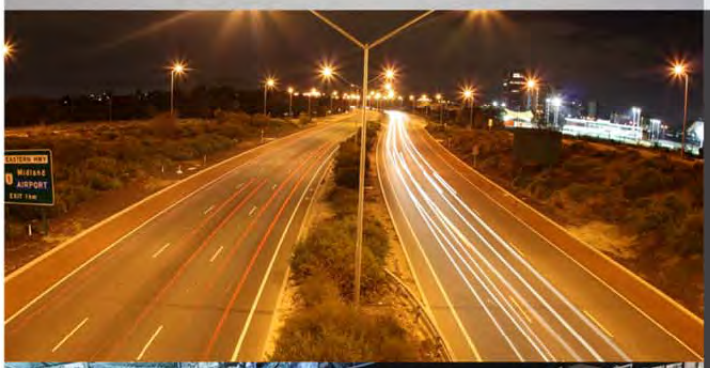
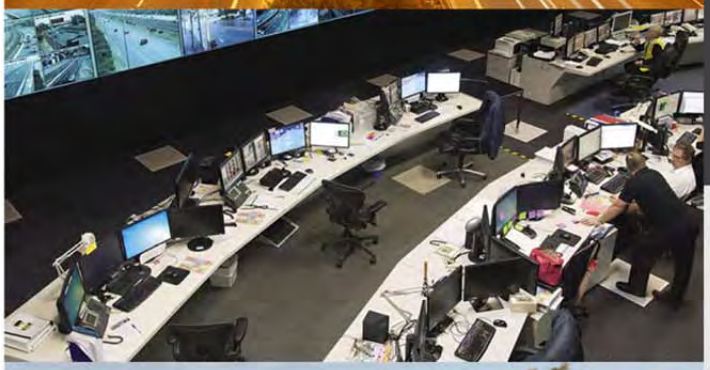
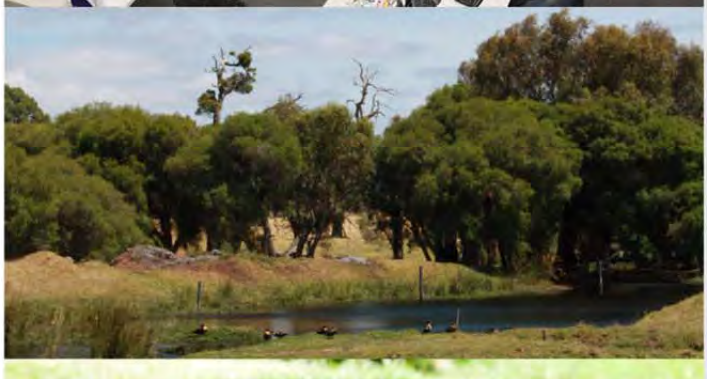
NorthLinkWA

Perth-Darwin National Highway







Level 2 Flora and Vegetation Assessment

Perth–Darwin National Highway

DOC NO / NLWA-03-EN-RP-0016

REV / 1

DATE / 29 May 2015

coffey

Australian Government

mainroads WESTERN AUSTRALIA

NorthLinkWA

EXECUTIVE SUMMARY

Main Roads Western Australia is proposing to construct the NorthLink WA Project (the project). The project will result in 37 km of new dual carriage highway between Tonkin Highway and Reid Highway interchange in the south and Great Northern Highway and Brand Highway interchange in the north (the project area).

The Environmental Protection Authority identified that potential adverse impacts on native flora and vegetation represent a preliminary key environmental factor for the assessment of the project. To identify and assess the values and significance of the flora and vegetation within the project area, a Level 2 flora and vegetation survey and targeted flora search was conducted.

In accordance with the EPA's Guidance Statement No. 51 for a Level 2 flora and vegetation survey, the assessment included:

- A desktop assessment completed prior to the field survey and involved a review of existing environmental or biological data available for the area and adjacent lands. It included a review of State and Federal databases, regional and local contextual data for the northern Swan Coastal Plain and existing biological surveys;
- A Level 2, flora and vegetation survey was undertaken between 15 to 19 September 2014, 22 to 26 September 2014 and 17 to 19 November 2014, with 54 person-days invested in the survey. A total of 120 flora sampling sites, consisting of 93 quadrats and 27 relevés were established and sampled. The survey included re-sampling of 29 quadrats previously established in 2013.
- A statistical multivariate analysis of the floristic data.
- A comprehensive report, including figures and appendices, detailing the results of the survey, the statistical analysis and an impact assessment to determine significance of the project.

Based on the results of the Level 2 flora and vegetation survey and statistical analysis, the significant environmental values include:

- Four Threatened Ecological communities (TECs), six confirmed and one potential Priority Ecological Communities (PEC) were recorded.
  - Threatened Ecological Communities
    - Mound Springs SCP recorded from one location.
    - SCP02 recorded from one location.
    - SCP20a recorded from three locations.
  - Priority Ecological Communities
    - SCP21c recorded from 23 locations.
    - SCP22 recorded from one location.
    - SCP23b recorded from ten locations.
    - SCP24 recorded from three locations.
    - Banksia dominated woodlands of the Swan Coastal Plain IBRA region recorded from numerous locations.

- Claypans of the Swan Coastal Plain (TEC); *Casuarina obesa* associations or Claypans with mid dense shrublands of *Melaleuca lateritia* over herbs recorded from one location.

- The potential identification of the Federal TEC Claypans of the Swan Coastal Plain. Consistent with the State Priority 1 Ecological Community Claypans with mid dense shrublands of Melaleuca lateritia over herbs.
- Thirteen vegetation associations that are locally significant, supporting and providing habitat for Threatened and Priority flora.
- Two Threatened and eight Priority flora recorded.
  - *Caladenia huegelii* (T) recorded from one location.
  - *Grevillea curviloba* subsp. *incurva* recorded from one existing, known location.
  - *Millotia tenuifolia* var. *laevis* (P2) recorded from eight locations.
  - *Poranthera moorokatta* (P2) recorded from seven locations.
  - *Cyathochaeta teretifolia* (P3) recorded from two locations.
  - *Meeboldina decipiens* subsp. *decipiens* (P3) recorded from two locations.
  - *Anigozanthos humilis* subsp. *chrysanthus* (P4) recorded from two locations.
  - *Hypolaena robusta* (P4) recorded from three locations.
  - *Ornduffia submersa* (P4) recorded from one location.
  - *Stylidium striatum* (P4) recorded from one location.
- Twenty-five locally significant taxa (i.e. significant flora of the Perth Metropolitan Region (PMR), range extensions and unique/unusual taxa).
  - *Allocasuarina campestris* (unusual/unique);
  - *Amperea simulans* (range extension);
  - *Aotus cordifolia* (significant flora of the PMR);
  - *Boronia purdieana* (significant flora of the PMR);
  - *Bossiaea eriocarpa* (unusual/unique);
  - *Caladenia huegelii* (T) (significant flora of the PMR);
  - *Calytrix fraseri* (unusual/unique);
  - *Conospermum incurvum* (significant flora of the PMR);
  - *Conostephium minus* (significant flora of the PMR);
  - *Conostylis aculeata* subsp. *cygnorum* (significant flora of the PMR);
  - *Conostylis teretiuscula* (range extension);
  - *Croninia kingiana* (formerly *Leucopogon kingianus*) (significant flora of the PMR);
  - *Cyathochaeta teretifolia* (P3) (significant flora of the PMR);
  - *Dielsia stenostachya* (significant flora of the PMR);
  - *Eremaea purpurea* (significant flora of the PMR);

  - *Hensmania turbinata* (significant flora of the PMR);
  - *Histiopteris incisa* (range extension);
  - *Macarthuria apetala* (significant flora of the PMR);
  - *Melaleuca amydra* (range extension);
  - *Monotaxis occidentalis* (unusual/unique); and
  - *Ornduffia submersa* (formerly *Villarsia submersa*) (P4) (significant flora of the PMR);
  - *Pithocarpa pulchella* var. *pulchella* (significant flora of the PMR);
  - *Pterostylis* sp. cauline leaves (N. Gibson & M.N. Lyons 1490) (significant flora of the PMR);
  - *Tetratheca hirsuta* (unusual/unique).
  - *Verticordia nitens* (significant flora of the PMR);
- Four weeds of national significance, **Asparagus asparagoides* (Bridal Creeper), **Eichhornia crassipes* (Water Hyacinth), **Opuntia stricta* (Prickly Pear) and **Rubus laudatus* (consistent with **Rubus fruticosus* aggregate).
- One Prohibited Pest, **Eichhornia crassipes* (Water Hyacinth), under Section 12 of the *Biosecurity and Agricultural Management Act 2007* (BAM Act)
- Five Declared Pests, **Asparagus asparagoides* (Bridal Creeper), **Moraea flaccida* (One-leaf Cape Tulip), **Opuntia stricta* (Prickly Pear), **Rubus laudatus* (Blackberry) and **Zantedeschia aethiopica* (Arum Lily), listed under Section 22 of the BAM Act.
- Seventeen weeds with High environmental weed rating and nine weeds of High Priority under the Weed Prioritisation Process.

According to the design of the project, the project area is approximately 765 ha in size. Native vegetation occurs across approximately 295.7 ha of the project area (here on rounded to 296 ha), with the remaining 469.6 ha within the project area consisting of cleared paddocks with scattered trees, infrastructure (including roads) and areas considered to be cleared of intact native vegetation.

Following the review of the results and the assessment of the potential impacts for the project, approximately 90.7 ha of the 296 ha of native vegetation is considered to be conservation significant vegetation. The vegetation consists of one Commonwealth listed, and two State listed TECs and five State listed PECs, and possibly one additional State listed PEC.

The project will not impact on the two threatened flora. Of the eight priority listed flora recorded during the survey, the project will impact on five. Apart from *Meeboldina decipiens* subsp. *decipiens* ms which has both records within the project area, the remaining four priority listed flora (*Millotia tenuifolia* var. *laevis, Poranthera moorokatta, Anigozanthos humilis* subsp. *chrysanthus* and *Hypolaena robusta*) have records within and outside of the project area.

The following recommendations are provided to manage and mitigate the potential impacts, while reducing the residual impacts to as low as reasonably practical.

- Avoid or minimise clearing of vegetation consistent with the three State TECs (Mound Springs SCP, SCP02 and SCP20a) located within and adjacent to the project area.
- Minimise the clearing of native vegetation consistent with the four known PECs located within the study area.

- Develop and implement a vegetation monitoring program before and after construction to observe impacts on the TECs and PECs adjacent to the project area.
- Minimise clearing within native vegetation of the Bassendean-Central and South, Reagan, Southern River and Yanga vegetation complexes.
- Conduct a follow-up targeted survey in spring 2015 to further identify and delineate the *Caladenia huegelii* population in the study area.
- Conduct additional targeted surveys within native vegetation that supports *Poranthera moorokatta* (P2) and *Millotia tenuifolia* var. *laevis* (P2) to further identify and delineate the population size and extent.
- Demarcate Threatened and Priority flora populations located adjacent to and within the project area before the construction phase.
- Develop and implement construction management plans to mitigate the potential direct and indirect impacts on *Caladenia huegelii* and *Grevillea curviloba* subsp. *incurva*. The management plan would include the monitoring of populations to determine if they are being impacted upon as a result of the project.
- Undertake additional targeted surveys for other Priority flora recorded within the study area to further define the population extent and size.
- Undertake additional sampling of the potential EPBC Act listed TEC Claypans of the Swan Coastal Plain (located in association with SVB086) to determine the presence and extent of the TEC. The additional sampling should be undertaken over two seasons, including early spring and late spring/early summer, thus representing a true (2 phase) Level 2 survey.
- Ensure final design and all site activities avoid the tentative location of the Federal TEC until confirmation of the EPBC Act listed TEC can be determined.
- Develop and implement an effective weed hygiene management plan prior to clearing and construction of the highway to reduce the spread and introduction of weeds, especially of WONS and Declared Pests.

CONTENTS

Tables

Plates

Figures

Appendices

Document *Control*

Revision	Date	Description	Prepared	Reviewed	Approved
A	11/02/2015	First draft to BG&E and Main Roads Western Australia (Coffey – v1)	M. Holliday L. Dadour C. van den Bergh	J. Mattner C. van den Bergh	D. True
0	27/03/2015	Final to BG&E and Main Road Western Australia (Coffey – v2)	L. Dadour C. van den Bergh	C. van den Bergh D. True	D. True
1	29/05/2015	Final to BG&E and Main Roads Western Australia (Coffey – v3)	C. van den Bergh	C. van den Bergh D. True	D. True

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ABBREVIATIONS AND UNITS

Term	Definition
BAM Act	*Biosecurity and Agriculture Management Act 2007*
BFF	broad floristic formations
BOM	Bureau of Meteorology
CALM	Conservation and Land Management
CALM Act	*Conservation and Land Management Act 1984*
CCW	conservation category wetland
cm	centimetres
Coffey	Coffey Environments Australia Pty Ltd
DAFWA	Department of Agriculture and Food Western Australia
DEC	Department of Environment and Conservation
DER	Department of Environment Regulation
DOP	Department of Planning
DOTE	Department of the Environment
DOW	Department of Water
DPAW	Department of Parks and Wildlife
EIA	environmental impact assessment
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPP	Environmental Protection Policy
ESA	Environmentally Sensitive Area
ESD	Environmental Scoping Document
FCT	floristic community type
ha	hectare
Hwy	Highway
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for Conservation of Nature
km	kilometres
LNA	local natural area

Term	Definition
m	metres
m^2	metres squared
mm	millimetres
MNES	matters of national environmental significance
MRS	Metropolitan Region Scheme
MRWA	Main Roads Western Australia
MUW	multiple use wetlands
NVIS	National Vegetation Information System
OEPA	Office of the Environmental Protection Authority
PBP	Perth Biodiversity Project
PDNH	Perth–Darwin National Highway
PEC	Priority Ecological Community
PER	Public Environmental Review
PMR	Perth Metropolitan Region
RE	Resource enhancement
REW	resource enhancement wetland
RIWI Act	*Rights in Water and Irrigation Act 1914*
SCP	Swan Coastal Plain
SVB	Swan Valley Bypass
TEC	Threatened Ecological Community
UFI	unique feature identifier
WA	Western Australia
WAH	Western Australian Herbarium
WALGA	Western Australian Local Government Association
WAPC	Western Australian Planning Commission
WC Act	*Wildlife Conservation Act 1950*
WONS	weeds of national significance
WSTH	Western Swamp Tortoise Habitat

1 INTRODUCTION

1.1 Background

Main Roads Western Australia (MRWA) is proposing to construct the NorthLink WA Project. The project will result in 37 km of new dual carriage highway between Tonkin Highway and Reid Highway interchange in the south and Great Northern Highway and Brand Highway interchange in the north (Figure 1).

NorthLink WA is the culmination of several decades of planning for the southern terminus of the Perth–Darwin National Highway (PDNH), a key road transport route linking Perth with northern Western Australia (WA) and the Northern Territory.

The NorthLink WA Project Team (hereafter referred to as 'the project team') has been commissioned by MRWA to complete the design and construction of the Swan Valley Bypass (SVB) section of the PDNH (hereafter referred to as 'the project') and to obtain the necessary environmental approvals.

