certain FCT.

Table 2-4 List of SWA quadrats used in PRIMER analysis within a 5 km buffer of the survey area

FLORISTIC COMMUNITY TYPE NAME AND ID	STATUS	QUADRATS
Southern <i>Corymbia calophylla</i> woodlands on heavy soils (1b)	TEC	AMBR-1, AMBR-4, AMBR-6, AMBR-9, AMBRAL-1, CAPEL-5, CARB-1, CARB-2, CARB-4, R116703, YALLIN-1, YOON-1
<i>Corymbia calophylla</i> – <i>Xanthorrhoea preissii</i> woodlands and shrublands (3c)	TEC	DUCK-1, DUCK-2, ELLEN-6, PEARCE-2, talb1, talb12, talb13, talb4, WATER-3, yar101
<i>Melaleuca preissiana</i> damplands (4)		AMBR-3, C58-1, CAPEL-3, dian02, FL-1, FL-9, GUTHR-1, Hamp01, kailis03, low14a, LYONS-1, MELA-1, Plant02, R116701, rowe02
Mixed shrub damplands (5)		AUSTB-5, GUTHR-4, jand06, low08, Mill01, MILT-1, PLINE-5, Swamp01
Weed dominated wetlands on heavy soils (6)		card10, card11, much02, PEARCE -1, Sunday01, TWIN-1, TWIN-2,
Herb rich saline shrublands in clay flats (7)	TEC ^	AUSTB-1, BAMBUN-1, BAMBUN-3, BULL-6, CARAB-2, FISH-1, gosn10, mrnp01, MUCK-2, Punr01, RUAB-4, Swamp02, YOON-3
Herb rich shrublands in clay pans (8)	TEC ^	C58-3, FL-3, FL-7, gosn08, Hay01, MEELON-1, MEELON-2, MUD-2, MUD-3, MUD-6, MUD-7, MUD-9, waro 03, waro 04, WATER-4
Dense shrublands on clay flats (9)	TEC ^	brick4, BYRD-1, DUCK-3, MANEA-1, Pind02, welr02, WONN-3, yar102
Shrublands on dry clay flats (10a)	TEC ^	C58-4, FISH-3, FISH-4, FL-2, gosn11, KOOLJ-6, KOOLJ-7, pinj10, Plant01, Punr03, waro 05
Wet forests and woodlands (11)		AUSTB-3, beel03, BULL-12, C71-1, CARAB-3, HARRY-6, hymus01, hymus02, low10b, MODO-3, rowe01, TWIN-11, yuri04
<i>Melaleuca raphiophylla</i> – <i>Gahnia trifida</i> seasonal wetlands (17)		Chid056, cool 01, cool 04, cool 11, ELLIS-1, Hay02, leda03, leda04, LESCH-6, MTB-5, PAGA-5, Possum5
Shrublands on calcareous silts (18)	TEC	boot01, boot03, ELE13, ELLIS-2, ELLIS-3, Hay05, xbeer02
Central <i>Banksia attenuata</i> – <i>Eucalyptus marginata</i> woodlands (21a)		AUSTRA-1, BULLER-1, C71-2, CAPEL-7, CLIFT01, CORON-1, FL-4, gelor02, Hamp03, KEME-2, KOOLI-2, MANEA-2, MGK01, MILT-6, NINE-2, REDL-1, RIVD-2, Sunday02
Southern <i>Banksia attenuata</i> woodlands (21b)	PEC *	boyan01, buffer01, CAPEL-1, CARB-3, dard02, gibson01, kelly02, MANEA-3, MGK03, R116702, RUAB-1, RUAB-2
Low lying <i>Banksia attenuata</i> woodlands or shrublands (21c)	PEC *	5C07, BULLER-3, DEJONG02, dillo01, FL-6, KEME-3, low07, MODO-2, PLINE-7, raven03, SF03, TWIN-7, white05

FLORISTIC COMMUNITY TYPE NAME AND ID	STATUS	QUADRATS
Southern <i>Eucalyptus gomphocephala</i> and/or <i>Agonis flexuosa</i> woodlands (25)	PEC **	bunb01, C71-4, colriv01, CORON-2, gelro01, GMaid01, GMaid02, GMaid03, GMaid04, KEME-1, MEAL-1, MINN-2, MYALUP-2, NMaid05, tokyu01, yela03
Coastal shrublands on shallow sands (29a)		BMaid02, BU01, BU04, MI21, NAVB-2, NMaid01, NMaid03, Pinn02, PRES-1, rich02
Quindalup <i>Eucalyptus gomphocephala</i> and / or <i>Agonis flexuosa</i> woodlands (30b)	PEC ***	LESCH-1, LESCH-2, LESCH-3, LESCH-4, LESCH-5, NMaid04, PEPB-1, pip01, Possum3
<i>Astartea</i> aff. <i>fascicularis</i>/ <i>Melaleuca</i> species dense shrublands (S01)		Cavs07, Della01, gosn06, pinj15, raven04, Swamp03, yang03
<i>Acacia saligna</i> wetlands (S05)		ELE09, ELE10, ELE36, Hay03

^ A component of the Critically Endangered Clay Pans of the Swan Coastal Plain EPBC listed TEC.

* A component of the Endangered Banksia Woodlands of the Swan Coastal Plain EPBC listed TEC.

** Can be a component of the Endangered Banksia Woodlands of the Swan Coastal Plain EPBC listed TEC or Tuart Woodlands of the SCP PEC.

*** Can be a component of the Tuart Woodlands of the Swan Coastal Plain EPBC listed TEC.

2.2.5 Vegetation condition

The vegetation condition was assessed and mapped in accordance with the vegetation condition rating scale for the South West and Interzone Botanical Provinces of Western Australia (devised by Keighery (1994) and adapted by EPA (2016)). The scale recognises the intactness of vegetation and consists of six rating levels. The vegetation condition rating scale is located in Appendix B.

2.2.6 Flora identification and nomenclature

Species well known to the survey botanists were identified in the field; all other species were collected and assigned a unique collection number to facilitate tracking. All specimens collected during the field assessment were dried and processed in accordance with the requirements of the WA Herbarium. Species were identified by a qualified taxonomist using taxonomic literature, electronic keys and online electronic databases.

The conservation status of all recorded flora was compared against the current lists available on FloraBase (WA Herbarium, 1998-) and the EPBC Act Threatened species database provided by DotEE (2019c).

Nomenclature used in this report follows that used by the WA Herbarium as reported on FloraBase (WA Herbarium, 1998-).

2.2.7 Targeted surveys for Threatened and Priority Ecological Communities (TEC/PEC)

Targeted surveys for the presence of TECs / PECs were undertaken by identifying vegetation units and delineating boundaries using a combination of aerial photography, topographical features, field data/observations and statistical analyses (multivariate analyses). Vegetation units were described based on structure, dominant species and cover characteristics as defined by quadrat data and field observations.

Banksia woodlands of the Swan Coastal Plain (TEC)

Targeted surveys for the presence of the Banksia Woodlands of the Swan Coastal Plain, listed as an Endangered TEC under the EPBC Act, were undertaken in 2019. Potential occurrences were described based on structure, dominant species, condition and cover characteristics by using quadrat sampling and field observations. To determine extent and boundaries, key diagnostic characteristics and condition thresholds were used to determine the Banksia Woodlands TEC as outlined in Threatened Species Scientific Community (TSSC) Approved Conservation Advice (TSSC, 2016). The TSSC (2016) provides guidance for determining whether the TEC is present. These criteria are summarised in Table 2-5.

Table 2-5 Diagnostic characteristics and condition thresholds for Banksia Woodlands TEC (TSSC, 2016)

DIAGNOSTIC CHARACTERISTICS / CONDITION THRESHOLDS	CRITERIA
Floristic Community Type	<p>Location and physical environment:</p> <ul style="list-style-type: none"> Occurs on the Swan Coastal Plain Interim Biogeographic Regionalisation for Australia (IBRA) bioregion <p>Soil and landform:</p> <ul style="list-style-type: none"> Typically occurs on well drained, low nutrient soils on sandplain landforms, particularly in deep Bassendean and Spearwood sands and occasionally on Quindalup sands. <p>Structure:</p> <ul style="list-style-type: none"> The community is a low woodland to forest, but may also include shrubland, open woodland or forest under some classification systems. The percentage canopy cover is more than 2% and typically less than 50%. The structure and appearance may also vary due to disturbance history. <p>Composition:</p> <ul style="list-style-type: none"> The canopy is commonly dominated by <i>Banksia attenuata</i> and or <i>B. menziesii</i>. Other <i>Banksia</i> species that dominate include <i>B. prionotes</i> or <i>B. ilicifolia</i>. The patch must include at least one of these diagnostic species.
Vegetation condition¹ and minimum patch size	<ul style="list-style-type: none"> Pristine – no minimum Excellent – 0.5 ha Very Good – 1 ha Good – 2 ha
Surrounding context	<p>A patch is a discrete and mostly continuous area of ecological community. A patch may include small scale (<30 m) variations, gaps and disturbances, such as tracks, that do not significantly alter the overall functionality of the ecological community. Such breaks are generally included in patch size calculations. The landscape and position of the patch including its position relative to surrounding vegetation also influences how important it is in the broader landscape.</p>

¹ As per the Keighery (1994) condition scale presented in Bush Forever (Government of Western Australia 2000).

Banksia Woodlands of the SCP (PEC)

The field assessment confirmed the presence of the Banksia Woodlands of the SCP PEC, listed as Priority 3 by DBCA. Potential occurrences were described based on structure, dominant species, condition and cover characteristics by using quadrat sampling and field observations. This PEC aligns with the Banksia Woodlands TEC key diagnostic characteristics and condition thresholds (TSSC, 2016).

Tuart woodlands and forests of the SCP (TEC)

Targeted surveys for the presence of the Tuart (*Eucalyptus gomphocephala*) woodland and forests of the SCP TEC, listed in July 2019 as a Critically Endangered TEC under the EPBC Act were undertaken. Potential occurrences were described based on number of trees (including stags), distance between trees and their canopies, vegetation structure and composition, condition and patch size using a combination of quadrat sampling and field observations. Four Tuart quadrats (JENO01, JENO02, Tuart01 and Tuart02) were assessed across three potential TEC Tuart patches (Figure 11, Appendix A). To determine the extent and boundaries of the potential TEC occurrences, key diagnostic characteristics and condition thresholds were used as outlined in Approved Conservation Advice (DotEE, 2019a) and Main Roads draft Tuart Guidance Factsheet version 9th July 2019 (Main Roads, 2019). To calculate distance between trees and their canopies, the Arc GIS Collector app was utilised in the field which displayed aerial imagery on field tablets to allow the measure tool to be used. This approach allowed the patch to be determined, including determining gaps between potential patches.

The key diagnostic characteristics of this community include, but are not limited to:

- Occurs on the SCP bioregion
- Primarily occurs on the Spearwood and Quindalup dune systems
- The primary defining feature is the presence of at least two living established (> 15 centimetre (cm) diameter at breast height) Tuart trees in the uppermost canopy layer, although they may co-occur with trees of other species
- There is a gap of no more than 60 metres (m) between the outer edges of the canopies of adjacent Tuart trees
- Biotic and patch size thresholds.

These criteria are summarised in Table 2-6.

Table 2-6 Diagnostic characteristics and condition thresholds for Tuart forests and woodlands TEC (DotEE, 2019a)

DIAGNOSTICS CHARACTERISTICS / CONDITION THRESHOLDS	CRITERIA
Floristic Community Type	Location and physical environment: <ul style="list-style-type: none"> • Occurs on the SCP IBRA bioregion Soil and landform: <ul style="list-style-type: none"> • Primarily occurs on the Spearwood and Quindalup dune systems, but can also occur on the Bassendean dunes and Pinjarra Plain. It can also occur on the banks of rivers and wetlands Structure:

DIAGNOSTICS CHARACTERISTICS / CONDITION THRESHOLDS	CRITERIA
	<ul style="list-style-type: none"> The presence of at least two living established <i>Eucalyptus gomphocephala</i> (Tuart) trees in the uppermost canopy layer, although they may co-occur with trees of other species. There is a gap of no more than 60 m between the outer edges of the canopies of adjacent Tuart trees Most often occurs as a woodland but can occur in other structural forms, (e.g. forest, open forest, woodland, open woodland, and various mallee forms). <p>Composition:</p> <ul style="list-style-type: none"> Other tree species may be present in the canopy or sub-canopy. They commonly include <i>Agonis flexuosa</i> (Peppermint), <i>Banksia grandis</i> (Bull Banksia), <i>Banksia attenuata</i> (Candlestick Banksia), <i>Eucalyptus marginata</i> (Jarrah), <i>Corymbia calophylla</i> (Marri), <i>Banksia menziesii</i> (Firewood Banksia) and <i>Banksia prionotes</i> (Acorn Banksia) An understorey of native plants is typically present, which may include grasses, herbs and shrubs, although this is often modified by disturbance.
Vegetation condition and minimum patch size	<ul style="list-style-type: none"> If the patch is < 0.5 ha, it is not part of the TEC For patches 0.5 ha to 2 ha in area or 2 ha to 5 ha, specific criteria will need to be met to be considered the TEC All patches >5 ha that meet the key diagnostic characteristics and patch definition are part of the TEC with no condition thresholds required Revegetated sites that meet the key diagnostics and minimum condition thresholds for the Tuart Woodlands and Forests are considered as part of the TEC. Sites outside of the described natural range of Tuart woodlands and forests are not part of the TEC.
Defining a patch	<ul style="list-style-type: none"> A patch is a discrete and mostly continuous area of vegetation that meets the key diagnostic characteristics Patch boundaries can extend beyond a site or property boundary The patch boundary is 30 m beyond the outer canopy of established Tuart trees (< 15 cm DBH), including dead Tuart trees (stags) Stags considered for inclusion in a patch, the vertical projection of its outermost branches is used to define the edge of its canopy. If the stag species is unclear, and its canopy is within 60 m of an identified Tuart tree, the stag is presumed to be a Tuart Patches may vary in structural or biological complexity (e.g. patch may vary in number of mature trees / ecological diversity, to other parts of the same patch with fewer mature trees / less groundcover). Patches may also contain exposed soil and/or plant litter areas. Patches vary spatially; higher condition areas may intersperse with lower condition areas Patches may include small areas without understorey vegetation. Small areas do not break up a patch as long there are some parts of the

DIAGNOSTICS CHARACTERISTICS / CONDITION THRESHOLDS	CRITERIA
	<p>canopy within 60 m of the outer edges of the canopies of adjacent Tuart trees</p> <ul style="list-style-type: none"> Existing buildings and other human-made structures and gardens are not part of the TEC and should be excluded, even if there are some parts of the canopy within 60 m of the outer edges of the canopies of adjacent Tuart trees.
<p>Minimum condition threshold for 0.5 ha to 2 ha patches of the Tuart Woodlands and Forests TEC</p>	<ul style="list-style-type: none"> High condition (needs to meet a minimum of high) ≥60 % of all understorey vegetation cover is native OR At least eight native understorey species per 0.01 ha AND Have an important landscape role (≤100 m to native vegetation) (refer to indicators of important landscape features below) OR Have a habitat role (≥2 very large trees per 0.5 ha) (refer to indicators of habitat features below) OR Show regeneration (≥15 seedlings and / or saplings per 0.5 ha).
<p>Minimum condition threshold for 2 ha to 5 ha patches of the Tuart Woodlands and Forests TEC</p>	<ul style="list-style-type: none"> Moderate condition ≥50 % of all understorey vegetation cover is native OR At least four native understorey species per 0.01 ha AND Have an important landscape role (≤100 m to native vegetation) OR Have a habitat role (≥2 very large trees per 0.5 ha) OR Show regeneration (≥15 seedlings and / or saplings per 0.5 ha).
<p>Indicators of Important Landscape, Habitat or Regeneration Features</p>	<ul style="list-style-type: none"> Show regeneration (≥15 seedlings and / or saplings per 0.5 ha) Landscape: patch occurs ≤100 m to another patch of native vegetation ≥1 ha in size. This vegetation can be the TEC and / or other vegetation where ≥50 % of the vegetation cover across all layers is comprised of native plant species OR Habitat: patch contains a mean of ≥2 very large trees (≥50 cm DBH) per half ha of any native plant species OR Regeneration: patch displays evidence of natural regeneration of native eucalypts (<i>Corymbia</i> or <i>Eucalyptus</i>), represented by seedlings, saplings or other sub-mature stages (<15 cm DBH) with at least a mean of 15 individuals per half ha.

