

# Appendix D Detailed Flora and Vegetation Assessment (RPS)

# DETAILED FLORA AND VEGETATION ASSESSMENT

METRONET Morley-Ellenbrook Line



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Detailed flora and vegetation  
assessment  
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## REPORT

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Prepared by:

**RPS**

Caroline Gill  
Managing Scientist

Level 2, 27-31 Troode Street  
West Perth WA 6005

T +61 8 9211 1111  
E caroline.gill@rpsgroup.com.au

Prepared for:

**METRONET**

140 William Street  
Perth WA 6000

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## SUMMARY

METRONET Office has undertaken a route options analysis to derive an indicative alignment for the Morley- Ellenbrook Line (MEL) transit option. The current option under consideration is a 21-kilometre (km) rail line running north from the existing Bayswater Station on the Midland line to the Ellenbrook town centre. This option spans two local government areas; the City of Swan and the City of Bayswater.

The 1,358.61 hectares (ha) flora and vegetation survey area (the survey area) is located entirely within the City of Swan, and predominantly in the Whiteman Park area. The location and extent of the proposed Malaga to Ellenbrook Rail Works development envelope and the survey area are presented in Figure A.

RPS Australia West Pty Ltd (RPS) has, to date, undertaken the detailed flora and vegetation assessment over four separate surveys between spring 2017 and spring 2019. The surveys covered different parts of the project area that were the focus of several rail alignment options. The most recent survey area is relevant to the proposed Malaga to Ellenbrook Rail Works development envelope. The components of the assessment undertaken for each of the surveys are presented in Table 1.

**Table 1: Flora and vegetation assessment component surveys undertaken between 2017 and 2019**

Survey timing	Survey type
Spring 2017	Detailed flora and vegetation survey (Primary visit)
	Targeted Threatened and Priority surveys
Spring 2018	Detailed flora and vegetation survey (Primary visit additional quadrats)
	Targeted Threatened and Priority surveys
	<i>Caladenia huegelii</i> (grand spider orchid) survey
	Reconnaissance survey
Autumn 2019	Detailed flora and vegetation survey (Supplementary visit)
Spring 2019	Detailed flora and vegetation survey (Primary visit addendum area quadrats)
	Targeted Threatened and Priority surveys
	Reconnaissance survey

## Survey objectives and scope of works

The objectives of this detailed flora and vegetation assessment were to:

- Identify and characterise the flora and vegetation within the survey area, via provision of a comprehensive flora inventory and vegetation unit and condition mapping.
- Identify the presence and extent of conservation significant flora and ecological communities that are currently listed under the *Biodiversity Conservation Act 2016* (BC Act) and the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) within the survey area.
- Identify and describe the vegetation and significant flora species present or likely to be present within the survey area, including an analysis of the significance of flora and vegetation in local, regional and state contexts.
- Map the location of significant flora and significant vegetation within the survey area.

This detailed flora and vegetation survey included:

1. Detailed flora and vegetation survey of the intact remnant native vegetation within the survey area
2. Reconnaissance flora and vegetation survey of the remainder of the survey area
3. Targeted Threatened and Priority Flora surveys of known or potentially suitable habitat for each of the target species within the survey area at the appropriate time (the documented peak flowering time).

The survey methods and sampling quadrat sizes used were based on the requirements for Detailed Flora and Vegetation Surveys in the Swan Coastal Plain region as outlined in with Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (Environmental Protection Authority [EPA] 2016).



## Detailed flora and vegetation survey findings

- A total of 374 vascular flora taxa were recorded by the current survey of which 290 (77.5%) were native species and 84 (22.5%) were naturalised alien (weed) species. The taxa recorded represent 74 families and 211 genera.
- No Threatened Flora (TF) species listed under the BC Act or the EPBC Act were recorded within the survey area.
- Three Department of Biodiversity Conservation and Attractions listed Priority Flora (PF) species were recorded within the survey area:
  - *Cyathochaeta teretifolia* (P3)
  - *Anigozanthos humilis* subsp. *chrysanthus* (P4)
  - *Tetraria* sp. Chandala (G.J. Keighery 17055) (P2).
- Additionally, a fourth PF was recorded just outside the survey area boundary:
  - *Stylidium longitubum* (P4).
- It should be noted that two of the three PF recorded within the survey area do not occur within the proposed Malaga to Ellenbrook Rail Works development envelope. The only PF taxon recorded within the development envelope was *Anigozanthos humilis* subsp. *chrysanthus* (P4) of which two individuals were recorded within the Banksia woodland vegetation in the vicinity of the proposed Malaga station.
- The following seven additional taxa recorded within the survey area are considered conservation significant based on geographic range anomalies, belonging to significant populations, being poorly reserved, or endemic to the Swan Coastal Plain (SCP) or the Perth Metropolitan Region portion of the SCP:
  - *Aotus cordifolia*
  - *Burchardia bairdiae*
  - *Conostephium minus*
  - *Conostylis aculeata* subsp. *cygnorum*
  - *Dielsia stenostachya*
  - *Verticordia nitens*
  - *Gahnia decomposita*.
- Eighty-four naturalised alien (weed) species were recorded for the survey area, representing 22.5% of the total flora taxa recorded. Annual and perennial Poaceae species (grasses) (16 taxa) and Asteraceae species (daisies) (12 taxa) accounted for 33% of the weed species recorded. The most widespread weeds included *\*Briza maxima*, *\*Bromus diandrus*, *\*Ehrharta calycina*, *\*Pennisetum clandestinum*, *\*Pentameris airoides* subsp. *airoides*, *\*Hypochaeris glabra* and *\*Ursinia anthemoides*. These naturalised bushland weeds were recorded at low to moderate densities throughout much of the intact vegetation, and at high densities throughout the previously cleared and highly modified portions of the survey area.
- Highly invasive exotic grass species *\*Cenchrus macrourus* (African feather grass) was recorded in the Bennett Brook wetland vegetation. The infestation should be prioritised for control to minimise its chance of spreading throughout the riparian vegetation along the watercourse.
- The Western Australian Organism List database was searched to determine the legal status of each weed recorded, and any control requirements that may apply under the *Biosecurity and Agriculture Management Act 2007*. Of the 47 weed species recorded two species (*Zantedeschia aethiopica* [arum lily]; and *Moraea flaccida* [Cape tulip]) were determined to be Declared Pests - s22(2)<sup>1</sup>, requiring C3<sup>2</sup> management. None of the weeds recorded were listed as Weeds of National Significance.

<sup>1</sup> Declared Pest - s22(2) - Declared pests must satisfy any applicable import requirements when imported and may be subject to an import permit if they are potential carriers of high-risk organisms. They may also be subject to control and keeping requirements once within Western Australia

<sup>2</sup> C3 - Organisms that should have some form of management applied that will alleviate the harmful impact of the organism, reduce the numbers or distribution of the organism or prevent or contain the spread of the organism

- Twenty-one intact vegetation units and six modified landform units were described and mapped including upland, wetland and transitional vegetation types. The 27 mapping units fall into one of six broad groups as follows:
  - Modified/cleared - The six modified/cleared units include previously cleared farmland with remnant isolated native trees, the recent clearing for the NorthLink Perth to Darwin Highway and the new Lord Street upgrade, other infrastructure including carparks, buildings and quarries, pine plantations, areas of rehabilitation, and private lots with some remnant trees but no intact native vegetation. The modified / cleared units cover approximately 68.1% (925.75 ha) of the survey area.
  - Marri on low slopes and flats - Four marri (*Corymbia calophylla*) vegetation units were mapped for the survey area ranging from sparse woodland to closed forest. The units were differentiated based on their co-dominant species, i.e., *Banksia* spp., jarrah (*Eucalyptus marginata*) generally on lower slopes, or *Melaleuca preissiana* and *Xanthorrhoea preissii* on the flats. This broad vegetation type covers approximately 7.6% (103.86 ha) of the survey area.
  - Low-lying Banksia woodland - Five low-lying Banksia woodland vegetation units were mapped for the survey area. The units were differentiated based on their dominant and co-dominant tree and shrub species. This broad vegetation type covers approximately 3.7% (50.87 ha) of the survey area.
  - Banksia woodland on dune slopes and crests - Two 'upland' Banksia woodland vegetation units were mapped for the upper dune slopes and crests within the survey area. *Banksia attenuata* and *B. menziesii* were the dominant tree species in both units which were differentiated based on the presence of co-dominant tree species (e.g. *Eucalyptus tottiana*), and different dominant shrub species. This broad vegetation type covers approximately 8.3% (112.45 ha) of the survey area.
  - Melaleuca wetland / dampland - Six Melaleuca wetland vegetation units were mapped for the survey area. This broad vegetation type occurred throughout the floodplains, palusplains, sumplands and damplands which are dominant features of the survey area. *Melaleuca preissiana* was the dominant tree species in this broad vegetation type with *M. raphiophylla* as a dominant or co-dominant in some of the vegetation units. Other co-dominant tree species included flooded gum (*Eucalyptus rudis* subsp. *rudis*) and marri (*Corymbia calophylla*). Dominant shrub species differed between the vegetation units. This broad vegetation type covers approximately 5.9% (80.76 ha) of the survey area.
  - *Eucalyptus rudis* wetland / dampland / creekline - Four flooded gum (*Eucalyptus rudis* subsp. *rudis*) wetland vegetation units were mapped for the survey area. This vegetation occurred along the banks (floodplains) of Bennett Brook, extending onto the palusplains. *Melaleuca raphiophylla* occurred as a co-dominant tree species in three of the four vegetation units. This broad vegetation type covers approximately 6.3% (84.92 ha) of the survey area.
- Vegetation condition within the survey area ranged from Excellent to Completely Degraded. A large proportion of the survey area (1,123.11 ha, or 82.7%) was in Degraded or worse condition. These areas comprised previously cleared farmland with remnant isolated trees, recent clearing for the NorthLink Perth to Darwin Highway and the new Lord Street upgrade, buildings, roads, tracks, bushland regeneration areas, pine plantation and developed private lots. The Degraded condition throughout much of the remnant trees over pasture vegetation units is due to historical grazing by livestock and kangaroos and weed infestation. Within the intact bushland portions, condition ranged from Good to Excellent, but these areas were generally small, isolated, and surrounded by cleared paddocks in Completely Degraded condition. Much of the low-lying vegetation, on the sand flats and throughout the palusplains was in Degraded, or at best Good, condition despite the presence of a dense tree canopy, again the result of historical grazing and infestation by weeds. The vegetation in the best condition (Excellent and Very Good) was recorded on the slopes and crests of dunes and comprised Banksia woodland with a dense or mid-dense shrub layer, and throughout the wetland vegetation along Bennett Brook and around some of the Conservation Category Wetlands (CCWs).
- One Commonwealth-listed Threatened Ecological Community was recorded within the survey area:
  - *Banksia woodlands of the Swan Coastal Plain ecological community* (Endangered). Five patches (covering a total area of 59.42 ha) were mapped within the survey area.
- Three P3 state-listed Priority Ecological Communities were recorded within the survey area as follows:
  - FCT21c - Low-lying *Banksia attenuata* woodlands or shrublands (two records)

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- FCT23b - Swan Coastal Plain *Banksia attenuata* - *Banksia menziesii* woodlands (one record)
- Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region (covering a total area of 158.37 ha).
- Two ecological communities of 'other' conservation significance were recorded within the survey area as follows:
  - FCT23c – North east *Banksia attenuata* – *Banksia menziesii* woodlands (four records)
  - FCTS17 - *Eucalyptus rudis* - *Taxandria linearifolia* wetlands in Bassendean Dunes (numerous patches).
- The survey area intersects the mapped extents of 14 CCWs and six Resource Enhancement Wetlands.

# 1 INTRODUCTION

## 1.1 Project background

METRONET Office has undertaken a route options analysis to derive an indicative alignment for the Morley- Ellenbrook Line (MEL) transit option. The current option under consideration is a 21-kilometre (km) rail line running north from the existing Bayswater Station on the Midland line to the Ellenbrook town centre. This option spans two local government areas; the City of Swan and the City of Bayswater.

The 1,358.61 hectares (ha) flora and vegetation survey area (the survey area) is located entirely within the City of Swan, and predominantly in the Whiteman Park area. The location and extent of the proposed Malaga to Ellenbrook Rail Works development envelope and the survey area are presented in Figure A.

RPS Australia West Pty Ltd (RPS) has, to date, undertaken the detailed flora and vegetation assessment over four separate surveys between spring 2017 and spring 2019. The surveys covered different parts of the project area that were the focus of several rail alignment options. The most recent survey area is relevant to the proposed Malaga to Ellenbrook Rail Works development envelope. The different survey areas are presented in Figure B. The components of the assessment undertaken for each of the surveys is presented in Table 2.

**Table 2: Flora and vegetation assessment component surveys undertaken between 2017 and 2019**

Survey timing	Survey type
Spring 2017	Detailed flora and vegetation survey (primary visit)
	Targeted threatened and priority surveys
Spring 2018	Detailed flora and vegetation survey (primary visit additional quadrats)
	Targeted Threatened and Priority surveys
	<i>Caladenia huegelii</i> (grand spider orchid) survey
	Reconnaissance survey
Autumn 2019	Detailed flora and vegetation survey (supplementary visit)
Spring 2019	Detailed flora and vegetation survey (primary visit addendum area quadrats)
	Targeted Threatened and Priority surveys
	Reconnaissance survey

## 1.2 Assessment objectives

The objectives of this detailed flora and vegetation assessment were to:

- Identify and characterise the flora and vegetation within the survey area, via provision of a comprehensive flora inventory and vegetation unit and condition mapping.
- Identify the presence and extent of conservation significant flora and ecological communities that are currently listed under the *Biodiversity Conservation Act 2016* (BC Act) and the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) within the survey area.
- Identify and describe the vegetation and significant flora species present or likely to be present within the survey area that may be indirectly impacted beyond the proposal, including an analysis of the significance of flora and vegetation in local, regional and state contexts.
- Map the location and extent of significant flora and significant vegetation within the survey area.

## 1.3 Scope of works and survey effort

This detailed flora and vegetation survey included:

1. Detailed flora and vegetation survey of the intact remnant native vegetation within the survey area
2. Reconnaissance flora and vegetation survey of the remainder of the survey area
3. Targeted Threatened and Priority flora surveys of known or potentially suitable habitat for each of the target species within the survey area at the appropriate time (the documented peak flowering time).

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The survey effort (as a function of survey duration and number of personnel) across all four field surveys, for each component of the assessment undertaken are shown in Table 3.

**Table 3: Flora and vegetation assessment dates and durations between 2017 and 2019**

Survey type	Survey timing	Duration (days)	No. of personnel	No. of person days
Detailed flora and vegetation survey	Spring 2017	2	4	8
	Spring 2018	2	4	8
	Autumn 2019	4	4	16
	Spring 2019	3	2	6
Targeted Threatened and Priority surveys	Spring 2017	2	4	8
	Spring 2018	1	4	4
	Spring 2019	2	2	4
Reconnaissance survey	Spring 2018	1	2	2
	Spring 2019	1	2	2
<i>Caladenia huegelii</i> (grand spider orchid) survey	Spring 2018	1	2	2
<b>Total</b>		<b>19</b>	<b>-</b>	<b>60</b>

The surveys involved the establishment and sampling of floristic sites within portions of the survey area containing intact remnant native vegetation, and targeted searches for conservation significant flora and vegetation. RPS sampled additional quadrats and relevés outside the survey area during the spring 2017 survey and prior to refinement of the alignment, however the data from these sites is not included in the analysis for this assessment.

This report documents the combined results of the spring 2017, spring 2018, autumn 2019 and spring 2019 surveys for only those sites within the survey area.

### 1.3.1 Detailed flora and vegetation survey

The detailed flora and vegetation assessment was undertaken over four surveys between spring 2017 and spring 2019 (Table 2 and Table 3). During the surveys a total of 32 floristic quadrats and 16 relevés were established and sampled within the current survey area. Nineteen of the quadrats have been the subject of two sampling efforts in accordance with Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016) guidance. The remaining 13 quadrats (METQ10 to METQ24) are scheduled for a revisit in Autumn 2020.

The floristic sites and the season in which they were established, sampled and revisited are presented in Table 4. An additional 14 floristic sites were sampled as part of the spring 2017 survey. These additional floristic sites, which are not within the most recent survey area (relevant to the proposed Malaga to Ellenbrook Rail Works development envelope), were also used to define the vegetation units. The additional 14 floristic sites are presented at the end of Table 4 and their location is shown in Figure B.

**Table 4: Floristic sites (quadrats and relevés) within the survey area and when they were sampled**

Floristic site (within the current survey area)	Site type	Established (and sampled)	Resampled
PTAQ08	Quadrat	Spring 2017	Autumn 2019
PTAQ09	Quadrat	Spring 2017	Autumn 2019
PTAQ10	Quadrat	Spring 2017	Autumn 2019
PTAQ11	Quadrat	Spring 2017	Autumn 2019
PTAQ12	Quadrat	Spring 2017	Autumn 2019
PTAQ13	Quadrat	Spring 2017	Autumn 2019
PTAQ14	Quadrat	Spring 2017	Autumn 2019
PTAQ15	Quadrat	Spring 2017	Autumn 2019
PTAQ20	Quadrat	Spring 2017	Autumn 2019

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Floristic site (within the current survey area)	Site type	Established (and sampled)	Resampled
PTAQ21	Quadrat	Spring 2017	Autumn 2019
PTAR04	Relevé	Spring 2017	Revisit not required
PTAR05	Relevé	Spring 2017	Revisit not required
PTAR06	Relevé	Spring 2017	Revisit not required
PTAR07	Relevé	Spring 2017	Revisit not required
PTAR08	Relevé	Spring 2017	Revisit not required
PTAR09	Relevé	Spring 2017	Revisit not required
PTAR10	Relevé	Spring 2017	Revisit not required
PTAR12	Relevé	Spring 2017	Revisit not required
PTAR14	Relevé	Spring 2017	Revisit not required
METQ01	Quadrat	Spring 2018	Autumn 2019
METQ02	Quadrat	Spring 2018	Autumn 2019
METQ03	Quadrat	Spring 2018	Autumn 2019
METQ04	Quadrat	Spring 2018	Autumn 2019
METQ05	Quadrat	Spring 2018	Autumn 2019
METQ06	Quadrat	Spring 2018	Autumn 2019
METQ07	Quadrat	Spring 2018	Autumn 2019
METQ08	Quadrat	Spring 2018	Autumn 2019
METQ09	Quadrat	Spring 2018	Autumn 2019
METQ10	Quadrat	Spring 2019	Scheduled for autumn 2020
METQ11	Quadrat	Spring 2019	Scheduled for autumn 2020
METQ12	Quadrat	Spring 2019	Scheduled for autumn 2020
METQ13	Quadrat	Spring 2019	Scheduled for autumn 2020
METQ14	Quadrat	Spring 2019	Scheduled for autumn 2020
METQ15	Quadrat	Spring 2019	Scheduled for autumn 2020
METQ16	Quadrat	Spring 2019	Scheduled for autumn 2020
METQ17	Quadrat	Spring 2019	Scheduled for autumn 2020
METQ18	Quadrat	Spring 2019	Scheduled for autumn 2020
METQ19	Quadrat	Spring 2019	Scheduled for autumn 2020
METQ22	Quadrat	Spring 2019	Scheduled for autumn 2020
METQ23	Quadrat	Spring 2019	Scheduled for autumn 2020
METQ24	Quadrat	Spring 2019	Scheduled for autumn 2020
METR01	Relevé	Spring 2018	Revisit not required
METR02	Relevé	Spring 2018	Revisit not required
METR03	Relevé	Spring 2018	Revisit not required
METR04	Relevé	Spring 2018	Revisit not required
METR05	Relevé	Spring 2018	Revisit not required
METR06	Relevé	Spring 2018	Revisit not required
METR07	Relevé	Spring 2018	Revisit not required
PTAQ01	Quadrat	Spring 2017	Revisit not required
PTAQ02	Quadrat	Spring 2017	Revisit not required
PTAQ03	Quadrat	Spring 2017	Revisit not required
PTAQ04	Quadrat	Spring 2017	Revisit not required
PTAQ05	Quadrat	Spring 2017	Revisit not required
PTAQ06	Quadrat	Spring 2017	Revisit not required
PTAQ07	Quadrat	Spring 2017	Revisit not required
PTAQ16	Quadrat	Spring 2017	Revisit not required
PTAQ17	Quadrat	Spring 2017	Revisit not required
PTAQ18	Quadrat	Spring 2017	Revisit not required
PTAQ19	Quadrat	Spring 2017	Revisit not required
PTAQ22	Quadrat	Spring 2017	Revisit not required
PTAQ23	Quadrat	Spring 2017	Revisit not required
PTAQ24	Quadrat	Spring 2017	Revisit not required



### 1.3.2 Reconnaissance flora and vegetation survey

A reconnaissance survey was undertaken over the parts of the survey area (approximately 964 ha) which do not represent 'intact remnant native vegetation', that is, areas which have been previously cleared and / or highly modified and / or are in poor condition (and therefore are not likely to support significant flora or vegetation).