The project was referred to the WA Environmental Protection Authority (EPA) on 25 October 2013 to determine the level of assessment required for the project. The EPA determined the Public Environmental Review (PER) level of assessment (6 January 2014), the highest level under the WA *Environmental Protection Act 1986* (EP Act).

The EPA's objective is to '*maintain representation, diversity, viability and ecological function at the species, population and community level*'. The potential impacts on the native flora and vegetation include:

- Loss of flora and vegetation through clearing for road construction.
- Loss of fauna habitat (vegetation loss) short and long term.
- Impacts to wetlands and their buffers.
- Impacts to riparian vegetation and ground water dependent ecosystems.
- Spread of weeds and Phytophthora Dieback.
- Fragmentation.

In accordance with the PER level of assessment and at the discretion of the EPA, the EPA determined that the Environmental Scoping Document would be prepared and issued by the EPA. The ESD identifies the preliminary key environmental factors that the PER will have regard for, and identifies the direct, indirect, cumulative and residual impacts as a result of the project. The scoping document identified that potential adverse impacts on native flora and vegetation represent preliminary key environmental factors. To identify and assess the values and significance of the flora and vegetation within the project area, a Level 2 flora and vegetation survey and targeted flora search was conducted.

1.2 Location

The southern terminus of the project area is located within the City of Swan and extends from the Reid Highway and Tonkin Highway interchange for 37 km to the Great Northern Highway and Brand Highway interchange in the Shire of Chittering (Figure 1 and 2). The project area intersects the suburbs of Malaga, Bennett Springs, Ballajura, Cullacabardee, Whiteman, Ellenbrook, Bullsbrook and Muchea.

The project area is approximately 765 ha in size and is a mixture of native vegetation, cleared paddocks, rehabilitated land, pine plantations, mine site and linear infrastructure (i.e. roads, railway, transmission

corridor and gas pipeline). The study area extended beyond the project area to provide local and regional context and is 3074.6 ha in size (Figure 2).

Subsequent to the detailed spring flora and vegetation survey being completed, the project area was altered to include local roads that are proposed to be (i.e. Halden Road, Cunningham Road) (Figures 1 and 2). A Level 1 survey was commissioned to review the vegetation and to determine if they are significant communities or support significant flora (Coffey, 2015). The methodology and results of the survey are presented in Appendix A. The results, discussion and impact assessment sections of this document include the results of the local roads survey.

1.3 Report Terms

The following terms have been used in this document:

- Project Area – refers to the construction of 37 km of the PDNH from the Tonkin Highway and Reid Highway interchange in the south to the Great Northern Highway and Brand Highway interchange in the north.
- The Project Team – refers to the NorthLink WA Project Team commissioned to design and construct the project.
- The Study Area – refers to the Swan Valley Bypass (and adjacent vegetation) section of the Perth–Darwin National Highway.
- Swan Valley Bypass (SVB) – is the same as the project area.

1.4 Objectives

The objectives of the Level 2 flora and vegetation survey were to:

- Complete a Level 2 flora and vegetation survey and targeted flora survey.
- Complete a targeted introduced flora survey.
- Identify and assess the values and significance of the flora and vegetation.
- Describe and assess the potential direct and indirect impacts of the project on the flora and vegetation.
- Identify an environmentally acceptable development footprint or a footprint of least environmental harm.
- Summarise the residual impacts of the project and identify management and mitigation measures to meet the EPA's objectives.

1.5 Scope

The scope conducted to meet the objectives consisted of:

- A desktop assessment, including a review of the following documents:
  - The State's Department of Parks and Wildlife (DPAW) Threatened and Priority flora and Ecological Communities databases;
  - The Western Australian Herbarium's (WAH) flora specimen database, including Threatened and Priority flora;

- The Commonwealth's Department of the Environment (DOTE) online database search tool for Matters of National Environmental Significance (MNES) protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- DPAW's *Geomorphic Wetlands of the Swan Coastal Plain* dataset; and
- Previous flora and vegetation surveys undertaken within and close to the study area.

- A site reconnaissance to identify access and to broadly describe the vegetation.
- A Level 2 flora and vegetation survey, which included:
  - The establishment and sampling of permanent 10 m x 10 m quadrats (equivalent to 100 m^2) within representative vegetation units;
  - The re-sampling of 100 m^2 established quadrats (360 Environmental, 2013);
  - The sampling of non-systematic flora survey points (relevés) within vegetation units
  - The mapping and description of broad floristic formations (BFF) and vegetation associations according to the National Vegetation Information System (NVIS) (ESCAVI, 2003);
  - The rating of vegetation condition (Keighery, 1994);
  - A targeted survey for Threatened flora and Threatened Ecological Communities (TECs);
  - A targeted introduced flora survey (with particular reference to Weeds of National Significance (WONS) and Declared Pests listed under Section 22 of the *Biosecurity and Agricultural Management Act 2007* (BAM Act)); and
  - Compilation of a comprehensive flora inventory, including native and non-native taxa recorded from the quadrats, the relevés and opportunistic observations.
- The preparation of a concise, technical report, which included:
  - Multivariate statistical analysis of the floristic data collected and regional quadrats (where applicable);
  - Discussion of the significance of the floristic values identified;
  - Identification of direct and indirect impacts of the project on the flora and vegetation;
  - Identification of a preferred, environmentally acceptable development footprint;
  - Discussion on the residual impacts of the project;
  - Recommendations regarding management and mitigation measures to ensure the EPA's objectives for flora and vegetation (see end of Section 1.1) can be met.

2 ENVIRONMENTAL POLICY AND LEGISLATION

The flora and vegetation assessment was undertaken in accordance with the requirements of the following key environmental legislation and regulations:

- *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act).
- *Environmental Protection Act 1986* (WA) (EP Act).
- *Wildlife Conservation Act 1950* (WA) (WC Act).
- Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (WA).
- Environmental Protection (Swan Coastal Plain Lakes) Policy 1992 (WA) (EPP Lakes).
- Environmental Protection (Gnangara Mound Crown Land) Policy 1992 (WA).
- Environmental Protection (Western Swamp Tortoise Habitat) Policy 2011 (WA).
- *Biosecurity and Agriculture Management Act 2007* (WA) (BAM Act).
- *Conservation and Land Management Act 1984* (WA) (CALM Act).
- Statement of Planning Policy No.2: Environment and Natural Resources Policy (WA) (SPP 2).
- State Planning Policy No. 2.8: Bushland Policy for the Perth Metropolitan Region (WA) (SPP 2.9).

2.1 Commonwealth Legislation

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the key Commonwealth environmental legislation that protects and manages matters of national and international environmental significance. The administering agency for this act is the Commonwealth Department of the Environment (DOTE).

The eight Matters of National Environmental Significance (MNES) addressed under the Act are:

- World Heritage sites.
- National Heritage places.
- Wetlands of international importance (i.e. Ramsar listed wetlands).
- Nationally Threatened species and ecological communities.
- Migratory species (protected under international agreements).
- Commonwealth marine areas.
- The Great Barrier Reef Marine Park.
- Nuclear actions.

The key MNES relevant to this survey are:

- Nationally threatened species;
- Nationally threatened ecological communities; and
- Wetlands of international importance.

2.2 State Legislation

2.2.1 Environment Protection Act 1986

The *Environmental Protection Act 1986* (EP Act) is the primary legislation that governs environmental impact assessment (EIA) and protection in Western Australia. The aim of the 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".*

In Section 4A of this Act there are five principles, which are necessary for the objectives of the Act to be realised. Three of these principles are applicable to native flora and vegetation:

- The precautionary principle.
- The principle of intergenerational equity.
- The principle of the conservation of biological diversity and ecological integrity.

Authorities under this Act include the Department of Environment Regulation (DER), Department of Parks and Wildlife (DPAW) (formerly the Department of Environment and Conservation (DEC)) and the Environmental Protection Authority (EPA), including the Office of the Environmental Protection Authority (OEPA).

Part IV of the EP Act relates to the assessment of environmental impacts, and Part V deals with licensing and control of pollution from prescribed premises and permits for land clearing.

2.2.2 Wildlife Conservation Act 1950

The Western Australia *Wildlife Conservation Act 1950* (WC Act) is:

> *"An Act to provide for Conservation and Protection of Wildlife".*

Under the Act, all native flora is protected throughout the whole state at all times. In addition the Minister for the Environment can publish a notice in the Government Gazette, declaring a list of flora species that are rare, likely to become extinct or otherwise in need of special protection.

Flora that is declared Threatened (gazetted Declared Rare Flora) is protected and may not be impacted on, unless authorised and carried out in accordance with the terms and conditions of the licences issued under Section 23C. The WC Act also protects fauna species that are rare, likely to become extinct or otherwise in need of special protection.

2.2.3 Environmental Protection (Swan Coastal Plain Lakes) Policy 1992

The purpose of the *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992* (EPP Lakes) is to protect the environmental values of lakes on the Swan Coastal Plain. The lakes protected under the EPP Lakes have in most cases been selected for inclusion in this policy on the basis that they consisted of areas of standing water of 1,000 m^2 or more as of 1 December 1991.

The EPP Lakes made the filling, draining, excavating, polluting and clearing of these lakes an offence unless authorised by the EPA. The EPP Lakes ensures the protection of the lakes by prohibiting the carrying out of activities which cause the destruction and degradation of the lakes and requiring persons who cause the destruction or degradation of lakes to undertake, in certain cases, the rehabilitation or re-establishment of those lakes. The destruction and degradation of the lakes includes the impact to the plant assemblages, soils and hydrology of the lakes.

2.2.4 Environmental Protection (Gnangara Mound Crown Land) Policy 1992

The purpose of the *Environmental Protection (Gnangara Mound Crown Land) Policy 1992* (EPP Gnangara) is to protect the level and quality of groundwater on or under the policy area (an area consisting of Crown land and covering a large portion of Gnangara Mound) and native vegetation and wetlands in the policy area.

The filling of wetlands and the clearing, destruction or removal of native vegetation on or from the policy area contravenes the purpose of this EPP. The project area is partially located within Crown land on the Gnangara Mound.

2.2.5 Environmental Protection (Western Swamp Tortoise Habitat) Policy 2011

The purpose of the *Environmental Protection (Western Swamp Tortoise Habitat) Policy 2011* (EPP WSTH) is to protect habitat suitable for the long-term survival of wild populations of the Western Swamp Tortoise.

This policy is related to the potential clearing and modifications of native vegetation that is consistent with wetland communities and the hydrological regimes that influence flows into Twin Swamp Nature Reserve (A Class Reserve No. 27621). Wetland vegetation and the hydrological regimes that may influence Twin Swamps Nature Reserve are located within and adjacent to the project area.

2.2.6 Biosecurity and Agriculture Management Act 2007

The Western Australian *Biosecurity and Agriculture Management Act 2007* (BAM Act) is:

> *"An Act to provide for; the control of certain organisms; the use of agricultural and veterinary chemicals; the identification and attainment of standards of quality and safety for agricultural products, animal feeds, fertilisers and other substances and things; the establishment of a Declared Pest Account, a Modified Penalties Revenue Account and accounts for industry funding schemes; and related matters".*

The Act is managed by the Department of Agriculture and Food Western Australia (DAFWA) and specifically relates to the prohibition and regulation of the introduction and spread of weeds (introduced species) declared under the Act for the protection of agricultural management.

2.2.7 Conservation and Land Management Act 1984

The *Conservation and Land Management Act 1984* (CALM Act) is managed by DPAW and is:

> *"An Act to make better provision for the use, protection and management of certain public lands and waters and the flora and fauna thereof, to establish authorities to be responsible therefor, and for incidental or connected purposes."*

DPAW manages lands and waters throughout WA to conserve ecosystems and species, and to provide for recreation and appreciation of the natural environment. DPAW manages Crown, freehold and pastoral lease lands jointly with other organisations.

The study area traverses four conservation and/or multiple-use lands that are vested in the Conservation Commission (Gnangara-Moore River State Forest; R46875; R46919; and R46920) and managed by DPAW under the CALM Act.

2.2.8 Statement of Planning Policy No. 2: Environment and Natural Resources Policy

The Environment and Natural Resources Statement of Planning Policy No.2 (WAPC, 2003) sets out a planning response to environmental and natural resource management issues within the framework of the State Planning Strategy (WAPC, 2014). The objectives of the policy are to integrate environment and natural resource management with broader land use planning, to protect, conserve and enhance the natural environment and promote and the wise and sustainable use and management of natural resources.

Policy areas relevant to this assessment include:

- General measures – implementation of planning decisions can have an impact on the environment, these policy measures recognise the significance of natural resources.
- Water resources – water is fundamental to human life and the environment. The careful management of water resources, both in terms of quantity and quality, is therefore essential to support natural ecosystems as well as future growth and development. This includes water catchments, waterways, wetlands, estuaries and the marine environment.
- Soil and land quality – land is an essential physical and economic resource, which is fundamental to the existence of flora and fauna and is essential in maintaining biodiversity. Specific consideration should be given to land capability and suitability, and exploration of different options for use when decisions are made about the future use and development of land.
- Biodiversity and landscapes – biodiversity describes the variability among living organisms from all sources and includes diversity within and between species and the diversity of ecosystems. Planning should recognise the State's biodiversity when considering changes of land use.

2.2.9 State Planning Policy No. 2.8: Bushland Policy for the Perth Metropolitan Region

The Bushland Policy for the Perth Metropolitan Region, State Planning Policy 2.8 (WAPC, 2010) applies to the Perth Metropolitan Region and relates to two distinct policy areas, being Bush Forever sites and local bushland. The policy provides an implementation framework for bushland protection and management in the Perth Metropolitan Region. The Policy ensures issues affecting local Bush Forever Sites and areas of local bushland in Perth are addressed and integrated in to broader land use planning and decision making. The policy aims to secure the long-term protection of biodiversity and environmental values of these areas. State Planning Policy 2.8 (SPP 2.8) has three key objectives:

- Establish a conservation system at the regional level (through Bush Forever areas and to operate with the clearing controls under the *Environmental Protection Act 1986*) that is, as far as is achievable, comprehensive, adequate and representative of the ecological communities of the Swan Coastal Plain portion of the Perth Metropolitan Region.
- Seek to protect and manage significant bushland recommended for protection and management for conservation purposes through a range of implementation mechanisms and as a collective and shared responsibility and general duty of care on the part of government, landowners and the community.
- Provide a policy and implementation framework for significant bushland areas recommended for protection and management to assist conservation planning, planning assessment and decision-making processes.

The application of the SPP 2.8 with regards to Bush Forever sites relates to any proposal or decision-making that is likely to have an adverse impact on regionally significant bushland within a Bush Forever site. An adverse impact includes direct impacts (i.e. clearing native vegetation) within a Bush Forever area and the indirect impacts (i.e. development abutting a Bush Forever area) on a Bush Forever area (WAPC, 2010).

Note that existing cleared or developed areas within Bush Forever sites are protected through SPP 2.8 and are not excluded from future development. However, any likely significant indirect impact on regionally significant bushland may be subject to planning or environmental controls (WAPC, 2010).