Southern SCP *Eucalyptus gomphocephala* – *Agonis flexuosa* woodlands (SCP25) / Tuart (*Eucalyptus gomphocephala*) woodlands of the Swan Coastal Plain

The field assessment also confirmed the presence of the Southern SCP *Eucalyptus gomphocephala* – *Agonis flexuosa* woodlands (SCP25) and Tuart (*Eucalyptus gomphocephala*) woodlands of the Swan Coastal Plain PECs, both listed as Priority 3 by DBCA. Potential occurrences were described based on number of trees, structure and composition, condition and patch size by using quadrat sampling / statistical analysis and field observations. The Tuart PEC aligns with the Tuart TEC key diagnostic characteristics and condition thresholds as outlined in the Approved Conservation Advice (DotEE, 2019a). The Quindalup *Eucalyptus gomphocephala* and / or *Agonis flexuosa* woodlands (30b) PEC was also assessed for potential occurrences.

2.2.8 Surveys for conservation significant flora

Prior to the field survey, information obtained from the desktop assessments (e.g. previous flora and vegetation investigations, aerial photography, geology, soils and topography data, EPBC Act PMST, TPFL, NatureMap and the WAHERB databases search results) was reviewed to determine conservation significant flora species potentially present within the study area and locations. Additionally, ecological information (e.g. habitat, associated flora species and phenology) was sourced from FloraBase (WA Herbarium, 1998-) to provide further details.

Potential habitats and locations of previous records were searched by opportunistic sampling. Where individuals were identified, the location and number of plants present were recorded using handheld GPS units.

Drakaea survey

A targeted survey was completed for *Drakaea elastica* and *D. micrantha*. The field survey was undertaken in reference to the Commonwealth of Australia *Draft Orchid Survey Guidelines* (2013) and the methodology was discussed with Mr Andrew Webb (DFCA Flora Officer) prior to commencing the field work. The methodology employed involved:

- Identification of potential habitat – this was based on the vegetation mapping and field observations during the spring surveys. Sites selected were nearby swamps / dampland areas and contained *Kunzea* thickets with *Banksia* woodlands within the survey area and adjacent areas (Figure 1, Appendix A). Areas that had been completely cleared, heavily grazed paddocks that did not contain remnant vegetation, were excluded from the survey
- Surveys were undertaken in mid to late August to coincide with the presence of *D. elastica* (and *D. micrantha*) leaf being conspicuous and detectable in the field
- Surveys involved one senior botanist and a one botanist, sites were traversed on foot with:
 - Higher quality habitat – sites that retained structure (had a upper / mid or ground layer that comprised native species) traversed on a parallel grid (at 10 m intervals)
 - Lower quality sites – sites that were almost completely cleared / or contained scattered native species but were grazed and had high visibility through the ground layer were traversed via meander surveys
- In total, 100 person hours were spent surveying for *D. elastica* and *D. micrantha*.

Figure 2, Appendix A shows the two survey sites assessed.

Diuris drummondii survey

A targeted survey was completed for *Diuris drummondii* (Ecoedge, 2019a). The field survey was undertaken in reference to the Commonwealth of Australia *Draft Orchid Survey Guidelines* (2013) and the methodology was discussed with Mr Andrew Webb (DFCA Flora Officer) prior to commencing the field work. The methodology employed involved:

- Identification of potential habitat – this was based on the vegetation mapping and field observations during the spring surveys. Sites selected were within swamps / dampland areas within the survey area and adjacent areas (Figure 2, Appendix A). Areas that had been completely cleared, heavily grazed paddocks that did not contain remnant vegetation, were excluded from the survey
- Prior to the field survey, Mr Andrew Webb confirmed that *D. drummondii* was flowering in the Bunbury region and one of the known sites (outside of the survey area) was visited to confirm that the species was in flower
- Surveys involved two senior botanists, three sites were traversed on foot with:
 - Higher quality habitat – sites that retained structure (had a upper / mid or ground layer that comprised native species) traversed on a parallel grid (at a 5-10 m intervals)

- Lower quality sites – sites that were almost completely cleared / or contained scattered native sedges (such as *Juncus pallidus*) but were grazed and had high visibility through the ground layer were traversed via meander surveys
- In total, 16 person hours were spent surveying for *D. drummondii*.

Figure 2, Appendix A shows the three survey sites assessed.

Other conservation listed species survey

A targeted survey for other Threatened orchid species, including *Caladenia huegelii*, *Diuris micrantha* and *Caladenia speciosa*, was undertaken in suitable Jarrah / Banksia and wetland habitat. Listed Threatened species *Eleocharis keigheryi*, *Austrostipa jacobsoniana* and *Austrostipa bronwenae* were also searched for in wetland / dampland habitat.

The methodology employed involved:

- Surveys involved two senior botanists, vegetation types VT1, VT2, VT3 and VT4 (Jarrah / Banksia) and VT6, VT7, VT8 (wetland habitat) were traversed on foot with:
 - Higher quality habitat – sites that retained structure (had an upper / mid or ground layer that comprised native species) traversed on a parallel grid (at a 5-10 m intervals)
 - Lower quality sites – sites that were almost completely cleared / or contained scattered native sedges (such as *Juncus pallidus*) but were grazed and had high visibility through the ground layer were traversed via meander surveys
- In total, 100 person hours were spent surveying for conservation listed orchid species.

2.3 Desktop and field assessment limitations

2.3.1 Desktop

The EPBC Act PMST is based on bioclimatic modelling for the potential presence of species. As such, this does not represent actual records of the species within the area. The records from the DBCA searches of Threatened and Priority flora provide more accurate information for the general area. However, some records of collections cannot be dated or are plain text interpretations of locations which can misrepresent the current range of Threatened or Priority species.

2.3.2 Field

The EPA (2016) Technical Guide states flora survey reports for environmental impact assessment in WA should contain a section describing the limitations of the survey methods used. The limitations and constraints associated with this field survey are discussed in Table 2-7. Based on this assessment, the present survey effort has not been subject to any constraints which affect the thoroughness of the assessment and the conclusions which have been formed.

Table 2-7 Field survey limitations

ASPECT	CONSTRAINT	COMMENT
Sources of information and availability of contextual information	Nil	Adequate information is available for the survey area, this includes: <ul style="list-style-type: none"> • Broad scale (1:250,000) mapping by Beard (1979), Hedde <i>et al.</i> (1980) and Webb <i>et al.</i> (2016) Regional biogeography Mitchell <i>et al.</i> (2002). Previous flora surveys within and adjacent to the survey area including GHD (2015); Ecoedge (2017) and Biota (2016; 2018) (see Section 4).

ASPECT	CONSTRAINT	COMMENT
Scope (what life forms were sampled etc.)	Nil	Vascular flora was sampled during the survey. Non-vascular flora were not surveyed.
Proportion of flora collected and identified (based on sampling, timing and intensity)	Minor	<p>A reconnaissance survey was undertaken on the 21 August and a single season detailed vegetation and flora survey was undertaken on the 22 October and 30 October to 1 November 2018 (four days), 23 to 30 August 2019, 23 September to 9 October 2019 (13 days). Targeted orchid survey on 30 November 2019. The surveys included late winter, early spring and late spring.</p> <p>The flora recorded from the field survey is detailed in Section 5.5 and a full flora species list is provided in Appendix E. The portion of flora collected and identified was considered high, based on survey effort and timing. The species accumulation curve for the survey area, based on flora recorded within quadrats, is approaching an asymptote, which suggests that the current survey effort is sufficient. Furthermore, the bootstrap estimate of species richness generated from this data indicates that 289 species could be expected from the survey area based on the diversity recorded within quadrats. The total species recorded from the survey area was 428 flora species (267 recorded in the current survey), which is substantially above the predicted species diversity estimate.</p>
Flora determination	Moderate	<p>Flora determination was undertaken by the BORR IPT botanists in the field and at the WA Herbarium by a consulting taxonomist.</p> <p>During the 2018 surveys over 94 % of species were identified to a species level. 17 specimens could be identified to genera / tentative species only of which five were weeds.</p> <p>It is unlikely these un-identified species are conservation significant, with the exception of the orchid (<i>Caladenia</i> species) which contained basal leaves only. Later surveys in 2019 recorded all <i>Caladenia</i> species within the survey area. The taxonomy and conservation status of the WA flora is dynamic. This report was prepared with reliance on taxonomy and conservation status current at the time of report development, but it should be noted this may change in response to ongoing research and review of International Union for Conservation Nature (IUCN) criteria.</p>

ASPECT	CONSTRAINT	COMMENT
Completeness and further work which might be needed (e.g. was the relevant area fully surveyed)	Moderate	<p>The survey area has previously been surveyed (see Section 4). Some areas that were previously assessed were also re-surveyed to determine change over time.</p> <p>Access to the survey area was made by vehicle tracks which extended along the site. Information gained from the survey was extrapolated across those sections of the survey area not accessed on foot during the field survey to assist with determining the vegetation units and condition. A total of approximately 560 person hours were spent on the various field surveys.</p>
Mapping reliability	Minor	<p>The vegetation was mapped using high-resolution ESRI aerial imagery obtained from Landgate, topographical features, previous broad scale mapping, previous vegetation mapping and field data.</p> <p>Data were recorded in the field using hand-held GPS tools (e.g. Samsung Tablet with ArcGIS Collector and Garmin GPS). Certain atmospheric factors and other sources of error can affect the accuracy of GPS receivers. The Garmin GPS units used for this survey are accurate to within ± 5 m on average. Therefore the data points consisting of coordinates recorded from the GPS may contain inaccuracies. Mapping was completed to a scale of 1:10,000.</p>
Timing/weather/season/cycle	Nil	<p>The field surveys were conducted from 20 August to 1 November 2018 and 23 to 30 August 2019, 23 September to 9 October 2019 (13 days). The closest Bureau of Meteorology (BoM) weather recording station to the survey area is Bunbury (No. 9965) (BoM, 2019). As shown in Plate 1, Section 3.1, the long-term averages (LTA) rainfall are slightly lower than the 2018 period for June and July, with the 2018 period recording lower rainfall averages in September, November and December. The temperature statistics indicate that the 2018 minimum and maximum temperatures were consistent with the LTAs. During 2019 higher rainfall was recorded in June 2019, compared with the long-term average (LTA) (Plate 2), where July and August total rainfall was lower than the LTA. Rainfall received was adequate for the flowering of flora species. The temperature statistics indicate that the 2019 minimum and maximum temperatures were consistent with the LTAs, except for the maximum temperatures during November and December 2019 were higher than the LTA. The weather conditions recorded during the survey periods are considered unlikely to have impacted upon the vegetation and flora survey. The survey timing was considered appropriate for the flora field survey.</p>
Disturbances (e.g. fire, flood, accidental human intervention)	Nil	<p>The survey area is largely located in an agricultural setting and as such has had previous land clearing. At the time of the survey one small area was burnt, no other disturbance such as fire / flooding etc. were present.</p>

ASPECT	CONSTRAINT	COMMENT
Intensity (in retrospect, was the intensity adequate)	Minor	The vascular flora of the survey area was sampled in accordance with EPA (2016); a minimum of three quadrats per vegetation type were established (where possible) along with relevés and photographic reference points to supplement the data. The survey area was sufficiently covered by the botanists during the survey.
Resources	Minor	Adequate resources were employed during the field survey. Field survey teams consisted of one senior botanist (more than 10-17 years' experience) and a field ecologist (2+ years' field experience). In total, 500 person hours were spent undertaking vegetation and flora surveys.
Access restrictions	Nil	The survey area included private properties; the BORR IPT arranged site access. However, not all properties were accessed for the survey. In some instances, access within and across properties was restricted due to biosecurity, electric fences and cattle. In these instances vegetation types and conditions were extrapolated from aerial photography / soil and landscape information and nearby survey points.
Experience levels	Nil	The botanists who executed the survey are practitioners suitably qualified and experienced in their respective fields. The detailed survey team consisted of senior botanists and support personnel. The senior botanists have previously undertaken targeted Threatened orchid surveys on the Swan Coastal Plain and are highly familiar with the species taxonomy and habitat requirements. The reconnaissance survey was carried out by two senior botanists. The senior botanists have more than 12 years' experience conducting flora surveys in WA, including the south-west. Field ecologists/ field support staff have 1 – 4 years' field experience.

3 DESKTOP ASSESSMENT

3.1 Climate

The Bunbury area experiences a Mediterranean climate and is characterised by hot, dry summers and cool, wet winters. Rainfall is largely received during the winter months as a result of cold fronts that regularly cross the South West coast. The closest BoM weather station is Bunbury (site number 009965) (BoM, 2019). Climate statistics for the Bunbury weather station are presented in Plate 1 (2018) and Plate 2 (2019).

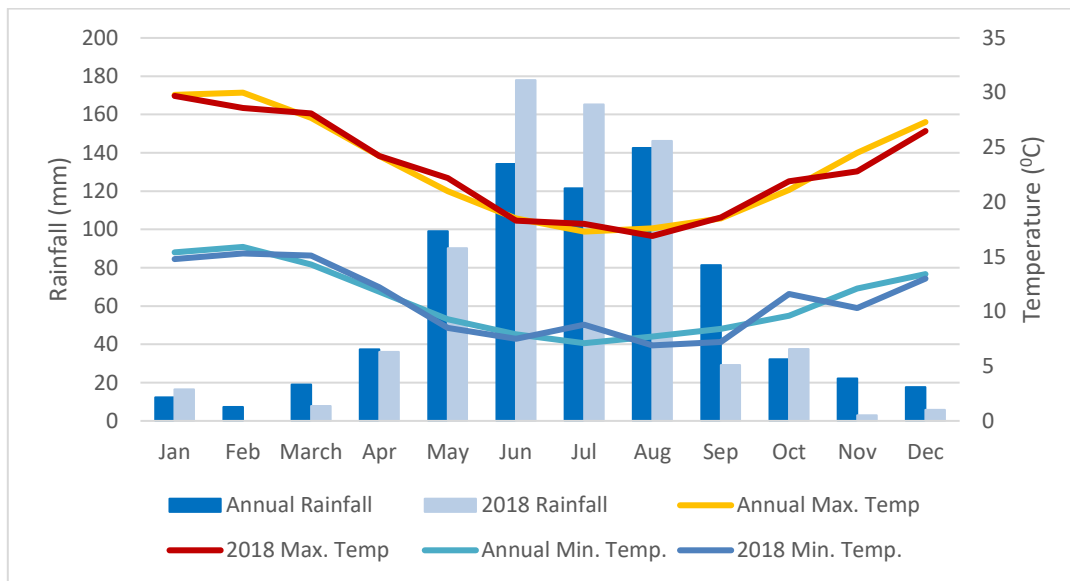


Plate 1 Climate statistics for Bunbury Weather Station (No. 9965) Annual and 2018

Note: April and May data for Bunbury Weather Station were not available at time of writing therefore data from Australind weather station (No. 9273) have been used instead for these two months. Annual climate statistics are from November 1995 to current.

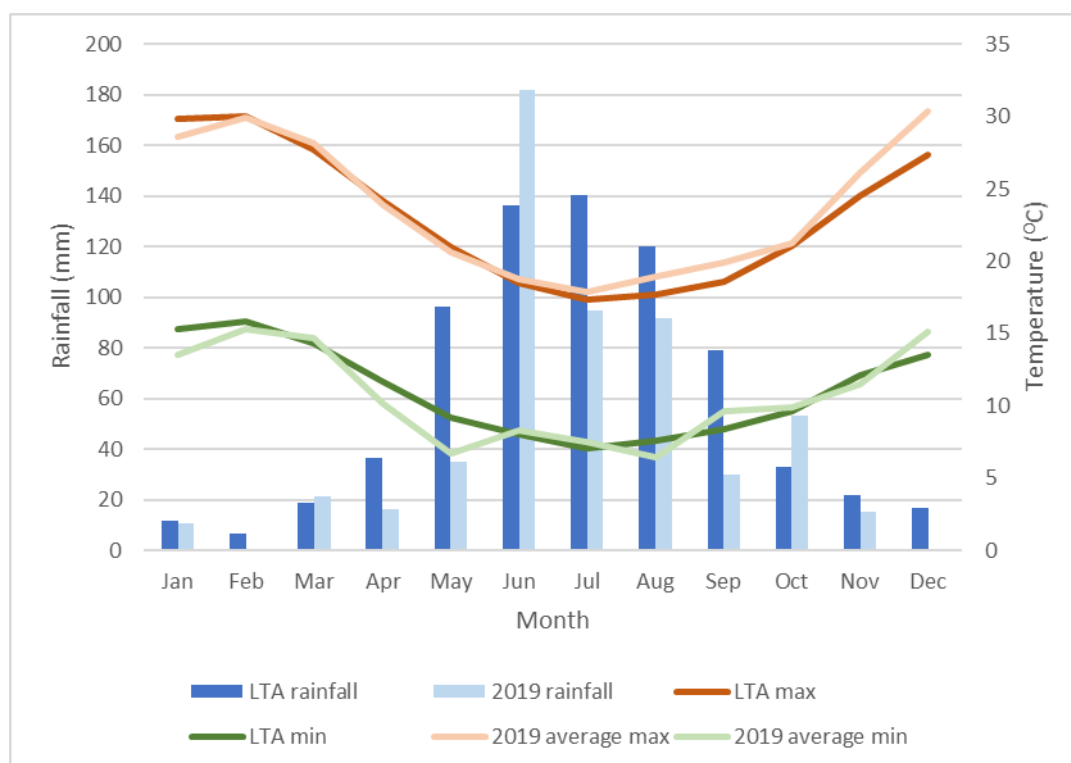


Plate 2 Climate statistics for Bunbury Weather Station (No. 9965) Annual and 2019

3.2 Province

The study area is located in the South West Botanical Province of WA (1980), the Swan Coastal Plain (SCP) bioregion and Perth (SWA2) subregion as described by the Interim Biogeographic Region of Western Australia (Department of the Environment, 2012).