The reconnaissance survey was undertaken in spring 2018 and spring 2019 over four person days to verify the information gathered from the desktop study. It involved site visits by experienced botanists to undertake low intensity sampling of the flora and vegetation, and to describe and map the vegetation units and condition present.

### 1.3.3 Targeted Threatened and Priority flora surveys

The targeted surveys involved systematic searches of all potentially suitable habitats for target species within the survey area. Significant flora taxa identified as having a moderate or high likelihood of occurring within the survey area (based on proximity of known records and / or presence of suitable habitat) were the focus of targeted searches at the appropriate time, that is, during their documented flowering time. These searches, including a dedicated *Caladenia huegelii* (grand spider orchid) targeted survey, were undertaken during the spring 2017, spring 2018 and spring 2019 surveys during the target species' documented peak flowering times. The *Caladenia huegelii* (grand spider orchid) targeted survey was undertaken on the 28 September 2018 at the height of the survey season for the species.

## 1.4 Guiding principles and legislative framework

Commonwealth and state legislation pertaining to the conservation of native flora and vegetation include the EPBC Act, BC Act and *Environmental Protection Act 1986* (EP Act). The EP Act is the primary legislation that governs environmental impact assessment and protection in Western Australia. The aim of the EP Act is "to provide for an Environmental Protection Authority, for the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with foregoing".

Section 4A of the EP Act states that the following principles, applicable to native flora and vegetation should be adhered to in order to protect the environment of Western Australia:

1. The Precautionary Principle – Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
2. The Principle of Intergenerational Equity – The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
3. The Principle of the Conservation of Biological Diversity and Ecological Integrity – Conservation of biological diversity and ecological integrity should be a fundamental consideration.

### 1.4.1 Conservation significant flora

Within Western Australia, Threatened Flora (TF) are listed as such if they are in danger of extinction, rare or otherwise in need of special protection. These taxa are legally protected under the BC Act. The removal of these taxa or impact to their surroundings is not permitted without prior ministerial approval. The Department of Biodiversity Conservation and Attractions (DBCA) maintains a list of Priority Flora (PF) species, which may be rare or threatened but for which there are either insufficient survey data to determine accurately their status, or which are rare but not currently considered to be threatened. A PF taxon is assigned to one of five priority categories. TF and PF categories are defined in Appendix A, Table A-1.

Many taxa listed as TF under the BC Act have additional protection as they are also listed as TF under one of six threat categories (Extinct, Extinct in the wild, Critically Endangered, Endangered, Vulnerable or Conservation Dependent) under the EPBC Act. TF taxa are defined as Matters of National Environmental Significance (MNES) under the EPBC Act and penalties apply for any damage to individuals, populations or habitats of these flora. EPBC Act conservation category codes are defined in Appendix A, Table A-2.

## 1.4.2 Conservation significant vegetation

Under the BC Act, Threatened Ecological Communities (TECs) are classified by DBCA into the TEC categories (Appendix A, Table A-3). Other ecological communities are classified by DBCA in the category of Priority Ecological Communities (PECs) (Appendix A, Table A-4) pending further survey and/or definition. A subset of the DBCA-listed TECs are also listed and protected as MNES under the EPBC Act. EPBC Act threat categories for TECs are defined in Appendix A, Table A-5.

## 2 METHODS

### 2.1 Desktop assessment

RPS undertook a thorough desktop assessment of flora and vegetation within the survey area and the local area as part of the 2017 detailed survey within Whiteman Park (RPS 2018). Prior to commencement of the field surveys this information was thoroughly reviewed. This involved a review of available literature including previous flora survey reports and spatial datasets; searches results of Commonwealth Government databases for TF and TECs protected under the EPBC Act; and DBCA databases and mapping for TF and PF.

#### 2.1.1 Previous biological surveys

A review of flora and vegetation studies that have been undertaken in the vicinity of the survey area including:

- Detailed Flora and Vegetation Assessment – METRONET Ellenbrook Alignment (RPS 2018)
- Environmental Impact Assessment and Environmental Management Plan: Ellenbrook Bus Rapid Transit (Aurecon 2016)
- Level 2 Spring Flora and Vegetation Assessment: NorthLink WA Perth–Darwin National Highway (Coffey 2015)
- Swan Valley Bypass, Perth–Darwin National Highway: Level 2 Flora and Vegetation Survey (360 Environmental 2014a)
- Tonkin Grade Separations: Flora, Vegetation and Fauna Survey (360 Environmental 2014b)
- Perth–Darwin National Highway – Tonkin Highway Link Alignment Definition Study: Environmental Impact Assessment and Biological Survey (GHD 2013).

#### 2.1.2 Regional data

A review of publicly available data and broad-scale vegetation mapping and remnant extent including:

- Vegetation Complex mapping (Hedde et al. 1980)
- Vegetation Association mapping (Beard 1981)
- Floristic Survey of the Swan Coastal Plain (Gibson et al. 1994)
- Bush Forever: Volumes 1 and 2 (Western Australian Planning Commission [WAPC] 2000).

#### 2.1.3 State and Commonwealth government databases

Interrogation of the following Commonwealth and state databases were undertaken within a 5 km radius of the survey area:

- Department of Agriculture, Water and the Environment (DAWE) Protected Matters Database for MNES including:
  - Wetlands of International Importance
  - Listed TECs
  - Listed TF Species
- Western Australian DBCA Threatened and Priority Flora Database, and the Western Australian Herbarium (WAH) Specimen Database
- Western Australian DBCA TEC / PEC database
- Western Australian Department of Primary Industries and Regional Development (DPIRD) Declared Plants list.

From the DBCA database search results, a table of significant species and their conservation codes was compiled. Additionally, a risk matrix and likelihood of occurrence table were produced. Species were scored against the following five criteria in order to rank them according to their likelihood of occurring within the survey area based on such factors as proximity of known records and presence of suitable habitat to arrive at an 'initial likelihood of occurrence'. After the final (spring 2019) field survey the likelihood of occurrence was revised for each species based on the survey results and presented as the 'residual likelihood of occurrence'. The factors considered in assessing likelihood of occurrence were:

- Known records within the survey area
- Known database records of the species within a 5 km radius of the survey area
- Known records within a 10 km radius of the survey area
- Known occurrence of the species within the local government area
- Potential presence of suitable habitat within the survey area.

Each species risk rank is calculated from the sum of factors that apply to it. The resulting 'likelihood of occurrence' ranks are as follows:

- Known
- High (Likely)
- Moderate (Possible)
- Low (Unlikely)
- Negligible (Suitable habitat not present or species not recorded during the field survey).

## 2.2 Field surveys

The field surveys were led by RPS' Managing Botanist Carrie Gill who was supported by a team of experienced, licensed and qualified botanists in the field (Table 5). The sampling regime (timing and effort) for each of the floristic sites is detailed in Table 4.

**Table 5: Botanical team personnel**

Personnel	Title	Role	Survey	Flora licence
Carrie Gill	Managing Botanist (RPS)	Team lead	2017 2018 2019	SOPP No. SL012170 (2017 – 2018) SOPP No. SL012440 (2018 – 2019) Reg. 62 FB62000151 (2019 – 2024)
Julijanna Hantzis	Graduate Botanist (RPS)	Field survey	2019	
Cate Tauss	Consultant botanist	Field survey, taxonomy	2017 2018 2019	
Brian Morgan	Consultant botanist	Field survey	2018 2019	
Kelli McCreery	Consultant botanist	Field survey	2017 2018	

### 2.2.1 Reconnaissance flora and vegetation survey

The reconnaissance survey was undertaken over the parts of the survey area (approximately 964 ha) which have been previously cleared and / or highly modified and / or are in poor condition (and therefore were not likely to support significant flora or vegetation).

The reconnaissance survey was undertaken in accordance with EPA (2016) and involved selective sampling of flora and vegetation to produce maps of vegetation units and vegetation condition at an appropriate scale and based on aerial imagery interpretation, preliminary mapping and ground-truthing.

The reconnaissance field survey involved traversing the survey area by vehicle and on foot to:

- Verify the data from the desktop survey at a local scale.
- Characterise the vegetation throughout the survey area.
- Identify any constraints and potential impacts of development on local flora and vegetation values, or ecological importance.

The reconnaissance survey involved the sampling of the range of flora taxa and vegetation community types observed within the previously cleared / highly modified portions of the survey area via relevés (unbounded flora survey sites comprising a similar area to a 10 m × 10 m quadrat which is the appropriate site size for the South-west region).

The following parameters were recorded for each relevé:

- Site code
- Location (GDA94 GPS coordinates)
- Digital photographs of the vegetation
- Landform and soil description
- Vegetation description - dominant growth form, height, cover and species for the three traditional strata (upper, mid and ground)
- Any other location information that might be useful in vegetation classification including slope, aspect, litter, fire history, vegetation/landform/soil correlations
- Assessment of vegetation and description of disturbances
- A comprehensive species list (annuals and perennials), including weeds and their percentage foliar cover.

### 2.2.2 Detailed flora and vegetation survey

The survey methods and sampling quadrat sizes used were based on the requirements for Detailed Flora and Vegetation Surveys in the Swan Coastal Plain (SCP) region as outlined in EPA (2016).

The detailed survey focused on areas of intact remnant native vegetation within the survey area which are managed by local and state government agencies (i.e. no private landholdings were accessed or surveyed).

Mapped remnant vegetation comprises approximately 29% of the total survey area. The remaining 71% of the survey area consists of highly modified landscapes; these areas were mapped according to their land use and broad condition. Intensive sampling of the vegetation at floristic sites was limited to areas of intact remnant native vegetation on public lands.

The number of quadrats required to adequately sample the flora is dependent on the diversity of vegetation units present, heterogeneity within these vegetation units, the size of the vegetation units mapped and the size of the survey area. The detailed survey involved the establishment of 32 floristic quadrats (bounded 10 m x 10 m sites) and 16 relevés (unbounded sampling sites) throughout the different vegetation types within the current survey area. An additional 14 floristic quadrats were sampled as part of the spring 2017 survey, however these quadrats are outside the current survey area. Most of the intact remnant native vegetation units were represented by between three and six floristic sites. Those units that were mapped for the cleared and highly modified areas (where vegetation was either absent or highly disturbed and degraded) were described from relevés and mapping notes because the vegetation was not in good enough condition to warrant establishing floristic quadrats. Vegetation units were described from fewer than three quadrats if they were small in size, and /or the poor condition of the vegetation did not allow for additional sampling sites.

The detailed survey involved:

- A targeted search for TF and PF, and Declared Plants as determined by the database search results, and the likelihood of any TECs and PECs occurring within the survey area
- Comprehensive quadrat-based flora recording and collection. Bounded 10 m × 10 m quadrats were established and sampled in intact, mature vegetation in areas of best condition to provide data for the floristic classification of the vegetation of the survey area
- Collection of information at each quadrat included:

- Site code
  - Location (GDA94 GPS coordinates)
  - Size, shape and orientation of quadrat
  - Photograph/s from north-west corner
  - Landform and soil description
  - Dominant growth form, height, cover and species for the three traditional strata (upper, mid and ground)
  - Any other location information that might be useful in vegetation classification including slope, aspect, litter, fire history, vegetation/landform/soil correlations
  - Assessment of vegetation and description of disturbances
  - A comprehensive species list (annuals and perennials), including weeds
- Opportunistic collections and relevés were also recorded to verify that the remnant vegetation has been well characterised and important values identified
  - Compilation of a comprehensive vascular flora inventory of all flora species recorded within the survey area including weed species
  - Floristic classification of the vegetation in the survey area. The conservation value of the FCTs within the survey area was determined to assess the native vegetation values
  - Vegetation unit description and mapping using the National Vegetation Information System (NVIS) (ESCAVI 2003). Vegetation types were described to Association (Level V) (Appendix A, Tables A-6 and A-7)
  - Vegetation condition mapping using the recommended EPA (2016) scale adapted from Keighery (1994) (Appendix A, Tables A-8) including the location of any Declared Plants listed under the *Biosecurity and Agriculture Management Act 2007* (BAM Act) and Weeds of National Significance (WONS) known to be invasive and threats to biodiversity
  - Identification and mapping of areas of ecological importance (e.g. TF, TECs, conservation significant wetlands, Bush Forever sites) within the survey area.

### 2.2.3 Targeted Threatened and Priority flora surveys

Targeted threatened and priority flora searches were conducted as part of the detailed survey and aimed to determine the size and extent of all significant flora populations or vegetation in the survey area and to place any impacts into context locally and regionally.

All potentially suitable habitats were systematically searched for target species and communities. Significant flora taxa identified as having a moderate or high likelihood of occurring within the survey area (based on proximity of known records and / or presence of suitable habitat) were the target of the searches.

RPS undertook a targeted search for *Caladenia huegelii* (grand spider orchid) as a separate targeted survey during the species' documented flowering period on 28 September 2018, and Eco Logical undertook an additional survey for the orchid species in the same Banksia woodland vegetation over three days between 26th to 28th September 2019.

For the spring 2019 targeted flora surveys RPS recorded GPS tracks as evidence of search effort. The tracks are presented in Figure C.

## 2.3 Data analysis

### 2.3.1 Taxonomic determinations

Flora specimens were either identified in the field, or collected and identified using the keys, publications and databases of the WAH. Plant specimens were identified by specialist taxonomist Cate Tauss. Nomenclature was aligned with the current names in FloraBase (WAH 2020).



## 2.3.2 Vegetation mapping

Vegetation community mapping was conducted using a combination of aerial photo-interpretation, regional and local vegetation mapping, on-ground confirmation, vegetation structure data, and multivariate analysis results. Vegetation types were described to Association (Level V) in accordance with the NVIS (ESCAVI 2003) (Appendix A, Table A-6 and Table A-7).

Vegetation condition mapping was conducted using the recommended EPA (2016) scale adapted from Keighery (1994) and Trudgen (1988) (Appendix A, Table A-8).

## 2.3.3 Multivariate analysis of floristic data

Floristic Community Types (FCTs) are based on a survey of the vegetation of the SCP from Seabird to Dunsborough, completed by Gibson et al. (1994). The purpose of the regional survey was to determine the number and type of vegetation communities present across the southern SCP and to then assess how much of each remained and whether they are adequately represented and protected within reserves. The Gibson et al. (1994) survey involved the sampling of 508 10 m x 10 m floristic quadrats. The original Gibson et al. (1994) floristic multivariate analysis discussed the site (quadrat) groups at two scales: the 'supergroup' level, which corresponded broadly with four major geomorphological elements, and the finer community group level (FCTs). The supergroups are defined as follows:

- Supergroup 1 – Community types of heavier soils
- Supergroup 2 - Community types of seasonal wetlands
- Supergroup 3 - Community types centred on the Bassendean system
- Supergroup 4 - Community types centred on the Spearwood and Quindalup systems.

The current survey data was analysed against the combined SCP (Gibson et al. 1994) and Supplementary dataset (Keighery et al. 2012), which is derived from the results of several additional floristic studies completed between 1990 and 1996. These supplementary studies involved the sampling of an additional 590 floristic plots. These studies are summarised in Table 6.

**Table 6: Floristic studies used in the preparation of the SCP and supplementary dataset**

Study	Reference	Coverage	No. of sampling sites	Years of survey
SCP	Gibson et al. (1994)	Southern SCP	508	1990–1993
SYS6ENV	DEP (1996) – 1994 data	Southern SCP	590	1993–1994
SYS6ENV2	DEP (1996) – 1994 data	Southern SCP		1995–1996
GRIFFIN	Griffin (1993, 1994), Weston et al. (1993)	SCP north of Perth		1993
GJKENV	Keighery (1996)	Tuart ( <i>Eucalyptus gomphocephala</i> ) woodlands on the SCP		1990–1994

The survey data was reconciled with the SCP and Supplementary datasets of Gibson et al. (1994) and Keighery et al. (2012) by standardising the names of taxa with those used in the earlier studies. This was necessary due to changes in nomenclature in the intervening period. Taxa that were only identified to genus level were excluded while some infraspecies that have been identified since these studies were reduced to species level.

Floristic quadrat data (presence / absence) was analysed using multivariate techniques (via PRIMERV7 software) to classify the vegetation types within the survey area. The survey data included weed species (as did the original studies) and was analysed against the combined SCP and Supplementary dataset to determine the FCT and the conservation significance of the vegetation; specifically, the presence of any TECs or PECs within the survey area.

Data from each of the 32 floristic quadrats was combined with the 1,098 site SCP and Supplementary dataset, separately in PRIMERV7, and a dendrogram classification (Hierarchical Cluster Analysis) conducted to identify statistically significant clusters. Analysing each test site separately with the SCP dataset is considered a more reliable means of deriving accurate FCT groups because the addition of a single test site (sample) causes minimal disruption to the dataset.

Additionally, all the floristic data from the wetland test sites were then added individually to Supergroup 2 SCP and Supplementary dataset sites which represent seasonal wetland FCTs and Hierarchical Cluster Analyses run. Similarly, the floristic data from the dryland sites were added to Supergroup 3 SCP and Supplementary dataset sites which represent upland FCTs centred on the Bassendean system and Hierarchical Cluster Analyses run in an effort to resolve mixed affinities.

Resemblance matrices of the presence / absence data for the combined datasets were constructed using the Bray Curtis Similarity Coefficient and Hierarchical Cluster Analyses were carried out on these matrices using the group average linkage method. The outputs were illustrated as dendrograms.

Once an FCT had been assigned to each site, a comparison could be made against the DBCA's TEC / PEC database to assess the conservation significance of the vegetation.

## 2.4 Limitations

### 2.4.1 Survey limitations

Practitioners who conduct ecological surveys for environmental impact assessment in Western Australia are obliged to report on the limitations and constraints in such studies. Some potential limitations / constraints on surveys may adversely impact on the scientific rigour, completeness or the validity of the survey results. EPA (2016) identifies standard limitations which can limit and constrain the validity of surveys. These limitations / constraints and their relevance to this assessment are presented in Table 7.

**Table 7: Survey limitations**

Limitation	Relevance	Details
Availability of contextual information at a regional and local scale	No	Vegetation of the southern SCP has been comprehensively sampled and mapped. Numerous surveys have been undertaken in the vicinity of the survey area including recent surveys for Northlink and New Lord Street developments. Floristic data for the current assessment was compared to the SCP and Supplementary datasets of Gibson et al. (1994) and Keighery et al. (2012).
Competency and experience of the field team	No	All botanical practitioners are suitably qualified and experienced. The number of years professional experience conducting botanical surveys for Environmental Impact Assessment in Western Australia for each team member are listed below: <ul style="list-style-type: none"> <li>• Carrie Gill – 12 years</li> <li>• Cate Tauss – 30 years</li> <li>• Brian Morgan – 25 years</li> <li>• Kelli McCreery – 20 years</li> <li>• Julijanna Hantzis – 2 years.</li> </ul>
Proportion of flora and fauna recorded and / or collected, and problems with taxonomic determinations	No	Flora taxa recorded were either identified in the field or collected and identified using the keys and resources of the WAH. The species accumulation curve indicates that the survey effort was excellent with a total of 374 taxa recorded from three years of surveys. One taxon, <i>Lepidosperma</i> sp. (a putative new taxon) was recorded at one location along Bennett Brook. The specimen is awaiting a taxonomic determination from sedge specialist Russell Barrett.
The effort and extent of the survey	No	The assessment was carried out over a total of 60-person field days which was deemed sufficient to complete the surveys to the required standard within the survey area boundaries (in accordance with EPA [2016]).
Access restrictions within the survey area	Minor	The field surveys focused on the portions of the survey area which are managed by local and State government agencies. No private landholdings were accessed or surveyed so vegetation mapping for these areas has been extrapolated from aerial imagery and topographical maps.
Survey timing, rainfall, season of survey	No	The surveys were undertaken in Spring which is the optimal time for Primary floristic surveys in the SCP bioregion in accordance with EPA (2016) guidance. A Supplementary survey was undertaken to resample established quadrats in Autumn 2019 which is prescribed by EPA (2016) as the best to undertake revisit surveys on the SCP. A final autumn revisit survey is planned for 2020 to resample the quadrats requiring a second visit.

Limitation	Relevance	Details
Disturbances that may have affected the results of survey such as fire, flood or clearing	Moderate	Much of the survey area covered highly modified landforms including linear infrastructure, urban development, previously cleared agricultural land and pine plantation. The remnant and / or degraded vegetation which occurred in these areas could not be intensively sampled because the floristics and structure of the vegetation were not representative of intact pre-disturbance vegetation. As such this proportion of the survey area was not mapped or described in terms of FCT group. Some of the vegetation units described and delineated for the assessment were not sampled at three floristic sites because of the degraded condition of the vegetation.

## 2.4.2 Floristic analysis limitations

It is generally accepted that the addition of new quadrats to the regional dataset to produce a combined classification, may disrupt the original classification of quadrats (Griffin and Trudgen 2004), the more data that is added, the higher the level of disruption. Analysing each test site separately with the regional dataset is considered a more reliable means of deriving accurate FCT groups because the addition of a single test site (sample) causes minimal disruption to the dataset.