2.3 Environmental Guidance and Policy

The EPA has produced a number of policy statements, guidelines and technical guides, which provide guidelines and advice regarding the EPA's position on the flora and vegetation of Western Australia. Relevant documents include:

- Guidance for the Assessment of Environmental Factors No. 6 Rehabilitation of Terrestrial Ecosystems (EPA, 2006).
- Guidance for the Assessment of Environmental Factors No. 10 Level of Assessment for Proposal Affecting Natural Areas within the System 6 Region and Swan Coastal Plain Portion of the System 1 Region (EPA, 2006).
- Guidance for the Assessment of Environmental Factors No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA, 2004a).
- Position Statement No. 2 Environmental Protection of Native Vegetation in Western Australia (EPA, 2000).
- Position Statement No. 3 Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA, 2002).
- Position Statement No. 4 Environmental Protection of Wetlands (EPA, 2004b)
- Position Statement No. 7 Principles of Environmental Protection (EPA, 2004c).
- Environmental Protection Bulletin No. 20 Protection of Naturally Vegetated Areas through Planning and Development (EPA, 2013).

3 EXISTING ENVIRONMENT

3.1 Existing and Historical Land Use

There are a variety of land uses in the project area including farmland, conservation reserves, transport corridors, rural infrastructure, industrial areas, Gnangara Pine Plantation, active mining tenement and private land.

The project area is located within the Metropolitan Region Scheme (MRS) (DOP, 2014) and the Shire of Chittering Town Planning Scheme No. 6 (TPS6) (DOP, 2013). The current project area alignment is zoned:

- MRS – Rural, Primary Regional Roads, Parks and Recreation and State Forest.
- TPS6 – Highway, Agricultural Resource, Parks and Recreation and Railway.

3.2 Climate

Perth has a Mediterranean climate with warm to hot summers and cool to mild, wet winters. The nearest operating Bureau of Meteorology (BOM) weather stations with relevant long term and recent climatic data to the study area are Pearce RAAF Airbase (Station No. 009053) in Bullsbrook (representative of the northern section of the study area), Gingin Aero (Station No. 009178) in Gingin (both representative of the northern section); the Perth Metro station (Station No. 009225) located in Mt Lawley and the Perth Airport (Station No. 009021) (both representative of the southern section) (Figure 1). Overall, the northern end of the project area receives approx. 50 mm per annum less rain than the southern end, and maximum summer temperatures are approximately 2^{o}C cooler at the southern end, as detailed from each of the BOM weather stations below.

Pearce RAAF Airbase (Station No. 009053)

The Pearce RAAF Airbase is located 2.8 km northeast of the study area and receives an average 680 mm of rain per annum with the majority of the rain (528 mm or 78%) falling between the months of May and September.

The average summer temperatures range from a maximum of 30°C to 33.5°C to a minimum of 14.5°C to 17.5°C during December and February. The average winter temperatures range from a maximum of 18.8°C to a minimum of 8.1°C during June and August (BOM, 2014a). The climatic conditions for Pearce RAAF Airbase are presented in Figure 3.

Gingin Aero (Station No. 009178)

The Gingin Aero is located approximately 15 km to the northwest of the Brand Hwy and Great Northern Hwy interchange. The Gingin Aero receives an average 655 mm of rain per annum, with the majority of the rain (515 mm or 78%) falling between the months of May and September. Average temperatures range from a minimum of 6.1^{o}C in winter to a maximum of 33.2^{o}C in summer (BOM, 2014b, Figure 3).

Perth Metro (Station No. 009225)

The Perth Metro weather station is located in Mt Lawley, approximately 8 km to the southwest of the Tonkin Hwy and Reid Hwy interchange and an average receives 732 mm of rain per annum. The majority of this rain (578 mm or 79%) is received during the late autumn to early spring months of May to September. Average temperatures range from a minimum of 7.6°C in winter to a maximum of 31.6°C in summer (BOM, 2014c, Figure 3).

Perth Airport (Station No. 009021)

The Perth Airport is located approximately 10 km southeast of the Tonkin Hwy and Reid Hwy interchange and receives on average 772 mm of rain per annum, with the majority of the rain (607 mm or 79%) falling between the months of May and September. Average temperatures range from a minimum of 8.0°C in winter to a maximum of 31.9°C in summer (BOM, 2014d, Figure 3).

3.3 Topography and Surface Hydrology

The study area is located within the Bassendean Dunes and the Pinjarra Plain landforms, which are typically flat with low topographical relief due to the old age of the landforms.

The Bassendean dune system is generally flat low relief with broad swales or moderately flat sand sheets between the dunes. The highest dune of up to 80 m occurs in the north of the Swan Region, east of Lake Pinjarra, Gnangara, immediately west of the study area (Swan Catchment Council, 2004).

The study area is located within the Bennett Brook catchment (in the south) and Ellen Brook catchment (north), which are sub-catchments of the Swan Coastal Basin and the Swan Avon (Lower Swan) Catchment.

The study area is located within the Swan River System Rights in Water and Irrigation (RIWI) surface water area. No RIWI rivers are located within the study area (DOW, 2014a).

3.4 Geomorphic Wetlands

DPAW's *Geomorphic Wetlands Swan Coastal Plain* dataset displays the location, boundary, geomorphic classification (wetland type) and management category of wetlands on the Swan Coastal Plain. The information contained within this dataset was originally digitised from the Wetlands of the Swan Coastal Plain Volume 2B Wetland mapping, Classification and Evaluation: Wetland Atlas, which was captured at a scale of 1:25, 000 (Hill *et al*., 1996).

Wetlands of the Swan Coastal Plain (SCP) have been classified using a geomorphic wetland classification system based on the characteristics of landform and water permanence (hydroperiod). Table 1 details the geomorphic classification of wetlands by Semeniuk and Semeniuk (1995), which DPAW (2013a) has adopted.

Table 1 Classification of geomorphic wetlands

Hydroperiod	Landform				
	Basin	Channel	Flat	Slope	Highland
Permanent inundation	Lake	River	-	-	-
Seasonal inundation	Sumpland	Creek	Floodplain	-	-
Intermittent inundation	Playa	Wadi	Barlkarra	-	-
Seasonal waterlogging	Dampland	Trough	Palusplain	Paluslope	Palusmont

Wetland Management Categories are assigned based on the wetland's ecological, hydrological and geomorphological significance, taking into account the degree of disturbance that had occurred. The Categories include:

1. Conservation Category Wetlands (CCW) – wetlands that support a high level of ecological attributes and functions (generally having intact vegetation and natural hydrological processes), or that have a reasonable level of functionality and are representative of wetland types that are rare or poorly protected.
2. Resource Enhancement Wetlands (REW) – wetlands that have been modified (degraded) but still support substantial ecological attributes (wetland dependent vegetation covering more than 10%) and functions (hydrological properties that support wetland dependent vegetation and associated fauna), and have some potential to be restored to CCW. Typically, such wetlands still support some elements of the original native vegetation, and hydrological function.
3. Multiple Use Wetlands (MUW) – wetlands that possess only few remaining ecological attributes and functions. While such wetlands can still play an important role in regional or landscape ecosystem management, including water management, they have low intrinsic ecological value. Typically, they have very little or no native vegetation remaining (less than 10%).

According to DPAW's *Geomorphic Wetlands Swan Coastal Plain* dataset, approximately 31 wetlands occur within or adjacent to study area); a further seven CCW and REW occur near the study area (Figure 4, Appendix B).

3.5 EPP Lakes

Three EPP Lakes partially occur within the study area, while an additional five EPP Lakes occur nearby (Table 2).

Table 2 EPP lakes located within and close to the study area

EPP lake no.	Location (inside/outside)	Unique feature identifier (UFI)	Wetland type	Management category
436	Outside	8793	Sumpland	Conservation
439	Inside (partially)	8664	Sumpland	Conservation
440	Outside	8812	Dampland	Conservation
441	Inside (partially)	8800	Sumpland	Conservation
451	Outside	15732	Palusplain	Multiple Use
450	Inside (partially)	8785	Floodplain	Multiple Use
449	Outside	8784	Floodplain	Multiple Use
405	Outside	15732	Palusplain	Multiple Use

3.6 Groundwater Hydrology

The project area is located above local and shallow aquifers, with the Perth-Superficial Swan aquifer located close to the surface (DOW, 2014b).

The superficial aquifer of the SCP consists of Quaternary and Late Tertiary sediments extending from Geraldton in the north to Busselton in the south. A number of superficial formations together make up the

superficial aquifer. The principal formations are Yoganup, Ascot Limestone, Bassendean Sand and Tamala Limestone formations, which overlie Cretaceous, Jurassic and Triassic sediments.

The coastal plain formations near the study area are bounded to the east by the Darling and Gingin scarps. They reach a maximum thickness of some 70 metres on Gnangara Mound. The aquifer consists mainly of quartz sands, especially in the Bassendean Sand, and calcareous sands and limestone in the Tamala Limestone formations.

The eastern part of the coastal plain between Gingin and Boyanup comprises clayey Guildford Formation. The groundwater level is close to the surface in the southern half of the coastal plain.

The superficial aquifer is the most exploited in the Perth Basin because it is near the surface. The aquifer is developed for Perth water supply from the Gnangara and Jandakot Mounds. It is used for garden bores in Perth, for horticulture between Gingin and Australind, and elsewhere for rural supply (DOW, 2014).

3.7 Landforms, Geology and Soils

The SCP is bounded to the east by the Darling and Gingin Faults, which rise to over 200 m above sea level. The SCP consists of a series of distinct landforms that roughly run parallel to the coast (McArthur and Bettenay, 1974). The landforms, from east to west, comprise the Pinjarra Plain, the Bassendean Dunes, the Spearwood Dunes and the Quindalup Dunes. The study area is located within the Bassendean Dunes and the Pinjarra Plains landforms (Figure 5).

To the west of the colluvial slopes of the Ridge Hill Shelf (a sand covered, wave-cut platform from the Darling and Gingin scarps) lies the Pinjarra Plain, a piedmont and valley-flat alluvial plain consisting predominantly of clayey alluvium transported by rivers and streams from the Darling and Dandaragan Plateaux. The plain is about 5 km wide (McPherson and Jones, 2005).

To the west of the Pinjarra Plain, the Bassendean Dune system, the oldest dune system on the SCP, forms a gently undulating Aeolian sand plain about 20 km wide, with the dunes to the north of Perth generally having greater topographic relief than those to the south. The dunes probably accumulated as shoreline deposits and coastal dunes during interglacial periods of high sea level and originally consisted of lime (calcareous) sand with quartz sand and minor fine-grained, black, heavy-mineral concentrations. Apart from a small local area to the south of Perth, the carbonate material has been completely leached, leaving dunes consisting entirely of quartz sand (McPherson and Jones, 2005). The Bassendean Dunes contain little silt or clay, and very low levels of plant nutrients, which are associated with organic matter (Bolland, 1998).

Overall, the study area is characterised by low relief, sandy geology and sandy, infertile soils. Churchward and McArthur (1978) have mapped the study area as:

- Bassendean: sand plains with low dunes and occasional swamps; iron or humus podzols; areas of complex steep dunes.
- Southern River: Sandplain with low dunes and may intervening swamps; iron and humus podzols, peats, and clays.
- Yanga: poorly drained plain with grey sandy benches and intervening swamps; also areas of bog iron ore, marl or solonetzic soils.
- Coonambidgee: gently sloping fringe to the Dandaragan Plateau; deep grey sands.

3.8 Bioregional Context

The Interim Biogeographic Regionalisation for Australia (IBRA) divides Australia into 89 bioregions based on major biological and geographical or geological attributes (Thackway & Cresswell, 1995). The bioregions have been further divided into 419 subregions which are more localised and homogenous geomorphological units in each bioregion. The study area is located within the Perth subregion (SWA02) of the SCP bioregion. The subregional area is 1,333,901 ha in size (Mitchell *et al*., 2002).

The SCP is a low-lying coastal plain, mainly covered with woodlands. It is dominated by Banksia (*Banksia* spp.) or Tuart (*Eucalyptus gomphocephala*) on sandy soils, *Casuarina obesa* on outwash plains, and paperbark (*Melaleuca* spp.) in swampy areas. In the east, the plain rises to duricrusted Mesozoic sediments dominated by Jarrah (*E. marginata*) woodland (Mitchell *et al*., 2002).

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

3.9 Regional Vegetation

3.9.1 Beard's Vegetation Mapping

The study area is located within the Drummond Botanical Subdistrict of the SCP Subregion (Beard, 1990). The Drummond Botanical Subdistrict comprises *Banksia* spp. low woodland on leached sands with *Melaleuca* spp. swamps where ill-drained, woodland of Tuart, Jarrah and Marri on less leached sands (Beard, 1990).

The Perth region was mapped by Beard (1979) at a 1:250,000 scale. The vegetation systems have since been reinterpreted and updated by Shepherd *et al*. (2002) to reflect the National Vegetation Information System (NVIS) standards (ESCAVI, 2003). The update also accounts for extensive clearing since Beard's (1979) mapping. Some of Beard's vegetation associations have been separated to remove mosaic vegetation associations; however, some mosaics still occur.

The vegetation associations (Beard, 1979); Shepherd *et al*., 2002), of the study area are:

- 4 – Medium woodland; Marri and Wandoo.
- 949 – Low woodland; *Banksia* spp.
- 1001 – Medium very sparse woodland; Jarrah, with low woodland; Banksia (*Banksia* spp.) & Casuarina (*Casuarina obesa*).
- 1018 – Mosaic: Medium forest; Jarrah -Marri/Low woodland; Banksia (*Banksia* spp.)/Low forest; Teatree (*Melaleuca* spp.)/Low woodland; *Casuarina obesa*.

The extent of the vegetation associations within the State, the Swan Coastal Plain bioregion, the Perth subregion and within the local government boundaries are provided in Table 3 and Table 4.

Table 4 details the current extent protected within reserves that meet the International Union for Conservation of Nature (IUCN) Class I to Class IV reserves (i.e. National Parks, Nature Reserves that are managed by the DPAW). The extent protected within each context (State, bioregion, subregion and local government area) is provided; however, the extent protected within the bioregion and subregion are reporting units for assessing the status of ecosystems and their level of protection in the National Reserve System (NRMMC, 2009).

Table 3 Vegetation association extent in the study area

Code	System	System code	Extent (ha)
4	Pinjarra	4.3	972.0
949	Bassendean	949.2	580.3
1001	Bassendean	1001.1	807.5
1018	Bassendean	1018.0	602.4
	Pinjarra	1018.1	111.07

Table 4 Vegetation system associations located within the study area

Code	Scale	Pre-European extent (ha)	Current extent (ha)	Current extent remaining (%)	Current extent within IUCN Class I–IV Reserves (ha)	Current extent remaining within IUCN Class I–IV Reserves (%)
Pinjarra 4.3	State	10,634	1,318	12.4	125	1.17
	Bioregion	10,633	1,318	12.4	125	1.17
	Subregion	10,273	1,179	11.48	112	1.09
	City of Swan	6,153	663	10.77	106	1.72
	Shire of Chittering	4,481	655	14.63	19	0.42
Bassendean 949.2	State	115,119	70,290	61.06	23,966	20.82
	Bioregion	115,119	70,290	61.06	23,966	20.82
	Subregion	114,453	69,905	61.08	23,793	20.79
	City of Swan	16,235	8,266	50.92	449	2.76
	Shire of Chittering	12,746	11,997	94.13	0	0.00
Bassendean 1001.1	State	53,284	12,743	23.91	650	1.22
	Bioregion	53,284	12,743	23.91	650	1.22
	Subregion	53,284	12,743	23.91	650	1.22
	City of Swan	9,050	2,506	27.69	2	0.02
	City of Bayswater	2,666	14	0.52	0	0.00
Bassendean 1018.0	State	8,008	1,316	16.43	12	0.15
	Bioregion	8,008	1,316	16.43	12	0.15
	Subregion	8,008	1,316	16.43	12	0.15

Code	Scale	Pre-European extent (ha)	Current extent (ha)	Current extent remaining (%)	Current extent within IUCN Class I–IV Reserves (ha)	Current extent remaining within IUCN Class I–IV Reserves (%)
	City of Swan	6,002	1,020	16.99	9	0.15
	City of Bayswater	20	0	0.00	0	0.00
Bassendean 1018.1	State	6,051	1,297	21.43	90	1.48
	Bioregion	6,051	1,297	21.43	90	1.48
	Subregion	5,938	1,272	21.42	90	1.51
	City of Swan	11	0	0.00	0	0.00
	Shire of Chittering	2,861	451	15.76	15	0.51

Source: Government of Western Australia (2013)

3.9.2 Vegetation Complexes

Vegetation complexes of the Darling System were described and mapped (Heddle *et al.* 1980) at a broad floristic scale of 1:250,000, based on data collected from the literature, ground surveys, road traverses and aerial photographs and is related to the landforms, soils and climatic conditions.