The Perth subregion is composed of colluvial, aeolian sands, alluvial river flats and coastal limestone. Heath and/or Tuart woodlands occur on limestone, Banksia and Jarrah-Banksia woodlands on Quaternary marine dunes of various ages and Marri on colluvial and alluvial soils. The subregion also includes a complex series of seasonal wetlands (Mitchell *et al.* (2002)).

3.3 Landform and soils

The SCP is comprised of five major geomorphological units, which lie more or less parallel to the coast, being the Quindalup, Spearwood and Bassendean Dunes, the Pinjarra Plain and the Ridge Hill Shelf (McArthur, W.M. and Bettenay, E., 1960; Churchward, H. and McArthur W.M., 1980). The survey area lies within the Spearwood and Bassendean Dunes and Pinjarra Plain elements, which are broadly described as:

- Spearwood dune system: Pleistocene and aeolian sands overlying Tamala limestone. Low dunes and swales of shallow pale grey sands over yellow sands are characteristic of the Spearwood system. Wetlands are associated with peats and carbonate sands, occasionally with clay overlaying sands.
- Bassendean dune and sandplain system: Pleistocene sand dunes with very low relief, leached grey siliceous sand intervening sandy and clayey swamps and gently undulating plains. These occur immediately west of, and partly overlie, the Pinjarra Plain.
- Pinjarra Plain: Broad low relief plain west of the foothills, comprising predominantly Pleistocene fluvial sediments and some Holocene alluvium associated with major current drainage systems. Major soils are naturally poorly drained with many swamps.

Desktop assessment of broad geological formations indicates that the survey area occurs within three broad formations in addition to rivers and wetland areas, which are outlined in Table 3-1.

Table 3-1 Geology and landform information for the survey area (Geological Survey of WA, 2009)

FORMATION	GEOLOGICAL TYPE	GEOLOGICAL DESCRIPTION/ LANDFORM
Tamala Limestone	Qts	Sand associated with Tamala Limestone, high dunes
Guildford Formation	Qpa	Mainly alluvial sandy clay
Bassendean Sand	Qpb	Low rounded dunes
	Qpb/Qpa	Thin Bassendean Sand over Guildford Formation
Rivers	Qha	Alluvium
Wetlands	Qhw	Swamp deposits, mainly peaty sand

Department of Primary Industries and Regional Development (DPIRD) soil-landscape mapping of the South West of WA (Government of Western Australia (GoWA) (2019c)) provides soil and landform data compiled from various sources. This mapping identified 23 different soil types within the survey area. In total, approximately 56 % of the mapped soil types occur within the Bassendean dune system, 24 % within the Spearwood dune system and 20 % within the Pinjarra Plain. The dominant soil types (greater than 20 ha / more than 7 % of the survey area each) are the:

- Spearwood S1b Phase (211Sp__S1b): Dune ridges with deep siliceous yellow brown sands or pale sands with yellow-brown subsoil and slopes up to 15%.
- Spearwood S2c Phase (211Sp__S2c): Lower slopes (1-5%) of dune ridge with bleached or pale sands with a yellow-brown or pale brown subsoil (like S1c). Usually occurs on the eastern edge of the Spearwood Dunes.
- Bassendean B1b Phase (212Bs_B1b): Very low relief dunes of undulating sand plain with deep bleached grey sandy A2 horizons and pale yellow B horizons.
- 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.
- Pinjarra P1b Phase (213Pj_P1b): Flat to very gently undulating plain with deep acidic mottled yellow duplex soils. Moderately deep pale sand to loamy sand over clay: imperfectly drained and moderately susceptible to salinity in limited areas.

Soil landscape types are illustrated in Figure 4 (Appendix A).

3.4 Hydrology

3.4.1 Watercourses

The survey area intersects Five Mile Brook and a number of small drainage lines and constructed drains (Figure 5, Appendix A). Large parts of the survey area have been extensively modified for agricultural irrigation / drainage. For the purposes of this report, these irrigation channels are considered part of the agricultural areas and are not mapped as waterways.

3.4.2 Wetlands

Large sections of the survey area are low-lying palusplain, which is seasonally waterlogged or has a high water table during winter. A search of the EPBC Protected Matters Database (DotEE, 2019b) did not identify any Ramsar listed, Directory of Important Wetlands in Australia or National Heritage Listed wetlands within or in a 5 km buffer of the survey area.

The Geomorphic Wetlands dataset (Hill, A.L., Semeniuk, C.A., Seneniuk, V. and del Marco, A., 1996) identified 27 wetlands within the survey area (Figure 5, Appendix A). These include one Conservation Category Wetland (CCW), 20 Multiple Use Wetlands (MUW), five Resource Enhancement Wetlands (REW) and one Not Assessed wetland. Approximately 24 % of the survey area is mapped as geomorphic wetlands.

A separate wetland assessment has been completed (BORR IPT, 2019) which provides further information on the geomorphic wetlands and an evaluation against their classification.

3.5 Vegetation and flora

3.5.1 Broad vegetation mapping and extents

Broad scale (1:250,000) pre-European vegetation mapping of the area has been completed by Beard (1979) at an association level. The mapping indicates that the survey area intersects three vegetation associations (Figure 6, Appendix A):

- Medium woodland; Tuart and Jarrah (association 6)
- Medium woodland; Tuart (association 998)
- Mosaic: Medium forest; Jarrah-Marri / Low woodland; Banksia / Low forest; Teatree (*Melaleuca spp.*) (association 1000).

The pre-European mapping has been adapted and digitised by Shepherd *et al.* (2002). The extent of vegetation associations has been determined by the state-wide vegetation remaining extent calculations maintained by DBCA (latest update March 2019 (GoWA, 2019b)). As shown in Table 3-2, the current extent of vegetation associations 6 and 1000 are less than 30 % of their pre-European extent at the IBRA bioregion and subregion. Less than 30 % of association 1000 remains at the Local Government Authority (LGA) level for both the Shires of Capel and the City of Bunbury (latest update March 2019) (GoWA, 2019b). Association 998 has more than 30 % remaining at the IBRA bioregion and subregion levels but less than 30 % at the LGA level for both LGAs listed above.

Table 3-2 Extents of vegetation associations mapped within the survey area (GoWA, 2019b)

VEGETATION ASSOCIATION	SCALE	PRE-EUROPEAN EXTENT (HA)	CURRENT EXTENT (HA)	REMAINING (%)	REMAINING WITHIN DBCA MANAGED LANDS (%)	
Swan Coastal Plain IBRA bioregion		1,501,221.93	579,813.47	38.62	38.45	
6	State: WA	56,343.01	13,362.25	23.72	39.83	
	IBRA bioregion: Swan Coastal Plain	56,343.01	13,362.25	23.72	39.83	
	Sub-region: Perth	56,343.01	13,362.25	23.72	39.83	
	LGA	City of Bunbury	712.97	281.18	39.44	NA
		Shire of Capel	5,245.29	2,301.14	43.87	16.51
998	State: WA	51,015.33	18,492.63	36.25	48.68	
	IBRA bioregion: Swan Coastal Plain	50,867.50	18,492.32	36.35	48.68	
	Sub-region: Perth	50,867.50	18,492.32	36.35	48.68	
	LGA	City of Bunbury	1,405.24	150.28	10.69	NA
		Shire of Capel	234.63	24.28	10.35	NA
1000	State: WA	99,835.86	27,768.84	27.81	18.64	
	IBRA bioregion: Swan Coastal Plain	94,175.31	24,869.20	26.41	19.18	
	Sub-region: Perth	94,175.31	24,869.20	26.41	19.18	
	LGA	City of Bunbury	2,171.67	621.00	28.60	2.12
		Shire of Capel	15,173.76	3,189.87	21.02	7.27

Note: orange indicates that less than 30 % of the pre-European extent remains.

Regional vegetation has been mapped by Heddle *et al.* (1980) and updated by Webb *et al.* (2016) based on major geomorphic units on the SCP. The mapping indicates that four vegetation complexes on Aeolian deposits of the SCP are present within the survey area (Figure 7, Appendix A):

- Bassendean Complex – Central and South: Vegetation ranges from woodland of *Eucalyptus marginata* (Jarrah) – *Allocasuarina fraseriana* (Sheoak) – *Banksia* species to low woodland of *Melaleuca* species, and sedgeland on the moister sites. This area includes the transition of *Eucalyptus marginata* to *Eucalyptus todtiana* (Pricklybark) in the vicinity of Perth.
- Karrakatta Complex – Central and South: Predominantly open forest of *Eucalyptus gomphocephala* (Tuart) – *Eucalyptus marginata* – *Corymbia calophylla* (Marri) and woodland of *Eucalyptus marginata* – *Banksia* species. *Agonis flexuosa* (Peppermint) is co-dominant south of the Capel River.
- Southern River Complex – Open woodland of *Corymbia calophylla* (Marri) - *Eucalyptus marginata* (Jarrah) - *Banksia* species with fringing woodland of *Eucalyptus rudis* (Flooded Gum) - *Melaleuca rhapsiophylla* (Swamp Paperbark) along creek beds.
- Yoongarillup Complex – Woodland to tall woodland of *Eucalyptus gomphocephala* (Tuart) with *Agonis flexuosa* in the second storey. Less consistently an open forest of *Eucalyptus gomphocephala* (Tuart) - *Eucalyptus marginata* (Jarrah) - *Corymbia calophylla* (Marri). South of Bunbury is characterised by *Eucalyptus rudis* (Flooded Gum)-*Melaleuca* species open forests.

GoWA (2019a) has assessed the current extent of vegetation complexes against predicted pre-European extents within the SWA IBRA bioregion (Table 3-3) and LGA levels (table 3-4). The current extents of the Bassendean Complex – Central and South, Karrakatta Complex – Central and South and Southern River Complex are less than 30 % of their pre-European extents within the IBRA bioregion. The current extents of the Bassendean Complex – Central and South, Southern River Complex and Yoongarillup Complex are also less than 30 % of their pre-European extents within the City of Bunbury and Shire of Capel LGAs.

Table 3-3 Extent of Heddle *et al.* (1980) vegetation complex on the SCP within the survey area (GoWA, 2019a)

VEGETATION COMPLEX	PRE-EUROPEAN EXTENT (HA)	CURRENT EXTENT (HA)	REMAINING EXTENT (%)	CURRENT EXTENT REMAINING WITHIN ALL DBCA MANAGED LAND (%)
Bassendean Complex – Central and South	87,476.26	23,508.66	26.87	5.00
Karrakatta Complex - Central and South	53,080.99	12,467.20	23.49	8.07
Southern River Complex	58,781.48	10,832.18	18.43	1.60
Yoongarillup Complex	27,977.93	10,018.14	35.81	18.41

Note: orange indicates that less than 30 % of the pre-European extent remains.

Table 3-4 Extent of Heddle *et al.* (1980) vegetation complex within Local Government Areas within the survey area (GoWA, 2019a)

VEGETATION COMPLEX	LGA	PRE-EUROPEAN EXTENT (HA)	CURRENT EXTENT (%)	REMAINING EXTENT (%)	PROPORTION OF COMPLEX WITHIN THE LGA (%)
Bassendean Complex – Central and South	City of Bunbury	0.0	0.0	0.0	0.0
	Shire of Capel	4,946.61	1,162.16	23.49	5.65
Karrakatta Complex - Central and South	City of Bunbury	756.61	283.96	37.53	1.43
	Shire of Capel	6,902.27	3,400.62	49.27	13.00
Southern River Complex	City of Bunbury	2,205.16	635.67	28.83	3.75
	Shire of Capel	7,876.12	1,794.33	22.78	13.40
Yoongarillup Complex	City of Bunbury	1,435.65	156.36	10.89	5.13
	Shire of Capel	1,022.21	233.64	22.86	3.65

Note: orange indicates that less than 30 % of the pre-European extent remains.

3.5.2 Swan Coastal Plain Floristic Studies

Floristic studies on the SCP include those completed by Gibson *et al.* (1994) and other unpublished data collected as part of the System 6 and Part System 1 Update program and from various sources (Weston A.S., Griffin E.A. and Trudgen M., 1993; Griffin, E.A., 1994; Department of Environmental Protection, 1996; Keighery G., 1996). This data has been compiled into a dataset, referred to in this report as the SWA dataset. A search of the SWA dataset identified 17 FCTs that are known to occur within a 5 km buffer of the survey area (Table 3-5).

Table 3-5 SWA dataset FCTs within 5 km of the survey area

FCT	DESCRIPTION AND STATUS
Foothills / Pinjarra Plain	
1b	Southern <i>Corymbia calophylla</i> woodlands on heavy soils.
Seasonal wetlands	
4	<i>Melaleuca preissiana</i> damplands
5	Mixed shrub damplands
6	Weed dominated wetlands on heavy soils
8	Herb rich shrublands in clay pans
9	Dense shrublands on clay flats
11	Wet forests and woodlands
17	<i>Melaleuca raphiophylla</i> – <i>Gahnia trifida</i> seasonal wetlands
18	Shrublands on calcareous silts
S01	<i>Astartea</i> aff. <i>fascicularis</i> / <i>Melaleuca</i> species dense shrublands
S05	<i>Acacia saligna</i> wetlands
Uplands centred on Bassendean dunes and Dandaragan Plateau	
21a	Central <i>Banksia attenuata</i> – <i>Eucalyptus marginata</i> woodlands
21b	Southern <i>Banksia attenuata</i> woodlands
21c	Low lying <i>Banksia attenuata</i> woodlands and shrublands
Uplands centred on Spearwood and Quindalup Dunes	
25	Southern <i>Eucalyptus gomphocephala</i> – <i>Agonis flexuosa</i> woodlands
29a	Coastal shrubland on shallow sands
30b	Quindalup <i>Eucalyptus gomphocephala</i> and/or <i>Agonis flexuosa</i> woodlands

3.5.3 Conservation significant ecological communities

A search of the EPBC Act PMST (DotEE, 2019b) and the DBCA TEC/PEC database identified 13 TEC / PECs that occur within the study area. A summary of the database findings is presented in Table 3-6 and the DBCA database results are shown in Figure 8, Appendix A.

Table 3-6 Threatened and Priority Ecological Communities identified in the desktop searches

COMMUNITY TYPE	EPBC ACT	DBCAs	DESCRIPTION	LOCATION ²
TECs / PECs within the survey area				
Banksia woodlands of the SCP (TEC, PEC)	Endangered	Priority 3	The ecological community is a woodland associated with the SWA. A key diagnostic feature is a prominent tree layer of <i>Banksia</i> , with scattered eucalypts and other tree species often present among or emerging above the <i>Banksia</i> canopy. The understorey is a species rich mix of sclerophyllous shrubs, graminoids and forbs. The ecological community is characterised by a high endemism and considerable localised variation in species composition across its range (TSSC, 2016).	89 occurrences mapped within the survey area 702 occurrences within the 5 km buffer of the survey area
Shrublands on dry clay flats (SCP10a)	Critically Endangered	Endangered	This ecological community forms a component of the Critically Endangered Clay Pans of the SWA TEC. This is the most rapidly drying of the clay flats vegetation community types. This vegetation community type has a high species richness and includes the aquatic annuals and geophytes typical of other clay pan and clay flat vegetation community types. The shrub layer is dominated by species of <i>Hakea</i> (<i>H. varia</i> and <i>H. sulcata</i>) which, along with <i>Pericalymma ellipticum</i> , is indicative of a short inundation period (TSSC, 2012)	One occurrence mapped within the survey area One occurrence within the 5 km buffer of the survey area
Tuart (<i>Eucalyptus gomphocephala</i>) Woodland and Forests of the SCP TEC, PEC Southern SCP <i>Eucalyptus gomphocephala</i> – <i>Agonis flexuosa</i> woodlands (SCP25)	Critically Endangered	Priority 3	Tuart (<i>Eucalyptus gomphocephala</i>) woodland and forests of the SCP TEC, listed in July 2019 as a Critically Endangered TEC under the EPBC Act and Priority 3 listed by DBCA. Mostly confined to Quindalup Dunes and Spearwood Dunes from Jurien Bay to the Sabina River, with outliers along some rivers. Tuart is the key dominant canopy species however Tuart communities comprise a variety of flora and fauna assemblages.	121 occurrences within 5 km buffer of the survey area

² Some TECs and PECs identified occur further than the study area. However since they were identified in the DBCA database searches they have been included.