The use of different statistical analysis software (PRIMERv7 rather than PATN, which was used in the original analysis) is recognised to cause differences in the hierarchical clustering of the data. This is because the two software programs use a different default beta value in the group-average linkage (UPGMA) clustering routine. Neil Gibson confirmed that it was likely that we would not be able to recreate the original analysis results exactly because PRIMER does not allow you to change the beta value in the UPGMA algorithm. The version of PATN used 20 years ago used a value of -0.1 as a default, this parameter is not accessible in PRIMER which uses a default of 0.0 (N. Gibson, pers. comm. 21 November 2016).

Finally, the success of the PRIMERv7 analysis to assign an FCT to survey quadrats can be limited to the extent that the type of vegetation in the study area was sampled in the SCP Supplementary surveys. It is generally acknowledged that the southern SCP regional surveys under-sampled the full range of vegetation across the bioregion and that there are likely to be as-yet-undefined FCTs as well as transitional vegetation types that do not align with any of the FCTs defined in the Gibson et al. (1994) or Keighery et al. (2012) analyses.

Other potential limitations / constraints which may adversely impact on the scientific rigour, completeness or the validity of the multivariate floristic analysis results include:

- Proportion of flora recorded and/or collected
- Problems with taxonomic determinations
- Survey timing
- Rainfall
- Season of survey
- Site inundation (in the case of wetlands).

### 3 EXISTING ENVIRONMENT

#### 3.1 Existing and historical land use

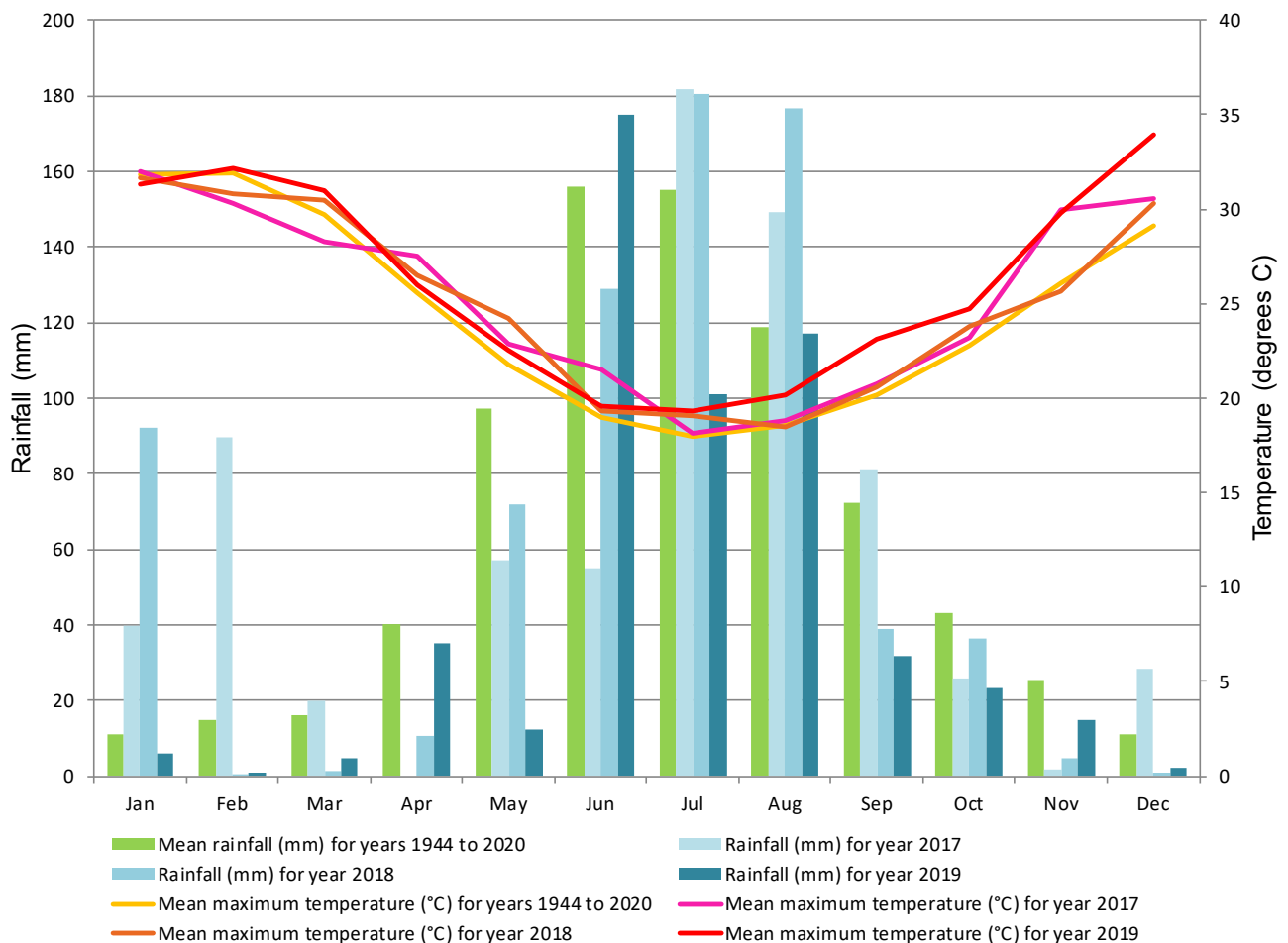
A range of land uses are represented within the survey area including linear infrastructure (roads and transmission lines), urban (residential and industrial) development, previously cleared agricultural land, nature reserves, Bush Forever sites and pine plantation (state forest). The survey area is located within the City of Swan's Local Government Area.

#### 3.2 Climate

The climate of the SCP is generally described as Warm Mediterranean with winter precipitation of 600–1000 millimetres (mm), and with 5–6 dry months per year (Beard 1990).

The Bureau of Meteorology (BoM) weather station closest to the survey area is the Perth Airport weather station no. 009021, located approximately 7 km to the south of the survey area. The 76-year average annual rainfall for the Perth Airport weather station is 766.7 mm. In 2017, 2018 and 2019 annual totals of 729.4 mm, 743.8 mm and 524.6 mm were received respectively which were all below the long term annual average. However, in 2017 and 2018 more rain than the long-term average was received in the months of July and August (BoM 2020) immediately preceding the spring surveys, which resulted in excellent survey seasons. In 2019, for the months of June to August the region received 10% less rain than the long-term average for the same period. All three survey years were hotter than average with the second half of 2019 tracking monthly temperature maxima 2 °C to 4.8 °C hotter than the long-term average.

Historical rainfall data collected from the Perth Airport weather station is presented in Graph 1 (BoM 2020).



**Graph 1: Mean monthly rainfall (mm) and maximum temperature data (°C) for Perth Airport weather station (009021) for years 1944 to 2020, and rainfall and temperature data for 2017, 2018 and 2019 (BoM 2020)**

### 3.3 Interim Biogeographical Regionalisation of Australia

The Interim Biogeographic Regionalisation for Australia (IBRA) divides Australia into bioregions based on major biological and geographical/geological attributes (Thackway and Cresswell 1995). The IBRA currently recognises 89 bioregions and 419 biological subregions in Australia. The survey area lies within the Perth (SWA02) subregion of the SCP bioregion.

The Perth subregion is composed of colluvial and aeolian sands, alluvial river flats and coastal limestone and the vegetation is described by Mitchell et al. (2002) as Heath and/or Tuart woodlands on limestone, Banksia and Jarrah-Banksia woodlands on Quaternary marine dunes of various ages and Marri on colluvial and alluvials.

### 3.4 Geology, landform and soils

The SCP consists of five major geomorphological elements as defined by McArthur and Bettanay (1960). From west to east these are the Quindalup Dunes, Spearwood Dunes, Bassendean Dunes, Pinjarra Plain, and Ridge Hill Shelf. These systems lie roughly parallel to the coast and are distinguished by their geology, topography, vegetation and soils. The survey area lies within the Bassendean Dunes and the Pinjarra Plain landforms. The Bassendean Dune System is of generally low relief, often with broad swales or relatively flat sand sheets between the low dunes. Soils are predominantly deep grey leached quartz sands. The Pinjarra Plain is a piedmont and valley-flat alluvial plain consisting predominantly of clayey alluvium that has been transported by rivers and streams from the Darling and Dandaragan Plateaus.

Surface geology mapping for the Perth region (Department of Mines, Industry Regulation and Safety (DMIRS) 2019) indicates that the survey area is a mosaic of four geological features (Table 8). Surface geology mapping for the survey area is presented in Figure D.

**Table 8: Surface geology within the survey area**

Code	Description
Mgs 1	PEBBLY SILT - strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weathered granite pebble, some fine to medium-grained quartz sand, of alluvial origin
Cps	PEATY CLAY - dark grey and black with variable sand content of lacustrine origin
S10	SAND - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted of eolian origin
S8	SAND - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted of eolian origin

(Data Source: DMIRS 2019)

### 3.5 Surface hydrology

The survey area lies within the Swan Avon – Lower Swan catchment and intersects two sub-catchments; the Bennett Brook catchment in the south, and the Ellenbrook catchment in the north (DPIRD 2019).

Interrogation of the linear hydrography database identified that the survey area intersects Bennett Brook (a significant stream and Conservation Category Wetland) (DPIRD 2019).

### 3.6 Groundwater hydrology

The survey area is located on the shallow, unconfined Superficial Aquifer, commonly known as the Gngangara Mound. The Superficial Aquifer, along with the shallow Mirrabooka Aquifer, the deep Leederville Aquifer and the deep Yarragadee Aquifer make up the Gngangara Groundwater System which extends north of the Swan River to Gingin in the north and from the coast east to the Darling Scarp and covers approximately 2,200 km<sup>2</sup> (DWER 2019). The Superficial Aquifer consists of several superficial formations including the Yoganup, Ascot Limestone, Bassendean Sand, and Tamala Limestone formations, which overlie Cretaceous, Jurassic and Triassic sediments.

### 3.7 Geomorphic wetlands

DBCA has developed a dataset which maps the location, boundaries and management category of wetlands on the SCP. Geomorphic wetlands have been categorised according to landform and water permanence (hydroperiod). A management category (Conservation, Resource Enhancement and Multiple Use in order of conservation priority) was assigned to each wetland to guide their management and protection.

The survey area intersects the mapped extents of 14 Conservation Category Wetlands (CCWs) and six Resource Enhancement Wetlands (REWs) (Figure E; Table 9). The definitions and management objectives for the three wetland management categories, and geomorphic wetland types are presented in Appendix A, Table A-9 and Table A-10.

**Table 9: Geomorphic wetlands of the SCP intersecting the survey area**

Unique feature identifier (UFI)	Management category	Wetland type
8429	Conservation	Sumpland
8548	Conservation	Sumpland
8572	Conservation	Palusplain
8550	Conservation	Dampland
8670	Conservation	Floodplain (West Bennett Brook)
8680	Conservation	Palusplain
8722	Conservation	Palusplain
8724	Conservation	Sumpland (Horse Swamp)
8726	Conservation	Lake (Mussel Pool)
8728	Conservation	Palusplain
8797	Conservation	Dampland
15033	Conservation	Floodplain
15259	Conservation	Floodplain
15260	Conservation	Palusplain
8678	Resource Enhancement	Sumpland
8679	Resource Enhancement	Dampland
8806	Resource Enhancement	Palusplain
14447	Resource Enhancement	Palusplain
15752	Resource Enhancement	Palusplain
15757	Resource Enhancement	Sumpland

### 3.8 Bush Forever

Bush Forever identifies areas of regional conservation value on the SCP portion of the Perth Metropolitan Region (PMR) with an aim to protect a comprehensive representation of the biological diversity on the Metropolitan Coastal Plain (WAPC 2000). The survey area intersects one Bush Forever site (Table 10 and Figure F).

**Table 10: Bush Forever site intersecting the survey area**

Site number	Site name	Significant features	Area of BF site intersecting the survey area (ha)
304	Whiteman park, Whiteman/West Swan	Priority Flora; rich and diverse flora and fauna; largest known stands of <i>Cyathochaeta teretifolia</i> ; CCWs including Bennett Brook; regionally significant river; Forms part of a regional ecological linkage	554.61



### 3.9 Perth regional ecological linkages

In the Perth region, regional and local ecological linkages have been identified following a methodology outlined in the Local Government Biodiversity Planning Guidelines for the Perth Metropolitan Region (Del Marco et al. 2004) which defines an ecological linkage as a series of non-contiguous natural areas that connect larger natural areas by forming stepping stones through the altered landscape that allows the movement over time of organisms (animals, seeds, pollen) between these larger areas and across the landscape.

The survey area forms part of a regionally significant ecological linkage, Greenways 32, 39, 21, 40, and 38 (Tingay and Associates 1998), which extends from Bennett Brook north through Whiteman Park to the northern-most part of the survey area in Ellenbrook (Figure G).

### 3.10 DBCA managed lands and reserves

One DBCA managed State Forest intersects the survey area north of Gnangara Road (Table 11 and Figure H). No regional parks are located within the survey area. The nearest regional parks, Herdsman Lake Regional Park and Yellagonga Regional Park lie approximately 5 km and 9 km respectively, to the west of the survey area.

**Table 11: DBCA managed lands and reserves intersecting the survey area**

Name	Category	Class	Purpose	Tenure	Vesting
Gnangara-Moore River State Forest	State Forest	A	State Forest	Crown land	Conservation Commission of WA

### 3.11 Regional reserves

The survey area intersects two portions of land reserved as Parks and Recreation under the Metropolitan Region Scheme (MRS); Whiteman Park and the A-Class Nature Reserve (Gnangara-Moore River State Forest) listed in Table 11. Parks and Recreation areas are managed to protect the integrity, function and environmental values of the bushland and landforms to the requirement of the WAPC on the advice of the EPA and are only to be used for conservation, landscape and complimentary purposes.

### 3.12 Environmentally sensitive areas (ESAs)

Environmentally Sensitive Areas (ESAs) are declared by the Minister for Environment under section 51B of the EP Act.

The following areas are declared to be ESAs:

- Declared World Heritage property as defined in section 13 of the EPBC Act
- Area that is included on the Register of the National Estate, because of its natural heritage value, under the *Australian Heritage Council Act 2003*
- Defined wetland and the area within 50 metres of the wetland. Defined wetlands include Ramsar wetlands, CCWs and nationally important wetlands
- Area covered by vegetation within 50 metres of rare flora, to the extent to which the vegetation is continuous with the vegetation in which the rare flora is located
- Area covered by a TEC
- Bush Forever site listed in Bush Forever: Volumes 1 and 2 (WAPC 2000), except to the extent to which the site is approved to be developed by the WAPC.

Within the survey area all the CCWs (Figure E), areas covered by TEC (Figure O) and Bush Forever site (Figure F) are considered ESAs.

### 3.13 Regional vegetation

#### 3.13.1 Beard vegetation mapping

The survey area is situated in South West Botanical Province and the Darling Botanical District (Beard 1990). This region typically consists of forest country with related woodlands and is divided into four botanical subdistricts. The survey area is located within the SCP Subregion in the Drummond Botanical Subdistrict, which according to Beard (1990) consists mainly of the following vegetation communities:

- Banksia Low Woodland on leached sands and Melaleuca Swamps in poorly drained areas
- Woodland of tuart (*Eucalyptus gomphocephala*); and jarrah (*Eucalyptus marginata*) and marri (*Corymbia calophylla*) on less leached soils.

Vegetation mapping was completed by Beard (1979) at a scale of 1:250,000. Shepherd et al. (2002) reassessed Beard's existing mapping dividing some of the broader vegetation units up into smaller units.

The vegetation within the survey area is mapped as the following four broad-scale associations:

- Vegetation Association 1001 - Medium very sparse woodland; jarrah, with low woodland; banksia and casuarina
- Vegetation Associations 1018 - Mosaic: Medium forest; jarrah-marri / Low woodland; banksia / Low forest; teatree / Low woodland; *Casuarina obesa*
- Vegetation Association 1009 - Medium woodland; marri and river gum
- Vegetation Association 949 – Low woodland banksia.

The remnant extent and reservation status of these vegetation associations within Western Australia, SWA02 Perth IBRA Subregion, and City of Swan are presented in Table 12.

Three of these vegetation associations (1001, 1018 and 1009) have between 10% and 30% of their pre-European extent remaining within the Perth (SWA02) Subregion. While the EPA's objective is to retain at least 30% of the pre-clearing extent of each ecological community, the EPA also has a modified objective to retain at least 10% of the pre-clearing extent of each ecological community within defined constrained (intensely developed) areas in the PMR portion of the SCP.

The Pre-European vegetation association mapping for the survey area is presented in Figure I.

**Table 12: Pre-European extent, current extent and reservation status of vegetation associations within the Western Australia, Perth IBRA subregion and City of Swan**

Vegetation association	Area	Pre-European extent (ha)	Present extent (ha) remaining	% of present extent remaining	% of present extent in secure tenure
1001	Western Australia	57,410	12,661	22.05	2.80
	SWA02 Bioregion	57,410	12,661	22.05	2.80
	City of Swan	8,868	2,321	26.18	0.02
1018	Western Australia	14,059	2,445	17.39	0.72
	SWA02 Bioregion	13,946	2,418	17.34	0.73
	City of Swan	6,013	987	16.42	0.15
1009	Western Australia	18,225	3,004	16.48	0.02
	SWA02 Bioregion	18,183	2,982	16.40	0.02
	City of Swan	8,520	379	4.45	0.00
949	Western Australia	218,194	123,104	56.42	13.81
	SWA02 Bioregion	184,475	104,129	56.45	14.89
	City of Swan	16,235	7,970	49.09	2.74

(Government of Western Australia 2019)

### 3.13.2 Heddle vegetation complexes

Vegetation complexes are vegetation associations that are characteristic of various combinations of soil, landform and rainfall. A large part of the SCP has been mapped for vegetation complexes by Heddle et al. (1980). These complexes are closely related to the SCP Dune Systems (Quindalup, Spearwood, Bassendean, and Pinjarra Plain) and north to south variations in climate and rainfall.

Heddle et al. (1980) mapped the vegetation within the survey area as:

- Bassendean Complex Central and South: Vegetation ranges from woodland of *E. marginata* – *C. fraseriana* – *Banksia* spp. to low woodland of *Melaleuca* spp. and sedgelands on the moister sites.
- Southern River Complex: Open woodland of *Corymbia calophylla*, *Eucalyptus marginata*, and *Banksia* spp. on the elevated areas and fringing woodland of *Eucalyptus rudis* and *Melaleuca raphiophylla* along streams.
- Bassendean Complex North: Vegetation ranges from low open forest and low woodland of *Banksia* spp. and *Eucalyptus todtiana* to low woodland of *Melaleuca* spp. and sedgelands on wetter sites.

The remnant extent and reservation status of these vegetation complexes on the SCP south of Moore River and City of Swan is presented in Table 13. Vegetation complex mapping is presented in Figure J.

Two of these vegetation complexes (Bassendean Central and South and Bassendean North) have greater than 30% of their pre-European extent remaining within the SCP and the City of Swan. However, there is between 10% and 30% of the pre-European extent remaining of the Southern River Complex. The extent remaining of the Southern River Complex does not meet the EPA's 30% retention target. However, it does meet the EPA's modified 10% retention target for constrained (intensely developed) areas in the PMR portion of the SCP.

**Table 13: Vegetation complex pre-European and current extent on the SCP south of Moore River, and City of Swan**

Vegetation complex	Area	Pre-European extent (ha)	2015 extent (ha)	% Remaining	Secure for conservation in the PPR (and in Bush Forever for the City of Swan) (ha)
Bassendean Central and South	SCP	87,416	22,846	26.1	733
	City of Swan	4,632	1,484.00	32.04	1,407
Southern River	SCP	57,163	10,533	18.40	629
	City of Swan	8,669	1,539.85	17.76	1,172
Bassendean North	SCP	74,131	53,218	71.80	9,092
	City of Swan	14,215	7,470.10	52.55	2,462

(Source: Perth Biodiversity Project 2013; EPA 2015)

## 4 RESULTS

### 4.1 Desktop assessment

#### 4.1.1 Database searches

##### 4.1.1.1 Threatened and Priority flora database search results

Searches of the DBCA Threatened and Priority Flora database and the WAH Specimen database were undertaken within a 10 km radius of the survey area boundary in October 2019 to ensure that the assessment was based on the most up-to-date conservation significant flora spatial data.

A total of 59 species of conservation significance were found to occur within the 10 km search radius comprising ten TF species, six Priority 1, eight Priority 2, twenty-one Priority 3 and fourteen Priority 4 flora taxa.

The list of significant species and their conservation codes retrieved from the databases for the search area, and their assessed 'likelihood of occurrence' are presented in Appendix B. These species were the focus of the targeted flora searches during the 2019 spring field survey. Previous years' targeted surveys had been informed by the results of a database search carried out at the commencement of the assessment in 2017.