Seven vegetation complexes occur across the area (Figure 6). The seven vegetation complexes are described below, while Table 5 and Table 6 provide a breakdown in a local and regional context.

- Bassendean Complex – Central and South: ranges from woodland of Jarrah Sheoak (*Allocasuarina fraseriana*)-Banksia (*Banksia* spp.) on the sand dunes, to a low woodland of *Melaleuca* spp., and sedgelands on the low-lying depressions and swamps.
- Bassendean Complex – North Transition: consists of low open forest and low woodland of Banksia (*Banksia* spp.)-Prickly Bark (*Eucalyptus todtiana*) and is structurally similar to several other vegetation complexes, but differs in the floristic composition of the understorey.
- Bassendean Complex – North: consists of a range of vegetation from low open forest and low woodland of Banksia (*Banksia* spp.)-Prickly Bark (*Eucalyptus todtiana*) to low woodland of *Melaleuca* spp., and sedgelands which occupy moister sites.
- Coonambidgee Complex: consists of vegetation ranging from a low open forest and low woodland of Prickly Bark (*Eucalyptus todtiana*)-Banksia (*Banksia attenuata-B. menziesii-B. ilicifolia*) with local admixtures of *B. prionotes*, to an open woodland of Marri (*Corymbia calophylla*)-Banksia (*Banksia* spp.).
- Reagan Complex: supports vegetation ranging from low open woodland of *B. attenuata-B. menziesii-Eucalyptus todtiana* to closed heath, depending on the depth of the soil.
- Southern River Complex: consists of open woodland of Marri (*Corymbia calophylla*)-Jarrah -Banksia (*Banksia* spp.) on the elevated areas and fringing woodland of *Eucalyptus rudis-Melaleuca rhaphiophylla* along the streams.
- Yanga Complex: a low open forest of Swamp Sheoak (*Casuarina obesa*) occurs on the low-lying flats, with patches of *Actinostrobus pyramidalis* and *Melaleuca* spp. (including *Melaleuca lateritia* and *M. hamulosa*).

Table 5 Extent of vegetation complexes within the study area

Vegetation complex	Extent within the study area	
	ha	%
Bassendean Complex-Central and South	314.96	16.3
Bassendean Complex-North Transition	31.18	1.6
Bassendean Complex-North	292.9	15.1
Coonambidgee Complex	24.1	1.2
Reagan Complex	13.2	0.7
Southern River Complex	288.18	14.9
Yanga Complex	175.07	9.0
Total	**1934.5**	**100**

Table 6 Vegetation complex representation

Vegetation complex	Scale	Pre-European extent remaining (ha)	Extent remaining (ha/%)	Current extent within conservation estate and Bush Forever sites (ha/%)
Bassendean Complex-Central and South	SCP (south of Moore River)[1]	87,392	24,206/27.70	2,244/2.57
	City of Swan[2]	4,632	1,484/32.04	1,423/30.73
	City of Bayswater[2]	2,750	13/0.48	0/0.0
Bassendean Complex-North transition	SCP (south of Moore River)[1]	17,640	16,126/91.42	11,318/64.16
	City of Swan[2]	619	383/61.89	297/41.75
	Shire of Chittering[3]	3122	3,037/97	0/0.0
Bassendean Complex-North	SCP (south of Moore River)[1]	74,133	5,3518/72.19	26,442/35.67
	City of Swan[2]	14,215	7,470/52.55	6,181/43.49
	Shire of Chittering[3]	6244	5,643/90.37	0/0.0
Coonambidgee Complex	SCP (south of Moore River)[1]	6,272	2,859/45.59	648/10.33
	City of Swan[2]	38	6/15.09	2.67/7.06
	Shire of Chittering[3]	1155	177/15.32	13/1.12
Reagan Complex	SCP (south of Moore River)[1]	9080	3,052/33.62	341/3.76
	City of Swan[2]	1655	380/23.00	270/16.33
	Shire of Chittering[3]	2023	935/46.21	0/0.0
Southern River Complex	SCP (south of Moore River)[1]	57,171	11,255/19.69	1,234/2.16
	City of Swan[2]	8,669	1,539/17.76	1,179/13.61
	City of Bayswater[2]	59	0.38/0.65	0.6/0.0
Yanga Complex	SCP (south of Moore River)[1]	26,176	4,645/17.75	530/2.02
	City of Swan[2]	5,776	882/15.28	508/8.80
	Shire of Chittering[3]	6494	400/6.15	103/1.58

1 Information obtained from WALGA (2013).
2 Addendum (2010 data) to Chapter 16 Local Government Biodiversity Planning Guidelines for the PMR (WALGA, 2004)
3 Local Biodiversity Strategy, Shire of Chittering (2010).

3.10 Bush Forever Strategy

The Bush Forever Strategy (Government of Western Australia, 2000b), is a ten year strategic plan which formally commenced in 2000 to protect approximately 51,200 ha of regionally significant bushland within approximately 290 Bush Forever Sites, representing, where achievable, at least 10% of each of the original 26 vegetation complexes of the SCP portion of the Perth Metropolitan Region (Government of Western Australia, 2000b).

There are 14 Bush Forever sites located within or adjacent (within 1 km) to the study area (Figure 4, Table 7).

Table 7 Bush Forever Sites in and near the study area

Site no.	Site name	Location (inside/outside)	Vegetation complexes	Significant flora
2	North East Ellen Brook Bushland, Bullsbrook	Outside	• Beermullah Complex • Yanga Complex	• *Verticordia lindleyi* subsp. *lindleyi* (P4)
6	Cooper Road Water Reserve and Adjacent Bushland, Bullsbrook	Outside	• Yanga Complex • Bassendean Complex-North	None
13	Sawpit Road Bushland, Bullsbrook	Outside (adjacent)	• Yanga Complex	None
97	Kirby Road Bushland, Bullsbrook	Inside	• Yanga Complex • Bassendean Complex-North	None
100	Neaves Road Creek, Bullsbrook	Inside	• Yanga Complex	None
192	Wetherell Road Bushland, Lexia/Ellenbrook	Inside	• Bassendean Complex-Central and South • Bassendean Complex-North Transition	None
195	Wetherell Road Bushland, Lexia/Ellenbrook	Outside		
198	Beechboro Road Bushland, Cullacabardee/Ballajura	Inside	• Bassendean Complex-Central and South • Southern River Complex	None
300	Maralla Road Bushland, Ellenbrook/Upper Swan	Inside	• Guildford Complex • Swan Complex • Yanga Complex • Bassendean Complex-North • Bassendean Complex-North Transition	• *Caladenia huegelii* (T) • *Grevillea curviloba* subsp. *curviloba* (T) • *Meionectes tenuifolia* (P3) • *Eryngium* sp. *Subdecumbens* (G. J. Keighery 5390) (P3) • *Eryngium pinnatifidum* subsp. Palustre (G. J. Keighery 13459) (P3)

Site no.	Site name	Location (inside/outside)	Vegetation complexes	Significant flora
304	Whiteman Park, Whiteman/West Swan	Inside	• Bassendean Complex-Central and South • Southern River Complex	• *Cyathochaeta teretifolia* (P3) • *Isopogon drummondii* (P3) • *Verticordia lindleyi* subsp. *lindleyi* (P4)
307	Lightning Swamp and Adjacent Bushland, Noranda	Inside	• Bassendean Complex-Central and South • Southern River Complex	None
385	Reid Highway Bushland, Mirrabooka/Malaga	Outside	• Bassendean Complex-Central and South • Karrakatta Complex-Central and South	None
399	Melaleuca Park and Adjacent Bushland, Bullsbrook/Lexia	Inside	• Yanga Complex • Bassendean Complex-North • Bassendean Complex-North Transitional	• *Caladenia huegelii* (T)
480	Victoria Road Bushland, Malaga/Beechboro	Inside	• Southern River Complex	None

4 METHODS

4.1 Desktop Assessment

In accordance with the EPA Guidance Statement No. 51 for a Level 2 flora and vegetation survey, a desktop assessment was undertaken prior to the field survey and involved a review of existing environmental or biological data available for the area and adjacent lands. It included a review of State and Federal databases, regional and local contextual data for the northern SCP and existing biological surveys.

4.1.1 State and Federal Government Databases

A request for searches of DPAW's threatened flora and ecological community's database was submitted on 3 July 2014 for a shapefile polygon that encompassed the entire alignment of the study area with a 10 km buffer (Appendix C). The following databases were searched:

- DPAW's Threatened (Declared Rare) and Priority Flora database.
- The WAH Specimen database for Priority species opportunistically collected.
- DPAW's Threatened and Priority Flora List, which contains Declared Rare taxa (Conservation Code T or X for those presumed to be extinct), poorly known taxa (Conservation Codes P1, P2 or P3), or taxa that require monitoring (Conservation Code P4).
- The Department's Threatened and Priority Ecological Communities database.

In addition, the online mapping tool NatureMap was interrogated to identify introduced taxa in and near the study area. A central point (115°58'54''E; 31°43'31''S) with a 20 km buffer was searched (Appendix D). The search also identified native taxa in and near the study area.

A search of DOTE online publicly available database for MNES was undertaken (Appendix E). A line search (-31.57526 115.993625 and -31.863796 115.918094) with a 10 km buffer was undertaken for the study area.

The relevant MNES include:

- Wetlands of International Importance (Ramsar listed wetlands).
- TECs.
- Threatened Species.
- Critical Habitats.

4.1.2 Regional and Local Contextual Data

A review of regional and local contextual data, with reference to flora and vegetation, was completed prior to the field survey component of the assessment. The review was undertaken to identify the flora and vegetation communities significant in a regional and local context. The review concentrated on broad scale mapping of plant communities and floristic units. The review included:

- Vegetation complexes of the Darling System Western Australia (Heddle *et al.*, 1980).
- Floristic Survey of the Southern Swan Coastal Plain (Gibson *et al.*, 1994).
- The Bush Forever Strategy: Volume 1 (Government of Western Australia, 2000a) and Volume 2 (Government of Western Australia, 2000b).

- Plant Life of Western Australia (Beard, 1990).
- Local Government Biodiversity Planning Guidelines for the Perth Metropolitan Region (WALGA, 2004).
- The Darling System – System 6, Part I: General Principles and Recommendations (DCE, 1983).
- Native Vegetation in Western Australia: Extent, Type and Status. Technical Report 249 (Shepherd *et al.*, 2002).

4.1.3 Existing Biological Surveys

At least 11 biological surveys have been undertaken within or close to the study area. These reports were reviewed to identify the plant communities, vegetation condition, and the location of conservation significant flora and ecological communities. The review, included:

- Perth–Darwin National Highway – Tonkin Highway Link Alignment Definition Study: Environmental Impact Assessment and Biological Survey (GHD, 2013a).
- Swan Valley Bypass, Perth–Darwin National Highway: Level 2 Flora and Vegetation Survey (360 Environmental, 2014).
- A flora and vegetation survey of Lots 46 and 47 Maralla Road and Lexia Avenue, Ellenbrook (M.E. Trudgen & Associates, 1999).
- Environmental Assessment – East Landsdale (Ecoscape, 2009a).
- East Landsdale Flora and Fauna Assessment – Lot 154 (Ecoscape, 2009b).
- Level 2 Flora and Vegetation Survey, North Ellenbrook (360 Environmental, 2012).
- Level 1 Flora and Fauna Assessment of Gaston Road, Muchea (GHD, 2009).
- Flora and Fauna Assessment, Mitchell Freeway Extension (Burns Beach Road to Romeo Road) (GHD, 2013b).
- Level 2 Flora and Vegetation Survey of Lot 5 Mornington Drive, Mariginiup (Monocot-Dicot Botanical Research, 2010).
- Flora and Vegetation Assessment, M70/138 Hopkins Road, Nowergup (Coffey Environments, 2010).
- Flora and Vegetation of Victoria Road Bushland, Ballajura (Bennett Environmental, 2008).

4.2 Field Survey

A Level 2, flora and vegetation survey, consistent with Guidance Statement No. 51 (EPA, 2004), was undertaken between 15 to 19 September 2014 and 22 to 26 September 2014, with 40 person-days invested in the survey.

The field studies were led by Senior Botanists Clinton van den Bergh and Bethea Loudon and were assisted by Botanists Lucy Dadour and Alison Saligari. The field survey team holds the necessary licences to sample flora and vegetation in Western Australia, including Threatened flora (Table 8).

Table 8 Scientific licences held by the field survey team

Team member	Role	Licence to take flora for scientific or other prescribed purposes	Permit to take Declared Rare Flora
Clinton van den Bergh	Senior Botanist	SL010743 &SL011157	73-1314 & 88-1415
Bethea Loudon	Senior Botanist	SL010956	108-1314
Lucy Dadour	Botanist	SL011069 & SL011158	89-1415
Alison Saligari	Botanist	SL010959	107-1314

The study area is located partially within conservation and multiple use estate (Unnamed Reserve 46875, Unnamed Reserve 46919, Unnamed Reserve 46920 and State Forest 65) (Figure 4). In accordance with the *Conservation and Land Management Regulations 2002*, the sampling of flora and vegetation within these lands was undertaken in accordance with Regulation 4 Authority CEO04590.

4.3 Flora and Vegetation Assessment

A total of 120 flora sampling sites, consisting of 93 quadrats (permanently marked plots) and 27 relevés (unmarked plots) were established and sampled (Figure 7). The survey included re-sampling of 29 quadrats previously established in 2013 (360 Environmental, 2014).

The quadrats were 100 m^2 in size (10 m x 10 m), consistent with advice provided by the EPA and DPAW (including its predecessors) and previous surveys. The northwest and southeast posts were left *in situ* to assist with re-sampling, if required. The relevés were marked by a central point recorded with a Global Positioning System (GPS) and an approximate radius of 20 m was sampled. Relevés are used for the purpose of recording vegetation structure, species composition, dominance and contribute to the species inventory.