COMMUNITY TYPE	EPBC ACT	DBCAs	DESCRIPTION	LOCATION ²
TECs / PECs within the 5 km buffer of the survey area				
Herb rich saline shrublands in clay pans (SCP07)	Critically Endangered	Vulnerable	This ecological community forms a component of the Critically Endangered Clay Pans of the SCP TEC. This vegetation community type occurs on heavy clay soils that are generally inundated from winter to mid-summer. Structurally this vegetation community type is quite variable ranging from woodlands to herblands, the most common overstorey species being <i>Melaleuca viminea</i> , <i>M. uncinata</i> , <i>M. cuticularis</i> or <i>Casuarina obesa</i> . Typical species in the understorey include the common herbs <i>Brachyscome bellidioides</i> , <i>Centrolepis polygyna</i> , <i>Pogonolepis stricta</i> and <i>Cotula coronopifolia</i> . In addition, species such as <i>Angianthus</i> aff. <i>drummondii</i> , <i>Eryngium pinnatifidum</i> subsp. <i>Palustre</i> (G.J. Keighery 13459) and <i>Blennospora drummondii</i> occur in low frequency (<50%) and are absent from the other four vegetation community types (SCP08, SCP09, SCP10a and 117) (TSSC, 2012).	Two occurrences mapped within the 5 km buffer of the survey area
Herb rich shrublands in clay pans (FCT - SCP08)	Critically Endangered	Vulnerable	This ecological community forms a component of the Critically Endangered Clay Pans of the SCP TEC. This vegetation community type occurs in low lying flats with a clay impeding layer allowing seasonal inundation. This vegetation community type is dominated by one or more of the shrubs: <i>Viminaria juncea</i> , <i>Melaleuca viminea</i> , <i>M. lateritia</i> , <i>Kunzea micrantha</i> or <i>K. recurva</i> with occasional emergent of <i>Eucalyptus wandoo</i> . Species such as <i>Hypocalymma angustifolium</i> , <i>Acacia lasiocarpa</i> var. <i>bracteolata</i> long peduncle variant (G. J. Keighery 5026) (P1) and <i>Verticordia huegelii</i> occur at moderate frequencies. This vegetation community type has a high percentage of weeds and appears to be the clay pan vegetation community type that has the greatest disturbance (TSSC, 2012).	Four occurrences mapped within the 5 km buffer of the survey area

COMMUNITY TYPE	EPBC ACT	DBCA	DESCRIPTION	LOCATION ²
Dense shrublands on clay flats (FCT – SCP09)	Critically Endangered	Vulnerable	<p>This ecological community forms a component of the Critically Endangered Clay Pans of the SCP TEC.</p> <p>This vegetation community type is shrublands or low open woodlands on clay flats that are inundated for long periods because it usually occurs very low in the landscape. Sedges are more apparent in this ecological community and include <i>Chorizandra enodis</i>, <i>Cyathochaeta avenacea</i>, <i>Lepidosperma longitudinale</i> and <i>Meeboldina coangustata</i>. Shrubs include <i>Hakea varia</i> and <i>Melaleuca viminea</i> and occasionally <i>Xanthorrhoea preissii</i>, <i>X. drummondii</i> and <i>Kingia australis</i>.</p> <p>This vegetation community type has a lower species richness and weed frequency than in the other clay pan community types, presumably because of the longer inundation times (TSSC, 2012).</p>	Two occurrences mapped within the 5 km buffer of the survey area
Shrublands on calcareous silts of the SCP (SCP18)		Vulnerable	<p>This ecological community is a very species rich community with a restricted distribution on calcareous silt flats. Common species are <i>Acacia saligna</i>, <i>Leptomeria lehmannii</i>, <i>Xanthorrhoea preissii</i>, <i>Gahnia trifida</i> and <i>Melaleuca teretifolia</i> (Gibson <i>et al.</i> (1994)).</p>	One occurrence within the 5 km buffer of the survey area
<i>Corymbia calophylla</i> woodlands on heavy soils of the southern SCP (SCP1b)		Vulnerable	<p>This ecological community consists largely of <i>C. calophylla</i> forests and woodlands of bushland remnants on the plain south of Capel (Gibson <i>et al.</i> (1994)).</p>	One occurrence within the 5 km buffer of the survey area

COMMUNITY TYPE	EPBC ACT	DBCAs	DESCRIPTION	LOCATION ²
Southern <i>Banksia attenuata</i> woodlands (SCP21b)	Endangered	Priority 3	<p>This ecological community forms a component of the Endangered <i>Banksia</i> Woodland TEC.</p> <p>This community is restricted to the sand sheets at the base of the Whicher Scarp, the sand sheets on elevated ridges or the sand plain south of Bunbury. Structurally, this community type is normally <i>Banksia attenuata</i> or <i>Eucalyptus marginata</i> – <i>B. attenuata</i> woodlands. Common species include <i>Acacia extensa</i>, <i>Jacksonia</i> sp. Busselton, <i>Laxmannia sessiliflora</i>, <i>Lysinema ciliatum</i> and <i>Johnsonia acaulis</i> (DBCAs, 2019a)</p>	Four occurrences mapped within the 5 km buffer of the survey area
Low lying <i>Banksia attenuata</i> woodlands or shrublands (SCP21c) <i>Banksia</i> woodlands of the SCP (TEC)	Endangered	Priority 3	<p>This ecological community forms a component of the <i>Banksia</i> Woodlands TEC.</p> <p>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 <i>Melaleuca preissiana</i>, <i>Banksia attenuata</i>, <i>B. menziesii</i>, <i>Regalia ciliata</i>, <i>Eucalyptus marginata</i> or <i>Corymbia calophylla</i>. Structurally, this community type may either be a woodland or occasionally shrubland (DBCAs, 2019a)</p>	One occurrence within the 5 km buffer of the survey area
Coastal shrublands on shallow sands (SCP29a)		Priority 3	Coastal shrublands on shallow sands are largely restricted to the Quindalup system, mostly heaths on shallow sands over limestone close to the coast.	Four occurrences mapped within the 5 km buffer of the survey area

COMMUNITY TYPE	EPBC ACT	DBCA	DESCRIPTION	LOCATION ²
Quindalup <i>Eucalyptus gomphocephala</i> and/or <i>Agonis flexuosa</i> woodlands (SCP30b)	Critically endangered	Priority 3	This ecological community can form a component of the 'Tuart (<i>Eucalyptus gomphocephala</i>) woodlands and forests of the Swan Coastal Plain' TEC and the Tuart Woodlands of the SCP PEC. This community is dominated by either Tuart or <i>Agonis flexuosa</i> . The presence of <i>Hibbertia cuneiformis</i> , <i>Geranium retrorsum</i> and <i>Dichondra repens</i> differentiate this group from other Quindalup community types. This type is found from the Leschenault Peninsular south to Busselton (DBCA, 2019a).	One occurrence within the 5 km buffer of the survey area
<i>Corymbia calophylla</i> - <i>Xanthorrhoea preissii</i> woodlands and shrublands of the SCP (SCP3c)	Endangered	Priority 3	The <i>Corymbia calophylla</i> - <i>Xanthorrhoea preissii</i> woodlands and shrublands of the SCP ecological community is one of three <i>Corymbia calophylla</i> dominated plant communities, which were historically probably some of the most common vegetation types on heavy soils on the eastern side of the SCP. Gibson <i>et al.</i> (1994) recognised three distinct communities in this group. The floristic composition of these communities varies with water regime, with this driest type dominated by <i>Corymbia calophylla</i> and <i>Xanthorrhoea preissii</i> . This ecological community aligns with the Gibson <i>et al.</i> (1994) community type 3c (DotEE, 2017)	Three occurrences mapped within the 5 km buffer of the survey area

3.5.4 Flora diversity

The NatureMap database search (DBCA, 2007-) identified 568 plant species, representing 92 families recorded within the study area. This total comprised 469 native flora species and 99 introduced flora species. Dominant families recorded within the study area included Fabaceae (70 species), Orchidaceae (50), Cyperaceae (39), Poaceae (39 species), and Asteraceae (32 species). The NatureMap database search is provided in Appendix C.

3.5.5 Conservation significant flora

Desktop searches of the EPBC Act PMST, NatureMap, DBCA TPFL and WAHERB databases identified the presence / potential presence of 39 conservation significant flora species within the study area, which includes two species that were identified by DBCA Flora Officer, Andrew Webb, as potentially occurring.

The desktop searches and consultation with DBCA identified 13 species listed under the EPBC Act and / or as Threatened under the BC Act and 26 listed as Priority species by the DBCA.

The locations of conservation significant flora registered on the DBCA databases are mapped in Figure 8, Appendix A.

4 SUMMARY OF PREVIOUS VEGETATION AND FLORA SURVEYS

A number of studies have been undertaken over sections of the survey area. An overview of previous survey effort is provided in Table 4-1 and the location of these surveys is illustrated in Figure 3, Appendix A.

Table 4-1 Summary of previous surveys

STUDY NAME	LOCATION/ EXTENT IN SURVEY AREA	COMMENTS
Lot 1 Ducane Road Environmental Values Assessment (GHD, 2014)	<p>GHD completed a flora and vegetation assessment of Lot 1 Ducane Road on the 13 June 2013. The assessment described the vegetation types present and their conditions and also searched for conservation significant flora.</p> <p>A total of 40.49 ha of this study is within the survey area.</p>	<p>The survey assessed vegetation types and floristic diversity for Lot 1 Ducane Road, which is located within the current survey area</p>
Vegetation and Flora survey of the BORR South Alignment (GHD, 2015)	<p>The GHD (2015) survey area was 112 ha in size and the report included a review of previous flora surveys for the alignment including:</p> <p>Bennett Environmental Consulting (2003) Vegetation and Flora of Selected Areas – Bunbury Outer Ring Road and Port Access Road for Main Roads Western Australia.</p> <p>Bennett Environmental Consulting (2008) Significant Flora Along Proposed Bunbury Ring Road for Main Roads Western Australia.</p> <p>GHD (2002) Bunbury Outer Ring Road and Port Access Road – Wetlands and Threatened Community Survey for Main Roads Western Australia.</p> <p>GHD (2009) Flora and Vegetation Survey for Main Roads Western Australia.</p> <p>GHD (2012) Flora and Vegetation Survey for Main Roads Western Australia.</p> <p>The survey was considered to be a level 2 assessment (as per the now superseded EPA guidelines). Phase 1 was carried out on the 21 – 23 September 2011 and Phase 2 from the 16 – 18 June 2014. A total of 21 quadrats were assessed and the vegetation types / their condition described. A total of 86.38 ha of this study is within the survey area.</p>	<p>This report has been used as the basis for the current assessment, including information on vegetation types and condition and species composition</p>
Bunbury Outer Ring Road Southern Section – Reassessment of Floristic	<p>Biota completed a targeted flora survey to further resolve the conservation status of vegetation types identified in the GHD (2012; 2015) flora surveys for BORR South. Two Biota botanists completed an additional seven quadrats on the 25 to 26 October 2016 and re-ran statistical analysis against both Biota and GHD quadrats to align vegetation types with</p>	<p>Re-assessment of FCTs within the current survey area and assessment of an additional seven quadrats (four within</p>

STUDY NAME	LOCATION/ EXTENT IN SURVEY AREA	COMMENTS
Communities (Biota, 2016)	Gibson <i>et al.</i> (1994) FCTs. The focus on this assessment was those vegetation types that were potentially TECs / PECs.	the current survey area)
Bunbury Outer Ring Road Southern Section – Banksia Woodlands TEC Assessment (Biota, 2018)	This assessment included a desktop component to identify potential areas of Banksia woodland TEC that were then targeted in the field survey. The field survey was carried out to determine the extent of Banksia Woodland TEC within the BORR South area and surrounds. The survey was carried out between 4 and 6 November 2017 by two Biota botanists. 24 target areas were sampled, using either quadrats (10 x 10 m) or mapping notes. A floristic analysis using PATN v3.1 was carried out to compare quadrats within the study area with those from the existing SCP vegetation data set arising from Gibson <i>et al.</i> (1994). A total of 25.58 ha of this study is within the survey area.	The area assessed provides the location of Banksia Woodland TEC within the survey area and surrounding vegetation
Report of a Targeted Rare Flora Survey for <i>Diuris drummondii</i> along four sections of the Bunbury Outer Ring Road proposed alignment (Ecoedge, 2017)	Ecoedge completed a targeted assessment on the 19 November and 30 November 2016 of portions of the BORR South proposed alignment that provide suitable habitat for <i>Diuris drummondii</i> . The survey was completed in accordance with the Commonwealths Draft Survey Guidelines for Australia’s Threatened Orchids (Commonwealth of Australia, 2013). A known population of the species nearby was used as a reference to determine when flowering had commenced and optimal timing for the survey. A total of 18.6 ha was searched, however no <i>D. drummondii</i> plants were found. A total of 15.50 ha of this study is within the survey area.	Provides information on the targeted survey for <i>D. drummondii</i> within the current survey area
Memorandum. Review of Potential Claypan Occurrences in the BORR Southern Section (Ecoedge, 2019b)	Ecoedge completed desktop review for the location of potential claypan wetlands, which identified one potential claypan wetland. The field survey determined that the wetland was not to be a claypan community.	Assessment for Claypan TEC within the Proposal Area that confirmed the TEC is not present

5 VEGETATION AND FLORA FIELD SURVEY RESULTS

5.1 Vegetation types

The survey area contains a combination of native vegetation and highly disturbed areas, including roads, road reserve and paddocks. A total of ten vegetation types comprising remnant native vegetation were identified and described from the survey area. A further three types, comprising highly disturbed areas, revegetation and planted vegetation were also identified and described.

The survey area occurs on the Bassendean and Spearwood Dunes and Pinjarra Plain. The sandy low dunes and plains were dominated by *Eucalyptus* / *Banksia* forests, in particular *Eucalyptus* / *Agonis* and *Banksia* woodlands / forests. The creeklines, swamps and low relief / seasonally inundated areas were dominated by *Eucalyptus rudis* / *Melaleuca preissiana* / *M. raphiophylla* woodlands. These were generally disturbed and the ground layer was dominated by introduced grasses and herbs. In the agricultural areas and some road reserves, native vegetation occurred as scattered remnant trees or stands over introduced grasses. The survey area included approximately 163.81 ha (53.18%) of native vegetation.

The survey identified ten vegetation types comprising remnant native vegetation. These include *Eucalyptus* and *Melaleuca* swamps / damplands, riverine / creekline vegetation, shrublands, *Eucalyptus* woodlands and *Eucalyptus* / *Banksia* woodlands as well as scattered remnant trees within agricultural areas and road reserves. A summary of these vegetation types, along with those comprising highly disturbed areas, revegetation or planted vegetation, is presented in Table 5-1 and they are mapped in Figure 9, Appendix A.

5.1.1 Floristic analysis

The similarity between all quadrats sampled within the survey area (BORR IPT, which includes GHD and Biota) sites was examined using PRIMER. Analysis was run using two scenarios:

- All species (base quadrat data)
- Native species only (weed species removed from each quadrat).

Of these two scenarios, the native species only scenario had the lowest stress value (0.13) indicating a reasonable representation. Using this scenario, the cluster analysis and resulting dendrogram (Appendix F) and two dimensional MDS scatter plot (Plate 3) showed general groupings of quadrats that broadly aligned with vegetation types.

Those vegetation units that most closely grouped were:

- VT6 – Closed tall scrub of *Melaleuca preissiana*, *Astartea scoparia* and *Kunzea glabrescens* over sedgeland: all four quadrats grouped together
- VT7 - Low open forest of *Melaleuca preissiana* and *M. raphiophylla* over sedgeland: four of the five quadrats grouped together.

The three *Eucalyptus* / *Agonis* / *Banksia* forest vegetation types (VT1, VT2 and VT4) generally grouped together across multiple clades. These vegetation types had 41 quadrats sampled from September 2011 to November 2018. They also occurred in varying degrees of condition (ranging from Degraded to Excellent). These vegetation types were very similar, with their differences in the field identified by changes in dominance of key species.

Those vegetation types that largely occurred in Degraded or worse condition and have experienced historical disturbance, occurred on multiple clades and showed limited similarity.