Of the 59 taxa retrieved from the database searches three are known to occur within the survey area having been recorded during the field surveys for this assessment. Additionally, 29 were deemed to have a 'high' or 'moderate' likelihood of occurrence, five a 'low' likelihood, and the remaining 22 'negligible' likelihood of occurring within the survey area. Refer to Appendix B for the rationale behind the assessment of likelihood for each species. It is important to note that because the DBCA used a 10 km search radius some of the species returned occur on the Darling Scarp and not on the SCP. As such we would not expect them to be present in the survey area because suitable, soils, landforms and habitat are not present. These species were determined to have a 'negligible' likelihood of occurrence within the survey area.

Conservation significant species records in the vicinity of the survey area derived from the database searches are shown in Figure K.

##### 4.1.1.2 Threatened and Priority ecological communities database search results

Searches of the DBCA ecological community database were undertaken within a 5 km radius of the survey area boundary.

A total of 348 records of nine TECs / PECs were found to occur within the search radius comprising *Banksia Woodlands of the Swan Coastal Plain ecological community* (312 records), Subtropical and Temperate Coastal Saltmarsh Ecological Community (five records), Shrublands and woodlands on Muchea Limestone (one record), Communities of Tumulus springs (Organic Mound springs, Swan Coastal Plain) Ecological Community (one record), SCP02 (one record), SCP20a (four records), SCP21c (eight records), SCP22 (six records), and SCP23b (nine records) (Table 14).

Table 14 identifies each community's protection status under the BC Act and EPBC Act.

Conservation significant ecological community records in the vicinity of the survey area are shown in Figure L.

**Table 14: TEC / PEC records within a 5 km radius of the survey area**

TEC / PEC	Description	BC Act status*	EPBC Act status†
Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	The ecological community is a woodland associated with the SCP of south-west Western Australia. A key diagnostic feature is a prominent tree layer of Banksia, with scattered eucalypts and other tree species often present among or emerging above the Banksia 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 (Threatened Species Scientific Committee 2016).	Priority 3	Endangered

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TEC / PEC	Description	BC Act status*	EPBC Act status†
Subtropical and Temperate Coastal Saltmarsh	The Subtropical and Temperate Coastal Saltmarsh (hereafter Coastal Saltmarsh) ecological community occurs within a relatively narrow margin of the Australian coastline, within the subtropical and temperate climatic zones south of the South-east Queensland IBRA bioregion boundary at 23°37' latitude along the east coast and south of (and including) Shark Bay at 26° on the west coast. The community consists mainly of salt-tolerant vegetation (halophytes) including grasses, herbs, reeds, sedges and shrubs. Succulent herbs and grasses generally dominate, and vegetation is generally <0.5 m tall with the exception of some reeds and sedges. Many species of non-vascular plants are also found in saltmarsh, including epiphytic algae, diatoms and cyanobacterial mats.	Priority 3	Vulnerable
Shrublands and woodlands on Muchea Limestone	This community occurs on the heavy soils of the eastern side of the SCP. Known patches include wetland and well-drained habitats, in a variety of landforms (Tauss and Weston 2010). It is defined on the basis of rare limestone-influenced substrates. Where the best developed limestone occurs, near Gingin, the plant community is located on shallow black clay or sandy clay soils on limestone. Typical and common native species in areas of best developed limestone are the tree <i>Casuarina obesa</i> , the mallees <i>Eucalyptus decipiens</i> and <i>Eucalyptus foecunda</i> and the shrubs <i>Melaleuca huegelii</i> , <i>Alyogyne huegelii</i> var. <i>huegelii</i> , <i>Grevillea curviloba</i> ssp. <i>incurva</i> , <i>Grevillea curviloba</i> ssp. <i>curviloba</i> , <i>Grevillea evanescens</i> , <i>Melaleuca acerosa</i> , and the herb <i>Thysanotus arenarius</i> .	Endangered	Endangered
Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain)	The habitat of this community is characterised by continuous discharge of groundwater in raised areas of peat. The peat and surrounds provide a stable, permanently moist series of microhabitats. Intact vegetated tumulus springs are only currently recorded at four locations. Typical and common native vascular plant species associated with the tumulus springs are the trees <i>Banksia littoralis</i> , <i>Melaleuca preissiana</i> and <i>Eucalyptus rudis</i> , and the shrubs <i>Taxandria linearifolia</i> , <i>Pteridium esculentum</i> , <i>Astartea fascicularis</i> and <i>Cyclosorus interruptus</i> . The following non-vascular plants have been located on peat mounds associated with the community: <i>Lycopodium serpentium</i> (bog clubmoss), <i>Riccardia aequicellularis</i> , <i>Jungermannia inundata</i> , <i>Goebelobryum unguiculatum</i> and <i>Hyalolepidozia longiscypha</i> .	Critically Endangered	Endangered
SCP02 - Southern wet shrublands, Swan Coastal Plain	This type occurs on Bassendean Dunes and the Pinjarra Plain in seasonally inundated areas and generally has a diverse and dense shrub layer.	Endangered	-
SCP20a - <i>Banksia attenuata</i> woodlands over species rich dense shrublands	This type occurs on the Southern River unit (Bassendean System) and Karrakatta unit (Spearwood System). Structurally either <i>Banksia attenuata</i> woodlands or <i>Banksia attenuata</i> – <i>Eucalyptus marginata</i> woodlands this vegetation type is the most species-rich of all the banksia communities with an average species richness of 67.4 species per site.	Endangered	Endangered
SCP21c – Low-lying <i>Banksia attenuata</i> woodlands or shrublands	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>Regelia ciliata</i> , <i>Eucalyptus marginata</i> or <i>Corymbia calophylla</i> . Structurally, this community type may be either a woodland or occasionally shrubland.	Priority 3	Endangered
SCP22 - <i>Banksia ilicifolia</i> woodlands	Low-lying sites generally consisting of <i>Banksia ilicifolia</i> – <i>B. attenuata</i> woodlands, but <i>Melaleuca preissiana</i> woodlands and scrubs are also recorded. Occurs on Bassendean and Spearwood systems in the central SCP north of Rockingham. Typically, has very open understorey, and sites are likely to be seasonally waterlogged.	Priority 2	Endangered

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TEC / PEC	Description	BC Act status*	EPBC Act status†
SCP23b - Swan Coastal Plain <i>Banksia attenuata</i> - <i>Banksia menziesii</i> woodlands	These woodlands occur in the Bassendean system, from Melaleuca Park to Gingin. Occurs in reasonably extensive <i>Banksia</i> woodlands north of Perth.	Priority 3	Endangered

\*BC Act

†These communities have additional protection under the EPBC Act.

## 4.2 Field survey

### 4.2.1 Flora

#### 4.2.1.1 Flora statistics

A total of 374 vascular flora taxa were recorded by the current survey of which 290 (77.5%) were native species and 84 (22.5%) were naturalised alien (weed) species. The list of taxa recorded for the survey area is presented in Appendix C. Species recorded by site (both quadrats and relevés) are presented in Appendix D, and detailed floristic quadrat data are presented in Appendix E.

There were several taxa that could not be identified to species level due to inadequate fruiting or flowering material available at the time of the survey. These taxa are labelled “sp.”.

The taxa recorded represent 74 families and 211 genera. The families represented by the greatest number of taxa are presented in Table 15. The genera represented by the greatest number of taxa are presented in Table 16.

**Table 15: Dominant families within the survey area**

Family	Common name	No. of taxa
FABACEAE	Acacias and peas	38
CYPERACEAE	Sedges	34
MYRTACEAE	Myrtles	31
ASTERACEAE	Daisies	27
POACEAE	Grasses	27
ORCHIDACEAE	Orchids	21
ASPARAGACEAE	Fringed lilies / mat rushes	20
PROTEACEAE	Proteas	14
HAEMODORACEAE	Bloodroots	12
STYLIDIACEAE	Trigger plants	10

**Table 16: Dominant genera within the survey area**

Genus	Common name	No. of taxa
Acacia	Wattles	10
Lomandra	Mat rushes	9
Stylidium	Trigger plants	9
Drosera	Sundews	8
Hibbertia	Guinea flowers	8
Schoenus	-	8
Lepidosperma	-	7
Banksia	-	6



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Genus	Common name	No. of taxa
Caladenia	-	6
Conostylis	-	6
Melaleuca	Honey myrtles	6
Thysanotus	Fringe lilies	6

### 4.2.1.2 Field survey effort

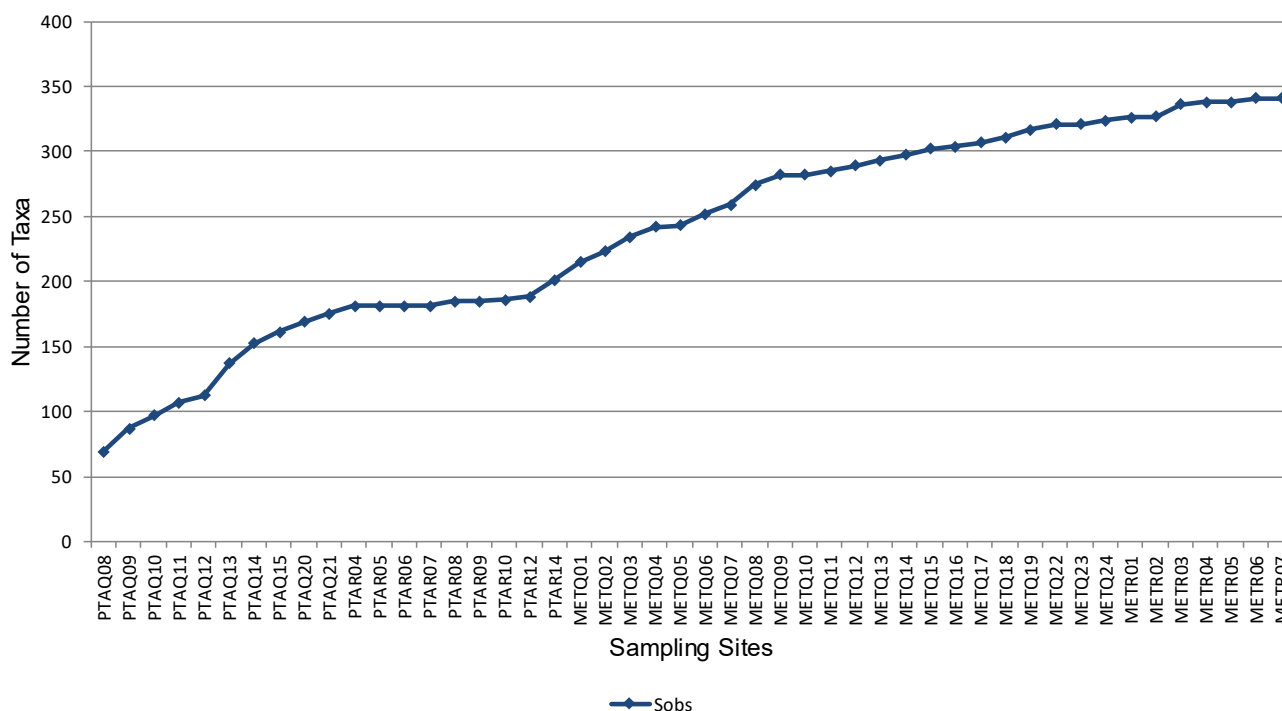
Species accumulation plots were generated for the survey site data using PRIMERV7 SPEC-ACCUM (Graph 2). This expressed the number of species recorded for the field surveys as a function of effort (i.e. number of sites sampled).

Initially, the analysis was run on the dataset in the order that the sampling sites (quadrats and relevés) were sampled in the field (i.e. chronologically) using the 'Sobs' index. This generated a 'stepped' curve showing the actual cumulative number of taxa recorded as each subsequent floristic site was sampled (Graph 2).

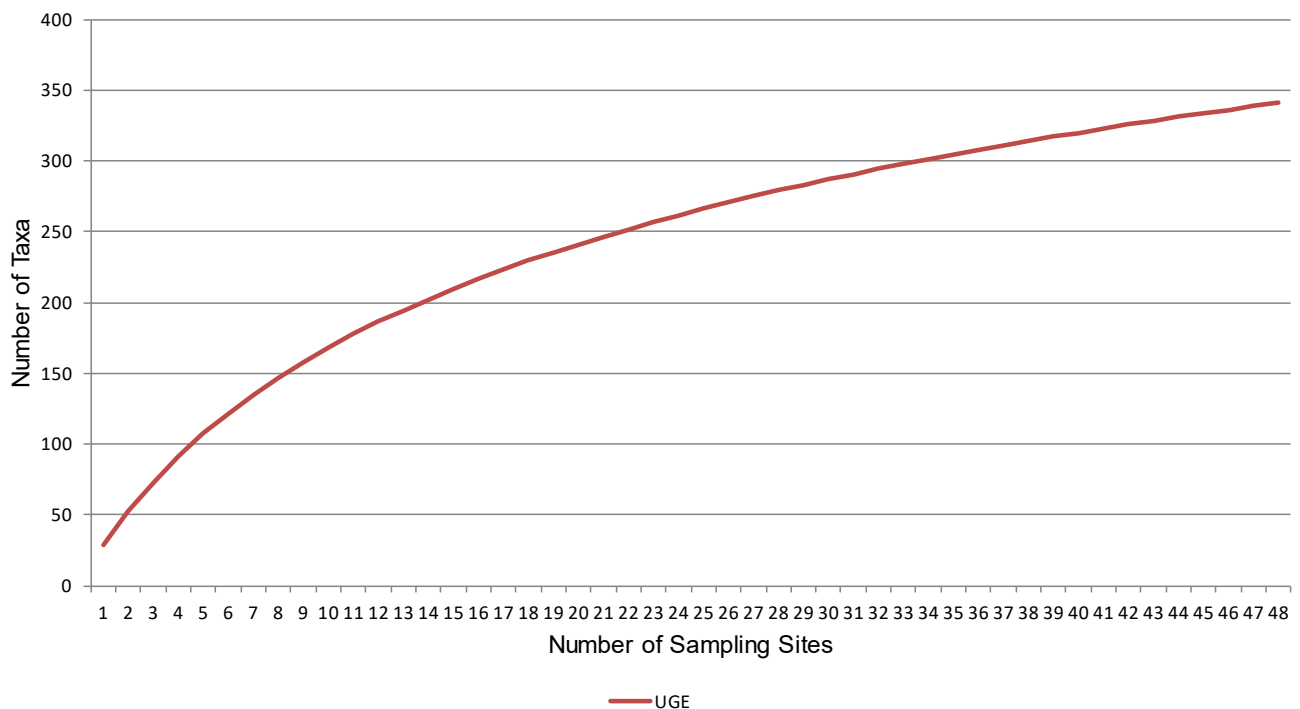
A second analysis was undertaken using the 'UGE' index to generate a smooth curve which was derived from the means of repeated re-sampling of all pooled samples (Graph 3). This curve represents the 'statistical expectation' for the curve shown in Graph 2.

The curves demonstrate that a total of 341 taxa were recorded for the 32 quadrats and 16 relevés. The shape of the curve indicates that fewer new species were recorded with the sampling of each additional site and that the number of sites that would have to be sampled to reach the asymptote (theoretical maximum) would be prohibitively large.

It was concluded that the survey effort for the current field survey was very good. It should also be noted that an additional 33 taxa were recorded opportunistically bringing the actual total to 374.



**Graph 2: Species accumulation curve (Sobs index)**



**Graph 3: Species accumulation curve (UGE index)**

#### 4.2.1.3 Flora of conservation significance

RPS undertook targeted searches for TF and PF within the survey area over a total of 16 person days as part of the 2017, 2018 and 2019 spring surveys. Additionally, RPS carried out a *Caladenia huegelii* (grand spider orchid) search as a separate targeted survey during the species’ documented flowering period, on 28 September 2018. The survey involved a systematic search of suitable habitat within the survey area. No *Caladenia huegelii* individuals were recorded for the survey. The methods and outcomes of the targeted survey are presented in Appendix F. Subsequent to this survey the METRONET Office commissioned Eco Logical to undertake a *Caladenia huegelii* survey of the same Banksia woodland vegetation in spring 2019. No *Caladenia huegelii* individuals were recorded for the Eco Logical survey. The resulting report is provided in Appendix G.

No TF species listed under the BC Act or the EPBC Act were recorded within the survey area.

Three DBCA-listed PF species were recorded within the survey area:

1. *Cyathochaeta teretifolia* (P3)
2. *Anigozanthos humilis* subsp. *chrysanthus* (P4)
3. *Tetraria* sp. Chandala (G.J. Keighery 17055) (P2).

Additionally, a fourth PF was recorded just outside the survey area boundary

4. *Stylidium longitubum* (P4).

It should be noted that two of the three PF recorded within the survey area do not occur within the proposed Malaga to Ellenbrook Rail Works development envelope. The only PF taxon recorded within the development envelope was *Anigozanthos humilis* subsp. *chrysanthus* (P4) of which two individuals were recorded within the Banksia woodland vegetation in the vicinity of the proposed Malaga station.

The location of the PF species records and their abundance (percentage cover or number of individuals) are presented in Figure M. Percentage cover was used to express the density of the species in the immediate vicinity of the point at which the record was taken, and was used as a method of recording abundance in instances where there were too many individuals to count. Additionally, a sedge species which is possibly *Schoenus natans* (P4) was recorded just outside the survey area boundary but due to the degraded nature of the plant material available (it was dead and had no flowering or fruiting parts present) it could not be positively identified. The record is labelled on Figure M as ‘?Schoenus natans’. Another sedge species (a *Lepidosperma* sp.) was recorded at one location within the survey area which potentially represents an as-

yet-undescribed taxon because it did not match with any of the taxa from this genus known from the region. This record is labelled on Figure M as '*Lepidosperma* sp. (putative new taxon)'. RPS is consulting Cyperaceae specialist Russell Barrett in an effort to determine the correct taxonomy for this collection.

The likelihood of occurrence assessment (Appendix B) was revised for each species after the spring 2019 field survey based on all survey results and presented as the 'residual likelihood of occurrence'. Three of the species on the list are now 'known' to occur within the survey area, and one, *Schoenus natans*, is determined 'likely' to occur there although its presence could not be confirmed. The remaining species on the list were not recorded within the survey area during the field surveys and so the 'residual likelihood of occurrence' was updated to 'negligible'.

Further information on the PF recorded within the survey area is provided in the following sections.

### ***Cyathochaeta teretifolia* (P3)**

*Cyathochaeta teretifolia* is a rhizomatous, clumped, robust perennial sedge which grows to 2 m high and 1 m wide. Flowers are brown. The species occurs on grey sand and sandy clay in swamps and along the banks of creeks (WAH 2020).

*Cyathochaeta teretifolia* was recorded from four floristic quadrats: PTAQ13 (within REW dampland UFI 8679); METQ07 and PTAQ20 (within CCW sumpland UFI 8548) in the eastern part of Whiteman Park, and METQ22 (within CCW UFI 8670 Floodplain (West Bennett Brook). The species is associated with the wetland vegetation type *Mp.Tl.Ct/Ca*, mapped for the current survey, in which it is often a dominant understorey species. Associated species included *Melaleuca preissiana*, *Taxandria linearifolia*, *Dielsia stenostachya* and *Lepidosperma longitudinale* (Plates 1–3). The species was widespread and often abundant within the vegetation flanking West Bennett Brook, where it was the focus of a targeted survey in spring 2019. The location and abundance (percentage cover) of the species within the survey area is presented in Figure M. This species was not recorded within the proposed Malaga to Ellenbrook Rail Works development envelope.



**Plate 1: *Cyathochaeta teretifolia* habitat (PTAQ13)**





**Plate 2: *Cyathochaeta teretifolia* habitat (METQ22)**



**Plate 3: *Cyathochaeta teretifolia* habitat (METQ07)**

***Anigozanthos humilis* subsp. *chrysanthus* (P4)**

*Anigozanthos humilis* subsp. *chrysanthus* is a rhizomatous, perennial herb growing 0.2 to 0.4 m high (Plate 4). Flowers are characteristically yellow and appear between July and October. The species occurs on grey or yellow sand (WAH 2019).

*Anigozanthos humilis* subsp. *chrysanthus* was recorded within PTAQ08 (one individual) and adjacent to PTAQ12 (one individual) within the Et.Ba.Bm.Ah. *Banksia attenuata* and *B. menziesii* with emergent *Eucalyptus todtiana* low woodland vegetation unit occurring on dune slopes and crests. Associated species included *Allocasuarina humilis*, *Hibbertia hypericoides*, *Conostephium pendulum*, *Astroloma xerophyllum* and *Alexgeorgea nitens* (Plates 4 and 5). The location of the species records within the survey area is presented in Figure M. These records are within the proposed Malaga to Ellenbrook Rail Works development envelope in the vicinity of the proposed Malaga station.