The information recorded at each quadrat and the relevé included:

- Location: GDA94 coordinates were taken from each of the four corners of the quadrat and from a central point for the relevé. The coordinates were taken using a handheld Garmin GPS to an accuracy of ±5 m.
- Vegetation description: the vegetation structure was described to broad floristic formation and vegetation association according to NVIS (ESCAVI, 2003) (Tables 9, 10 and 11).
- Disturbance details: vegetation condition was assessed according to Keighery (1994) (Table 12). Additional information on feral pests, introduced weeds, dieback and anthropogenic disturbances were recorded.
- Taxa list: an inventory of all taxa was taken.
- Foliage cover and height: the percentage foliar cover was estimated to the nearest percentage point, and height was visually estimated to within 0.1 m for each taxon present.
- Habitat: the aspect and slope was recorded. Additional information of wetlands, or other prominent geological features was also recorded.
- Soil: colour and soil texture of surface soils was recorded.
- Rock and litter cover: estimates were made on the rock type, size and litter cover.

The broad floristic formations (BFF) and vegetation associations were described based on the floristic data recorded from the quadrats, relevés and visual observations while traversing the study area, based on NVIS hierarchical level III (Broad Floristic Formation) and V (Vegetation Association) (ESCAVI, 2003). Hierarchical level III requires the dominant growth form, cover, height and dominant land cover genus for the upper most or the ecologically or structurally dominant stratum. Hierarchical level V requires the dominant growth form, cover, height and dominant species (three for each stratum) for each of the three traditional strata (i.e. upper, mid and ground to a maximum of 9 taxa). These are provided in Tables 9, and 10; the NVIS height class definition is provided in Table 11.

Table 9 NVIS hierarchical structure

Hierarchical level	Description	NVIS structural/floristic component required
I	Class	Dominant growth form for the ecologically or structurally dominant stratum
II	Structural Formation	Dominant growth form, cover and height for the ecologically or structurally dominant stratum
III	Broad Floristic Formation	Dominant growth form, cover, height and dominant land cover genus for the upper most or the ecologically or structurally dominant stratum
IV	Sub-formation	Dominant growth form, cover, height and dominant genus for each of the three traditional strata (i.e. Upper, Mid and Ground)
V	Association	Dominant growth form, height, cover and species (3 species) for each of the three traditional strata (i.e. Upper, Mid, Ground)
VI	Sub-association	Dominant growth form, height, cover and species (5 species) for all layers/sub-strata

Source Table 1 from ESCAVI (2003).

Table 10 NVIS structural terminology

Stratum	Growth form	Height ranges (m)[1]	Structural formation classes (% cover)					
			80–100	50–80	20–50	0.25–20	0–0.25	Unknown
U	Tree, palm	Low; Mid; Tall	Closed forest	Open forest	Woodland	Sparse woodland	Isolated trees	Isolated clumps of trees
	Tree mallee	Low; Mid; Tall	Closed mallee forest	Open mallee forest	Mallee woodland	Sparse mallee woodland	Isolated mallee trees	Isolated clumps of mallee trees
M	Shrub, cycad	Low; Mid; Tall	Closed shrubland	Shrubland	Open shrubland	Sparse shrubland	Isolated shrubs	Isolated clumps of shrubs
	Mallee shrub	Low; Mid; Tall	Closed mallee shrubland	Mallee shrubland	Open mallee shrubland	Sparse mallee shrubland	Isolated mallee shrubs	Isolated clumps of mallee shrubs
	Heath shrub	Low; Mid; Tall	Closed heath shrubland	Heath shrubland	Open heath shrubland	Sparse heath shrubland	Isolated heath shrubs	Isolated clumps of heath shrubs
	Chenopod shrub	Low; Mid; Tall	Closed chenopod shrubland	Chenopod shrubland	Open chenopod shrubland	Sparse chenopod shrubland	Isolated chenopod shrubs	Isolated clumps of chenopod shrubs
	Samphire shrub	Low; Mid	Closed samphire shrubland	Samphire shrubland	Open samphire shrubland	Sparse samphire shrubland	Isolated samphire shrubs	Isolated clumps of samphire shrubs
G	Hummock grass	Low; Mid	Closed hummock grassland	Hummock grassland	Open hummock grassland	Sparse hummock grassland	Isolated hummock grasses	Isolated clumps of hummock grasses
	Tussock grass	Low; Mid	Closed tussock grassland	Tussock grassland	Open tussock grassland	Sparse tussock grassland	Isolated tussock grasses	Isolated clumps of tussock grasses
	Other grass	Low; Mid	Closed grassland	Grassland	Open grassland	Sparse grassland	Isolated grasses	Isolated clumps of grasses
	Sedge	Low; Mid	Closed Sedgeland	Sedgeland	Open sedgeland	Sparse sedgeland	Isolated sedges	Isolated clumps of sedges

Stratum	Growth form	Height ranges (m)[1]	Structural formation classes (% cover)					
			80–100	50–80	20–50	0.25–20	0–0.25	Unknown
G	Rush	Low; Mid	Closed rushland	Rushland	Open rushland	Sparse rushland	Isolated rushes	Isolated clumps of rushes
	Herb	Low; Mid	Closed herbland	Herbland	Open herbland	Sparse herbland	Isolated herbs	Isolated clumps of herbs

Source ESCAVI (2003).
Note Growth forms that do not occur or were not sampled within the study area were omitted (i.e. seagrass bed).
1 Refer to Table 5 for height range information.

Table 11 NVIS height class definition

Height class	Height range (m)	Growth forms			
		Tree, palm	Shrub (all forms), cycad	Tree mallee, mallee shrub	Hummock grass, tussock grass, other grass, sedge, rush, herb
8	>30	Tall			
7	10–30	Mid		Tall	
6	<10	Low		Mid	
5	<3			Low	
4	>2		Tall		Tall
3	1–2		Mid		Tall
2	0.5–1		Low		Mid
1	<0.5		Low		Low

Source Table 3 from ESCAVI (2003).

Vegetation condition was described following Keighery (1994) and published in the Bush Forever Strategy (Government of Western Australia, 2000b) (Table 12).

Table 12 Vegetation condition rating scale

Condition code	Definition
P Pristine	Pristine or nearly so, no obvious signs of disturbance.
E Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
VG Very Good	Vegetation structure altered obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
G Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
D Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
CD Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often referred to as parkland cleared with the flora composing weed or crop species with isolated native trees or shrubs.

Source Bush Forever (Government of Western Australia, 2000b), originally developed by Keighery (1994).

4.4 Targeted Searches

Sections of the study area with native vegetation in Good or better condition were traversed on foot in September and November 2014. Approximately eight person days in September 2014 and six person days in November were invested.

The purpose of the targeted searches was to:

- Identify additional taxa not recorded in the sampling points.
- Identify and define populations of Threatened and Priority taxa listed under the EPBC Act, WC Act and by DPAW.
- Identify and define the extent of TECs and PECs listed under the EPBC Act and DPAW.
- WONS listed under the EPBC Act.
- Declared Pests listed under Section 22 of the *Biosecurity and Agricultural Management Act 2007.*
- Environmental weeds with a "High" rating (CALM, 1999).

If a population or individual of known or potential conservation significant taxa, ecological community or introduced taxa was recorded, a specimen was taken, the GPS location and a photo were recorded, while information on the population extent and vegetation and condition was documented.

4.5 Specimen Identification

A reference sample up to 90% of the taxa recorded was collected to ensure quality and integrity in the data. The reference samples were assigned a unique number in the field to facilitate tracking of the data. In addition, a small sub-sample was included in a field herbarium to ensure consistency in the tracking numbers within the sample points. Over 700 specimens were collected, pressed and dried during the field survey.

The specimens were then sufficiently dried prior to submitting to a specialist taxonomist, Mr Malcolm Trudgen for identification. The identification process was assisted by the field botanists. The specimens were identified using taxonomic keys, Mr Trudgen's reference herbarium and comparison with the reference collections held at WAH. Additional assistance was sought from expert taxonomists for several families and genera (Table 13).

Table 13 Specialist taxonomical assistance

Taxonomist	Family/genera
Allen Lowrie	Droseraceae and Stylidiaceae
Andrew Brown	Orchidaceae
Garry Brockman	Orchidaceae
Dr Ryonen Butcher	Tetratheca specimen
Greg Keighery	Various genera

Threatened and Priority taxa, geographic range extensions, poorly sampled taxa and unique/unusual taxa were retained for vouchering at WAH, in accordance with the flora collecting licences.

Nomenclature was checked against the current listing of scientific names recognised by WAH and updated as necessary.

The raw data was entered into a Microsoft Access Database, with species names entered following formal identification.

4.6 Statistical Analysis

4.6.1 Multivariate Analysis

Statistical multivariate analysis was conducted on the floristic data (Appendix F) using the PATN analysis package (Belbin, 1987). Several modules of the PATN analysis package were used for the statistical analysis, including:

- ASO (calculation of similarity matrix);
- FUSE (classification based on the results of ASO);
- DEND (representation of classification, in a dendrogram); and
- NNB (Determination of sites most similar to each site, called nearest neighbour analysis).

The analysis was undertaken on 94 sites assessed during this survey and an additional ten sites originally sampled in 2013 (360 Environmental 2014). Only permanent quadrats with sufficient data of high quality were used in the analysis.

The floristic data were compared against the 509 sites sampled by Gibson *et al*. (1994) to determine regionally significant vegetation associations. An additional analysis was undertaken which included a comparison of the floristic data collected from this survey and the floristic data collected from surveys nearby, in order to identify additional locally significant vegetation associations. The data included in this analysis were sourced from:

- Trudgen, M. E. (1998) Objection Assessment of the Ellenbrook National Estate Area Flora and Vegetation Values. Prepared for the Australian Heritage Commission.
- Trudgen, M. E & Associates. (1999). A flora and vegetation survey of Lots 46 and 47 Maralla Road and Lexia Avenue, Ellenbrook. Volumes 1–4. Unpublished report prepared for the Crown Solicitors Office, Government of Western Australia. December 1999.
- Weston A., Griffin, E. A., and Trudgen, M. E. (1993). Flora and Vegetation Conservation Values of the Ellenbrook Estate. Unpublished report prepared for Bowman Bishaw Gorham, West Perth.

Prior to running PATN, the data was reconciled and reviewed to ensure consistency with current nomenclature, and where appropriate to previous nomenclature used in the *Floristic Survey of the Southern Swan Coastal Plain* (Gibson *et al*., 1994).

4.6.2 Species Accumulation Curves

Species accumulation curves were plotted with the ordinate (y) axis as estimated species richness and the sampling effort on the abscissa (x axis). For the purposes of this assessment, data from 94 sites were used. Opportunistically collected taxa and taxa recorded from the relevés were omitted from the analysis.

4.7 Survey Limitations

The survey was undertaken in September 2014, with a subsequent, further targeted survey in November 2014. The timing of the surveys was not a limiting factor, as it coincided with the peak flowering times. This

includes the majority of the Threatened and Priority taxa (including spring flowering orchids) identified in the desktop assessment.

The rainfall recorded at the four nearest weather stations were between 5 and 25% below average (year to date and the winter months of June, July and August). Although not ideal conditions, the number of flowering ephemerals, annuals and orchids were high. For example, over 35 spring flowering orchids were recorded during the September 2014 survey. As is typical for vascular flora surveys, fungi and non-vascular flora (e.g. bryophytes, mosses, etc.) were not collected or recorded.

Several vegetation associations are represented by only a single sampling site. The vegetation association determination is considered to be a low level of synthesis. The vegetation associations represented by a single site are considered to be similar to either each other or additional vegetation associations. Therefore, the under-representation of vegetation associations with sample sites is not considered to be a limiting factor to the survey.

Some sections of the project area are located on private property and government managed lands (i.e. Nature Reserves, State Forest, Whiteman Park and Bush Forever Sites). As a result, access was restricted to areas where permission to enter the properties had been granted by the land owners/managers. Two properties, located outside of the proposed project area, were not accessed due to permission not being granted. The vegetation and wetlands present on these properties will not be directly impacted; however the indirect impacts could not be fully understood due to a lack of access.

Limitations of this survey are summarised in Table 14.

Table 14 Survey limitations

Limitation	Constraint (yes or no)	Comment
Competency/experience of the survey team conducting the survey and the identifications	No	The survey team has a combined 25+ years' experience conducting flora and vegetation surveys in Western Australia, with particular experience on the Swan Coastal Plain. The specialist taxonomist is considered to be a leading expert on the flora of Western Australia with extensive experience with the flora of the Swan Coastal Plain
Level of survey	No	A Level 2 flora and vegetation survey was conducted, which involved the sampling of 120 sites and targeted searches. This included 29 sites that were previously established in 2013 and re-sampled. A total of 46-person days were invested in the survey.
Sources of information	No	The Swan Coastal Plain has been extensively surveyed since the 1950s, including recent flora and vegetation surveys within and adjacent to the study area in 2012 and 2013.
Scope	No	The entire scope was met.
Proportion of: 1. Flora collected and identified; and 2. Task achieved and further work that may be required	1. No 2. No	1. Approximately 100% of the taxa has been recorded (Section 5.6.1), including the taxa identified in the GHD (2013a) and 360 Environmental (2014) flora and vegetation surveys. The proportion of flora identified is based on the seasonal conditions experienced prior to the survey, influencing the species accumulation curve. 2. The entire task was achieved. No further work is necessary.

Limitation	Constraint (yes or no)	Comment
Completeness	No	The study area was adequately traversed and sampled.
Mapping reliability	No	The mapping reliability is high due to the density of the flora sampling sites and the previous surveys. The TECs and PECs were mapped in relation to the sample sites, mapped vegetation associations, interpretation of aerial imagery and review of soils and landforms.
Timing/weather/season/cycle	No	The survey was undertaken in September 2014, with a follow-up targeted search in November 2014. Although Perth recorded below average winter rainfall, the lack of rainfall is not a constraint. The vegetation was flowering (although slightly earlier than usual) and generally in good health.
Disturbances which affected the results of the survey	Yes	Portions of the study area have been impacted by *Phytophthora* Dieback and as a result, the overstorey and understorey of some of the plant communities were disturbed sufficiently that the plant community identification, especially *Banksia* vegetation, may have been compromised.
Intensity of the survey	No	The intensity of the survey was sufficient to identify the major plant communities. A total of 120 sites were sampled (including 29 sites re-sampled). Approximately 0.04 sampling sites per ha were established and assessed.
Resources	No	Adequate resources were assigned to the field survey, specimen identifications, statistical analysis and the reporting components of the assessment.
Remoteness and/or access problems	Yes	Access was available to the majority of the study area. However, certain land holdings that are privately owned and do not occur within the proposed project alignment could not be accessed in September. The constraint is considered to be minor because the land holdings due not occur along the alignment. The indirect impacts on the flora and vegetation may not be sufficiently identified as a result of the lack of survey in September 2014.
Availability of contextual information	No	The Swan Coastal Plain has been extensively surveyed in the past, with numerous documents with contextual information available. These documents were accessed prior, during and after the field survey (Section 4.1.2 and 4.1.3).

5 RESULTS

5.1 Desktop Assessment

The results of the desktop assessment have been separated into three components

- State database searches;
- Federal database searches; and
- Review of existing flora and vegetation surveys.

Within each component, the information has been further separated into native flora; vegetation or ecological communities; and introduced flora.

5.1.1 State Database Searches

5.1.1.1 Flora

The DPAW Threatened and Priority flora database searches identified 25 Threatened (Declared Rare-Extant) and 45 Priority (two Priority 1; nine Priority 2; 21 Priority 3; and 12 Priority 4) taxa as potentially occurring (Appendix G).