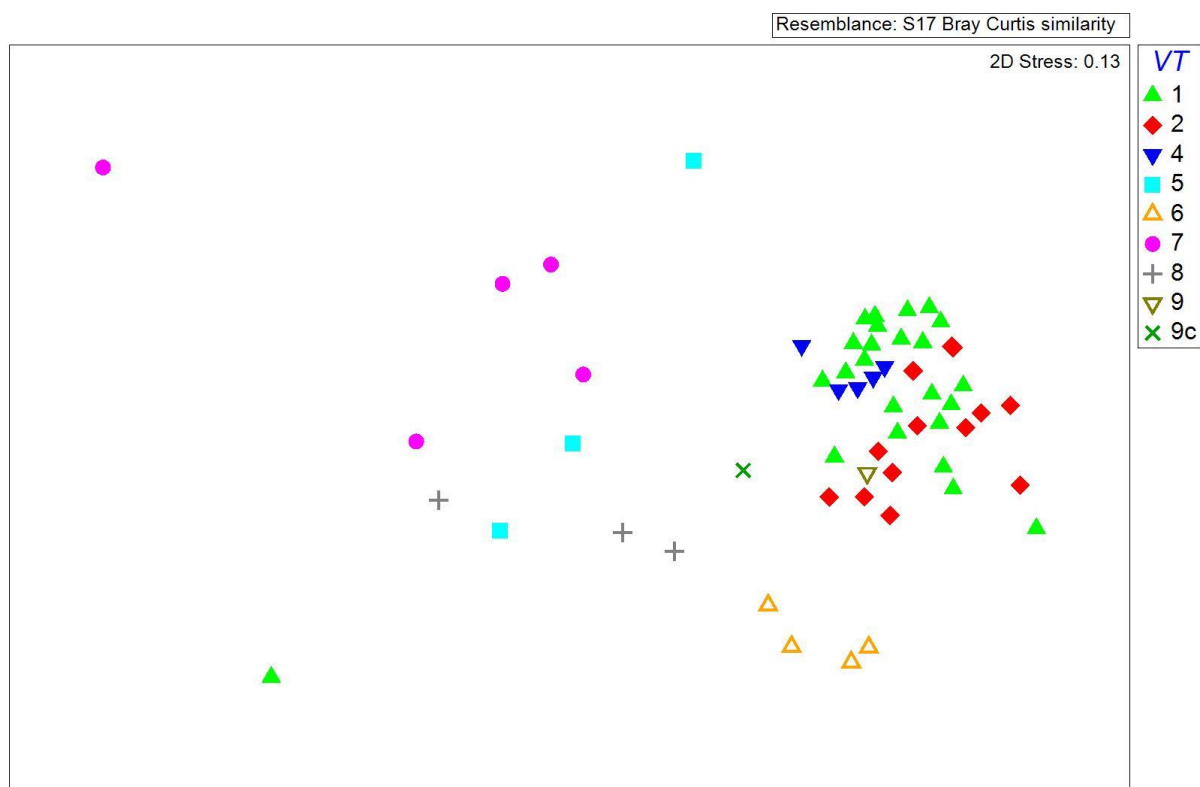


Plate 3 MDS showing general clustering of quadrats

All quadrats sampled within the survey area (BORR IPT, which includes GHD and Biota) and the SWA dataset for sites within the 5 km buffer (see section 2.2) were compared to assist in FCT assignment. The cluster analysis and resulting dendrogram (Appendix F) showed some similarities between the BORR IPT quadrats (which include GHD and Biota quadrats) and the SWA FCTs with some quadrats having affinities to:

- FCT 5
- FCT 21a and 21c
- FCT 6
- FCT 11

A two dimensional MDS scatter plot was also produced (Plate 4) and indicated that the survey quadrats (BORR IPT quadrats, which include GHD and Biota quadrats) plot near the following FCTs:

- FCT 17
- FCT 11
- FCT S05
- FCT 6
- FCT 25
- FCT 21c
- FCT 21a

However, there is no strong statistical alignment with any of the FCTs, and the stress value of 0.22 indicated a poor / random representation. Given the degraded nature of much of the survey area it was difficult to make firm conclusions regarding the appropriate FCT to assign to each vegetation type. Best matches were drawn from a combination of the statistical analysis and FCT descriptions.

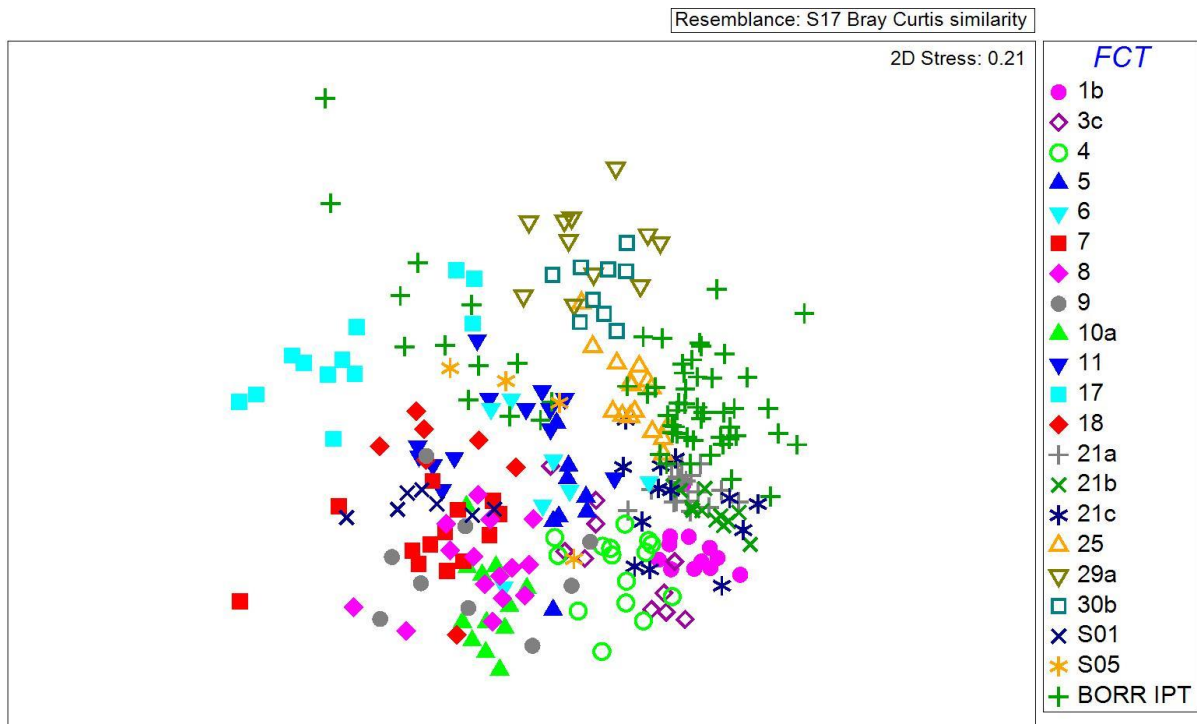


Plate 4 MDS showing showing BORR IPT quadrats compared to the SWA dataset

A species accumulation curve was generated using PRIMER to assess adequacy of sampling effort within the survey area (Plate 5). The species accumulation curve for the survey area, based on flora recorded within quadrats, is approaching an asymptote, which suggests that the current survey effort is sufficient. Furthermore, the bootstrap estimate of species richness generated from this data indicates that 289 species could be expected from the survey area based on the diversity recorded within quadrats. The total species recorded from the survey area was 428 flora species (267 recorded in the current survey), which is substantially above the predicted species diversity estimate. The survey area is considered representative of the floristic diversity in the area.

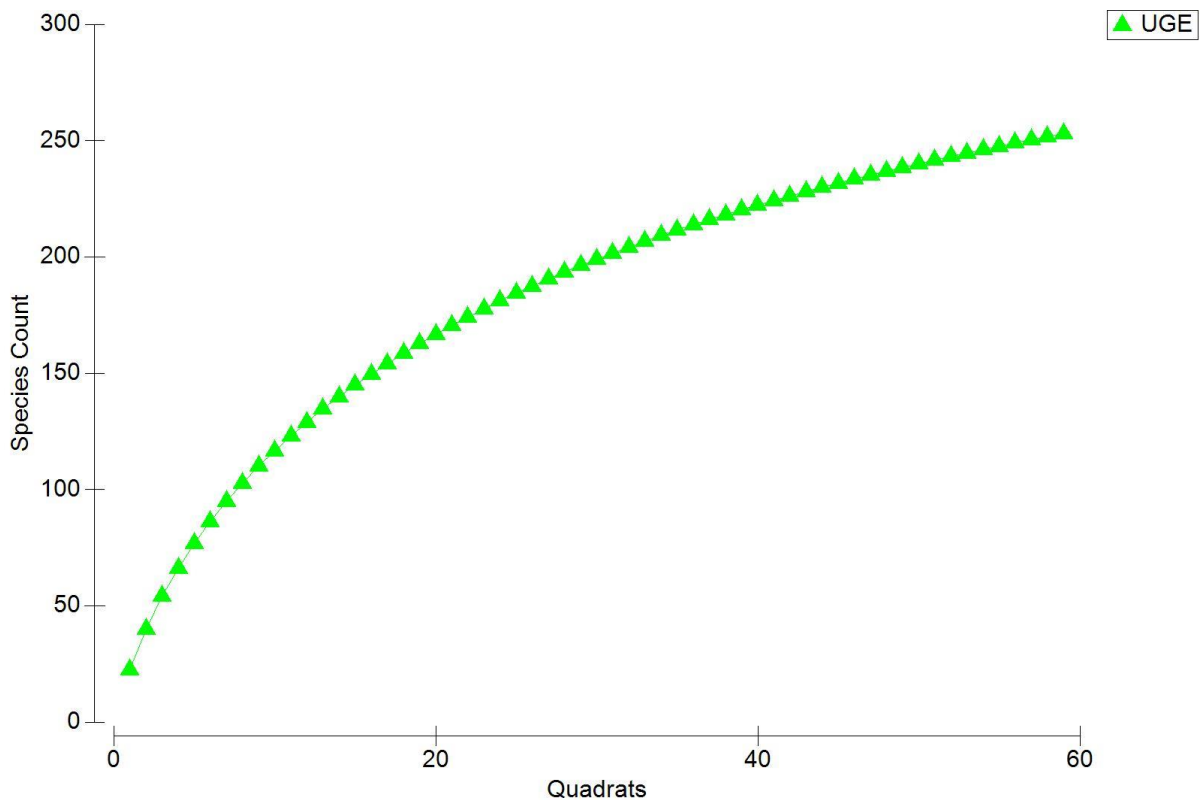


Plate 5 Species accumulation curve for quadrats within the survey area

5.1.2 Biota 2016


Biota (2016) completed additional floristic surveys (seven quadrats) and analysis of the combined GHD (2015) and Biota (2016) quadrat data against the SWA dataset. This assessment was targeted at the areas that were identified by GHD (2015) as potentially corresponding to SCP FCT 08 and SCP FCT 21b.



Biota (2016) concluded that floristic classification and analysis did not demonstrate that any of the quadrats sampled in the survey area should be assigned to either FCT 8 or FCT 21b. The most appropriate assignments for the vegetation types sampled comprise:



1. VT5 - Tall shrubland *Kunzea micrantha* subsp. *micrantha* and *Melaleuca viminea* over weeds: FCT 11, 'Wet forests and woodlands'.
2. VT2 'Open forest of *Eucalyptus marginata*, *Corymbia calophylla*, *Banksia attenuata* and *Agonis flexuosa* on Bassendean dunes': FCT 21a, 'Central *Banksia attenuata*-*Eucalyptus marginata* woodlands'.



Best matches were drawn from a combination of the statistical analysis and FCT descriptions (using dominant species and landform). FCT assignment to the BORR ITP vegetation types are shown in Table 5-1.



Table 5-1 Recorded vegetation types


VEGETATION DESCRIPTION	PHOTOGRAPH	LOCATION, CONDITION AND EXTENT WITHIN THE SURVEY AREA	SAMPLE LOCATIONS AND FLORISTIC COMMUNITY TYPES (FCT) COMPARISON
<i>Eucalyptus / Banksia</i> forests on sand dunes and plains			
<p>VT1 – Open forest of <i>Eucalyptus marginata</i>, <i>Corymbia calophylla</i> and <i>Banksia attenuata</i> on Karrakatta deep sands</p> <p>Open forest of <i>Eucalyptus marginata</i> and <i>Corymbia calophylla</i> +/- <i>Agonis flexuosa</i> over low open forest of <i>Banksia attenuata</i> over shrubland of <i>Hibbertia hypericoides</i>, <i>Macrozamia riedlei</i> and <i>Xanthorrhoea brunonis</i> over grassland over *<i>Ehrharta</i> spp., *<i>Briza maxima</i> over herbland of <i>Dasyopogon bromeliifolius</i>, <i>Lomandra</i> species and <i>Phlebocarya ciliata</i> over open sedgeland of <i>Lepidosperma pubisquameum</i>.</p>		<p>27.1 ha</p> <p>5.8 ha Excellent to Very Good</p> <p>4 ha Very Good</p> <p>0.6 ha Good / Very Good</p> <p>3.7 ha Good</p> <p>11.7 ha Good to Degraded</p> <p>0.7 ha Degraded</p> <p>0.5 ha Degraded – Completely Degraded</p> <p>0.02 ha Completely Degraded</p>	<p>Quadrats:</p> <p>GHD (2015a): Q1, Q2, Q3, Q4, Q5, Q6, Q9, Q10, Q18, Q20, T1, T2, T5, T8, T9</p> <p>Biota (2018) : GEL01 and GELREL01, 2018 : Quadrats GBRS01, GBRS02, GBRS05, GBRS08, GBRS11, GBRS13, GBRS14, GBRS15, GBRS16, GBRS17, GBRS18, GBRS19</p> <p>Photo points: GB01, GB04 - GB06, GB08 - GB10, GB22 - GB25, GB38, GB49 - GB51, GB58, GB75 - GB93</p> <p>FCT: Affinity to Southern <i>Eucalyptus gomphocephala</i>-<i>Agonis flexuosa</i> woodlands (FCT 25), however, Tuart did not form part of the overstorey. Represents occurrence of <i>Banksia</i> Woodlands TEC/PEC</p>



VEGETATION DESCRIPTION	PHOTOGRAPH	LOCATION, CONDITION AND EXTENT WITHIN THE SURVEY AREA	SAMPLE LOCATIONS AND FLORISTIC COMMUNITY TYPES (FCT) COMPARISON
<p>VT1b – Open forest of <i>Eucalyptus gomphocephala</i> with occasional <i>Eucalyptus marginata</i> over <i>Agonis flexuosa</i> and <i>Banksia attenuata</i> on yellow sand over limestone</p> <p>Open forest of <i>Eucalyptus gomphocephala</i> with occasional <i>Eucalyptus marginata</i> over <i>Agonis flexuosa</i> and <i>Banksia attenuata</i> scattered trees over *<i>Ehrharta</i> spp. and *<i>Briza maxima</i> grassland and mixed introduced herbs on yellow sand over limestone with some limestone outcropping at the surface. Some areas contain revegetation in the understorey.</p>		<p>7.4 ha</p> <p>3.7 ha Very Good</p> <p>2.9 ha Good to Degraded</p> <p>0.10 ha Degraded – Completely Degraded</p> <p>0.7 ha Completely Degraded</p>	<p>Quadrats: GBQ11</p> <p>Photo points: GB76, GB77, GB75</p> <p>FCT: Considered to be aligned with Southern <i>Eucalyptus gomphocephala</i>-<i>Agonis flexuosa</i> woodlands (FCT 25) and Tuart (<i>Eucalyptus gomphocephala</i>) woodlands of the Swan Coastal Plain TEC</p>
<p>VT2 – Open forest of <i>Eucalyptus marginata</i>, <i>Corymbia calophylla</i>, <i>Banksia attenuata</i> and <i>Agonis flexuosa</i> on Bassendean dunes</p> <p>Open forest of <i>Eucalyptus marginata</i>, <i>Corymbia calophylla</i> and <i>Agonis flexuosa</i> over low forest of <i>Banksia attenuata</i> and <i>B. ilicifolia</i> over tall shrubland of <i>Kunzea glabrescens</i>, <i>Jacksonia furcellata</i> and <i>Xylomelum occidentale</i> over shrubland of <i>Hibbertia hypericoides</i>, <i>Acacia</i> spp. and <i>Xanthorrhoea brunonis</i> over grassland / Sedgeland of <i>Tetraria octandra</i>, <i>Desmocladius fascicularis</i> and introduced grasses.</p>		<p>44.4 ha</p> <p>0.5 ha Excellent</p> <p>1.4 ha Excellent – Very Good</p> <p>0.5 ha Good</p> <p>36.8 ha Good to Degraded</p> <p>4.7 ha Degraded</p> <p>0.2 ha Degraded / Completely Degraded</p> <p>0.2 ha Completely Degraded</p>	<p>Quadrats:</p> <p>GHD (2014): Q2, Q3, Q6, Q4 and Q9.</p> <p>GHD (2015a): Q11, Q12, Q17, T6</p> <p>Biota (2016) : BOR05, BOR06 and BOR07</p> <p>2018: Quadrat GBR520</p> <p>Photo points: WPP53, WPP54, WPP57, WPP59 – WPP61, WPP63 – WPP65</p> <p>FCT: Central <i>Banksia attenuata</i> – <i>Eucalyptus marginata</i> woodland (FCT 21a)</p> <p>Represents occurrence of Banksia Woodlands TEC/PEC</p>