**Plate 4:** *Anigozanthos humilis subsp. chrysanthus*

Photo source: WAH 2019



**Plate 5:** *Anigozanthos humilis subsp. chrysanthus* habitat (PTAQ08)

***Tetragia* sp. Chandala (G.J. Keighery 17055) (P2)**

*Tetragia* sp. Chandala (G.J. Keighery 17055) is a rhizomatous perennial sedge growing to 50 centimetres (cm) with narrow leaves and culms. It has a loose, branched inflorescence with dark brown florets. It occurs in *Melaleuca preissiana*, *M. raphiophylla* and *Eucalyptus rudis* forests and woodlands on the edge of swamps and standing water, and on mound springs in black peat and peaty sand, and black peat over clay and humic sand. It is known only from five locations on the SCP (WAH 2020).



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*Tetraria* sp. Chandala (G.J. Keighery 17055) was recorded from one floristic quadrat: METQ22 (within CCW UFI 8670 Floodplain (West Bennett Brook) as well as at numerous locations along the banks of West Bennett Brook during the targeted survey in spring 2019. The species is associated with the wetland vegetation type *Mp.Tl.Ct/Ca*, mapped for the current survey, in which it is a common and sometimes dominant understorey species. Associated species included *Melaleuca preissiana*, *Taxandria linearifolia*, *Lepidosperma longitudinale*, *Cyathochaeta teretifolia* and *Gastrolobium ebracteolatum* (Plates 6 and 7). The location and abundance of the species within the survey area is presented in Figure M. This species was not recorded within the proposed Malaga to Ellenbrook Rail Works development envelope.



**Plate 6:** *Tetraria* sp. Chandala (G.J. Keighery 17055) habitat along West Bennett Brook



**Plate 7:** *Tetraria* sp. Chandala (G.J. Keighery 17055) habitat (METQ22)



***Stylidium longitubum* (P4)**

*Stylidium longitubum* is a small annual ephemeral herb growing to 10 cm with pink flowers and a basal rosette. It occurs in *Melaleuca* spp. forests, woodland and tall shrublands on seasonally wet broad flat depressions on plains, floodplains and claypans (WAH 2020).

*Stylidium longitubum* was not recorded within the survey area but was recorded from three locations within CCW UFI 8670 Floodplain (West Bennett Brook) just outside the survey area boundary. The species is associated with the wetland vegetation type *Mp. Tl. Ct/Ca*, mapped for the current survey, in which it occurred in small localised patches of up to 100 individuals. Associated species included *Melaleuca raphiophylla*, *M. preissiana*, *Astartea scoparia*, *Eutaxia virgata* and *Cyathochaeta avenacea* (Plates 8 and 9). The species was the focus of a targeted survey in spring 2019. The location and abundance of the species in relation to the survey area is presented in Figure M.



**Plate 8:** *Stylidium longitubum* on seasonally wet flat adjacent to West Bennett Brook



**Plate 9:** *Stylidium longitubum*

#### 4.2.1.4 Flora of other conservation significance

There are a number of other criteria (apart from the Commonwealth and Western Australian criteria of TF and PF) under which flora taxa of the PMR may be considered to be of 'other' conservation significance. These taxa are listed by Bush Forever: Volumes 1 and 2 (WAPC 2000) as significant under various categories which include:

- Being confined to scarce or refugial habitats
- Having an uncommon form
- Belonging to regionally significant populations
- Being outside, disjunct from, or at the limit of their known geographical range
- Being undescribed taxonomic entities
- Being poorly reserved.

These taxa are not protected under Commonwealth or state legislation but are required to be assessed as part of flora and vegetation assessments.

A total of six additional taxa recorded within the survey area are conservation significant based on geographic range anomalies, belonging to significant populations, being poorly reserved, or endemic to the SCP or the PMR portion of the SCP (Table 17).

**Table 17: Significant flora of the PMR**

Taxon	Other significance*	Location within the survey area
<i>Aotus cordifolia</i>	p, s	PTAQ13, PTAQ20
<i>Burchardia bairdiae</i>	r, s	PTAQ14, adjacent to METQ02
<i>Conostephium minus</i>	p, s, e	PTAQ09
<i>Conostylis aculeata</i> subsp. <i>cygnorum</i>	e	PTAQ08, PTAQ11, PTAQ12, adjacent to METQ09
<i>Dielsia stenostachya</i>	e	PTAQ13, PTAQ14, PTAQ15, PTAR10, PTAR12, METQ02, METQ05
<i>Verticordia nitens</i>	s	PTAQ15

\*Adapted from Table 13 (WAPC 2000)

r - populations at the northern or southern limit of their known geographic range

d - populations disjunct from their known geographic range

p - considered to be poorly reserved (applies to all Threatened and Priority taxa)

s - significant populations (applies to all Threatened and Priority taxa)

X - considered lost in the PMR

e - taxa endemic to the SCP

E - taxa endemic to the SCP in the PMR

A seventh species, *Gahnia decomposita*, recorded within METQ22 in the wetland vegetation associated with Bennett Brook, is also considered to be of conservation significance because although not recognised by Bush Forever: Volumes 1 and 2 (WAPC 2000) as significant, it is considered to be of significance because these records represent the northern limit of the species' known geographic range.

RPS is aware that the Metronet Office received a Decision on Referral for the Morley-Ellenbrook Line Part 2: Malaga to Ellenbrook proposal from the DAWE as a 'controlled action' specifically stating that the proposed action is "likely to have a significant impact on areas containing suitable habitat for EPBC-listed Threatened flora species *Andersonia gracilis*, *Eleocharis keigheryi*, *Lepidosperma rostratum*, and *Trithuria occidentalis*". The DAWE comment is based on the results of a Protected Matters search of an area of unknown radius around the proposal area. The search of state government databases within the DBCA-recommended radius of 10 km however, returned only two of these species, *Eleocharis keigheryi*, and *Trithuria occidentalis* which were assessed as having a 'moderate' 'likelihood of occurrence' within the survey area based on proximity of known records and the potential for suitable habitat to be present. A thorough search was conducted for both of these species as part of the targeted wetland flora surveys in spring 2019 and neither species were

recorded, however, suitable habitat<sup>3</sup> for both species does occur in the wetland areas in the vicinity of Bennett Brook, so presence of these species within the greater survey area cannot be categorically ruled out. The residual (post-survey) likelihood of occurrence of both species was updated to 'possible' (Appendix B).

Although not returned in the DBCA database searches the EPBC-listed Threatened flora species *Andersonia gracilis*<sup>4</sup> and *Lepidosperma rostratum*<sup>5</sup> were also the subject of the targeted searches throughout the wetland vegetation within the survey area because the species had been flagged by DAWE as being potentially impacted by the proposal. Despite thorough searches neither species was observed to be present within the survey area, and their presence is considered highly unlikely due to the absence of known associated species and ecological communities within the survey area, and the fact that no records of either species occur within 10 km of the survey area.

### 4.2.1.5 Introduced flora (weeds)

Eighty-four naturalised alien (weed) species were recorded for the survey area, representing 22.5% of the total flora taxa recorded. Annual and perennial Poaceae species (grasses) (16 taxa) and Asteraceae species (daisies) (12 taxa) accounted for 33% of the weed species recorded. The most widespread weeds included *\*Briza maxima*, *\*Bromus diandrus*, *\*Ehrharta calycina*, *\*Pennisetum clandestinum*, *\*Pentameris airoides* subsp. *airoides*, *\*Hypochaeris glabra* and *\*Ursinia anthemoides*. These naturalised bushland weeds were recorded at low to moderate densities throughout much of the intact vegetation, and at high densities throughout the previously cleared and highly modified portions of the survey area.

An infestation of the highly invasive exotic grass species *\*Cenchrus macrourus* (African feather grass) was recorded in the Bennett Brook wetland vegetation (at Zone 50J: 399369.45 m E; 6476551.17 m S). The infestation covered an approximate 200 m<sup>2</sup> extent and should be prioritised for control to minimise its chance of spreading throughout the riparian vegetation along the watercourse.

*\*Cenchrus macrourus* is a perennial, caespitose / rhizomatous grass growing to around 1 m. It is an environmental weed known to infest riparian areas and pastures. The suggested method of management and control involves hand removal of the whole of the plant including the root stock for small infestations. For larger infestations treatment with 1% glyphosate in spring to autumn is recommended with follow up treatment until regrowth ceases (WAH 2020).

#### 4.2.1.5.1 Declared pests and WONS

The Western Australian Organism List database (DPIRD 2020) was searched to determine the legal status of each weed recorded, and any control requirements that may apply under the BAM Act. Of the 75 weed species recorded, *Zantedeschia aethiopica* (Arum Lily) and *Moraea flaccida* (Cape Tulip) were determined to be Declared Pests - s22(2)<sup>6</sup> requiring C3<sup>7</sup> management. None of the weeds recorded were listed as WONS.

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<sup>3</sup> *Trithuria occidentalis* habitat - small shallow basins lined with alluvial sediments e.g. clay and mud shallowly inundated for part of the year

*Eleocharis keigheryi* habitat - emergent in freshwater: creeks and claypans.

<sup>4</sup> *Andersonia gracilis* is currently known from the Badgingarra, Dandaragan and Kenwick areas where it is found on seasonally damp, black sandy clay flats near or on the margins of swamps, often on duplex soils supporting low open heath vegetation with species such as *Calothamnus hirsutus*, *Verticordia densiflora* and *Kunzea recurva* over sedges (DEC 2006)

<sup>5</sup> Beaked *Lepidosperma* is associated with Marsh Banksia (*Banksia telmatiaea*) and Hairy Clawflower (*Calothamnus hirsutus*), and grows in sandy soil among low heath in a winterwet swamp (DAWE 2020)

<sup>6</sup> Declared Pest - s22(2) - Declared pests must satisfy any applicable import requirements when imported, and may be subject to an import permit if they are potential carriers of high-risk organisms. They may also be subject to control and keeping requirements once within Western Australia.

<sup>7</sup> C3 - Organisms that should have some form of management applied that will alleviate the harmful impact of the organism, reduce the numbers or distribution of the organism or prevent or contain the spread of the organism.



4.2.1.5.1.1 *Zantedeschia aethiopica* – arum lily

*Zantedeschia aethiopica* (Plate 10) is a tall fleshy herb with big, dark green, arrowhead-shaped leaves and large white funnel-shaped 'arum-type' flower structures with a central yellow spike. It is a common ornamental garden plant that has escaped from cultivation. Arum lily has become a widespread weed, invading mainly damp habitats in pastures, wetlands and forest. All parts of the plant are toxic to humans, stock and pets (DPIRD 2019b).

The species was recorded along the banks of Bennett Brook and within REW UFI 8678.



Photo source: WAH 2019

Plate 10: *Zantedeschia aethiopica*

4.2.1.5.1.2 *Moraea flaccida* – Cape tulip

*Moraea flaccida* (Plate 11) is a perennial weed introduced from South Africa. This species is a garden escapee which has now become a significant weed throughout southern Australia. Cape tulip is difficult to control chemically due to the dormancy of corms below the ground. It is highly toxic to stock and may invade pastures (DPIRD 2019b). Cape tulip was widespread and recorded at low densities throughout much of the Degraded and Completely Degraded previously cleared low-lying (palusplain) portions of the survey area mapped as Cc./Mp./Er. Cleared and Cc./Mp.Xp. Cleared (Figures N-1 to N-6). The species was not recorded however within any of the sampling sites (quadrats or relevés).



Photo source: DPIRD 2019

**Plate 11:** *Moraea flaccida*

## 4.2.2 Vegetation

### 4.2.2.1 Vegetation units

Twenty-one vegetation units were described and mapped including upland, wetland and transitional vegetation types. Additionally, another six units were described which represented highly modified and degraded areas, generally cleared of native vegetation. There are 32 quadrats and 16 relevés within the survey area. The vegetation units were derived from the analysis of these sampling sites. An additional 14 floristic sites were sampled as part of the spring 2017 survey. These additional floristic sites, which are not within the most recent survey area (relevant to the proposed Malaga to Ellenbrook Rail Works development envelope), were also used to define the vegetation units.

The survey aimed to sample each vegetation unit at three or more floristic sites (quadrats or relevés) in accordance with EPA (2016) guidance, however some were sampled at fewer than three for one of the following reasons:

- The area of a particular vegetation type was too small to sample at more than one floristic site.
- The vegetation unit was described from some sites outside the survey area which were sampled during previous surveys.
- The vegetation type was in generally poor condition which meant quadrats were not appropriate (for example, the *Er.*, *Er.Mr.* and all the modified mapping units).

The 27 mapping units (vegetation and modified) are presented in Figures N-1 to N-6. The 27 mapping units fall into one of six broad groups.

#### Modified/cleared

The six modified/cleared units include previously cleared farmland with remnant isolated native trees, the recent clearing for the NorthLink Perth to Darwin Highway and the new Lord Street upgrade, other infrastructure including carparks, buildings and quarries, pine plantations, areas of rehabilitation, and private lots with some remnant trees but no intact native vegetation. The modified / cleared units cover approximately 68.14% (925.75 ha) of the survey area.

### **Marri on low slopes and flats**

Four Marri (*Corymbia calophylla*) vegetation units were mapped for the survey area ranging from sparse woodland to closed forest. The units were differentiated based on their co-dominant species, i.e., *Banksia* spp., Jarrah (*Eucalyptus marginata*) generally on lower slopes, or *Melaleuca preissiana* and *Xanthorrhoea preissii* on the flats. This broad vegetation type covers approximately 7.64% (103.86 ha) of the survey area.

### **Low-lying Banksia woodland**

Five low-lying Banksia woodland vegetation units were mapped for the survey area. The units were differentiated based on their dominant and co-dominant tree and shrub species. This broad vegetation type covers approximately 3.74% (50.87 ha) of the survey area.

### **Banksia woodland on dune slopes and crests**

Two 'upland' Banksia woodland vegetation units were mapped for the upper dune slopes and crests within the survey area. *Banksia attenuata* and *B. menziesii* were the dominant tree species in both units which were differentiated based on the presence of co-dominant tree species (e.g. *Eucalyptus tottiana*), and different dominant shrub species. This broad vegetation type covers approximately 8.28% (112.45 ha) of the survey area.

### **Melaleuca wetland / dampland**

Six Melaleuca wetland vegetation units were mapped for the survey area. This broad vegetation type occurred throughout the floodplains, palusplains, sumplands and damplands which are dominant features of the survey area. *Melaleuca preissiana* was the dominant tree species in this broad vegetation type with *M. raphiophylla* as a dominant or co-dominant in some of the vegetation units. Other co-dominant tree species included Flooded Gum (*Eucalyptus rudis* subsp. *rudis*) and Marri (*Corymbia calophylla*). Dominant shrub species differed between the vegetation units. This broad vegetation type covers approximately 5.94% (80.76 ha) of the survey area.

### ***Eucalyptus rudis* wetland / dampland / creekline**



Four Flooded Gum (*Eucalyptus rudis* subsp. *rudis*) wetland vegetation units were mapped for the survey area. This vegetation occurred along the banks (floodplains) of Bennett Brook, extending onto the palusplains. *Melaleuca raphiophylla* occurred as a co-dominant tree species in three of the four vegetation units. This broad vegetation type covers approximately 6.25% (84.92 ha) of the survey area.

A description of the 27 mapping units is provided in Table 18.






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Table 18: Vegetation units mapped for the survey area

Photograph	Code	Vegetation description	Extent (ha)	Floristic sites
<b>Marri on low slopes and flats</b>				
	<b>Cc.Em.Xp</b>	<i>Corymbia calophylla</i> Sparse Woodland to Mid Open Forest with <i>Eucalyptus marginata</i> subsp. <i>marginata</i> isolated clumps of trees over <i>Xanthorrhoea preissii</i> Shrubland over an exotic Closed Grassland/Forbland	1.31 (0.10%)	NA (Described from relevés sampled as part of a wider survey in 2017)
No photo available	<b>Cc./Em./Af.Bm.Xp</b>	<i>Corymbia calophylla</i> / <i>Eucalyptus marginata</i> subsp. <i>marginata</i> / <i>Allocasuarina fraseriana</i> Sparse Woodland to Mid Open Forest with isolated clumps of trees over <i>Xanthorrhoea preissii</i> Shrubland over an exotic Closed Grassland / Forbland	17.68 (1.30%)	NA (Described from mapping notes. Area too small and degraded for floristic sites)
	<b>Cc.Mp.Xp</b>	<i>Corymbia calophylla</i> Mid Open Forest to Mid Closed Forest over <i>Melaleuca preissiana</i> Low isolated trees to Low Woodland over <i>Xanthorrhoea preissii</i> isolated Shrubs to Mid Open Shrubland over <i>Dielsia stenostachya</i> Rushland with a mixed exotic Open Grassland	82.32 (6.06%)	METQ01 METQ11 METQ06 METQ17 PTAQ21 PTAQ15

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Photograph	Code	Vegetation description	Extent (ha)	Floristic sites
	<b>Cc.Km.Ep</b>	<i>Corymbia calophylla</i> Mid Open Woodland over <i>Kunzea micrantha</i> and patches of <i>Hypocalymma angustifolium</i> subsp. Swan Coastal Plain (G.J. Keighery 16777) Tall to Mid Sparse Shrubland over <i>Eremaea pauciflora</i> Low Open Heathland over <i>Patersonia occidentalis</i> var. <i>occidentalis</i> and <i>Dasypogon bromeliifolius</i> Mid Open Forbland	2.54 (0.19%)	VSR01 VSR02 (These sites were sampled for a different project)
<b>Low-lying Banksia woodland</b>				
	<b>Ba.Bm.Bi.Xp</b>	<i>Banksia attenuata</i> , <i>B. menziesii</i> and <i>B. ilicifolia</i> Low Woodland over <i>Xanthorrhoea preissii</i> Mid Open Shrubland over <i>Scholtzia involucreta</i> Low Sparse Shrubland over an Open to Closed Rushland / Forbland	18.98 (1.40%)	PTAR02 PTAR04 (Described from two relevés and mapping notes. Area too small for multiple floristic sites and in degraded to completely degraded condition)
	<b>Ba.Bm.Bi.Hh.Po</b>	<i>Banksia menziesii</i> , <i>B. attenuata</i> and <i>B. ilicifolia</i> Low Woodland to Low Open Forest over <i>Hibbertia hypericoides</i> , <i>Patersonia occidentalis</i> var. <i>occidentalis</i> and mixed myrtaceous species Low Open Shrubland	22.18 (1.63%)	METQ12 METQ13 METQ18 METQ23

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Photograph	Code	Vegetation description	Extent (ha)	Floristic sites
	<b>Bi.Bm.Ms.Xb</b>	<i>Banksia ilicifolia</i> and <i>B. menziesii</i> Low Woodland with emergent <i>Eucalyptus marginata</i> subsp. <i>marginata</i> and <i>Corymbia calophylla</i> over <i>Melaleuca seriata</i> , <i>Xanthorrhoea brunonis</i> and <i>Hypocalymma angustifolium</i> subsp. Swan Coastal Plain (G.J. Keighery 16777 Mid Open Shrubland over <i>Hibbertia racemosa</i> , <i>Calytrix fraseri</i> and <i>Patersonia occidentalis</i> var. <i>occidentalis</i> Low Sparse Shrubland over a mixed Sparse Forbland	2.39 (0.18%)	METQ19 (and PTAQ22, PTAQ23, PTAQ24 outside the current survey area but within the 2017 survey area)
	<b>Bm.Xb.Si</b>	<i>Banksia menziesii</i> Low Woodland over <i>Xanthorrhoea brunonis</i> , <i>Scholtzia involucrata</i> and <i>Eremaea pauciflora</i> Open Low Heath over <i>Alexgeorgea nitens</i> , <i>Lyginia barbata</i> and <i>Patersonia occidentalis</i> var. <i>occidentalis</i> Open Forbland	2.37 (0.17%)	PTAQ09 (Mapped from one floristic quadrat because it only occurs over a very small area)
	<b>Ba.As.Jf</b>	<i>Banksia attenuata</i> Low Isolated Trees over <i>Acacia saligna</i> and <i>Jacksonia furcellata</i> Tall Sparse Shrubland over a mixed exotic Closed Grassland	4.95 (0.36%)	METR06 (Described from one relevé and mapping notes. Area generally too degraded for multiple floristic sites)