No Threatened taxa are known to occur in the project area. Three Priority taxa (*Cyathochaeta teretifolia, Eryngium pinnatifidum* subsp. Palustre (G. J. Keighery 13459) and *Hypolaena robusta*) occur in the study area. An additional five Threatened (Declared Rare-Extant) (*Acacia anomala, Caladenia huegelii, Darwinia foetida, Grevillea curviloba* subsp. *curviloba* and *Grevillea curviloba* subsp. *incurva*) and eight Priority taxa (*Acacia drummondii* subsp. *affinis, Drosera occidentalis* subsp. *occidentalis, Guichenotia tuberculata, Hydrocotyle lemnoides, Jacksonia sericea, Stylidium paludicola, Verticordia lindleyi* subsp. *lindleyi* and *Verticordia serrata* var. *linearis*) occur within 500 m of the study area (Figure 8).

The likelihood of Threatened and Priority Listed flora occurring within the project area was assessed on known proximity to the project area and the presence of suitable habitat. Fifteen were considered likely, 25 possible and 30 unlikely to occur in the project area (Appendix G).

5.1.1.2 Introduced Flora

A search of NatureMap identified 63 introduced taxa as previously been recorded from close proximity to the study area. The list of introduced taxa (and native taxa) is provided in Appendix D. The majority of the 63 introduced taxa are common in bushland of the Swan Coastal Plain. No WONS or Declared Pests were identified from the NatureMap search.

5.1.1.3 Vegetation and Ecological Communities

Eight TECs and four PECs potentially occur within the study area (Table 15) (Figure 8).

Table 15 Threatened and Priority Ecological Communities occurring near the study area

Community name	TEC/PEC	Community description	State conservation code[1]	Federal conservation code[1]
Claypans of the Swan Coastal Plain	TEC & PEC	Claypans of the Swan Coastal Plain	(TECs and PECs under numerous communities with clay soils)	Critically Endangered
Mound Springs SCP	TEC	Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain)	Critically Endangered	Endangered
Muchea Limestone	TEC	Shrublands and woodlands on Muchea Limestone of the Swan Coastal Plain	Critically Endangered	Endangered
SCP3a	TEC	*Corymbia calophylla – Kingia australis* woodlands on heavy soils, Swan Coastal Plain	Critically Endangered	Endangered
SCP3c	TEC	*Corymbia calophylla – Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain	Critically Endangered	Endangered
SCP20c	TEC	Shrublands and woodlands of the eastern side of the Swan Coastal Plain	Critically Endangered	Endangered
Coastal Saltmarsh	PEC	Subtropical and Temperate Coastal Saltmarsh	Priority 1	Vulnerable
SCP20a	TEC	*Banksia attenuata* woodland over species rich dense shrublands	Endangered	
SCP20b	TEC	*Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain	Endangered	
SCP07	TEC	Herb rich saline shrublands in clay pans	Vulnerable	
SCP3b	TEC	*Corymbia calophylla – Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	
SCP21c	PEC	Low lying *Banksia attenuata* woodlands or shrublands	Priority 3	
SCP22	PEC	*Banksia ilicifolia* woodlands	Priority 3	
Central Granite Shrublands (Com 5, Markey)	PEC	Central Northern Darling Scarp Granite Shrubland Community	Priority 4	

1 Definitions of the State and Federal conservation codes are presented in Appendix H.
NB *Eucalyptus calophylla* is more recently known as *Corymbia calophylla* (Hill and Johnson, 1995).

5.1.2 Federal Database Searches

The EPBC Act online database does not provide GPS coordinates for MNES, therefore, the distribution of EPBC listed threatened flora and ecological communities cannot be obtained. Refer to Figure 8 for the

location of threatened flora and ecological communities within the study area, based on the results of the DPAW database searches.

5.1.2.1 Flora

The online EPBC Act database search identified 28 threatened listed taxa as potentially occurring within the study area (Appendix G). The search identified one Critically Endangered taxon, 21 Endangered taxa and six Vulnerable taxa (Appendix H for Federal conservation code definitions). The likelihood of EPBC listed flora occurring within the project area was assessed on known proximity to the project area and the presence of suitable habitat. Five were considered likely, five possible and 16 unlikely to occur in the project area (Appendix G).

The search identified *Epiblema grandiflorum* var. *cyaneum* and *Verticordia plumosa* var. *pleiobotrya* within the search buffer, however, the taxonomy for both species has been reviewed and they are no longer considered threatened under the WC Act or Priority Listed flora under DPAW. *Epiblema grandiflorum* var. *cyaneum* is an informal synonym and is now considered *Epiblema grandiflorum*. *Verticordia plumosa* var. *pleiobotrya* is a taxonomic synonym of *Verticordia plumosa* var. *brachyphylla*.

5.1.2.2 Introduced Flora

The EPBC Act online database search identified a total of 22 introduced taxa potentially occurring within the study area (Appendix I). The management and control categories for each introduced taxa is provided in Appendix I.

5.1.2.3 Ecological Communities

Five TECs were identified as potentially occurring (community known to occur or likely to occur) within the study area. The list of ecological communities listed as threatened under the EPBC Act potentially occurring within the study area is presented in Table 15 and Figure 8.

5.1.3 Previous Flora and Vegetation Surveys

The flora and vegetation information collected from the review of the previous, relevant biological surveys is detailed in Table 16 and Figure 8. Surveys completed by GHD (2013a) and 360 Environmental (2014) were undertaken along portions of the study area, while the survey completed by M.E. Trudgen & Associates (1999) is located adjacent to the study area at Ellenbrook.

Table 16 Review of existing biological surveys

Reference	Size of study area (ha)	Number of plots	Location	Objective and survey intensity	Results	
					Flora	Vegetation
GHD (2013a)	1,659	24	Perth–Darwin National Highway (between Hepburn Avenue and Gnangara Road).	Undertake a detailed environmental and heritage investigation. Spring biological flora survey.	• 248 vascular plant taxa recorded. • No DRF, two priority taxa recorded: – *Eucalyptus caesia* (P4) (planted). – *Verticordia lindleyi* (P4).	• 11 plant communities. • No TECs, one PEC recorded: – FCT21c recorded (P3, PEC).
GHD (2013b)	438	28	Mitchell Freeway Extension between Burns Beach Road and Romeo Road.	Undertake a detailed environmental investigation. Level 2 flora and vegetation survey.	• 392 vascular plant taxa recorded. • No DRF, five priority taxa recorded: – *Acacia benthamii* (P2). – *Eucalyptus caesia* (P4) (planted). – *Jacksonia sericea* (P4). – *Pimelea calcicola* (P3). – *Stylidium maritimum* (P3).	• Six plant communities. • One TEC and one PEC recorded: – FCT26a (EN). – FCT24 (P3, PEC).
360 Environmental (2014)	937	48	Swan Valley Bypass (between Tonkin Hwy and Reid Hwy interchange and Brand Hwy and GNH interchange).	Undertake a detailed environmental investigation. Level 2 flora and vegetation survey, including targeted conservation significant flora search	• 283 vascular taxa recorded. • No DRF, one priority taxa recorded: – *Cyathochaeta teretifolia* (P3).	• 16 plant communities. • No TECs, three PECs recorded: – SCP21c (P3, PEC). – SCP23b (P3, PEC). – Banksia dominated woodlands (P3, PEC).

Reference	Size of study area (ha)	Number of plots	Location	Objective and survey intensity	Results	
					Flora	Vegetation
360 Environmental (2012)	1,000	22	North Ellenbrook (north of Maralla Road).	Undertake a detailed environmental investigation. Level 2 flora and vegetation survey, including targeted conservation significant flora search.	• 226 vascular taxa recorded. • No DRF, one priority taxa recorded: – *Cyathochaeta teretifolia* (P3).	• 14 plant communities. • No TECs, two PECs recorded: – SCP21c (P3, PEC). – SCP23b (P3, PEC).
M.E. Trudgen & Associates (1999)	~400	64	Lots 46 and 47 Maralla Road and Lexia Avenue, Ellenbrook.	Review of environmental values. Level 2 flora and vegetation survey and review of existing surveys.	• 324 vascular taxa recorded. • No DRF, three priority taxa recorded: – *Cyathochaeta teretifolia* (P3). – *Hypolaena robusta* (P4). – *Phlebocarya pilosissima* subsp. *pilosissima* (P3).	• 50 plant communities. • No TECs, two PECs recorded: – SCP21c (P3, PEC). – SCP23b (P3, PEC).
Ecoscape (2009a)	13	unknown	Lots 50 and 51 Queensway Road, Landsdale.	Undertake a detailed environmental investigation. Level 2 flora and vegetation survey.	• 97 vascular taxa recorded. • No DRF, one priority taxa recorded: – *Jacksonia sericea* (P4).	• Two plant communities. • No TECs or PECs recorded.
Ecoscape (2009b)	4	unknown	Lot 154 Alexander Drive, Landsdale.	Undertake a detailed environmental investigation. Level 2 flora and vegetation survey.	• 112 vascular taxa recorded. • No DRF or priority taxa recorded.	• Four plant communities. • No TECs or PECs recorded.
GHD (2009)	unknown	unknown	110 Gaston Road, Muchea.	Determine ecological value of remnant bushland. Level 1 flora and vegetation assessment.	• 26 vascular taxa recorded. • No DRF or priority taxa recorded:	• Three plant communities. • No TECs or PECs recorded.

Reference	Size of study area (ha)	Number of plots	Location	Objective and survey intensity	Results	
					Flora	Vegetation
Coffey (2010)	8	8	M70/138 Hopkins Road, Nowergup.	Undertake a detailed environmental investigation. Level 2 flora and vegetation survey.	• 141 vascular taxa recorded. • No DRF, two priority taxa recorded: – *Melaleuca* sp. Wanneroo (G. J. Keighery 16705) (P1). – *Jacksonia sericea* (P4).	• Eight plant communities. • One TEC and one PEC recorded: – SCP26a (TEC). – SCP24 (P3, PEC).
Monocot-Dicot Botanical Research (2010)	8	10	Lot 5 Mornington Drive, Mariginiup.	Undertake a detailed environmental investigation. Level 2 flora and vegetation survey.	• 154 vascular taxa recorded. • No DRF or priority taxa recorded.	• One plant community. • One TEC, no PECs recorded: – FCT20a (TEC).
Bennett Environmental Consulting Pty Ltd (2008)	21	6	Victoria Road, Ballajura.	Undertake a detailed Level 2 flora and vegetation survey. Search for and record all significant species at the site and determine the presence of any TECs.	• 156 vascular taxa recorded. • No DRF or priority taxa recorded.	• Four plant communities. • No TECs recorded. • One PEC recorded: – FCT22 (P2, PEC).

5.2 Vegetation Condition

Vegetation condition ranged from Pristine to Completely Degraded (Figure 9, Table 12). Approximately 80% of vegetation was Degraded, Completely Degraded or Cleared. Condition depends on the size, connectivity and structure of the vegetation along the study area. For example, the fragmented vegetation located in the north of the study area is in a degraded or worse condition due to historical clearing and grazing pressures, while the vegetation in the south of the study area is large and well connected with minimal anthropogenic disturbances, and is therefore in good or better condition.

Vegetation condition north of Maralla Road through the palusplain zone was highly variable, with large portions Completely Degraded or cleared. There were isolated pockets of vegetation in Good or better condition, however they were generally surrounded by cleared paddocks or (Completely) Degraded vegetation.

Vegetation condition south of Maralla Road was variable; however, the majority was in Good or better condition, with isolated (Completely) Degraded and cleared areas.

Isolated pockets of pristine vegetation were identified along the study area adjacent to Ellenbrook. The vegetation condition coverage across the study area is presented in Table 17.

Table 17 Vegetation condition of the study area

Vegetation condition	Study area		Project area	
	ha	%	ha	%
Pristine	9.3	03	1.2	0.2
Pristine to Excellent	36.4	1.2	3.6	0.5
Excellent	226.7	7.4	53.2	7.0
Excellent to Very Good	51.2	1.7	23.3	3.0
Very Good	175.7	5.7	39.8	5.2
Very Good to Good	35.4	1.2	9.1	1.2
Good	51.0	1.7	24.6	3.2
Good to Degraded	23.8	0.8	6.7	0.9
Degraded	530.0	17.2	134.2	17.5
Degraded to Completely Degraded	145.3	4.7	48.8	6.4
Completely Degraded	1,666.7	54.3	358.4	46.8
Cleared and Infrastructure/Roads etc.	122.4	4.0	62.3	8.1
Total	3074.1	100.0	765.2	100.0

Disturbances impacting on the vegetation include:

- Vegetation clearing (historical and current).
- Stock grazing (i.e. sheep, horses and cows).
- Uncontrolled vehicle and motorbike access through the Ellenbrook area.
- Dumping of rubbish, especially in the Ellenbrook area.

- Introduction and spread of plant pathogens (*Phytophthora* Dieback) and introduced taxa (including Declared Pests).
- Feral pests (i.e. European Rabbit) grazing on native flora.
- Urban development encroaching on the native vegetation (e.g. Ellenbrook development).

5.3 Broad Floristic Formations and Vegetation Associations

Eight broad floristic formations were delineated and are described below in order of spatial extent.

- *Cenchrus* grassland

The *Cenchrus* grassland occurred in association with cleared paddocks and included scattered paddock trees, generally *Corymbia calophylla* and *Eucalyptus rudis* subsp. *rudis* trees. The broad floristic formation occurred mainly in the north of the study area where the cleared paddocks were located. *Cenchrus* grassland covers approximately 22.2% of the study area.

- *Corymbia* sparse mid woodland.

The *Corymbia* sparse mid woodland was dominated by *Corymbia calophylla* and at times as a co-dominant with *Melaleuca preissiana*, *Eucalyptus marginata* subsp. *thalassica* and *Eucalyptus rudis* subsp. *rudis*, especially in wetter areas. This broad floristic formation occurred throughout the study area; however it occurred more often in transitional landscapes (i.e. dryland to wetland) and in the Cullacabardee region *Corymbia* sparse mid woodland covers approximately 17.7% of the study area.

- *Eucalyptus* sparse mid woodland.

The *Eucalyptus* sparse mid woodland consisted of two dominant species that occurred in different landforms. *Eucalyptus marginata* subsp. *thalassica* occurred in the dryland landforms consisting of deeper sands, while *Eucalyptus rudis* subsp. *rudis* occurred in the wetland landforms and along the banks and floodplains of the Ellen Brook. *Eucalyptus* sparse mid woodland covers approximately 8.9% of the study area.

- *Banksia* sparse low woodland

The *Banksia* sparse low woodland was the dominant formation along the study area. It occurred in sandy soils particularly south of Maralla Road to Reid Highway. The *Banksia* sparse low woodland consisted of a single dominant or co-dominant *Banksia* species, with *Banksia attenuata* the more prolific taxa. Other *Banksia* species included *Banksia menziesii* and *B. ilicifolia*. *B. littoralis* occurred at seven sampling sites, but generally occurred in association with *Melaleuca preissiana* or *Eucalyptus rudis* subsp. *rudis* in the wetlands. *Banksia* sparse low woodland covers approximately 8.1% of the study area.

- *Melaleuca* open low woodland.