VEGETATION DESCRIPTION	PHOTOGRAPH	LOCATION, CONDITION AND EXTENT WITHIN THE SURVEY AREA	SAMPLE LOCATIONS AND FLORISTIC COMMUNITY TYPES (FCT) COMPARISON
<p>VT3 – <i>Corymbia calophylla</i> and <i>Eucalyptus marginata</i> +/- <i>Banksia</i> spp.</p> <p>Scattered <i>Eucalyptus marginata</i>, <i>Corymbia calophylla</i> and +/- <i>Agonis flexuosa</i> over a tall very open shrubland of <i>Banksia attenuata</i>, <i>B. ilicifolia</i>, <i>Xylomelum occidentale</i> and <i>Kunzea glabrescens</i> over a grassland of introduced species.</p> <p>Occurs in paddocks and road reserves.</p> <p>In the road reserve along South West Highway the shrubland is largely devoid and <i>Agonis flexuosa</i> is present in the tree layer.</p>		<p>4.0 ha</p> <p>3.8 Degraded</p> <p>0.10 ha Degraded to Completely Degraded</p> <p>0.10 ha Completely Degraded</p>	<p>Photo-points: GB18, GB26, GB27, GB35, GB36, GB43 – GB46, GB71</p> <p>FCT: Likely to be a degraded form of Central <i>Banksia attenuata</i> – <i>Eucalyptus marginata</i> woodland (FCT 21a) but as it only occurs in Degraded or worse condition, alignment with an FCT has not been confirmed.</p>
<p>VT4 – Open forest of <i>Banksia attenuata</i> and <i>Agonis flexuosa</i></p> <p>Open forest of <i>Banksia attenuata</i> and <i>Agonis flexuosa</i> over shrubland of <i>Hibbertia hypericoides</i>, <i>Macrozamia riedlei</i> and <i>Leucopogon propinquus</i> over open grassland of <i>*Ehrharta</i> spp. and <i>*Briza maxima</i> over herbland of <i>Dichopogon capillipes</i>, <i>Phlebocarya ciliata</i> and <i>Conostylis aculeata</i>.</p> <p>Scattered <i>Eucalyptus marginata</i> as an emergent.</p> <p>Occurs in one location on grey sands on a rounded hill slope.</p>		<p>3.5 ha</p> <p>0.7 ha in Very Good</p> <p>2.7 ha Very Good to Good</p>	<p>Quadrats:</p> <p>GHD (2015a): Q7, Q8</p> <p>Biota (2018): GEL03</p> <p>2018: Quadrats: GBR04 and GBR06</p> <p>Photo points: GB11, GB12, GB15, GB16</p> <p>FTC: Southern <i>Eucalyptus gomphocephala</i>-<i>Agonis flexuosa</i> woodlands (FCT 25)</p> <p>Represents occurrence of Banksia Woodlands TEC/PEC</p>

VEGETATION DESCRIPTION	PHOTOGRAPH	LOCATION, CONDITION AND EXTENT WITHIN THE SURVEY AREA	SAMPLE LOCATIONS AND FLORISTIC COMMUNITY TYPES (FCT) COMPARISON
<i>Eucalyptus / Melaleuca</i> Woodlands and Shrublands in creeklines / swamps and seasonally wet areas			
<p>VT5 - Tall shrubland of <i>Kunzea micrantha</i> subsp. <i>micrantha</i> and <i>Melaleuca viminea</i> over weeds</p> <p>Tall open shrubland of <i>Kunzea micrantha</i> subsp. <i>micrantha</i> and <i>Melaleuca viminea</i> over open sedgeland of <i>Lepidosperma longitudinale</i> and <i>Juncus subsecundus</i> over grassland of <i>*Briza maxima</i>, <i>*B. minor</i> and <i>*Ehrharta calycina</i>.</p>		<p>0.05 ha All Completely Degraded</p>	<p>Quadrats: GHD (2015a): Q13 Biota (2016): BOR03 and BOR04 FCT: Wet forests and woodlands (FCT 11)</p>
<p>VT6 - Closed tall scrub of <i>Melaleuca preissiana</i>, <i>Astartea scoparia</i> and <i>Kunzea glabrescens</i> over sedgeland</p> <p>Closed tall scrub of <i>Melaleuca preissiana</i>, <i>Kunzea glabrescens</i> and <i>Astartea scoparia</i> over a sedgeland of <i>Baumea juncea</i>, <i>Lyginia imberbis</i> and <i>*Cyperus tenellus</i> with introduced grass species over open herbland of <i>*Hypochaeris</i> sp., <i>*Ornithopus compressus</i> and <i>*Ursinia anthemoides</i>.</p>		<p>4.5 ha 0.6 ha Excellent – Good 2.6 ha Very Good to Good 0.3 ha Good 0.6 ha Good to Degraded 0.4 ha Completely Degraded</p>	<p>Quadrats: GHD (2014): Q5, Q8 GHD (2015a): Q14 2018: Quadrat GBR510 Photo points: GB68 - GB70, PP16, WPP58, WPP62. FCT: <i>Melaleuca preissiana</i> damplands (FCT 4)</p>

VEGETATION DESCRIPTION	PHOTOGRAPH	LOCATION, CONDITION AND EXTENT WITHIN THE SURVEY AREA	SAMPLE LOCATIONS AND FLORISTIC COMMUNITY TYPES (FCT) COMPARISON
<p>VT7 – Low open forest of <i>Melaleuca preissiana</i> and <i>Melaleuca raphiophylla</i> over sedgeland</p> <p>Low open forest of <i>Melaleuca preissiana</i>, <i>M. raphiophylla</i> and <i>M. viminea</i> over sedgeland of <i>Lepidosperma longitudinale</i>, <i>Juncus pallidus</i> and *<i>Carex divisa</i> with introduced grasses and herbs including *<i>Cynodon dactylon</i>, *<i>Lotus subbiflorus</i> and *<i>Cotula</i> species.</p> <p>Attached and floating aquatic species were present including: <i>Lemna disperma</i>, <i>Cycnogeton lineare</i> and *<i>Callitriche stagnalis</i>.</p>		<p>31.3 ha</p> <p>15.2 ha Good 3.6 ha Good to Degraded 3.5 ha Degraded 7.6 ha Degraded / Completely Degraded</p> <p>1.5 ha Completely Degraded</p>	<p>Quadrats: GHD (2015a): Q15, Q16, T7 2018: Releve and Quadrats GBRel01, GBRel02, GBRel03 and GBRS09 Photo points: GB56, GB57, GB61, GB64, GB67, GB73, PP14, PP19, PP22 FCT: <i>Melaleuca preissiana</i> damplands (FCT 4) / Wet forests and woodlands (FCT 11)</p>
<p>VT8 – Low open forest of <i>Eucalyptus rudis</i> and <i>Melaleuca preissiana</i> over sedgeland</p> <p>Low open forest of <i>Eucalyptus rudis</i> and <i>Melaleuca preissiana</i> over grassland of *<i>Ehrharta longiflora</i> and *<i>Avena</i> species over sedgeland of <i>Lepidosperma longitudinale</i> over herbland of *<i>Rumex</i> species.</p> <p>In Lot 1 Ducane Road an open tall shrubland of <i>Kunzea glabrescens</i> and <i>Melaleuca teretifolia</i> over open heath of <i>Astartea scoparia</i> over a sedgeland of <i>Hypolaena exsulca</i> and <i>Lepidosperma longitudinale</i> was present. This was the only occurrence of the vegetation in Very Good condition.</p> <p>Occurs along drainage lines and seasonally inundated areas.</p>		<p>3.4 ha</p> <p>1.1 ha Excellent to Very Good 1.7 ha Degraded 0.7 ha Degraded to Completely Degraded</p>	<p>Quadrats: GHD (2014): Q7 GHD (2015a): Q19, T3 2018: Quadrat GBRS03 Photo points: GB02, GB03, GB07, GB28, GB42, WPP55, WPP56, WPP42 FCT: Wet forests and woodlands (FCT 11)</p>

VEGETATION DESCRIPTION	PHOTOGRAPH	LOCATION, CONDITION AND EXTENT WITHIN THE SURVEY AREA	SAMPLE LOCATIONS AND FLORISTIC COMMUNITY TYPES (FCT) COMPARISON
Scattered remnant vegetation / Highly modified vegetation types			
<p>VT9 - Scattered remnant vegetation present in agricultural areas and along road reserves:</p> <ul style="list-style-type: none"> • VT09a - <i>Corymbia calophylla</i> and <i>Eucalyptus marginata</i> +/- <i>Agonis flexuosa</i> with very occasional <i>E. gomphocephala</i> • VT09b – <i>Melaleuca raphiophylla</i> • VT09c – <i>Corymbia calophylla</i> and <i>Eucalyptus marginata</i> with <i>Agonis flexuosa</i> over introduced grasses • VT09d: <i>Eucalyptus rudis</i> and <i>Corymbia calophylla</i> +/- <i>M. raphiophylla</i>, <i>M. preissiana</i> 		<p>VT9a: 19.1 ha (Degraded 1.6 ha, 12.7 ha Degraded to Completely Degraded, 4.8 Completely Degraded)</p> <p>VT9b: 1.6 ha (0.2 ha Degraded to Completely Degraded, 1.4 Completely Degraded)</p> <p>VT9c: 6.6 ha (Degraded 5.4 ha, 1.2 ha Degraded to Completely Degraded, 0.01 Completely Degraded)</p> <p>VT9d: 1.7 ha (Good to Degraded 0.02 ha, 0.6 ha Degraded, 0.4 ha Degraded to Completely Degraded, 0.7 Completely Degraded)</p>	<p>Quadrats: GHD (2015a): T1, T4 2018: Quadrats : GBR507</p> <p>Photo points: GB29 – GB31, GB40, GB53 – GB55, GB59, GB60, GB74, GB14, GB21, GB66, PP52, PP53</p> <p>FCT: N/A</p>

VEGETATION DESCRIPTION	PHOTOGRAPH	LOCATION, CONDITION AND EXTENT WITHIN THE SURVEY AREA	SAMPLE LOCATIONS AND FLORISTIC COMMUNITY TYPES (FCT) COMPARISON
<p>VT10 – Parkland cleared with scattered native / planted species</p> <p>Parkland cleared with occasional <i>Corymbia calophylla</i>, <i>Eucalyptus gomphocephala</i>, <i>E. marginata</i> and <i>Agonis flexuosa</i> trees with planted tree species over an understorey of weedy herbs and grasses.</p>		<p>7.4 ha</p> <p>0.5 ha Degraded</p> <p>0.1 ha Degraded to Completely Degraded</p> <p>6.8 ha Completely Degraded</p>	<p>Photo points: 2018: GB48, GB19, GB20, GB41, GB47</p> <p>FCT: N/A</p>
<p>VT10b - Revegetation in road reserves</p> <p>This includes revegetation as well as areas planted with a mixture of native and non-native vegetation. There are scattered remnant trees occasionally present (including <i>Corymbia calophylla</i>, <i>Eucalyptus marginata</i>, <i>E. utilis</i> (planted), <i>E. rudis</i>, <i>Agonis flexuosa</i> and <i>Casuarina obesa</i>). Common shrubs include <i>Melaleuca nesophila</i>, <i>M. lanceolata</i>, <i>Kunzea glabrescens</i> and <i>Acacia saligna</i>. The understorey was mostly dominated by introduced grasses and herbs. This vegetation unit occurred within the median strip of Bussell Highway.</p>		<p>1.7 ha</p> <p>0.9 ha Degraded</p> <p>0.2 ha Degraded to Completely Degraded</p> <p>0.5 ha Completely Degraded</p>	<p>Photo points: 2018: GB45, GB42</p> <p>FCT: N/A</p>

VEGETATION DESCRIPTION	PHOTOGRAPH	LOCATION, CONDITION AND EXTENT WITHIN THE SURVEY AREA	SAMPLE LOCATIONS AND FLORISTIC COMMUNITY TYPES (FCT) COMPARISON
<p>Cleared / highly modified</p> <p>Areas where clearing or other activities have fundamentally altered the composition of native vegetation and are not in a condition of self-sustaining. These areas are completely without native species.</p>		<p>186.1 ha</p>	<p>Photo points: 2018 GB13, GB37, GB39, GB62, GB63, GB65, PP13, PP17, WPP43 FCT: N/A</p>

5.2 Vegetation condition

The vegetation condition of the survey area ranged from Excellent to Completely Degraded. Over half of the survey areas was cleared / highly modified (186.1 ha or 53.2 %). Historical clearing and aggressive weed species have influenced the structure and composition of the remaining native vegetation. There was 43.5 ha of vegetation in Good or better condition (approximately 12.4 % of the survey area) and 119.7 ha in Good to Degraded or worse condition (approximately 34.2 % of the survey area).

Through the southern section of the survey area, the vegetation condition predominantly was rated between Very Good to Degraded. Native vegetation within this section has been severely impacted by partial clearing and weed invasion.

The northern section of the survey area was largely rated between Degraded to Completely Degraded. These areas were highly disturbed for agricultural purposes and comprised scattered native trees over weedy herbs and grasses.

The majority of vegetation within the survey area has not been burnt in the last five to 20 years. A section of recently burnt bushland located within the median strip along Bussell Highway has been burnt in the last year and was observed to be regenerating. Within the survey area, small patches of vegetation have been burnt in the last 5- 10 years, however, this has not significantly impacted the vegetation condition.

A summary of the vegetation condition is provided in Table 5-2 and vegetation condition mapping is shown in Figure 10, Appendix A.

Table 5-2 Extent of vegetation condition ratings mapped within the survey area

VEGETATION CONDITION	EXTENT IN SURVEY AREA (HA) (%)
Excellent	0.5 ha (0.1 %)
Excellent – Very Good	9.0 ha (2.6 %)
Very Good	8.4 ha (2.4 %)
Very Good – Good	5.9 ha (1.7 %)
Good	19.7 ha (5.6 %)
Good – Degraded	56.3 ha (15.9 %)
Degraded	22.9 ha (6.5 %)
Degraded – Completely Degraded	24.0 ha (6.9 %)
Completely Degraded	17.2 ha (4.9 %)
Cleared / highly modified	186.1 ha (53.2 %)
Total	349.9 ha

5.3 Threatened and Priority Ecological Communities

Threatened and Priority Ecological Communities were identified by assessing the vegetation types, landform features and field observations, coupled with the statistical analyses. Two TECs and three PECs were identified within the survey area Table 5-3.

Table 5-3 Extent of TECs and PECs mapped within the survey area

TEC / PEC	STATUS	EXTENT IN SURVEY AREA
Banksia Woodlands of the SCP TEC	Endangered TEC – EPBC Act	33.9 ha
Banksia Woodlands of the SCP PEC	Priority 3 PEC – DBCA	33.9 ha
Tuart (<i>Eucalyptus gomphocephala</i>) Woodlands and Forests of the SCP TEC	Critically Endangered TEC – EPBC Act	7.3 ha
Tuart (<i>Eucalyptus gomphocephala</i>) Woodlands and Forests of the SCP PEC	Priority 3 PEC – DBCA	7.3 ha
Southern SCP <i>Eucalyptus gomphocephala</i> – <i>Agonis flexuosa</i> woodlands (FCT25)*	Priority 3 PEC – DBCA	7.4 ha

* can be a component of the Endangered Banksia Woodlands of the Swan Coastal Plain EPBC listed TEC, or the Tuart woodlands of the Swan Coastal Plain PEC


A discussion is also provided on other TECs / PECs considered to show affinities to vegetation but were deemed to not meet the descriptions / criteria for the TEC or PEC determination.



The spatial distribution of these communities are presented in Figure 11, Appendix A.



5.3.1 Banksia Woodlands of the Swan Coastal Plain (TEC / PEC)



The Banksia Woodlands were assessed by Biota (2018) during the 2018 and 2019 flora and vegetation surveys. Vegetation types 1, 2 and 4 were considered to contain patches that represent the Banksia Woodland TEC. In total, 33.9 ha of vegetation types 1, 2 and 4 met the criteria for the Banksia TEC over five patches. The spatial distribution of these TECs patches is presented in Figure 11, Appendix A. Table 5-4 outlines the TEC assessment and patch sampling details.