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Photograph	Code	Vegetation description	Extent (ha)	Floristic sites
<b>Banksia woodland on dune slopes and crests</b>				
	<b>Et.Ba.Bm.Ah</b>	<i>Banksia attenuata</i> and <i>B. menziesii</i> Low Woodland with <i>Eucalyptus tottiana</i> Isolated Trees over <i>Allocasuarina humilis</i> Mid Open Shrubland over <i>Hibbertia hypericoides</i> , <i>Conostephium pendulum</i> and <i>Astroloma xerophyllum</i> Low Open Shrubland to Low Sparse Shrubland over <i>Alexgeorgea nitens</i> Sparse Rushland	94.19 (6.93%)	PTAQ08 PTAQ10 PTAQ11 PTAQ12 PTAR07
	<b>Ba.Bm.Si.Po</b>	<i>Banksia attenuata</i> and <i>B. menziesii</i> Low Woodland over a mixed Low Shrubland including <i>Scholtzia involucrata</i> , <i>Eremaea pauciflora</i> var. <i>pauciflora</i> , <i>Hibbertia hypericoides</i> and <i>Calytrix angulata</i> Low Shrubland over <i>Patersonia occidentalis</i> var. <i>occidentalis</i> var. <i>occidentalis</i> Sparse Forbland	18.27 (1.34%)	METQ08 METQ09 (Defined for a small area, two quadrats deemed adequate to accurately define the vegetation)
<b>Melaleuca wetland / dampland</b>				
	<b>Cc.Tl.Pe</b>	<i>Corymbia calophylla</i> Mid Open Forest over <i>Taxandria linearifolia</i> Tall Closed Shrubland to Tall Sparse Shrubland over <i>Pteridium esculentum</i> Mid Closed Shrubland to Mid Sparse Shrubland	1.49 (0.11%)	NA (Defined from mapping notes within the survey area. Occurs over a very small area and vegetation too degraded to warrant a floristic quadrat)

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Photograph	Code	Vegetation description	Extent (ha)	Floristic sites
	<b>Mp.Tl.Ct/Ca.</b>	<i>Melaleuca preissiana</i> isolated trees to Mid Closed Forest over <i>Taxandria linearifolia</i> Tall Closed Shrubland to Tall Sparse Shrubland over an Open to Closed Rushland/Sedgeland including <i>Cyathochaeta teretifolia</i> (P3), <i>C. avenacea</i> , <i>Dielsia stenostachya</i> , <i>Lepidosperma longitudinale</i> , <i>Baumea juncea</i> and <i>Tetraria</i> sp. Chandala (G.J. Keighery 17055)	27.04 (1.99%)	METQ07 PTAQ20 METQ10 PTAQ13 METQ22 METQ24 PTAQ14 PTAR09 PTAR10
	<b>Mp.Xp.</b>	<i>Melaleuca preissiana</i> Low isolated trees to Low Woodland over <i>Xanthorrhoea preissii</i> isolated Shrubs to Mid Open Shrubland over a mixed exotic Open Grassland	20.73 (1.53%)	NA (Described from mapping notes because all this vegetation was in too degraded condition to warrant floristic quadrats)
	<b>Mp.As.</b>	<i>Melaleuca preissiana</i> Low Woodland to Low Open Forest over <i>Astartea scoparia</i> Mid Shrubland to Mid Sparse Shrubland over a mixed Open Sedgeland / Rushland / Forbland / Grassland	5.70 (0.42%)	PTAR05 PTAR06 PTAR08 METR02

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Photograph	Code	Vegetation description	Extent (ha)	Floristic sites
	<b>Mr./ Standing Water</b>	<i>Melaleuca raphiophylla</i> over a mixed exotic Closed Forbland/Sedgeland on wetland fringe and over standing water in wetland	23.97 (1.76%)	METR07 (described and mapped at one location within the survey area at Horse Swamp)
	<b>Mr.MI.TI.As.</b>	<i>M. raphiophylla</i> Low Woodland over <i>M. lateritia</i> , <i>Taxandria linearifolia</i> and <i>Astartea affinis</i> Tall Shrubland over <i>Centella asiatica</i> Low Forbland on wetland fringe and standing water in wetland	1.83 (0.13%)	METR01 (described and mapped for one small wetland adjacent to Beechboro Rd North. Too small for multiple floristic sites)
<b><i>Eucalyptus rudis</i> wetland / dampland</b>				
	<b>Er.Mr.As/TI</b>	<i>Eucalyptus rudis</i> subsp. <i>rudis</i> Mid Open Forest over <i>Melaleuca raphiophylla</i> Low Woodland over <i>Astartea scoparia</i> / <i>Taxandria linearifolia</i> isolated Shrubs over <i>Juncus pallidus</i> and <i>Lepidosperma longitudinale</i> Sparse Sedgeland over <i>Centella asiatica</i> Open Forbland	21.10 (1.55%)	PTAR14 METQ15 METQ16 METQ03 METQ14



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Photograph	Code	Vegetation description	Extent (ha)	Floristic sites
	<i>Er.Mr.LI</i>	<i>Eucalyptus rudis</i> subsp. <i>rudis</i> and <i>Melaleuca raphiophylla</i> Closed Forest over <i>Lepidosperma longitudinale</i> Sedgeland	2.62 (0.19%)	METQ02 METQ04 METQ05
	<i>Er.Mr.</i>	<i>Eucalyptus rudis</i> subsp. <i>rudis</i> and <i>Melaleuca raphiophylla</i> Mid Open Forest over a mixed exotic Closed Forbland / Grassland	55.43 (4.08%)	NA (Described and mapped from mapping notes for large portions of the wetland fringing vegetation throughout the survey area but generally in Degraded or Completely Degraded condition not good enough for sampling at floristic quadrats)
	<i>Er.</i>	<i>Eucalyptus rudis</i> subsp. <i>rudis</i> Closed an exotic Closed Grassland	5.76 (0.42%)	NA (Described and mapped from mapping notes for large portions of the wetland fringing vegetation throughout the survey area but generally in Degraded or Completely Degraded condition not good enough for sampling at floristic quadrats)

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Photograph	Code	Vegetation description	Extent (ha)	Floristic sites
<b>Modified / cleared</b>				
<b>C/M</b>		Completely cleared or modified. Includes private lots and infrastructure (roads, car parks, buildings, quarries) - some remnant trees but no intact native vegetation	330.71 (24.34%)	NA
<b>Cc./Mp./Er. Cleared</b>		Isolated remnant <i>Corymbia calophylla</i> , <i>Melaleuca preissiana</i> and/or <i>Eucalyptus rudis</i> subsp. <i>rudis</i> over pasture/weeds - previously cleared	406.46 (29.92%)	NA
<b>Cc./Mp.Xp. Cleared</b>		Isolated remnant <i>Corymbia calophylla</i> and / or <i>Melaleuca preissiana</i> and <i>Xanthorrhoea preissii</i> over weeds - previously cleared	131.20 (9.66%)	NA
<b>Rehab.</b>		Rehabilitated areas and native regrowth (post-clearing)	32.98 (2.43%)	METR04 METR05
<b>Eucs.</b>		Planted eastern states Eucalypts	1.09 (0.08%)	NA
<b>Pp.</b>		Pinus pinaster plantation	23.30 (1.72%)	METR03

## 4.2.2.2 Floristic community type (FCT) assignment

### 4.2.2.2.1 Multivariate analysis of floristic data

#### 4.2.2.2.1.1 Data compatibility

Floristic data from the 32 quadrats (test sites) sampled for the 2017, 2018 and 2019 surveys were considered compatible with the SCP (Gibson et al. 1994) and Supplementary (Keighery et al. 2012) datasets due to consistencies in quadrat size (10 m × 10 m), nomenclature, species-richness (indicative of sampling effort) and vegetation condition between the test sites and the combined SCP and Supplementary dataset.

#### 4.2.2.2.1.2 Hierarchical cluster analysis and FCTs

The Hierarchical Cluster Analyses was undertaken using PRIMERv7 comparing the floristics of each test site from the current survey with the combined 1,098 site SCP and Supplementary dataset.

#### Survey floristic quadrats (test sites)

An analysis was initially run on the floristic data from the 32 floristic quadrats (test sites) (Appendix H; Graph H-1) to determine existing groupings based on floristic similarities between sites. Landform was added as a factor to investigate the influence of landscape position and substrate on floristic composition. The outcomes of this analysis assisted in the vegetation unit mapping for the survey area. Graph H-1 shows the 32 quadrat sites forming two distinct groups (wetland and dryland), and four statistically significant clusters (denoted by the black lines) within the wetland sites and four statistically significant clusters within the dryland group. The cluster analysis demonstrates how well correlated floristics are to landform with sites on each landform consistently forming floristically distinct groups.

#### Combined SCP and supplementary datasets (Keighery et al. 2012)

A Hierarchical Cluster Analysis was run on the combined SCP and Supplementary (Keighery et al. 2012) dataset to see if the output showed similar groupings to the SCP dataset. Keighery et al. (2012) made the following proviso regarding the updated dataset: "It is important to know that the data in this dataset are not ideal for floristic community type analysis due to inconsistencies in the grouping and splitting of some species compared to that used in the Gibson et al. (1994) analysis. This dataset is not the exact dataset used to analyse FCTs for Bush Forever (Western Australian Planning Commission)".

The dendrogram for the combined SCP and Supplementary dataset shows differences in clustering of sites to the original Gibson analysis, however, despite these differences the majority of the sites did group according to their FCTs and within the four supergroups. This dendrogram was too large to present in this report.

#### Test sites plus the combined SCP and supplementary datasets

All the floristic data from the 32 test sites were then added to the combined SCP and Supplementary dataset and a Hierarchical Cluster Analysis run. The dendrogram output from the analysis showed 24 of the sites showing a strong affinity to one FCT, however eight of the survey sites showed affinities to more than one FCT (Table 19).

Each of the test sites was then added separately to the combined SCP and Supplementary dataset in an effort to minimise disruption to the original groupings and to clarify mixed FCT affinities. This analysis resolved some but not all of these mixed affinities. The relevant portions of the classification dendrograms for each of the survey sites are presented in Appendix H, Graphs H-2 to H-33.

### **Test sites plus Supergroup 2 (wetland) and Supergroup 3 (dryland) SCP and supplementary datasets**

All the floristic data from the wetland test sites were then added individually to Supergroup 2 SCP and Supplementary dataset sites which represent seasonal wetland FCTs and Hierarchical Cluster Analyses run. Similarly the floristic data from the dryland sites were added to Supergroup 3 SCP and Supplementary dataset sites which represent upland FCTs centred on the Bassendean system and Hierarchical Cluster Analyses run in an effort to resolve mixed affinities however, this did not resolve any of the remaining mixed affinities.

#### **4.2.2.2 Landform and species occurrence as an indicator of FCT**

When assigning FCTs to the vegetation, consideration was also given to the landform on which each vegetation type is located, as well as indicator species recorded for the survey.

#### **4.2.2.3 Geographic distribution of FCTs**

Geographic distribution of FCTs was an additional factor considered in assigning FCTs to vegetation units within the survey area. Proximity of SCP (Gibson et al. 1994) and Supplementary (Keighery et al. 2012) study sites to the survey area, on like soils and landforms lent strength to the classification results and helped in some cases to resolve mixed affinities.

A summary of the determination of FCTs for each of the floristic quadrat sites and their State-listed conservation significance is presented in Table 19. Further discussion on the FCT determinations for the sites with mixed FCT affinities follows.

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**Table 19: Floristic community type (FCT) determination**

Survey sites	FCT - SCP + supp. data (all sites)	FCT - SCP + supp. data (SSI)	FCT – Supergroup 3 data (SSI)	FCT – Supergroup 2 data (SSI)	Geographic distribution of FCTs	Soil, landform, species presence	Final FCT determination	Significance of final FCT determination (state)	Significance of final FCT determination (national)	Current survey mapping unit
PTAQ08	FCT23a	FCT23a	FCT23a	-	FCT23a	FCT23a	<b>FCT23a</b>	-	Endangered	<i>Et.Ba.Bm.Ah.</i>
PTAQ09	FCT23a	FCT23a; FCT23b	FCT23a; FCT23b	-	FCT23b	FCT23b	<b>FCT23b</b>	Endangered	Endangered	<i>Bm.Xb.Si.</i>
PTAQ10	FCT23a	FCT23a	FCT23a	-	FCT23a	FCT23a	<b>FCT23a</b>	-	Endangered	<i>Et.Ba.Bm.Ah.</i>
PTAQ11	FCT23a	FCT23a	FCT23a	-	FCT23a	FCT23a	<b>FCT23a</b>	-	Endangered	<i>Et.Ba.Bm.Ah.</i>
PTAQ12	FCT23a	FCT23a	FCT23a	-	FCT23a	FCT23a	<b>FCT23a</b>	-	Endangered	<i>Et.Ba.Bm.Ah.</i>
PTAQ13	FCT11; FCT06; FCTS17; FCTS07	FCT13; FCTS17	-	FCT13; FCTS17	FCTS17	FCTS17	<b>FCTS17</b>	Other conservation significance	-	<i>Mp.Tl.Ct/Ca</i>
PTAQ14	FCT11; FCT06; FCTS17; FCTS07	FCT04; FCTS02	-	FCT04; FCTS02	FCT11; FCTS02; FCT04; FCTS17; FCTS07	FCTS17	<b>FCTS17</b>	Other conservation significance	-	<i>Mp.Tl.Ct/Ca</i>
PTAQ15	FCT11	FCT11	-	-	FCT11	FCT11	<b>FCT11</b>	-	-	<i>Cc.Mp.Xp.</i>
PTAQ20	FCT11; FCT06; FCTS17; FCTS07	FCT13; FCTS17	-	FCT11	FCT11; FCT06; FCTS17; FCTS07	FCTS17; FCTS07	<b>FCTS17</b>	Other conservation significance	-	<i>Mp.Tl.Ct/Ca</i>
PTAQ21	FCT11	FCT11	-	-	FCT11	FCT11	<b>FCT11</b>	-	-	<i>Cc.Mp.Xp.</i>
METQ01	FCT04; FCT05	FCT04; FCT05; FCTS02	-	FCT04; FCT05	FCT04; FCT05	FCT04	<b>FCT04</b>	-	-	<i>Cc.Mp.Xp.</i>
METQ02	FCT11	FCT11	-	-	FCT11	FCT11	<b>FCT11</b>	-	-	<i>Er.Mr.Ll.</i>
METQ03	FCT15; FCTS07	FCT15	-	FCT15; FCT13	FCT15; FCT11	FCT11	<b>FCT11</b>	-	-	<i>Er.Mr.As/Tl.</i>
METQ04	FCT11	FCTS07	-	FCTS07	FCTS07	FCTS07	<b>FCTS07</b>	-	-	<i>Er.Mr.Ll.</i>
METQ05	FCT11	FCT11	-	-	FCT11	FCT11	<b>FCT11</b>	-	-	<i>Er.Mr.Ll.</i>
METQ06	FCT11	FCT11	-	-	FCT11	FCT11	<b>FCT11</b>	-	-	<i>Cc.Mp.Xp.</i>
METQ07	FCT11; FCT06; FCTS17; FCTS07	FCT05 (FCT11; FCT06; FCTS17; FCTS07)	-	FCT05 (loose affiliation)	FCT05; FCTS17; FCTS07	FCTS17; FCTS07	<b>FCTS17</b>	Other conservation significance	-	<i>Mp.Tl.Ct/Ca.</i>

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Survey sites	FCT - SCP + supp. data (all sites)	FCT - SCP + supp. data (SSI)	FCT – Supergroup 3 data (SSI)	FCT – Supergroup 2 data (SSI)	Geographic distribution of FCTs	Soil, landform, species presence	Final FCT determination	Significance of final FCT determination (state)	Significance of final FCT determination (national)	Current survey mapping unit
METQ08	FCT23a	FCT23c	FCT23c	-	FCT23c	FCT23c	<b>FCT23c</b>	Other conservation significance	Endangered	<i>Ba.Bm.Si.Po.</i>
METQ09	FCT23a	FCT23a	FCT23a	-	FCT23c; FCT23a	FCT23a	<b>FCT23a</b>	-	Endangered	<i>Ba.Bm.Si.Po.</i>
METQ10	FCTS17	FCTS17	-	FCTS17; FCT13	FCTS17	FCTS17	<b>FCTS17</b>	Other conservation significance	-	<i>Mp.Tl.Ct/Ca</i>
METQ11	FCTS07	FCTS07	-	FCTS07	FCTS07	FCTS07	<b>FCTS07</b>	-	-	<i>Cc.Mp.Xp.</i>
METQ12	FCT21c	FCT21a; FCT21c	FCT21a; FCT21c	-	FCT21a	FCT21a; FCT21c	<b>FCT21a</b>	-	Endangered	<i>Ba.Bm.Bi.Hh.Po</i>
METQ13	FCT21c	FCT23c	FCT23c	-	FCT23c	FCT23c	<b>FCT23c</b>	Other conservation significance	Endangered	<i>Ba.Bm.Bi.Hh.Po</i>
METQ14	FCTS07	FCT13	-	FCT13; FCT11	FCTS07	FCTS07	<b>FCTS07</b>	-	-	<i>Er.Mr.As/TL</i>
METQ15	FCTS07	FCTS07	-	FCTS07	FCTS07	FCTS07	<b>FCTS07</b>	-	-	<i>Er.Mr.As/TL</i>
METQ16	FCTS07	FCT17	-	FCT17	FCTS07	FCTS07	<b>FCTS07</b>	-	-	<i>Er.Mr.As/TL</i>
METQ17	FCT23c	FCT23c	FCT23c	-	FCT23c	FCT23c	<b>FCT23c</b>	Other conservation significance	Endangered	<i>Cc.Mp.Xp.</i>
METQ18	FCT21c	FCT23c	FCT23c	-	FCT23c	FCT23c	<b>FCT23c</b>	Other conservation significance	Endangered	<i>Ba.Bm.Bi.Hh.Po</i>
METQ19	FCT21c	FCT21c; FCT21a	FCT21c; FCT21a	-	FCT21c; FCT21a	FCT21c	<b>FCT21c</b>	Priority 3	Endangered	<i>Bi.Bm.Ms.Xb</i>
METQ22	FCTS03; FCTS17; FCT14; FCT11	FCTS17; FCTS03 FCT14	-	FCTS17; FCTS03 FCT14	FCTS17	FCTS17	<b>FCTS17</b>	Other conservation significance	-	<i>Mp.Tl.Ct/Ca</i>
METQ23	FCT21c	FCT21c; FCTS09; FCT21a	FCT21c	-	FCT21c	FCT21c	<b>FCT21c</b>	Priority 3	Endangered	<i>Ba.Bm.Bi.Hh.Po</i>
METQ24	FCTS03; FCTS17; FCT14; FCT11	FCT11	-	FCT11; FCTS03; FCTS17	FCTS17	FCTS17	<b>FCTS17</b>	Other conservation significance	-	<i>Mp.Tl.Ct/Ca</i>



#### 4.2.2.2.4 FCT determinations for sites with mixed affinities

##### 4.2.2.2.4.1 Seasonal wetland sites (Supergroup 2)

Twenty of the 32 floristic quadrats sampled for the current assessment represented seasonal wetland community type (Supergroup 2) vegetation (Gibson et al. 1994) (Table 19).

Six of the seasonal wetland sites were assigned to FCT11 based on the multivariate analysis results, and consideration of location, soil, landform and species presence. FCT11 – Wet forests and woodlands is well-reserved and has a ‘low risk’ conservation status (Gibson et al. 1994).

Seven sites (PTAQ13, PTAQ14, PTAQ20, METQ07, METQ10, METQ22 and METQ24) in wetland vegetation were mapped as vegetation unit *Mp.Tl.Ct/Ca* (*Melaleuca preissiana* isolated trees to Mid Closed Forest over *Taxandria linearifolia* Tall Closed Shrubland to Tall Sparse Shrubland over an Open to Closed Rushland/Sedgeland including *Cyathochaeta teretifolia* (P3), *C. avenacea*, *Lepidosperma longitudinale*, *Baumea juncea* and *Tetraria* sp. Chandala (G.J. Keighery 17055)) (Figures M-2 to M-4).

When analysed against the SCP and Supplementary dataset these seven sites had affinities with eight wetland FCTs (FCT04, FCT06, FCT11, FCT13, FCT14, FCTS03, FCTS07 and FCTS17). These results, however, were not particularly strong with the similarity between the test sites and the SCP and Supplementary sites generally less than 30%. Many of the SCP and Supplementary study sites belonging to these FCTs also showed low levels of similarity in the cluster analysis suggesting that the original groupings of the Gibson et al. (1994) SCP dataset had been somewhat disrupted by the inclusion of the additional 590 sites from the Supplementary studies. This was noted by Keighery et al. (2012) in the explanatory notes which accompanied the Supplementary dataset.

The floristic composition, and soil and landform on which the seven test sites occurred was further investigated in an effort to resolve the mixed FCT affinities for these sites, and it was concluded that all of the sites were most likely to represent FCTS17 based on location, landform and substrate, and the presence of species both common to, and indicators for, FCTS17 (Table 20). *Taxandria linearifolia* which was a defining and often dominant species in the vegetation at all seven test sites does not occur in any of the potential FCTs except FCTS17 (as determined by the SIMPER analysis in PRIMERV7).