The *Melaleuca* open low woodland was recorded from wetlands, with a high proportion from the northern section where the palusplain was a dominant feature. *Melaleuca preissiana* was the dominant taxon, while *M. rhaphiophylla* occurred as the dominant or co-dominant in several sampling sites. *M. preissiana* was also recorded as a structurally dominant feature with *Eucalyptus rudis* subsp. *rudis* throughout the palusplain section. *Melaleuca* open low woodland covers approximately 2.7% of the study area.

- *Pinus* mid woodland

The *Pinus* mid woodland was recorded at the Pine plantation north of Gnangara Road, towards Ellenbrook. This is a man-made formation and is not a significant formation, as it mainly comprises the introduced tree **Pinus pinaster*. *Pinus* mid woodland covers approximately 2.4% of the study area.

- *Xanthorrhoea* open tall shrubland.

The *Xanthorrhoea* open tall shrubland was recorded from one location on Muchea South Road. This BFF occurred along the road and rail reserve between cleared paddocks. *Xanthorrhoea preissii* was the structurally dominant species, however it was also recorded from an additional 39 sampling sites, while *X. brunonis* and *X. gracilis* were recorded from an additional 10 sites. *Xanthorrhoea* open tall shrubland covers approximately 1.4% of the survey

- *Astartea* tall shrubland to open tall shrubland.

The *Astartea* tall shrubland to open tall shrubland occurred within wetlands. *Astartea scoparia* was the dominant. At times, *Astartea* was co-dominant with other Myrtaceae shrubs (i.e. *Pericalymma*, *Hypocalymma* and *Melaleuca*). This BFF was recorded from five sites, however, *A. scoparia* was a dominant understorey species in approximately 29 other sites. *Astartea* tall shrubland to open tall shrubland covers approximately 0.6% of the study area.

Upon further statistical analysis, review of the aerial imagery and the information available on the soils and landforms, the eight broad floristic formations were differentiated into 60 vegetation associations or floristic community types (FCTs), based on the dominant growth form, height, cover and species for the three traditional strata (i.e. upper, middle and ground) (ESCAVI, 2003).

A further five mapping units were delineated including rehabilitated and revegetated areas (two mapping units), Pine plantations (two mapping units) and one mapping unit classified as 'Cleared' which includes highways, roads, infrastructure, industry and areas that have been completely cleared of native vegetation.

The 60 vegetation associations and five mapping units are described in Table 18 and mapped on Figure 10, while the floristic information collected from the sampling sites is provided as Appendix J.

Table 18 Vegetation associations mapped in the study area

Unit code	Quadrats, species richness and average weed density	Broad floristic formation and site preference	Vegetation association description	Area within study area (ha)	Photograph
Dryland					
Ba	SVB004 30.0 ± 0.0 4.0	*Banksia* sparse low woodland. Flat plain.	*Banksia attenuata* sparse low woodland and *Eucalyptus todtiana* isolated low mallee trees over *Melaleuca seriata, Eremaea pauciflora* var. *pauciflora* and *Xanthorrhoea preissii* sparse low shrubland over *Phlebocarya ciliata* open low herbland.	3.7 (0.1%)	
BaBm[1]	360Q16, 360Q25, SVB043, SVB049, 360Q17, SVB093. SVB047 33.1 ± 11.1 6.4	*Banksia* sparse low woodland. Dune slopes and crests.	*Banksia attenuata* and *Banksia menziesii* low woodland to sparse low woodland over *Eremaea pauciflora* var. *pauciflora, Hibbertia hypericoides, Hibbertia subvaginata* sparse low shrubland over *Patersonia occidentalis* subsp. *occidentalis* sparse low herbland.	41.7 (1.4%)	
BaBm[2]	360Q03, SVB019, 360Q39, SVB012, SVB030, SVB039, 360Q26, 360Q28, SVB057, SVB024, SV09 49.4 ± 7.8 6.8	*Banksia* sparse low woodland. Dune slopes and crests.	*Banksia attenuata* and *Banksia menziesii* low woodland to sparse low woodland over *Calytrix fraseri* (Ellenbrook Form), *Verticordia nitens* and *Beaufortia elegans* sparse mid shrubland over *Alexgeorgea nitens* and *Desmocladus flexuosus* sparse low rushland.	147.6 (4.8%)	

Unit code	Quadrats, species richness and average weed density	Broad floristic formation and site preference	Vegetation association description	Area within study area (ha)	Photograph
BaBm[3]	360Q04, SVB022, SVB034, SVB003, SVB013, SV05, SV18 40.5 ± 9.9 6.1	*Banksia* low woodland. Flat plain to lower dune slopes.	*Banksia attenuata, Banksia menziesii* low woodland over *Eremaea pauciflora* var. *pauciflora, Scholtzia* aff. *involucrata, Hibbertia hypericoides* open to sparse low shrubland over *Patersonia occidentalis* subsp. *occidentalis* sparse mid herbland.	41.9 (1.4%)	
Cc[3]	360Q13 23.0 ± 0.0 3.0	*Corymbia* mid woodland. Dune slope.	*Corymbia calophylla* mid woodland over *Banksia attenuata* and *Banksia ilicifolia* sparse low woodland over *Xanthorrhoea preissii* and *Macrozamia fraseri* sparse tall shrubland.	3.7 (0.1%)	
Cc[5]	SV08, SVB031 6.5 ± 0.7 12.5	*Corymbia* mid woodland. Flat plain.	*Corymbia calophylla* mid woodland over *Xanthorrhoea preissii* and *Jacksonia furcellata* sparse tall shrubland over *Dasypogon bromeliifolius*, *Patersonia occidentalis* subsp. *occidentalis*, **Ursinia anthemoides* low herbland.	45.1 (1.5%)	
Cc[6]	SVB026 34.0 ± 0.0 4.0	*Corymbia* sparse mid woodland. Flat plain.	*Corymbia calophylla* sparse mid woodland over *Banksia menziesii, Banksia attenuata* and *Nuytsia floribunda* sparse low woodland over *Xanthorrhoea preissii* sparse tall shrubland.	16.9 (0.6%)	

Unit code	Quadrats, species richness and average weed density	Broad floristic formation and site preference	Vegetation association description	Area within study area (ha)	Photograph
Cc[7]	360Q27, SVB035 31.0 ± 9.9 7.5	*Corymbia* sparse mid woodland. Plain on edge of dampland.	*Corymbia calophylla* sparse mid woodland over *Banksia menziesii, Banksia attenuata* and occasional *Banksia ilicifolia* low woodland to sparse low woodland over *Hibbertia subvaginata* and *Petrophile linearis* sparse low shrubland.	4.9 (0.2%)	
CcEm[1]	SVB055, SVB058 19.5 ± 3.5 5.0	*Corymbia* sparse mid woodland. Depression to low slopes.	*Corymbia calophylla* and *Eucalyptus marginata* subsp. *thalassica* isolated clumps of mid trees over *Banksia attenuata, Banksia menziesii* and *Banksia ilicifolia* low woodland to sparse low woodland over *Xanthorrhoea brunonis* mid shrubland to open mid shrubland.	3.9 (0.1%)	
CcEm[2]	360Q02, 360Q36, SVB025, SVB021, 360Q06, SVB020, SVB029, SVB023, SVB028 41.3 ± 2.8 7.6	*Corymbia* sparse mid woodland. Flat plain, gently sloping.	*Corymbia calophylla* and *Eucalyptus marginata* subsp. *thalassica* mid woodland to sparse mid woodland over *Xanthorrhoea preissii*, *Calytrix fraseri* (Ellenbrook Form), *Verticordia nitens* sparse mid shrubland over *Hibbertia hypericoides, Eremaea pauciflora* var. *pauciflora, Scholtzia* aff. *involucrata* open to sparse low shrubland.	92.5 (3.0%)	
CcEr[2]	SVB017 5.0 ± 0.0 7.0	*Corymbia* sparse mid woodland. Flat plain, depressions.	*Corymbia calophylla* and *Eucalyptus rudis* subsp. *rudis* isolated clumps of low trees over *Jacksonia furcellata* sparse tall shrubland over **Ehrharta calycina, *Bromus diandrus* and **Ehrharta longiflora* closed mid grassland.	20.6 (0.7%)	

Unit code	Quadrats, species richness and average weed density	Broad floristic formation and site preference	Vegetation association description	Area within study area (ha)	Photograph
Em[2]	SVB088 46.0 ± 0.0 11.0	*Eucalyptus* sparse mid woodland. Low hill.	*Eucalyptus marginata* subsp. *thalassica* sparse mid woodland over *Banksia menziesii* low woodland over *Xanthorrhoea preissii* sparse tall shrubland.	30.4 (1.0%)	
Ep	SV38 22.0 ± 0.0 4.0	*Banksia* sparse low woodland. Flat plain.	*Banksia* spp. sparse low woodland over *Eremaea pauciflora* subsp. *pauciflora Melaleuca striata, Beaufortia elegans* low shrubland over *Patersonia occidentalis* and *Dasypogon bromeliifolius* sparse herbland.	4.8 (0.2%)	
EpRi	SV33 13.0 ± 0.0 8.0	*Banksia* sparse low woodland. Dune slope.	*Banksia* spp. sparse low woodland over *Eremaea pauciflora, Calytrix flavescens* and *Regelia inops* sparse low shrubland over *Patersonia occidentalis, Dasypogon bromeliifolius* and *Podotheca gnaphalioides* sparse herbland.	0.9 (0.1%)	
Et[1]	SVB001, SVB016, SVB014A 43.0 ± 5.2 7.6	*Eucalyptus* sparse mid woodland. Dune rise.	*Eucalyptus todtiana* isolated mid mallee trees over *Banksia attenuata, Banksia menziesii* and *Nuytsia floribunda* sparse low woodland over *Allocasuarina humilis, Jacksonia floribunda* and *Stirlingia latifolia* sparse mid shrubland.	13.8 (0.4%)	
Et[2]	360Q12, 360Q22, 360Q14, 360Q23, SVB054, 360Q21, SVB036, SVB092, SVB037, SVB038 40.3 ± 3.6 6.0	*Eucalyptus* sparse mid woodland. Dune slopes, crests and flats.	*Eucalyptus todtiana* isolated mid mallee trees over *Banksia attenuata, Banksia menziesii* and *Nuytsia floribunda* sparse low woodland over *Verticordia nitens, Beaufortia elegans*, *Jacksonia floribunda*.	81.9 (2.7%)	

Unit code	Quadrats, species richness and average weed density	Broad floristic formation and site preference	Vegetation association description	Area within study area (ha)	Photograph
Et[3]	SVB059 9.0 ± 0.0 5.0	*Eucalyptus* sparse mid woodland. Dune rise.	*Eucalyptus todtiana* sparse mid mallee trees over *Banksia attenuata, Banksia menziesii* and *Banksia ilicifolia* sparse low woodland over *Adenanthos cygnorum* subsp. *cygnorum* and *Jacksonia furcellata* sparse tall shrubland.	20.5 (0.7%)	
Xp[1]	SVB100 4.0 ± 0.0 7.0	*Xanthorrhoea* open tall shrubland.	*Xanthorrhoea preissii* tall open shrubland over **Ehrharta calycina* sparse mid grassland.	8.4 (0.3%)	
Wetland					
As	360Q35, SVB077 8.5 ± 0.7 8.5	*Astartea* tall shrubland to open tall shrubland. Floodplain/Dampland.	*Astartea scoparia*, *Kunzea glabrescens* tall shrubland to tall open shrubland over **Holcus lanatus, *Bromus diandrus* and **Vulpia bromoides* low grassland over **Romulea rosea, *Hypochaeris glabra* and **Lotus subbiflorus* open to isolated low herbs.	3.4 (0.1%)	

Unit code	Quadrats, species richness and average weed density	Broad floristic formation and site preference	Vegetation association description	Area within study area (ha)	Photograph
AsMlEv	SVB002, SVB005 16.0 ± 5.7 2.5	*Astartea* tall shrubland to closed tall shrubland. Dampland.	*Astartea scoparia, Melaleuca lateritia, Eutaxia virgata* closed mid shrubland over *Lepidosperma striatum* and *Lepidosperma longitudinale* sparse tall sedgeland with occasional *Meeboldina* spp. and *Hypolaena exsulca* sparse tall rushland.	5.4 (0.2%)	
Bl	SVB094 27.0 ± 0.0 3.0	*Banksia* sparse low woodland. Dampland.	*Banksia littoralis* sparse low woodland over *Hypocalymma angustifolium* and *Pericalymma crassipes* closed mid shrubland over *Meeboldina scariosa* sparse tall rushland.	4.8 (0.2%)	
BlMp	SVB040, SVB045 13.5 ± 2.1 2.0	*Melaleuca* open low woodland. Low depression, dampland.	*Banksia littoralis* and *Melaleuca preissiana* sparse low woodland over *Astartea scoparia*, *Pericalymma crassipes* and *Kunzea glabrescens* closed mid shrubland to mid shrubland over *Schoenus caespititius* open tall sedgeland.	8.2 (0.3%)	
Cc/Mp	SVB046, SVB056 29.0 ± 2.8 10.0	*Corymbia* mid woodland. Dampland.	*Corymbia calophylla* and/or *Melaleuca preissiana* mid woodland over *Banksia littoralis* sparse low woodland over *Xanthorrhoea preissii* and *Taxandria linearifolia* open to sparse tall shrubland.	15.8 (0.5%)	

Unit code	Quadrats, species richness and average weed density	Broad floristic formation and site preference	Vegetation association description	Area within study area (ha)	Photograph
CcEr[1]	SVB066, SVB067 8.0 ± 2.8 6.0	*Corymbia* sparse mid woodland.	*Corymbia calophylla* and *Eucalyptus rudis* subsp. *rudis* isolated mid trees over *Astartea scoparia* and *Taxandria linearifolia* tall shrubland over **Cenchrus clandestinus* and **Holcus lanatus* closed low grassland.	9.3 (0.3%)	
Co	SVB086 8.0 ± 0.0 6.0	*Melaleuca* open low woodland. Palusplain.	*Casuarina obesa* isolated low trees over *Melaleuca concreta* open tall shrubland over *Lepidosperma longitudinale, Juncus pallidus* and *Schoenus caespititius* open mid sedgeland.	5.2 (0.2%)	
Er[1]	360Q34, SVB076, SVB098 11.0 ± 2.0 12.3	*Eucalyptus* sparse mid woodland. Palusplain.	*Eucalyptus rudis* subsp. *rudis* and occasional *Corymbia calophylla* sparse mid woodland over *Astartea scoparia*, *Kunzea glabrescens* and *Aotus gracillima* open tall shrubland over *Desmocladus flexuosus* and *Dielsia stenostachya* isolated low rushes.	8.3 (0.3%)	
Er[2]	360Q20, SVB091, SVB006 7.0 ± 0.0 9.5	*Eucalyptus* sparse mid woodland. Dampland/Palusplain.	*Eucalyptus rudis* subsp. *rudis* isolated mid trees over *Astartea scoparia, Melaleuca teretifolia* and *Melaleuca lateritia* closed tall shrubland to open tall shrubland over *Lepidosperma longitudinale* and *Schoenus caespititius* sparse mid sedgeland.	4.8 (0.2%)	