Table 5-4 Summary of patch field assessment for Banksia Woodland TEC/PEC

PATCH	MAPPED VT AND SURVEY SITES	CONDITION AND SIZE	TEC/PEC NOTES	PHOTOGRAPH	OUTCOME
<p>Patch 1 - Bussell Highway road reserve from Calinup and Lakes road intersection extending north of Woods road.</p>	<p>VT1 – Open forest of <i>Eucalyptus marginata</i>, <i>Corymbia calophylla</i> and <i>Banksia attenuata</i> on Karrakatta deep sands and</p> <p>VT4 - Open forest of <i>Banksia attenuata</i> and <i>Agonis flexuosa</i></p> <p>Quadrats GBQ18, GBQ17, GBQ16, GBQ14, GBQ15, GBQ13, GBQ5, GBQ4, GBQ6</p>	<p>Very Good to Completely Degraded (24.0 ha) within the survey area:</p> <ul style="list-style-type: none"> • 1.2 ha Excellent to Very Good • 4.7 ha Very Good • 3.3 ha Very Good to Good • 1.6 ha Good • 11.7 ha Good to Degraded • 0.7 ha Degraded • 0.5 ha Degraded to Completely Degraded • 0.07 ha Completely Degraded 	<p><i>B. attenuata</i> present in patch at 2 – 20 % cover.</p> <p>Patch size outside survey area to the west is approximately > 200 ha in size of similar <i>Eucalyptus / Banksia</i> open forest vegetation type in Very Good condition.</p>		<p>23.9 ha Banksia Woodlands of the SCP TEC/PEC</p> <p>Patch extends outside the survey area > 200 ha in size in total.</p>

PATCH	MAPPED VT AND SURVEY SITES	CONDITION AND SIZE	TEC/PEC NOTES	PHOTOGRAPH	OUTCOME
Patch 2 – North of Jilly Road	VT1 – Open forest of <i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> and <i>Banksia attenuata</i> on Karrakatta deep sands Quadrats GBQ2	Excellent to Very Good (4.6 ha) within the survey area. Not mapped in the adjacent land, visual assessment only ranged from Very Good to Degraded.	<i>B. attenuata</i> present in patch at 2 – 20 % cover. Patch size outside of the survey area to the north is continuous and contains similar <i>Eucalyptus</i> / <i>Banksia</i> open forest vegetation type with areas in Very Good to Degraded condition.		4.6 ha Banksia Woodlands of the SCP TEC/PEC Patch extends outside the survey area.
Patch 3 – Marchetti Road	VT2 - Open forest of <i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> , <i>Banksia attenuata</i> and <i>Agonis flexuosa</i> on Bassendean dunes. Visual assessment.	Excellent within the survey area (0.5 ha). Not mapped in the adjacent land, visual assessment only ranged from Excellent to Degraded.	<i>B. attenuata</i> present in patch at 2 – 20 % cover. Patch size outside survey area to the north is continuous and contains similar <i>Eucalyptus</i> / <i>Banksia</i> open forest vegetation type with areas in Very Good condition.		0.5 ha Banksia Woodlands of the SCP TEC/PEC Patch extends outside the survey area.

PATCH	MAPPED VT AND SURVEY SITES	CONDITION AND SIZE	TEC/PEC NOTES	PHOTOGRAPH	OUTCOME
Patch 4 - South of Ducane Road	VT2 Open forest of <i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> , <i>Banksia attenuata</i> and <i>Agonis flexuosa</i> on Bassendean dunes. Visual assessment.	Degraded to Completely Degraded (0.7 ha) within the survey area.	<i>B. attenuata</i> is present in patch at 2-5 % cover. Does not meet patch size and condition criteria for the TEC/PEC.		Does not meet Banksia Woodlands TEC/PEC due to small size and condition.
Patch 5	VT2 Open forest of <i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> , <i>Banksia attenuata</i> and <i>Agonis flexuosa</i> on Bassendean dunes. Visual assessment.	Very-Good to Excellent to Completely Degraded (39 ha) within the survey area: <ul style="list-style-type: none"> • 1.5 ha Very-Good to Excellent • 0.5 ha Good • 36.8 ha Good to Degraded • 0.02 ha Degraded • 0.04 ha Degraded to Completely Degraded • 0.2 ha Completely Degraded 	<i>B. attenuata</i> present in patch at 2 – 20 % cover. Patch size outside of the survey area to the north and west is continuous and contains similar <i>Eucalyptus</i> / <i>Banksia</i> open forest vegetation type with areas in Good to Completely Degraded condition. Patch		2.8 ha Banksia Woodlands of the SCP TEC/PEC.

PATCH	MAPPED VT AND SURVEY SITES	CONDITION AND SIZE	TEC/PEC NOTES	PHOTOGRAPH	OUTCOME
			condition is mostly Degraded.		
Patch 6	<p>VT3 Scattered <i>Eucalyptus marginata</i>, <i>Corymbia calophylla</i> and +/- <i>Agonis flexuosa</i> over a tall open Shrubland of <i>Banksia attenuata</i>, <i>Banksia ilicifolia</i>, <i>Xylomelum occidentale</i> and <i>Kunzea glabrescens</i> over grassland over introduced grasses. Larger <i>B. attenuata</i> trees present.</p> <p>Visual assessment</p>	Degraded to Completely Degraded (2.1 ha) within the survey area.	<i>B. attenuata</i> is present in patch at 2-5 % cover. Does not meet patch size and condition criteria for the TEC/PEC.		Does not meet Banksia Woodlands TEC/PEC due to condition.
Patch 7 – Lot 161	<p>VT3 Scattered <i>Eucalyptus marginata</i>, <i>Corymbia calophylla</i> and +/- <i>Agonis flexuosa</i> over a tall open shrubland of <i>Banksia attenuata</i>, <i>Banksia ilicifolia</i>, <i>Xylomelum occidentale</i> and <i>Kunzea glabrescens</i> over grassland over introduced grasses. Larger <i>B. attenuata</i> trees present.</p>	Degraded to Completely Degraded (0.2 ha) within the survey area. Extends outside the survey area.	<p><i>B. attenuata</i> is present in patch at 2-20 % cover.</p> <p>Does not meet patch size and condition criteria for the TEC/PEC.</p>		Does not meet Banksia Woodlands TEC/PEC due to condition.

PATCH	MAPPED VT AND SURVEY SITES	CONDITION AND SIZE	TEC/PEC NOTES	PHOTOGRAPH	OUTCOME
	Visual assessment				
Patch 8 – Centenary road	VT1 – Open forest of <i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> and <i>Banksia attenuata</i> on Karrakatta deep sands Quadrat GBQ08	Good (2.11 ha) within the survey area. Extends outside the survey area.	<i>B. attenuata</i> is present in patch at 2-20 % cover. Patch size outside survey area to the north is continuous and contains similar <i>Eucalyptus</i> / <i>Banksia</i> open forest vegetation type with areas in Excellent to Very Good condition.		2.11 ha Banksia Woodlands of the SCP TEC/PEC (part of larger patch) Patch extends outside the survey area.
Patch 9 - Bussell highway near Golf course	VT3 Scattered <i>Eucalyptus marginata</i> , <i>Corymbia calophylla</i> and +/- <i>Agonis flexuosa</i> over a tall open shrubland of <i>Banksia attenuata</i> , <i>Banksia ilicifolia</i> , <i>Xylomelum occidentale</i> and <i>Kunzea glabrescens</i> over grassland over introduced grasses. Larger <i>B. attenuata</i> trees present.	Degraded (0.9 ha) within the survey area.	<i>B. attenuata</i> is present in patch at 2-5 % cover. Does not meet patch size and condition criteria for the TEC/PEC.	Photo unavailable	Does not meet Banksia Woodlands TEC/PEC due to condition.

PATCH	MAPPED VT AND SURVEY SITES	CONDITION AND SIZE	TEC/PEC NOTES	PHOTOGRAPH	OUTCOME
	Visual assessment				
Patch 10 – Bussell Highway at junction with Hasties Road	<p>VT3 Scattered <i>Eucalyptus marginata</i>, <i>Corymbia calophylla</i> and +/- <i>Agonis flexuosa</i> over a tall open shrubland of <i>Banksia attenuata</i>, <i>Banksia ilicifolia</i>, <i>Xylomelum occidentale</i> and <i>Kunzea glabrescens</i> over grassland over introduced grasses. Larger <i>B. attenuata</i> trees present.</p> <p>Visual assessment</p>	Degraded to Completely Degraded (0.8 ha) within the survey area.	<i>B. attenuata</i> is present in patch at 2-5 % cover. Does not meet patch size and condition criteria for the TEC/PEC.	Photo unavailable	Does not meet Banksia Woodlands TEC/PEC due to condition.

5.3.2 Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain (TEC/PEC)

Areas of potential Tuart TEC were identified through the desktop review (including soils mapping), previous surveys in the area (GHD, 2015; Biota, 2018), initial site reconnaissance visit and aerial photography. These areas were assessed (using quadrats and traverses) during the 2018 and 2019 surveys. In addition, Ecoedge sampled two Tuart quadrats (JENO01 and JENO02) during the 2019 surveys. Tuart assessment quadrats were assessed across potential Tuart TEC patches. The Tuart TEC assessment was undertaken in accordance with the Approved Conservation Advice (DotEE, 2019a) and Main Roads draft Tuart Guidance Factsheet version 9th July 2019 (Main Roads, 2019).

Part of VT1b is considered to be representative of the Tuart TEC. VT1b contained two separate Tuart patches, patch 1 and patch 2. Patch 1 was assessed and determined to meet the key diagnostic characteristics of the Tuart TEC as the patch is > 5 ha and therefore no condition thresholds are required to be met. The Tuart quadrats assessed had between 18-20 native species (< 3 m) in the understorey which is classed as Very High Tuart condition. In total, 7.3 ha of Tuart TEC occurs within the survey area (patch 1). Patch 1 extends outside the survey area to the north and south with an approximate area of 25 ha. Total patch 1 size is approximately 32.3 ha.

Patch 2 was assessed and determined not to meet the key diagnostic characteristics of the Tuart TEC as the patch is between 0.5 – 2 ha (0.52 ha in total with 0.10 ha inside survey area) and therefore must have at least eight native understorey species per 0.01 ha (10 x 10 m) to qualify as the TEC. The Tuart01 quadrat has only seven native understorey species (10 x 10 m).

Patch 3, which occurs as part of vegetation type VT9a *Corymbia calophylla* and *Eucalyptus marginata* +/- *Agonis flexuosa* with very occasional *E. gomphocephala* was assessed and determined that it does not meet key diagnostic characteristics of the Tuart TEC as the patch is < 0.5 ha (0.4 ha). The patch is predominately parkland cleared.



The spatial distribution of Tuart survey quadrats and patches 1- 3 are presented in Figure 11, Appendix A. Detailed patch assessment information is presented in Appendix I. A summary of the patch assessment is presented in Table 5-5.



5.3.3 Southern SCP *Eucalyptus gomphocephala* – *Agonis flexuosa* woodlands (FCT 25) PEC

The field assessment also confirmed the presence of the Southern SCP *Eucalyptus gomphocephala*-*Agonis flexuosa* woodlands (FCT25) PEC listed as Priority 3 by DBCA. Vegetation type 1b (patches 1 and 2) are considered to be representative of the PEC. VT9a patch 3 is not considered to be representative of the PEC as VT9a is dominated by Jarrah (*E. marginata*) and Marri (*C. calophylla*) and is not dominated by Tuart trees across the vegetation type extent. In total, 7.3 ha of the Southern SCP *Eucalyptus gomphocephala*-*Agonis flexuosa* woodlands (FCT25) PEC occurs within the survey area. The spatial distribution of Tuart survey quadrats and patches 1- 3 are presented in Figure 11, (Appendix A). Detailed patch assessment information is presented in Appendix H. A summary of the patch assessment is presented in Table 5-5.

FCT 25 - Southern *Eucalyptus gomphocephala*-*Agonis flexuosa* woodlands has been mapped by DBCA within the survey area. Consultation with Mr. Andrew Webb from DBCA (pers. comm. 2011 and 2015) has confirmed that the vegetation types in this area represent FCT 25.

Table 5-5 Summary of patch field assessments for Tuart Woodland TEC/PEC

PATCH	MAPPED VT AND SURVEY SITES	CONDITION AND SIZE	TEC/PEC NOTES	PHOTOGRAPH	OUTCOME
Patch 1	VT1b – Open forest of <i>Eucalyptus gomphocephala</i> with occasional <i>Eucalyptus marginata</i> over <i>Agonis flexuosa</i> and <i>Banksia attenuata</i> on yellow sand over limestone. Quadrats JENO01, JENO02	Very Good to Completely Degraded (7.3 ha) within the survey area: <ul style="list-style-type: none"> • 3.7 ha Very Good • 2.9 ha Good to Degraded • 0.008 ha Degraded – Completely Degraded • 0.7 ha Completely Degraded 	Patch contains numerous mature trees within the patch. There are >200 Tuart trees in the patch over 15 cm DBH. Patch extends outside the survey area. Patch size outside of the survey area is approximately 25 ha. Total is 32.3 ha	 <p>JENO01</p>	7.3 ha Tuart (<i>Eucalyptus gomphocephala</i>) Woodlands and Forests of the Swan Coastal Plain TEC/PEC 7.3 ha Southern SCP <i>Eucalyptus gomphocephala</i> - <i>Agonis flexuosa</i> woodlands (FCT25) PEC Patch extends outside the survey area > 32 ha in size in total.
				 <p>JENO02</p>	

PATCH	MAPPED VT AND SURVEY SITES	CONDITION AND SIZE	TEC/PEC NOTES	PHOTOGRAPH	OUTCOME
Patch 2	VT1b – Open forest of <i>Eucalyptus gomphocephala</i> with occasional <i>Eucalyptus marginata</i> over <i>Agonis flexuosa</i> and <i>Banksia attenuata</i> . Quadrat Tuart01	Degraded to Completely Degraded (0.1 ha) within the survey area <ul style="list-style-type: none"> 0.10 ha Degraded – Completely Degraded 	Patch contains 10 mature Tuart trees within the patch. Patch extends outside the survey area. Patch size outside of the survey area is approximately 0.42 ha. Total is 0.52 ha.	 Tuart01	Does not meet Tuart (<i>Eucalyptus gomphocephala</i>) Woodlands and Forests of the SCP TEC/PEC due to small size and lack of understorey species diversity. 0.1 ha Southern SCP <i>Eucalyptus gomphocephala</i> - <i>Agonis flexuosa</i> woodlands (FCT25) PEC
Patch 3	VT9a – <i>Corymbia calophylla</i> and <i>Eucalyptus marginata</i> +/- <i>Agonis flexuosa</i> with very occasional <i>E. gomphocephala</i> . Quadrat Tuart02	Degraded to Completely Degraded (0.4 ha) within the survey area <ul style="list-style-type: none"> 0.13 ha Degraded 0.24 ha Degraded – Completely Degraded 	Patch contains 4 mature Tuart trees within the patch. Patch extends outside the survey area. Patch size outside of the survey area is approximately 0.1 ha. Total is 0.46 ha.	 Tuart02	Does not meet Tuart (<i>Eucalyptus gomphocephala</i>) Woodlands and Forests of the SCP TEC/PEC due to small size and lack of understorey species diversity, and due to VT9a being dominated by Jarrah (<i>E. marginata</i>) and Marri (<i>C. calophylla</i>) and not dominated by Tuart trees across the vegetation type extent. Does not meet Southern SCP <i>Eucalyptus gomphocephala</i> - <i>Agonis flexuosa</i> woodlands (FCT25) PEC.

5.3.4 Herb rich shrublands in clay pans (TEC)

The clay pan communities occur where clay substrate is low in the landscape and form an impermeable layer close to the surface. These wetlands rely on rainfall and local surface drainage to fill and are unlikely to be connected to groundwater. A suite of perennial plants and annual herbs flower as the clay pans dry out (DBCA, 2019b).

Herb rich shrublands in clay pans (FCT 8), which is a State (Vulnerable) and Federally listed (Critically Endangered) TEC (as a component of the Claypans of the SCP TEC), is located within 2.8 km of the survey area. GHD (2015) quadrat 13, which is located within vegetation type 5 shares some similarities in dominant overstorey species and annual weed species to that of FCT 8. Biota (2016) assessed two quadrats at this location and determined that the most appropriate assignment for this vegetation type is 'FCT 11 - Wet forests and woodlands' and VT5 is therefore not considered to be consistent with the FCT 8 TEC.