**Table 20: Common and indicator species for FCTS17 recorded within PTAQ13, PTAQ14, PTAQ20, METQ07, METQ10, METQ22 and METQ24**

Taxa	PTAQ13	PTAQ14	PTAQ20	METQ07	METQ10	METQ22	METQ24
<i>Aotus cordifolia</i>	x		x				
<i>Astartea</i> sp.	x		x			x	x
<i>Baumea juncea</i>		x				x	
<i>Cyathochaeta teretifolia</i>	x		x	x	x	x	
<i>Eucalyptus rudis</i>	x				x		
<i>Lepidosperma longitudinale</i>	x	x			x	x	x
<i>Melaleuca preissiana</i>	x	x	x	x	x	x	x
<i>Pteridium esculentum</i>			x		x		
<i>Taxandria linearifolia</i>	x	x	x	x	x	x	x

The remaining three wetland sites, METQ04, METQ11 and METQ15 were assigned to FCTS07 - Northern woodlands to forests over tall sedgeland alongside permanent wetlands.

##### 4.2.2.2.4.2 Supergroup 3 – uplands centred on Bassendean dunes sites

Thirteen of the 32 floristic quadrats sampled for the current assessment represented uplands centred on Bassendean dunes community type (Supergroup 3) vegetation (Gibson et al. 1994) (Table 19).

Five of these upland sites were assigned to FCT23a based on the multivariate analysis results, and consideration of location, soil, landform and species presence. FCT23a – Central *Banksia attenuata* - *Banksia menziesii* woodlands is well-reserved and has a ‘low risk’ conservation status (Gibson et al. 1994).

One site, PTAQ09, was determined to be representative of the state-listed PEC FCT23b – Northern *Banksia attenuata* – *Banksia menziesii* woodlands, which is ‘unreserved’ and has a conservation status of ‘susceptible’. The site was determined to be this FCT based on geographic distribution, species presence and landform; PTAQ09 is within metres of a FCT23b DBCA record returned from the communities database search, shown on Figure L.

Four sites were assigned to FCT23c - North-eastern *Banksia attenuata* - *Banksia menziesii* woodlands, considered ‘Rare’ in the PMR.

Two sites, METQ19 and METQ23, were assigned to FCT21c - Low lying *Banksia attenuata* woodlands or shrublands, a state-listed PEC.

One site, METQ12, was assigned to FCT21a - Central *Banksia attenuata* - *Eucalyptus marginata* woodlands, which is well-reserved and has a ‘low risk’ conservation status (Gibson et al. 1994).

### 4.2.2.3 TECs and PECs within the survey area

The results of the floristic analysis (Table 19) determined which FCTs were present, and consequently the potential location of conservation significant ecological communities (TECs and PECs) within the survey area.

#### 4.2.2.3.1 Commonwealth-listed conservation significant ecological communities

##### ***Banksia* woodlands of the Swan Coastal Plain ecological community TEC**

The *Banksia* woodland vegetation mapped as *Ba.Bm.Bi.Xp*, *Bi.Bm.Ms.Xb*, *Bm.Xb.Si*, *Et.Ba.Bm.Ah*, *Ba.Bm.Si.Po*, and *Ba.Bm.Bi.Hh.Po*, vegetation units in Figures N-1 to N-6, determined via multivariate analyses to belong to FCT21a, FCT21c, FCT23a, FCT23b and FCT23c, represent potential records of both the State-listed PEC *Banksia dominated woodlands of the Swan Coastal Plain IBRA region* (P3) and the EPBC-listed TEC *Banksia Woodlands of the Swan Coastal Plain ecological community* (Endangered). All occurrences of *Banksia* woodland within the survey area, regardless of vegetation condition, represent the State-listed PEC, however, to qualify as an EPBC-listed TEC record the *Banksia* woodland vegetation within the survey area must satisfy the key diagnostic characteristics for the ecological community as set out in the Conservation Advice for the community (DAWE 2020) in terms of its location and physical environment, soils and landform, structure and composition. It must:

- Occur within the Swan Coastal Plain IBRA bioregion
- Occur on well-drained, low nutrient soils on deep Bassendean and Spearwood sands, Quindalup sands, or sandy colluvium and aeolian sands of the Ridge Hill Shelf
- Comprise a low woodland to forest community and have a
  - Distinctive upper sclerophyllous layer of low trees, most commonly dominated or co-dominated by *Banksia attenuata* and/or *B. menziesii*. Other *Banksia* species that dominate in some examples of the ecological community are *B. prionotes* or *B. ilicifolia*, sometimes with an emergent tree layer or *Allocasuarina fraseriana*, *Corymbia calophylla*, *Eucalyptus gomphocephala* and / or *E. marginata*
  - Highly species-rich understorey comprising a layer of sclerophyllous shrubs of various heights
  - Herbaceous ground layer of cord rushes, sedges and perennial and ephemeral forbs, that sometimes includes grasses.

Additionally, the vegetation must meet the minimum condition threshold of Good (adapted from Keighery 1994 and Trudgen 1988), and finally, the vegetation must meet the minimum patch size thresholds ( $\geq 0.5$  ha in Excellent condition;  $\geq 1$  ha in Very Good condition; or  $\geq 2$  ha in Good condition).

All the *Banksia* woodland vegetation within the survey area with an intact native understorey (vegetation units *Ba.Bm.Bi.Xp*, *Bi.Bm.Ms.Xb*, *Bm.Xb.Si*, *Et.Ba.Bm.Ah*, *Ba.Bm.Si.Po*, and *Ba.Bm.Bi.Hh.Po*) meets the diagnostic characteristics for the TEC.

All the *Banksia* woodland vegetation within the survey area in Good or better condition meets the minimum condition thresholds for the TEC.

Areas of *Banksia* woodland in Good or better condition within the survey area were assessed to determine whether each ‘patch’ met the minimum size thresholds according to their condition. The assessment of each potential patch is presented in Table 21 including a determination of whether or not the patch assessed is a legitimate TEC record.

**Table 21 Assessment of potential *Banksia Woodlands of the Swan Coastal Plain ecological community* TEC patches within the survey area**

TEC patch	Vegetation unit	Condition	Area (ha)	Satisfies TEC condition and patch size criteria	Rationale
Patch 1	<i>Et.Ba.Bm.Ah.</i>	Excellent	4.37	YES	>2 ha in Good or better condition
	<i>Et.Ba.Bm.Ah.</i>	Very Good	8.94		
	<i>Et.Ba.Bm.Ah.</i>	Good	1.40		
	<i>Ba.Bm.Bi.Xp.</i>	Very Good	7.55		
		<b>Total patch size</b>	<b>22.26</b>		
Patch 2	<i>Ba.Bm.Bi.Hh.Po</i>	Very Good - Good	10.48	YES	>2 ha in Good or better condition
		<b>Total patch size</b>	<b>10.48</b>		
Patch 3	<i>Ba.Bm.Bi.Hh.Po</i>	Very Good	9.14	YES	>1 ha in Very Good condition
		<b>Total patch size</b>	<b>9.14</b>		
Patch 4	<i>Ba.Bm.Bi.Hh.Po</i>	Very Good	2.56	YES	>1 ha in Very Good condition
	<i>Bi.Bm.Ms.Xb</i>	Very Good	2.12		
		<b>Total patch size</b>	<b>4.69</b>		
Patch 5	<i>Ba.Bm.Si.Po</i>	Very Good	5.59	YES	>2 ha in Good or better condition
	<i>Ba.Bm.Si.Po</i>	Very Good - Good	2.46		
		<b>Total patch size</b>	<b>8.05</b>		

All five potential EPBC-listed *Banksia* woodlands TEC patches within the survey area qualify as TEC records and therefore MNES because they satisfy all criteria relating to diagnostic characteristics, vegetation condition and patch size for the TEC. These patches are mapped in Figures O-1 to O-5.

#### 4.2.2.3.2 State-listed conservation significant ecological communities

##### **Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region (P3)**

The six *Banksia* woodland vegetation units mapped for the survey area also represent the State-listed *Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region* PEC, which is synonymous with the EPBC-listed TEC, but does not have size or condition thresholds, that is, an area of *Banksia* woodland vegetation is considered a record of the PEC if the diagnostic characteristics are met regardless of patch size or vegetation condition. A total area of 158.37 ha of the PEC was mapped within the survey area (Figures O-1 to O-5).

##### **FCT21c – Low-lying *Banksia attenuata* woodlands or shrublands (P3)**

FCT21c was recorded at two floristic quadrats within low-lying *Banksia* woodland. This type occurs sporadically between Gingin and Bunbury and is largely restricted to the Bassendean system. The type tends to occupy lower lying wetter sites and is variously dominated by *Melaleuca preissiana*, *Banksia attenuata*, *B. menziesii*, *Regelia ciliata*, *Eucalyptus marginata* or *Corymbia calophylla*. Structurally, this community type may be either a woodland or, occasionally, a shrubland.

The point locations of this PEC within the survey area are presented in Figures O-1 to O-5.

##### **FCT23b - Swan Coastal Plain *Banksia attenuata* - *Banksia menziesii* woodlands (P3)**

FCT23b was recorded for one floristic quadrat within the *Banksia* woodland vegetation of the survey area. These woodlands occur in the Bassendean system, from Melaleuca Park to Gingin in reasonably extensive *Banksia* woodlands north of Perth.

The point location of this PEC record within the survey area is presented in Figure O-1.

#### 4.2.2.3.3 Ecological communities of ‘other’ conservation significance

Two other FCTs (FCTS17 and FCT23c) recorded for the survey area, although not listed by the state or Commonwealth as PECs or TECs, are considered to be of ‘other’ conservation significance because they were identified by Bush Forever as having regional conservation value on the SCP portion of the PMR.

##### FCT23c – North east *Banksia attenuata* – *Banksia menziesii* woodlands (Rare in the PMR)

FCT23c is considered ‘Rare’ within the PMR by Bush Forever (WAPC 2000). The FCT was determined to be present via the multivariate analysis of the floristic data at floristic sites: METQ08, METQ13, METQ17 and METQ18.

The point locations of FCT23c within the survey area are presented in Figures O-1 to O-5.

##### FCTS17 - *Eucalyptus rudis* - *Taxandria linearifolia* wetlands in Bassendean Dunes (Rare in the PMR)

FCTS17 is considered ‘Rare’ on the SCP by Keighery et al. (2012) and ‘Rare’ within the PMR by Bush Forever (WAPC 2000). FCTS17 - *Eucalyptus rudis*/*Taxandria linearifolia* wetlands in Bassendean Dunes, was recorded at numerous locations throughout the wetland vegetation mapped for the survey area as *Mp.Tl.Ct/Ca*. The FCT determined to be present via the multivariate analysis of the floristic data at floristic sites: PTAQ13, PTAQ14, PTAQ20, METQ07, METQ10, METQ22 and METQ24. FCTS17 is listed in Bush Forever (WAPC 2000) as Rare in the PMR. It is recognised as one of the Seasonal Wetlands Group of FCTs.

The mapped extent of FCTS17 within the survey area is presented in Figures O-1 to O-5.

These conservation significant ecological communities, their conservation status at the state and Commonwealth levels, and the floristic sites where they were recorded within the survey area are presented in Table 22.

**Table 22 Conservation significant vegetation recorded within the survey area**

FCT	Ecological community	Description	BC Act status*	EPBC Act status†	Floristic site
FCT21c	Low-lying <i>Banksia attenuata</i> woodlands or shrublands	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>Regelia ciliata</i> , <i>Eucalyptus marginata</i> subsp. <i>marginata</i> or <i>Corymbia calophylla</i> . Structurally, this community type may be either a woodland or occasionally shrubland.	PEC (Priority 3)	TEC (Endangered)	METQ19; METQ23
FCT23b	Swan Coastal Plain <i>Banksia attenuata</i> - <i>Banksia menziesii</i> woodlands	These woodlands occur in the Bassendean system, from Melaleuca Park to Gingin. Occurs in reasonably extensive <i>Banksia</i> woodlands north of Perth.	PEC (Priority 3)	TEC (Endangered)	PTAQ09
FCT21a; FCT21c; FCT23a; FCT23b; FCT23c	<i>Banksia</i> Dominated Woodlands of the Swan Coastal Plain IBRA Region	The ecological community is a woodland associated with the SCP of south-west Western Australia. 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 (Threatened Species Scientific Committee 2016).	PEC (Priority 3)	TEC (Endangered)	PTAQ08; PTAQ09; PTAQ10; PTAQ11; PTAQ12; METQ08; METQ09; METQ12; METQ13; METQ17; METQ18; METQ19; METQ23

FCT	Ecological community	Description	BC Act status*	EPBC Act status†	Floristic site
FCTS17	<i>Eucalyptus rudis</i> / <i>Taxandria linearifolia</i> wetlands in Bassendean Dunes	This type occurs in the Bassendean system, in riparian vegetation	N/A (Rare in the PMR)	-	PTAQ13; PTAQ14; PTAQ20; METQ07; METQ10; METQ22; METQ24
FCT23c	North east <i>Banksia attenuata</i> – <i>Banksia menziesii</i> woodlands	These woodlands occur in the Bassendean system, on the north eastern portion of the SCP	N/A (Rare in the PMR)	-	METQ08; METQ13; METQ17; METQ18

#### 4.2.2.4 Vegetation condition

Vegetation condition within the survey area ranged from Excellent to Completely Degraded (Figures P-1 to P-5, and Table 23). A large proportion of the survey area (1,123.11 ha, or 82.7%) was in Degraded or worse condition. These areas comprised previously cleared farmland with remnant isolated trees, recent clearing for the NorthLink Perth to Darwin Highway and the new Lord Street upgrade, buildings, roads, tracks, bushland regeneration areas, pine plantation and developed private lots. The Degraded condition throughout much of the remnant trees over pasture vegetation units is due to historical grazing by livestock and kangaroos and weed infestation. Within the intact bushland portions, condition ranged from Good to Excellent, but these areas were generally small, isolated, and surrounded by cleared paddocks in Completely Degraded condition. Much of the low-lying vegetation, on the sand flats and throughout the palusplains was in Degraded, or at best Good, condition despite the presence of a dense tree canopy, again the result of historical grazing and infestation by weeds. The vegetation in the best condition (Excellent and Very Good) was recorded on the slopes and crests of dunes and comprised *Banksia* woodland with a dense or mid-dense shrub layer, and throughout the wetland vegetation along Bennett Brook and around some of the CCWs mapped as *Mp. Tl. Ct/Ca*. These areas of wetland and upland vegetation appeared to be very healthy and exhibited structural integrity and complexity with evidence of recruitment of tree, shrub and herb / grass species from the soil seed bank, and generally low disturbance from weeds. Species richness in the *Banksia* vegetation units was generally high.

**Table 23: Vegetation condition within the survey area**

Vegetation condition		Survey area	
		Hectares (ha)	Percentage (%)
E	Excellent	20.02	1.47
VG	Very Good	51.16	3.77
G-VG	Good to Very Good	12.94	0.95
G	Good	42.36	3.12
G-D	Good to Degraded	109.02	8.02
D	Degraded	222.25	16.36
D-CD	Degraded to Completely Degraded	10.27	0.76
CD	Completely Degraded	756.94	55.71
C	CLEARED	133.65	9.84



## 5 DISCUSSION AND CONCLUSIONS

### 5.1 Floristic diversity and representation

In assessing the conservation significance of flora within the survey area, consideration is given to rarity and biodiversity of the flora in the area.

#### 5.1.1 Rarity

The rarity of the flora was assessed via the various categories of TF (protected under the BC Act and EPBC Act) and PF (listed by DBCA). No TF were recorded within the survey area.

Three PF species as currently listed by DBCA were recorded within the survey area: *Cyathochaeta teretifolia* (P3), and *Anigozanthos humilis* subsp. *chrysanthus* (P4) and *Tetraria* sp. Chandala (G.J. Keighery 17055) (P2).

- *Cyathochaeta teretifolia* and *Tetraria* sp. Chandala (G.J. Keighery 17055) were associated with the conservation significant ecological community FCTS17 - *Eucalyptus rudis*/*Taxandria linearifolia* wetlands in Bassendean Dunes. All populations of these taxa within the PMR of the SCP are considered significant. Neither *Cyathochaeta teretifolia* nor *Tetraria* sp. Chandala (G.J. Keighery 17055) were recorded within the proposed Malaga to Ellenbrook Rail Works development envelope.
- *Anigozanthos humilis* subsp. *chrysanthus* was recorded at two locations (one individual at each location) within the *Et.Ba.Bm.Ah. Banksia attenuata* and *B. menziesii* with emergent *Eucalyptus tottiana* low woodland vegetation unit occurring on dune slopes and crests (representative of FCT23a and the EPBC-listed TEC, *Banksia Woodlands of the Swan Coastal Plain ecological community*). *Anigozanthos humilis* subsp. *chrysanthus* is the only PF species recorded within the proposed Malaga to Ellenbrook Rail Works development envelope and is recorded within the *Banksia* woodland vegetation in the vicinity of the proposed Malaga station

A fourth PF taxon, *Stylidium longitubum*, associated with the conservation significant ecological community FCTS17 - *Eucalyptus rudis*/*Taxandria linearifolia* wetlands in Bassendean Dunes was recorded just outside the survey area boundary to the north of West Bennett Brook.

Additionally, two other sedge species with potential conservation significance were recorded at separate locations: *Lepidosperma* sp. (putative new taxon) was recorded at one location along West Bennett Brook within the survey area but outside the proposed Malaga to Ellenbrook Rail Works development envelope; and ?*Schoenus natans* (P4) was recorded just outside the survey area boundary to the north of West Bennett Brook. Both of these taxa were associated with the conservation significant ecological community FCTS17.

Seven species of 'other' conservation significance on the SCP were recorded within the survey area. The species and the reason for their conservation significance is as follows:

- *Aotus cordifolia* - all populations within the PMR of the SCP are considered significant; the taxon is poorly reserved; the taxon is associated with a conservation significant ecological community (FCTS17).
- *Burchardia bairdiae* - all populations within the PMR of the SCP are considered significant; the population is at the limit of its known geographic range.
- *Conostephium minus* - all populations within the PMR of the SCP are considered significant; the taxon is poorly reserved; the taxon is endemic to the SCP.
- *Conostylis aculeata* subsp. *cygnorum* - the taxon is endemic to the SCP.
- *Dielsia stenostachya* - the taxon is endemic to the SCP.
- *Verticordia nitens* - the population is at the limit of its known geographic range
- *Gahnia decomposita* - these records represent the northern limit of the species' known geographic range.

## 5.1.2 Biodiversity

A total of 290 native vascular flora taxa were recorded for the 1,358.61 ha survey area. A total of 1,289 native taxa are known from the City of Swan Local Government Area (WAH 2020), which covers 10,423 ha. The number of taxa recorded for this assessment represents 22.4% of the total number of taxa known from the LGA, however the survey area only represents 13% of the LGA in size.

When the number of flora taxa recorded for survey area is compared with those known to occur in much larger City of Swan Local Government Area the biodiversity of terrestrial vascular flora within the survey area is considered high.

## 5.2 Vegetation conservation significance

In assessing the conservation significance of the vegetation within the survey area, consideration is given to bioregional representation, conservation significant ecological communities and the maintenance of ecological processes and natural systems.

### 5.2.1 Bioregional representation

On a regional scale the survey area is mapped as Vegetation Associations 949; 1001; 1018 and 1009 (Shepherd et al. 2002), and Bassendean Complex Central and South; Southern River Complex and Bassendean Complex North (Heddle et al. 1980). Of the four Shepherd et al. (2002) vegetation associations, three have between 10% and 30% of their original (pre-European) extent remaining and less than 3% or their current extent protected for conservation (Government of Western Australia 2016).

Of the three Heddle et al. (1980) vegetation complexes represented within the survey area, Bassendean Complex Central and South and Southern River Complex have between 10% and 30% of their original (pre-European) extent remaining and have 3% and 6% respectively remaining in secure tenure.

While the EPA's objective is to retain at least 30% of the pre-clearing extent of each ecological community, the EPA also has a modified objective to retain at least 10% of the pre-clearing extent of each ecological community within defined constrained (intensely developed) areas in the PMR portion of the SCP. All the vegetation associations and complexes that occur within the survey area satisfy this modified objective as they all have greater than 10% remaining of their pre-clearing extent.

### 5.2.2 Conservation significant ecological communities

#### 5.2.2.1 Commonwealth-listed threatened ecological communities

One Commonwealth-listed TEC was recorded within the survey area:

- *Banksia woodlands of the Swan Coastal Plain ecological community* (Endangered). Five patches (covering a total area of 59.42 ha) were mapped within the survey area.

#### 5.2.2.2 State-listed threatened and priority ecological communities

Three P3 state-listed PECs were recorded within the survey area as follows:

- FCT21c - Low-lying *Banksia attenuata* woodlands or shrublands (two records)
- FCT23b Swan Coastal Plain *Banksia attenuata* - *Banksia menziesii* woodlands (one record)
- Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region (covering a total area of 158.37 ha).

#### 5.2.2.3 Other conservation significant ecological communities

Two ecological communities of 'other' significance, as identified by Bush Forever as having regional conservation value on the SCP portion of the PMR, were recorded within the survey area as follows:

- FCT23c – North east *Banksia attenuata* – *Banksia menziesii* woodlands (four records)
- FCTS17 - *Eucalyptus rudis* - *Taxandria linearifolia* wetlands in Bassendean Dunes (numerous patches).