Ecoedge (2019b) (Appendix G) completed desktop review for the location of potential claypan wetlands, which identified one potential claypan wetland on lots 5 and 160 south of Centenary Road. The site was visited on 1 August 2019 by two Ecoedge botanists, DBCA Senior Botanist (Andrew Webb) and a MRWA representative, Senior Environmental Officer (Dr. Freea Itzstein-Davey).

The wetland was found not to be a claypan community, the soil being a sandy-loam at the surface. The vegetation was dominated by *Melaleuca raphiophylla* and *M. viminea*, with an open sedgeland of *Lepidosperma longitudinale* over a grassland of *Sporobolus virginicus*. A copy of the memorandum on the site visit is included at Appendix G.

5.4 Other significant vegetation

The survey area traverses a number of creeklines, small drainage lines, as well as seasonally inundated areas (wetlands) that support riparian vegetation. Vegetation associated with the riverine and wetland areas includes remnant trees and shrubs (e.g. *E. rudis*, *Melaleuca preissiana* and *Melaleuca raphiophylla*) over introduced grasses and herbs, with mixed sedges present. Vegetation types 5, 6, 7 and 8 are all associated with riparian vegetation.

There is approximately 39.2 ha of vegetation within the survey area that grows in association with a watercourse and/or wetland. This vegetation has a restricted distribution and has been historically impacted by extensive clearing throughout the local and broad areas. Riparian and wetland vegetation in Good or better condition (approximately half of the riparian vegetation) is considered to be other locally significant vegetation, not listed as a TEC / PEC:

- 19.8 ha in Good to Very Good condition – other significant vegetation
- 19.5 ha in Good – Degraded to Completely Degraded condition – mostly occurs as scattered trees over introduced grasses and herbs, not considered to be other significant vegetation.

5.5 Flora diversity

The floristic diversity of the survey area has been assessed by combining survey data from GHD (2014; 2015), Biota (2016; 2018) and the current survey (Appendix E). A total of 428³ species have been recorded across these surveys including 119 introduced or planted species (28 %).

During the recent survey, 289 plant species (including subspecies and varieties) representing 227 genera and 71 plant families were recorded within the survey area. This total included 198 (68.5 %) native species and 91 introduced (exotic/planted) (31.5 %) species.

³ Some of these surveys extended outside the current survey area.

Table 5-6 provides a summary of the records of previous flora surveys and the current survey.

Table 5-6 Floristic diversity of the survey area

SURVEY	TOTAL SPECIES	TOTAL NATIVE: WEED	COMMENTS
Current survey (2018 and 2019)	289	198: 91	Survey over multiple sites, August, September and October survey with over 30 % introduced species.
GHD 2014	101	81: 23	Smaller survey area with few vegetation types, winter survey only.
GHD 2015	194	145: 53	Similar survey area as the current survey, September and June survey period.
Biota 2016	96	62: 34	Restricted to small survey area with only few vegetation types.
Biota 2018	115	92: 20	Survey of potential Banksia woodland TEC only.

5.6 Conservation significant flora

No EPBC Act or BC Act listed flora were recorded within the survey area. Furthermore, the previous surveys in November 2007 (Bennett Environmental Consulting, 2008), October 2008 (GHD, 2009), November 2011 and June 2014 (GHD, 2015), June 2013 (GHD, 2014), October 2016 (Biota, 2016) and November 2017 (Biota, 2018) did not record any EPBC Act or BC Act listed flora. Ecoedge (2017; 2019a) completed a targeted assessment for *Diuris drummondii* (an EPBC Act and BC Act listed species), and did not identify any *D. drummondii* plants (further details on this assessment are provided below).

5.6.1 Species recorded during field surveys

Three DBCA Priority-listed flora species were recorded within the survey area during the field surveys.

The location of the three priority flora is shown in Figure 11 (Appendix A). Species location data and number of plants recorded is presented in Appendix E.

Lasiopetalum membranaceum (Priority 3)

Lasiopetalum membranaceum is a shrub to 1 m high with pink-purple flowers, and flowers during September to December. The species grows in sand over limestone and is recorded from the SCP bioregion, with outliers in the Jarrah Forest and Warren bioregions (WA Herbarium, 1998-). This species is known locally from nine records within 5 km of the survey area (WA Herbarium, 1998-), with the closest record 0.23 km from the survey area. Regionally the species is known from 73 records (DBCA, 2007-) across its full distribution.

Lasiopetalum membranaceum was recorded from one location with one individual that has been impacted by stock grazing (Plate 6). It was recorded in degraded habitat in open forest of *Eucalyptus gomphocephala* with occasional *Eucalyptus marginata* (VT1b). The record is from the northern extent of the survey area.

Caladenia speciosa (Priority 4)

The Sandplain White Spider Orchid (*Caladenia speciosa*) (Plate 7) is a tuberous, perennial herb approximately 0.35 to 0.6 m high, with white to pink flowers. This species is reported to flower in September to October. It grows in white, grey or black sands and is recorded from the Jarrah Forest and Swan Coastal Plain IBRA bioregions (WA Herbarium, 1998-). This species is known locally from 19 records

within 5 km of the survey area (WA Herbarium, 1998-). Regionally the species is known from 84 records (DBCA, 2007-) across its full distribution.

C. speciosa was recorded from 30 locations (45 individuals) within the survey area in *Eucalyptus / Banksia* woodland in the southern end of the alignment beside Bussell Highway and adjoining Woods Road.

***Acacia semitrullata* (Priority 4)**

Acacia semitrullata (Plate 8) is an erect, pungent shrub to about 0.5 m high with cream-white flowers. The species grows in white to grey sand on sand plains and is recorded from the Jarrah Forrest, SCP and Warren IBRA bioregions (WA Herbarium, 1998-). This species is known locally from 15 records within 5 km of the survey area (WA Herbarium, 1998-). Regionally the species is known from 116 records (DBCA, 2007-) across its full distribution.

Acacia semitrullata was recorded from six locations (six plants) within the survey area. It was recorded from *Eucalyptus* woodlands and *Eucalyptus / Banksia* woodlands.



Plate 6 *Lasiopetalum membranaceum* (Priority 3)



Plate 7 *Caladenia speciosa* (Priority 4)



Plate 8 *Acacia semitrullata* (Priority 4)

5.6.2 Targeted search results

Desktop searches have identified several EPBC Act / BC Act listed flora that may have the potential to occur based on the results of field surveys in the local area and/or the presence of potentially suitable habitat. Further information on the likelihood of occurrence for these species is provided below post survey:

- *Caladenia huegelii* (King Spider Orchid) EPBC Act – Endangered / BC Act – Critically Endangered
- *Diuris drummondii* (Tall Donkey orchid) EPBC Act/ BC Act – Vulnerable
- *Diuris micrantha* (Dwarf bee-orchid) EPBC Act/ BC Act – Vulnerable
- *Drakaea elastica* (Glossy-leaved hammer orchid) EPBC Act – Endangered / BC Act – Critically Endangered
- *Drakaea micrantha* (Dwarf hammer orchid) EPBC Act – Vulnerable / BC Act – Endangered
- *Eleocharis keigheryi* (Keighery's Eleocharis) EPBC Act/ BC Act – Vulnerable
- *Synaphea* sp. Fairbridge Farm (D. Papenfus 696) EPBC Act/ BC Act – Critically Endangered
- *Austrostipa jacobsoniana* EPBC Act/ BC Act – Critically Endangered
- *Austrostipa bronwenae* EPBC Act/ BC Act – Endangered

Drakaea elastica and *Drakaea micrantha*

Targeted surveys for *Drakaea* were undertaken by Senior Botanist/Botanist between 23 and 30 August and 23 September to 9 October, 2019. Two *Drakaea* survey areas were searched as well as all potential habitat (VT1, 2, 3 and 4). These searches did not locate any *Drakaea elastica* or *D. micrantha*. Mapping showing the location of the search sites is shown in Figure 2 (Appendix A).

The post survey likelihood for both *Drakaea elastica* and *D. micrantha* concludes that these species are unlikely to occur in the survey area when considering that suitable survey effort covering all potential habitats over multiple surveys has been undertaken during the preferred survey timing for species detection. While suitable habitat exists within the survey area, disturbances such as weed invasion, grazing, edge effects, tracks, clearing and rubbish dumping have led to the habitat being disturbed and reducing the habitat condition. Known locations of *Drakaea elastica* and *D. micrantha* outside of the survey area that have been previously surveyed by a GHD Senior Botanist in the Kemerton area are typically in larger continuous patches containing suitable habitat that is in Very Good to Excellent condition. The preferred habitat for the species consists of thickets of *Kunzea glabrescens* with open patches of white sand, often shaded, near damplands. This specific habitat was not commonly recorded in the survey area, and when targeted the habitat was often degraded by one or a number of disturbances listed above. While the species may not flower each year, targeted surveys for the presence of the *Drakaea* leaf were undertaken early in the season to ensure that if *Drakaea* species were present it would have been detected through

adequate survey effort. The common species *Drakaea livida* was recorded within the survey area, showing that the survey timing was appropriate for *Drakaea* species detection.

Diuris drummondii

Ecoedge (2017) completed a targeted survey over four areas within the survey area and adjacent that were identified by Mr. Andrew Webb (Flora Conservation Officer, Department of Biodiversity Conservation and Attractions) as potential habitat for *Diuris drummondii*. A two day survey of potential habitat was completed on the 19 November and 30 November 2016. No *D. drummondii* plants were found within the area. Ecoedge concluded that the majority of the potential habitat was too disturbed by many years of grazing by livestock for *D. drummondii* to be present. Other areas within the survey extent were considered by Ecoedge to be too dry for the orchid and likely too deeply inundated over winter and early spring for the orchid to be able to survive. Ecoedge (2019a) completed a follow up targeted survey for *D. drummondii* over three locations on 30 November 2019 (Figure 3, Appendix A). No *D. drummondii* plants were recorded. The potential habitat on Lots 4 and 5 had been searched twice previously in a wetter year (Ecoedge, 2017) without any plants being found, and together with the result of the 2019 survey, it can be concluded that it is very unlikely that *D. drummondii* occurs within these Lots (which are subject to livestock grazing). There were parts of Lot 5 which could not be accessed because of the depth of water. These areas are unlikely to support the growth of *D. drummondii* as the area is mostly grazed pasture.

Diuris micrantha

It is considered that *D. micrantha* is unlikely to occur in the survey area when considering that suitable survey effort covered all potential habitats, such as *Kunzea* thickets in *Banksia* woodlands near wetlands. Targeted surveys were undertaken over multiple trips during the preferred survey timing for species detection. Suitable small areas of habitat exists within the survey area, however disturbances such as weed invasion, edge effects, tracks, clearing and rubbish dumping have led to the habitat being disturbed and reducing the habitat condition. Areas in better condition were adequately surveyed.

Caladenia huegelii

The post survey likelihood for *Caladenia huegelii* is considered unlikely to occur in the survey area when considering that suitable survey effort using systematic transects covering all potential habitats over multiple surveys has been undertaken during the preferred survey timing for species detection. These surveys were undertaken during the targeted searches for *Drakaea* species in *Banksia* woodland habitat. Mapping showing the location of the search sites (*Drakaea* species search areas) is shown in Figure 2 (Appendix A). Suitable habitat exists within the survey area, however disturbances such as weed invasion, grazing, edge effects, tracks, clearing and rubbish dumping have led to the habitat being disturbed and reducing the habitat condition.

Eleocharis keigheryi

The post survey likelihood for *Eleocharis keigheryi* is considered unlikely to occur in the survey area when considering that suitable survey effort covering all potential specific claypan habitats has been undertaken during the preferred survey timing for species detection. Suitable small areas of claypan habitat exists within the survey area. Disturbances such as weed invasion, edge effects, tracks, clearing and rubbish dumping have led to the habitat being disturbed and reducing the habitat condition. Areas in better condition, were adequately surveyed. The closest known record is near St Helena Road, this location is considered unreliable as the point is located in a cleared paddock. Suitable survey effort in this area in potential habitat did not record the species and it is considered unlikely to occur in the survey area.

Synaphea sp. Fairbridge Farm (D. Papenfus 696)

The post survey likelihood for *Synaphea* sp. Fairbridge Farm (D. Papenfus 696) is considered unlikely to occur in the survey area. This species is endemic to the Pinjarra Plains and grows on grey clayey sand with lateritic pebbles soils, near winter-wet flats in low woodlands of *Corymbia calophylla* with *Viminaria juncea*,

Xanthorrhoea preissii, *Adenthos meisneri*, *Hypocalymma angustifolia* and *Allocasuarina humilis* shrubs (WA Herbarium, 1998-). The survey area does not contain suitable habitat on the Pinjarra Plain landform. Suitable search effort did not record the species.

Austrostipa jacobiana

The post survey likelihood for *Austrostipa jacobiana* is considered unlikely to occur in the survey area after suitable survey effort covering all wetland habitats has been undertaken during the preferred survey timing for species detection. The species was also targeted during the surveys for *Diuris drummondii* as both share similar habitat. Wetland habitat exists within the survey area, however disturbances such as weed invasion, edge effects, tracks, clearing and rubbish dumping have led to the habitat being disturbed causing a reduction in the habitat condition. Areas in better condition, were adequately surveyed. The closest recorded occurrence is approximately 1.06 km from the survey area in protected habitat that is in Excellent-Very Good condition. Suitable search effort did not record the species in the survey area.

Austrostipa bronwenae

The post survey likelihood for *Austrostipa bronwenae* is considered unlikely to occur in the survey area after suitable survey effort covering all wetland habitats has been undertaken during the preferred survey timing for species detection. The species was also targeted during the surveys for *Diuris drummondii* as both share similar habitat. Wetland habitat exists within the survey area, however disturbances such as weed invasion, edge effects, tracks, clearing and rubbish dumping have led to the habitat being disturbed causing a reduction in the habitat condition. Areas in better condition, were adequately surveyed. The closest recorded occurrence is approximately 2.73 km from the survey area in protected habitat that is in Excellent-Very Good condition. Suitable search effort did not record the species in the survey area.

5.6.3 Likelihood of occurrence

A likelihood of occurrence assessment was conducted post-field survey for all conservation significant flora species identified in the desktop assessment, including TPFL and WAHERB database records (Appendix I). This assessment took into account previous records, habitat requirements, efficacy of the survey, intensity of the survey, flowering times and the cryptic nature of the species.

The likelihood of occurrence assessment post-field survey concluded that three species are known to occur (recorded), 11 species may possibly occur and the remaining 40 species are unlikely or highly unlikely to occur within the survey area. The species listed as may potentially occur are typically cryptic species that are small, such as the annuals and small *Schoenus* species. A summary of conservation significant species which are known, likely or possibly occur within the survey area has been included in Table 5-7.

Table 5-7 Summary of conservation significant species recorded as occurring or potentially occurring within or near the survey area

SPECIES	EPBC ACT STATUS	BC ACT/ DBCA STATUS	LIKELIHOOD OF OCCURRENCE
<i>Acacia semitrullata</i>	-	P4	Recorded
<i>Angianthus drummondii</i>	-	P3	Possible
<i>Blennospora doliiformis</i>		P3	Possible
<i>Caladenia speciosa</i>	-	P4	Recorded
<i>Chamaescilla gibsonii</i>	-	P3	Possible
<i>Eucalyptus rudis</i> subsp. <i>cratyantha</i>	-	P4	Possible
<i>Lasiopetalum membranaceum</i>	-	P3	Recorded
<i>Leptomeria furtiva</i>	-	P2	Possible
<i>Schoenus benthamii</i>	-	P3	Possible
<i>Schoenus loliaceus</i>	-	P2	Possible
<i>Schoenus natans</i>	-	P4	Possible
<i>Stylidium longitubum</i>	-	P4	Possible
<i>Stylidium paludicola</i>	-	P3	Possible
<i>Verticordia attenuata</i>	-	P3	Possible

Note: P: Priority.

5.7 Other significant flora

None of the flora identified within the survey area are considered to be other significant flora i.e. they are not locally endemic, new species, range extensions, unusual species or relictual status.

5.8 Introduced flora

One-hundred and nineteen (119) introduced flora species were recorded in the survey area. Of the introduced species, five are listed as Declared Pests under the *Biosecurity and Management Act 2007* and / or as a WONS:

- *Asparagus asparagoides* (Bridal Creeper) – Declared Pest and WONS
- *Lantana camara* – Declared Pest and WONS
- *Moraea flaccida* (One-leaf Cape Tulip) – Declared Pest
- *Opuntia stricta* (Common Prickly Pear) – Declared Pest and WONS
- *Zantedeschia aethiopica* (Arum lily) – Declared Pest.

The remaining introduced species are considered environmental weeds and all have been previously recorded on the SWA. The locations of the declared weeds is shown in Figure 10, Appendix A and the co-ordinates for these species is provided in Appendix E.

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