### 5.2.3 Maintenance of ecological processes and natural systems

The survey area consists predominantly of isolated pockets of intact remnant native wetland and upland vegetation surrounded by highly modified and degraded tracts of cleared or modified land. *Australia's Biodiversity Conservation Strategy 2010-2030* (Natural Resource Management Ministerial Council (NRMMC) 2010) asserts the importance of promoting conservation across land tenures to ensure the survival of the small isolated remnants of vegetation that characterise much of the PMR portion of the SCP, to maintain ecological connectivity in the landscape, and to protect the biodiversity they maintain. Maintaining and restoring habitat connectivity is critical to ensuring species' resilience and to maintaining ecological processes and systems (NRMMC 2010).

The survey area intersects Regional Ecological Linkages as identified by Del Marco et al. (2004) at several locations (Figure G). These linkages provide connectivity between areas of refugial habitat for flora and fauna species to the north, south, east and west of the survey area and are integral to the maintenance of biodiversity within the region. These linkages happen to intersect with the areas within the survey area that have the highest conservation significance, for example, Bennett Brook and the wetlands identified as FCTS17 records within Whiteman Park.

## 6 RECOMMENDATIONS

RPS recommends that a targeted survey for Priority 4 taxon *Schoenus natans* be undertaken after autumn or winter rain to confirm the presence or absence of the species within the survey area, which could not be confirmed during the spring 2019 survey due to the absence of adequate living plant material.

RPS hopes to determine the taxonomic identity of the sedge species *Lepidosperma* sp. (putative new taxon) prior to finalisation of the flora report in June 2020.

## 7 REFERENCES

- 360 Environmental 2014a, Swan Valley Bypass, Perth–Darwin National Highway: Level 2 Flora and Vegetation Survey. Report prepared for Main Roads Western Australia.
- 360 Environmental 2014b, Tonkin Grade Separations: Flora, Vegetation and Fauna Survey. Report prepared for Main Roads Western Australia.
- Aurecon. 2016. Environmental Impact Assessment and Environmental Management Plan: Ellenbrook Bus Rapid Transit. Report prepared for Main Roads Western Australia.
- Beard, JS 1979, Vegetation Survey of Western Australia, Perth Sheet (SH50.14) (1:250 000 series). Vegmap Publications, Perth.
- Beard, JS 1990, Plant Life of Western Australia, Kangaroo Press Pty Ltd, Kenthurst NSW.
- Bureau of Meteorology. 2020. Climate Data Online, retrieved January 2020, from <http://www.bom.gov.au/climate/data/>.
- Coffey 2015, Level 2 spring Flora and Vegetation Assessment: NorthLink WA Perth–Darwin National Highway. May. Report prepared for NorthLink WA by Coffey Environments Australia Pty Ltd, Burswood, Western Australia.
- Commonwealth of Australia, 2019, Weeds of National Significance, retrieved January 2020, from <http://www.environment.gov.au/biodiversity/invasive/weeds/weeds/lists/wons.html>
- Del Marco, A, Taylor, R, Clarke, K, Savage, K, Cullity, J & Miles, C, 2004, Local Government Biodiversity Planning Guidelines for the Perth Metropolitan Region, Perth Biodiversity Project, Western Australian Local Government Association. West Perth.
- Department of Agriculture, Water and the Environment, 2020, *Lepidosperma rostratum* in Species Profile and Threats Database, Department of the Environment, Canberra. Retrieved April 2020: <http://www.environment.gov.au/sprat>.
- Department of Agriculture, Water and the Environment, 2020, Banksia Woodlands of the Swan Coastal Plain ecological community in Community and Species Profile and Threats Database, Department of the Environment, Canberra. Retrieved February 2020: <http://www.environment.gov.au/sprat>.
- Department of Environment and Conservation, 2006, Slender *Andersonia* (*Andersonia gracilis*) Interim Recovery Plan 2006-2011. Interim Recovery Plan No. 228. Department of Environment and Conservation, Western Australia.
- Department of Parks and Wildlife, 2008, Definitions, Categories and Criteria for Threatened and Priority Ecological Communities and Priority Ecological Communities List for Western Australia. Department of Environment and Conservation (Threatened Communities Branch), Kensington.
- Department of Parks and Wildlife 2013. A methodology for the evaluation of specific wetland types on the Swan Coastal Plain, Western Australia. Department of Parks and Wildlife, Bentley, Western Australia.
- Department of Primary Industries and Regional Development (DPIRD), 2019a, Soil-landscape mapping for Western Australia (Dataset DAFWA-033), retrieved January 2020, from <https://maps.agric.wa.gov.au/nrm-info/>.
- Department of Primary Industries and Regional Development (DPIRD), 2019b, Declared plant list, retrieved January 2020, from <https://www.agric.wa.gov.au/declared-plants/arum-lily-declared-pest>
- English, V., Blyth, J. 1997, Identifying and conserving threatened ecological communities in the South West Botanical Province (ANCA National Reserves System Cooperative Program No. N702). Department of Conservation and Land Management, Wanneroo.
- Environmental Protection Authority, 2016, Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment, Environmental Protection Authority, WA.



## REPORT

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- Environmental Protection Authority, 2015, Perth and Peel @ 3.5 million Environmental impacts, risks and remedies Interim strategic advice of the Environmental Protection Authority to the Minister for Environment under section 16(e) of the Environmental Protection Act 1986, Environmental Protection Authority, WA.
- Executive Steering Committee for Australian Vegetation Information (ESCAVI) 2003, Australian Vegetation Attribute Manual: National Vegetation Information System, Version 6.0. Department of the Environment and Heritage, Canberra.
- GHD, 2013, Perth–Darwin National Highway – Tonkin Highway Link Alignment Definition Study: Environmental Impact Assessment and Biological Survey. October. Report prepared for Main Roads Western Australia, by GHD Pty Ltd.
- Gibson, N., Keighery, B.J., Keighery, G.J., Burbidge, A.H. and Lyons, M.N. 1994, A Floristic Survey of the Southern Swan Coastal Plain. Unpublished Report for the Australian Heritage Commission prepared by Department of Conservation and Land Management and the Conservation Council of Western Australia (Inc.).
- Government of Western Australia. 2019. 2018 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis Government of Western Australia. 2017, 2016 South West Vegetation Complex Statistics, Current as of December 2016, Perth WA, retrieved October 2017, from <https://catalogue.data.wa.gov.au/dataset/dpaw/resource/688c6f7c-08c6-4f2e-b629-24d8aea47974>
- Griffin E.A. 1993, Flora of the Quindalup Dunes between the Swan and Irwin Rivers, Western Australia. Unpublished report to the Coastal Planning Branch, the Department of Planning and Urban Development and the Heritage Council of WA, East Perth, Western Australia.
- Griffin E.A. 1994, Floristic Survey of Northern Sandplains between Perth and Geraldton. Unpublished report to the Heritage Council of WA for the Australian Heritage Commission, Canberra, Australian Capital Territory.
- Hedde, E.M., Loneragan. O.W. and Havel J.J. 1980, Vegetation Complexes of the Darling System, WA, in Atlas of Natural Resources, Darling System WA, Department of Conservation and Environment.
- Keighery, B.J. 1994, Bushland Plant Survey: A Guide to Plant Community Survey for the Community, Wildflower Society of WA (Inc.), Nedlands, WA.
- Keighery G.J. 1996, Plot records from Tuart dominated communities. Unpublished database. Department of Conservation and Land Management, Wanneroo, WA.
- Keighery B.J., Keighery G.J., Longman V.M. and Clarke K.A. 2012, Native and Weed Flora of the Southern Swan Coastal Plain: 2005 Dataset. Department of Environment and Conservation, Kensington, Western Australia.
- McArthur, W.M. & Bettenay, E., 1960, The development and distribution of the soils of the Swan Coastal Plain, Western Australia. Soil Publ. 16, CSIRO, Melbourne.
- Mitchell, D., Williams, K. and Desmond, A. 2002, SCP 2 (SWA2 — SCP subregion), in Department of Conservation and Land Management (ed), A Biodiversity Audit of WA's 53 Biogeographical Subregions in 2002, pp 724.
- Natural Resource Management Ministerial Council 2010, Australia's Biodiversity Conservation Strategy 2010-2030, Australian Government, Department of Sustainability, Environment, Water, Population and Communities, Canberra
- RPS 2018, Detailed Flora and Vegetation Assessment – METRONET Ellenbrook Alignment. Unpublished report prepared for the Public Transport Authority of Western Australia, East Perth.
- Shepherd, D.P., Beeston, G.R., and Hopkins, A.J.M. 2002, Native Vegetation in WA – Extent, Type and Status, Resource Management Technical Report 249, Department of Agriculture, WA.
- Tauss C. & Weston A.S. 2010, The flora, vegetation and wetlands of the Maddington – Kenwick Strategic Employment Area. A survey of the rural lands in the vicinity of the Greater Brixton St Wetlands. A report to the City of Gosnells by C. Tauss and A. Weston, Perth, Western Australia.

## REPORT

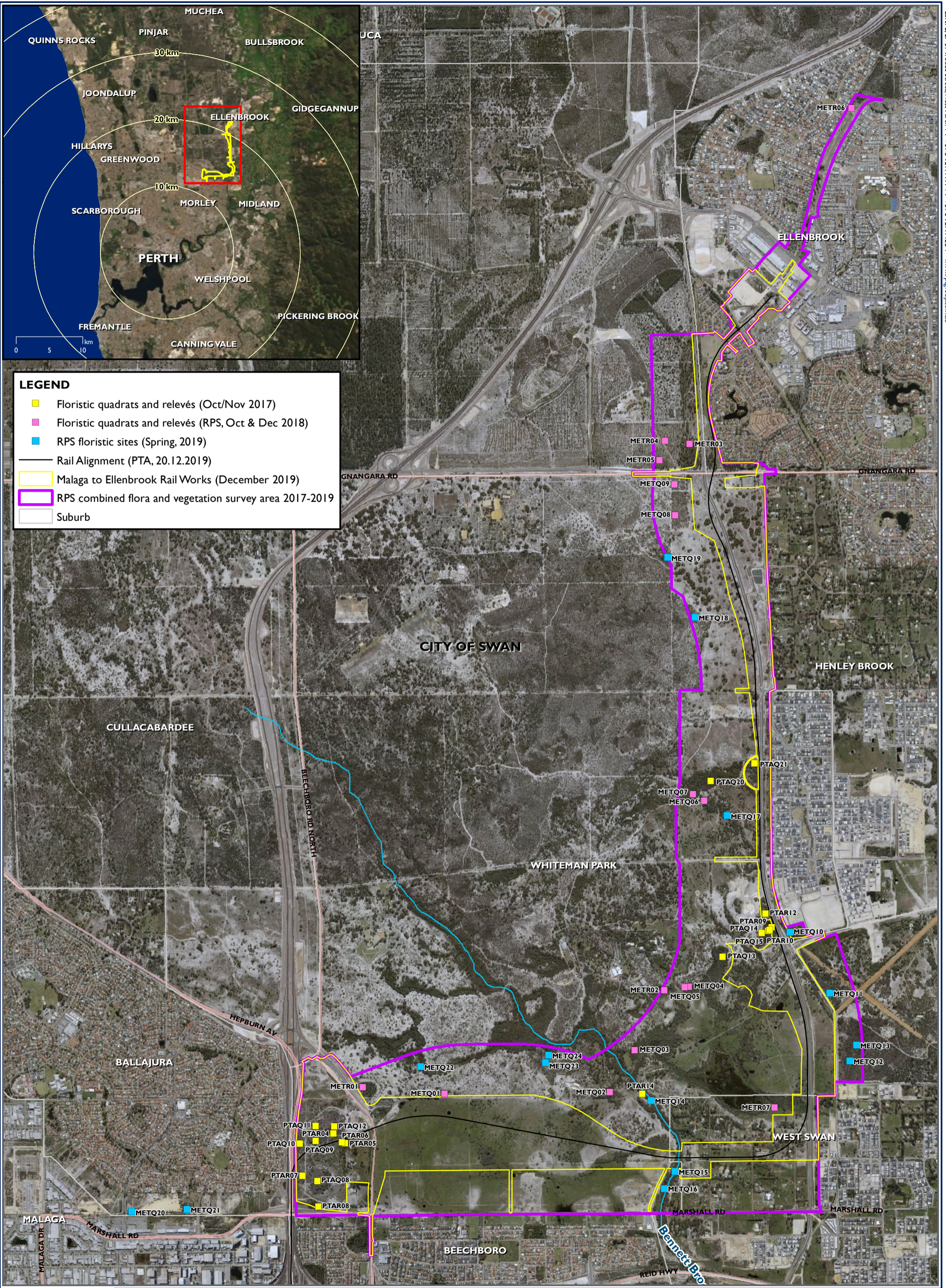
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- Thackway, R. and Cresswell, I.G. 1995, (Eds., An Interim Biogeographic Regionalisation for Australia: a framework for establishing the national system of reserves, Version 4.0. Australian Nature Conservation Agency, Canberra.
- Tingay, Alan & Associates 1998, A Strategic Plan for Perth's Greenways – Final Report. Prepared for Environment Australia, Ministry for Planning, Department of Conservation and Land Management, Western Australia Municipal Association, Department of Environmental Protection, Water and Rivers Commission, Main Roads WA, Swan Catchment Centre, Conservation Council, Greening WA and Australian Trust for Conservation Volunteers.
- Trudgen, M.E. 1988, A Report on the Flora and Vegetation of the Port Kennedy Area. Unpublished report prepared for Bowman Bishaw and Associates, West Perth.
- Urban Bushland Council of WA (UBCWA) 2013, Roe 8 Highway Extension - Botanical analysis and report prepared for the Urban Bushland Council WA September 2013.
- Western Australian Herbarium 2017, FloraBase – The Western Australian Flora. Online database of the Western Australian Herbarium. <http://florabase.DPaW.wa.gov.au>. Department of Environment and Conservation, Kensington.
- Western Australian Planning Commission, 2000. Bush Forever: Volumes 1 & 2, Keeping the Bush in The City – Policies, Principles and Processes and Directory of Bush Forever Sites. Perth.



**FIGURES**





**LEGEND**

- Floristic quadrats and relevés (Oct/Nov 2017)
- Floristic quadrats and relevés (RPS, Oct & Dec 2018)
- RPS floristic sites (Spring, 2019)
- Rail Alignment (PTA, 20.12.2019)
- Malaga to Ellenbrook Rail Works (December 2019)
- RPS combined flora and vegetation survey area 2017-2019
- Suburb



Job Number: L17158.008  
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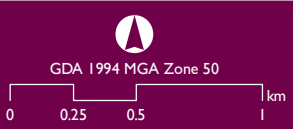
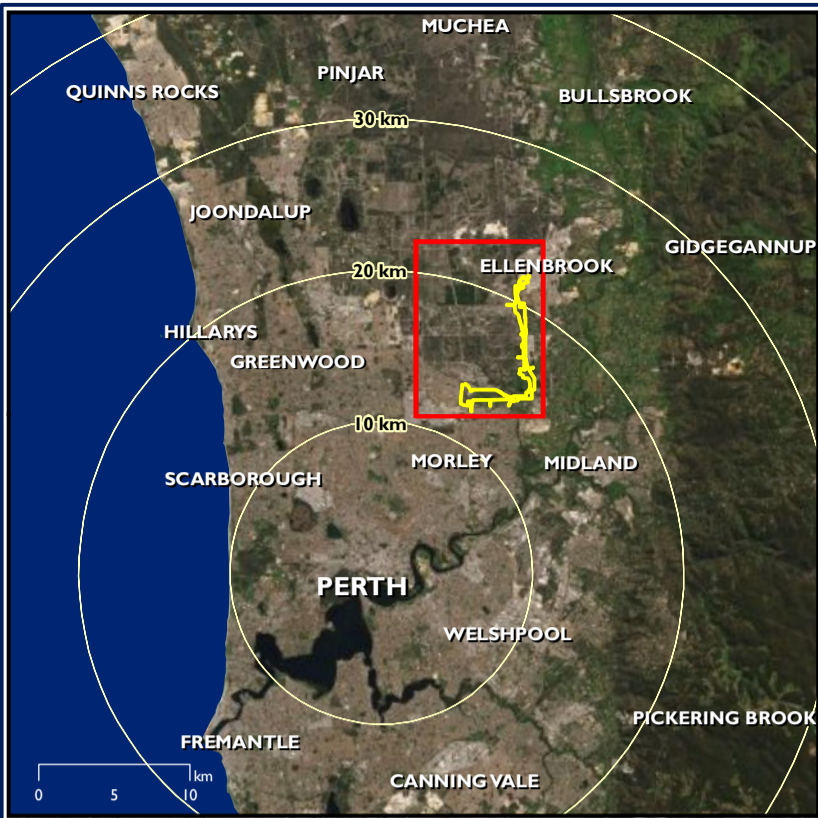


Figure A

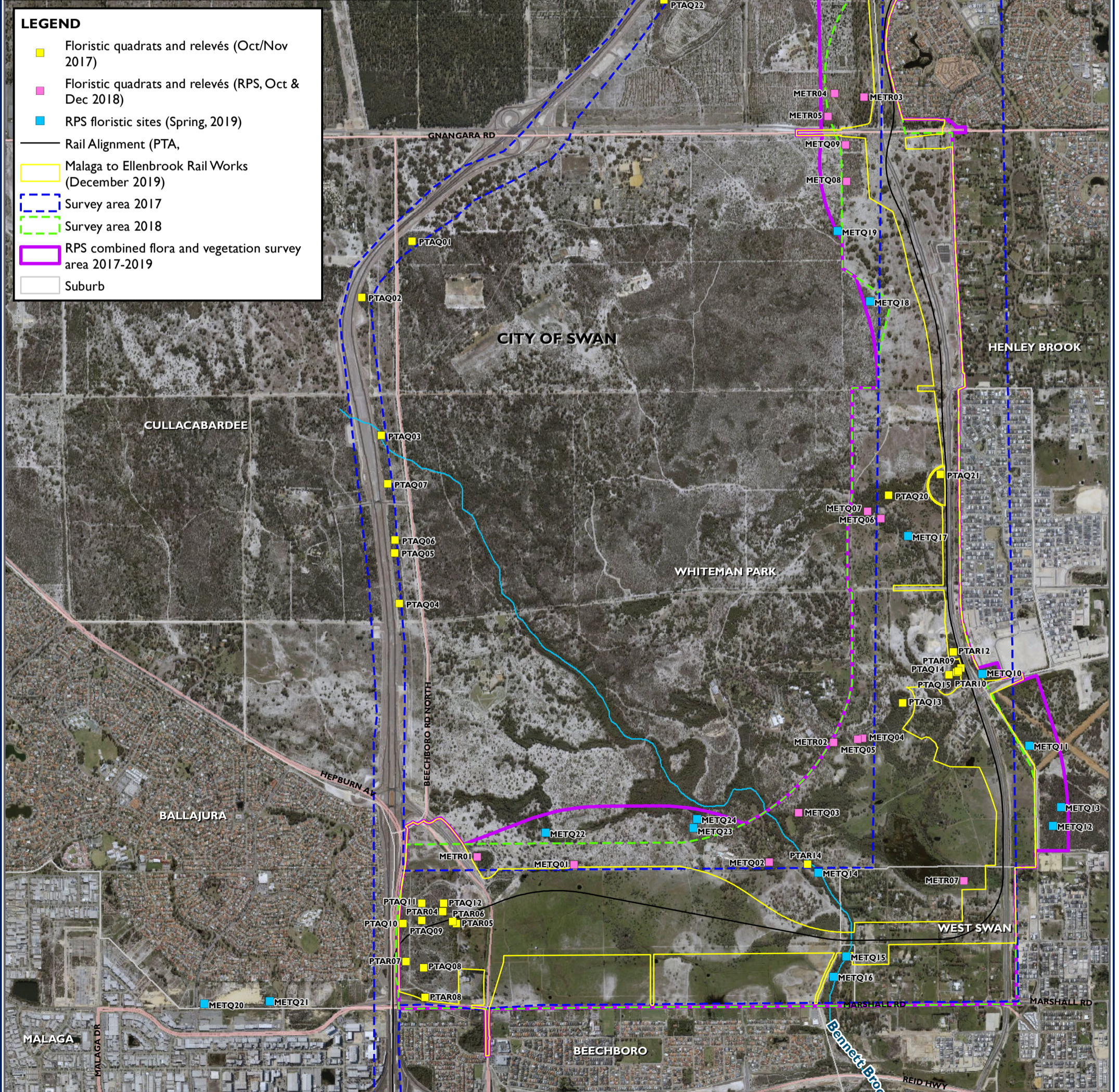
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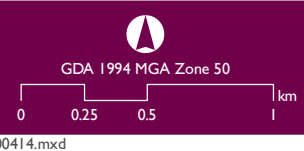
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**RPS**

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**Figure B**  
 Survey area boundaries 2017 to 2019