Unit code	Quadrats, species richness and average weed density	Broad floristic formation and site preference	Vegetation association description	Area within study area (ha)	Photograph
Er[3]	SVB041, SVB044, SVB052, SVB053 10.7 ± 1.0 3.6	*Eucalyptus* sparse mid woodland. Dampland.	*Eucalyptus rudis* subsp. *rudis* isolated mid trees over *Melaleuca preissiana, Banksia littoralis* and occasional *Melaleuca rhaphiophylla* sparse low woodland over *Astartea scoparia, Melaleuca teretifolia,* and *Hypocalymma angustifolium* closed tall shrubland to tall shrubland.	12.8 (0.4%)	
Er[4]	SVB018 4.0 ± 0.0 2.0	*Eucalyptus* mid woodland. Floodplain.	*Eucalyptus rudis* subsp. *rudis* open mid forest over *Hardenbergia comptoniana* open tall shrubland over *Pteridium esculentum* subsp. *esculentum* tall herbland.	3.5 (0.1%)	
Er[5]	SVB075 6.0 ± 0.0 4.0	*Eucalyptus* sparse mid woodland. Creekline/floodplain.	*Eucalyptus rudis* subsp. *rudis* sparse mid woodland over *Melaleuca preissiana* and *Melaleuca rhaphiophylla* low woodland over **Zantedeschia aethiopica* and **Rorippa nasturtium-aquaticum* open mid herbland.	0.9 (0.1%)	
Er[6]	SVB080, SVB081, SVB082, SVB087, SVB089, SVB090 3.0 ± 1.2 6.0	*Eucalyptus* sparse mid woodland. Creekline/floodplain.	*Eucalyptus rudis* subsp. rudis sparse mid woodland over *Melaleuca rhaphiophylla* sparse low woodland over **Lolium rigidum, *Ehrharta longiflora* and **Cenchrus clandestinus* low grassland.	51.8 (1.7%)	

Unit code	Quadrats, species richness and average weed density	Broad floristic formation and site preference	Vegetation association description	Area within study area (ha)	Photograph
Er[7]	SVB065 1.0 ± 0.0 7.0	*Eucalyptus* sparse mid woodland. Creekline/floodplain.	*Eucalyptus rudis* subsp. *rudis* sparse mid woodland over **Zantedeschia aethiopica* tall herbland over low grassland (dominated by introduced species).	4.4 (0.1%)	
Er[8]	SVB070, SVB071 4.5 ± 2.1 7.5	*Eucalyptus* sparse mid woodland. Creekline/floodplain.	*Eucalyptus rudis* subsp. *rudis*, *Corymbia calophylla* sparse mid woodland over *Melaleuca preissiana* and *Melaleuca rhaphiophylla* isolated clumps of low trees over **Holcus lanatus* and **Cenchrus clandestinus* closed mid grassland.	6.2 (0.2%)	
ErMp	SVB010 6.0 ± 0.0 5.0	*Eucalyptus* sparse mid woodland Sumpland.	*Eucalyptus rudis* subsp. *rudis* and *Melaleuca preissiana* sparse mid woodland over **Acacia longifolia* subsp. *longifolia* closed tall shrubland over *Astartea scoparia* sparse mid shrubland.	11.7 (0.4%)	
ErMrMc	SVB084 6.0 ± 0.0 12.0	*Eucalyptus* mid woodland. Floodplain.	*Eucalyptus rudis* subsp. *rudis, Melaleuca rhaphiophylla* and *Melaleuca concreta* open low forest over **Moraea flaccida* sparse mid herbland over **Lolium rigidum, *Ehrharta longiflora* and **Cynodon dactylon* mid grassland.	2.3 (0.1%)	

Unit code	Quadrats, species richness and average weed density	Broad floristic formation and site preference	Vegetation association description	Area within study area (ha)	Photograph
Mp[1]	SVB078 6.0 ± 0.0 6.0	*Melaleuca* low woodland. Mound spring.	*Melaleuca preissiana* closed low forest over *Histiopteris incisa* and *Pteridium esculentum* subsp. *esculentum* sparse tall herbland over *Cyathochaeta teretifolia* open mid sedgeland.	1.5 (0.1%)	
Mp[2]	SV11, SVB042 20.0 ± 8.5 2.0	*Melaleuca* open low woodland. Transitional dampland/dryland.	*Melaleuca preissiana* isolated mid trees over *Banksia attenuata, Banksia menziesii* and occasional *Banksia ilicifolia* sparse low woodland over *Xanthorrhoea preissii, Adenanthos cygnorum* subsp. *cygnorum* and *Hypocalymma angustifolium* mid shrubland.	8.5 (0.3%)	
Mp[3]	SVB011, SVB079 12.0 ± 0.0 9.0	*Melaleuca* open low woodland. Dampland.	*Melaleuca preissiana* low woodland over *Astartea scoparia, Taxandria linearifolia* and *Aotus gracillima* open tall shrubland over *Cyathochaeta avenacea* and *Juncus pallidus* open tall sedgeland.	5.3 (0.2%)	
Mp[4]	360Q32, SV01 9.0 ± 1.4 6.0	*Melaleuca* open low woodland. Dampland/depression.	*Melaleuca preissiana* mid woodland over *Banksia littoralis* sparse low woodland over *Lepidosperma striatum* and *Lepidosperma longitudinale* closed tall sedgeland.	12.5 (0.4%)	

Unit code	Quadrats, species richness and average weed density	Broad floristic formation and site preference	Vegetation association description	Area within study area (ha)	Photograph
Mp[5]	SV19 12.0 ± 0.0 6.0	*Melaleuca* open low woodland. Depression.	*Melaleuca preissiana* low open woodland over *Astartea scoparia, Eutaxia virgata* and *Hypocalymma angustifolium* open low shrubland over *Cyathochaeta avenacea, Lepyrodia glauca* open low sedgeland.	1.4 (0.1%)	
Mp[6]	SVB007 13.0 ± 0.0 1.0	*Melaleuca* open low woodland. Dampland.	*Melaleuca preissiana* sparse low woodland over *Pericalymma crassipes, Hypocalymma angustifolium* and *Xanthorrhoea preissii* open tall shrubland over *Lepidosperma striatum* and *Lepidosperma longitudinale* tall sedgeland.	2.7 (0.1%)	
Mp[7]	SVB073A, SVB069 8.0 ± 0.0 3.0	*Melaleuca* open low woodland.	*Melaleuca preissiana* sparse to open low woodland over **Zantedeschia aethiopica* sparse tall herbland over **Cenchrus clandestinus* and **Holcus lanatus* sparse mid grassland.	3.1 (0.1%)	
Mp[8]	SVB008A, SVB014, SVB015 4.0 ± 2.0 1.0	*Melaleuca* open low woodland.	*Melaleuca preissiana* sparse to open low woodland over *Xanthorrhoea preissii* sparse mid shrubland over *Lepidosperma longitudinale* sparse mid sedgeland.	9.4 (0.3%)	

Unit code	Quadrats, species richness and average weed density	Broad floristic formation and site preference	Vegetation association description	Area within study area (ha)	Photograph
Mp[9]	SVB048 15.0 ± 0.0 5.0	*Melaleuca* open low woodland. Dampland.	*Melaleuca preissiana* sparse to open low woodland over *Xanthorrhoea preissii* tall shrubland over *Astartea scoparia* and *Taxandria linearifolia* sparse mid shrubland.	0.9 (0.1%)	
Mp[10]	SVB085 3.0 ± 0.0 5.0	*Melaleuca* open low woodland. Dampland.	*Melaleuca preissiana* open low woodland to forest over *Juncus kraussii* subsp. *australiensis* sparse mid sedgeland over **Cynodon dactylon* open low grassland.	4.6 (0.1%)	
MpBl	SVB051 12.0 ± 0.0 5.0	*Melaleuca* open low woodland. Dampland.	*Melaleuca preissiana* and *Banksia littoralis* open low woodland to forest over *Melaleuca lateritia* and *Melaleuca teretifolia* sparse mid shrubland over *Schoenus caespititius* sparse mid sedgeland.	5.4 (0.2%)	
MpCc	360Q24 20.0 ± 0.0 6.0	*Melaleuca* open low woodland. Wetland slope, depression.	*Melaleuca preissiana* and *Corymbia calophylla* sparse mid woodland over *Astartea scoparia* and *Hypocalymma angustifolium* open mid shrubland.	1.3 (0.1%)	

Unit code	Quadrats, species richness and average weed density	Broad floristic formation and site preference	Vegetation association description	Area within study area (ha)	Photograph
MpMr	SVB073 5.0 ± 0.0 8.0	*Melaleuca* open low woodland.	*Melaleuca preissiana* and *Melaleuca rhaphiophylla* low (open) woodland over **Zantedeschia aethiopica* and **Typha orientalis* open mid herbland.	7.1 (0.2%)	
PeAsMtMl	SVB050 11.0 ± 0.0 6.0	*Astartea* tall shrubland to open tall shrubland. Dampland.	*Pericalymma ellipticum* var. *floridum, Astartea scoparia, Melaleuca teretifolia* tall shrubland.	8.4 (0.3%)	
Transitional					
BaBmMp	360Q29 39.0 ± 0.0 10.0	*Banksia* sparse low woodland Flat, dampland.	*Banksia attenuata, Banksia menziesii* and *Melaleuca preissiana* sparse low woodland over *Adenanthos cygnorum* subsp. *cygnorum, Regelia inops* and *Banksia ilicifolia* sparse tall shrubland over *Verticordia nitens* and *Astroloma xerophyllum* isolated mid shrubs.	7.5 (0.2%)	

Unit code	Quadrats, species richness and average weed density	Broad floristic formation and site preference	Vegetation association description	Area within study area (ha)	Photograph
Cc[2]	SVB008 13.0 ± 0.0 3.0	*Corymbia* sparse mid woodland. Dampland.	*Corymbia calophylla* isolated mid trees over *Melaleuca preissiana* isolated low trees over *Xanthorrhoea preissii* sparse mid shrubland.	7.6 (0.2%)	
Cc[4]	360Q37, SVB068, SVB079A 12.6 ± 5.7 6.3	*Corymbia* mid woodland. Dampland.	*Corymbia calophylla* mid woodland over *Melaleuca preissiana* low woodland to sparse low woodland over *Dielsia stenostachya* closed mid rushland.	13.4 (0.4%)	
CcMp	360Q15 28.0 ± 0.0 4.0	*Corymbia* sparse mid woodland. Relatively flat, on edge of depression.	*Corymbia calophylla* and *Melaleuca preissiana* sparse mid woodland over *Banksia attenuata* and *Banksia ilicifolia* sparse low woodland over *Kunzea glabrescens* open tall shrubland.	1.0 (0.1%)	
Em[1]	360Q30, 360Q31, SV07 15.0 ± 5.0 7.6	*Eucalyptus* sparse mid woodland. Flat plain.	*Eucalyptus marginata* subsp. *thalassica* isolated mid trees over *Melaleuca preissiana* and occasional *Banksia attenuata* and *Banksia ilicifolia* low woodland over *Xanthorrhoea preissii*, *Hypocalymma angustifolium* and *Astroloma xerophyllum* open to sparse mid shrubland.	7.6 (0.2%)	

Unit code	Quadrats, species richness and average weed density	Broad floristic formation and site preference	Vegetation association description	Area within study area (ha)	Photograph
Disturbed/altered					
Cc[1]	SVB015a 2.0 ± 0.0 2.0	*Corymbia* sparse mid woodland. Flat plain.	*Corymbia calophylla* isolated clumps of mid trees with occasional *Eucalyptus marginata* subsp. *thalassica* mid trees over *Xanthorrhoea preissii* sparse mid shrubland over **Ehrharta calycina* and **Briza maxima* sparse low grassland.	263.2 (8.6%)	
CcMpMr	N/A	*Corymbia* sparse mid woodland. Road and rail verge (Brand Highway).	*Corymbia calophylla* isolated clumps of mid trees over *Melaleuca preissiana* and *Melaleuca rhaphiophylla* isolated clumps of low trees over grassland dominated by introduced grasses.	11.1 (0.4%)	
ErCo	SVB083 3.0 ± 0.0 5.0	*Eucalyptus* sparse mid woodland. Floodplain.	*Eucalyptus rudis* subsp. *rudis, Casuarina obesa* and *Melaleuca* sp. open low forest over **Ehrharta longiflora, *Ehrharta calycina* and **Lolium rigidum* low grassland over **Lotus subbiflorus* and **Moraea flaccida* sparse low herbland.	4.7 (0.2%)	
MpAl	SVB009 5.0 ± 0.0 8.0	*Melaleuca* open low woodland.	*Melaleuca preissiana* and **Acacia longifolia* subsp. *longifolia* sparse low woodland over *Xanthorrhoea preissii* sparse mid shrubland over **Bromus diandrus, *Ehrharta calycina* and **Avena barbata* tall grassland.	4.3 (0.1%)	
Xp[2]	N/A	Xanthorrhoea open tall shrubland.	*Xanthorrhoea preissii* sparse mid shrubland to open tall shrubland.	35.3 (1.2%)	
CcEr[3]	N/A	*Cenchrus* grassland.	Open paddocks with remnant *Corymbia calophylla* and *Eucalyptus rudis* subsp. *rudis* over pasture species (introduced) dominated by **Cenchrus clandestinus.*	665.5 (21.6%)	

Unit code	Quadrats, species richness and average weed density	Broad floristic formation and site preference	Vegetation association description	Area within study area (ha)	Photograph
Pr	360Q10 20.0 ± 0.0 5.0	*Pinus* mid woodland. Dune crest.	**Pinus radiata* sparse low woodland over *Eucalyptus todtiana* isolated mid mallee trees over *Adenanthos cygnorum* subsp. *cygnorum* and *Macrozamia fraseri* sparse tall shrubland.	8.6 (0.3%)	
Pp	N/A	*Pinus* mid woodland. Plain.	**Pinus pinaster* plantation.	74.6 (2.4%)	
R	SVB072, SVB074 5.0 ± 0.0 3.5	*Corymbia* mid woodland. Undulating Plain.	*Corymbia calophylla, Eucalyptus camaldulensis* and *Eucalyptus todtiana* low woodland over *Calothamnus quadrifidus* and *Banksia nivea* sparse mid shrubland over **Bromus diandrus* and **Ehrharta calycina* sparse mid grassland over **Ursinia anthemoides* and **Hypochaeris glabra* sparse low herbland (Revegetation site).	35.9 (1.2%)	
Rehab	N/A	N/A.	Rehabilitation sites associated with Rocla mine site and other sites of rehabilitation, including road sides.	11.2 (0.4%)	
Cl	N/A	N/A.	Cleared areas, consisting of paddocks, infrastructure corridors (i.e. Roads and Highways), building envelopes (i.e. residential housing, industry etc.) and the former Ellenbrook settlement (within Rocla mine tenement).	1,109.1 (36.1%)	

5.4 Floristic Community Types

The dendrogram of the PATN analysis shows the high similarity of quadrats in the study area with 20 FCTs on the Swan Coastal Plain. Seven of these FCTs were represented by one or two quadrats, while 13 FCTs were represented by three or more quadrats. Several quadrats fit two FCTs. Five quadrats share a high degree of similarity with a TEC, while numerous quadrats align with PECs (Table 19).

Gibson *et al*. (1994) described 43 FCTs, these FCTs have since been renamed to reflect the region in which they were described, the Swan Coastal Plain. As such, FCT02 is now referred to as SCP02 and so on, for each of the 43 FCTs described by Gibson *et al.* (1994).

Table 19 Determination of floristic community types

FCT	Description	Quadrats	Significance (State)
S02	Northern *Pericalymma ellipticum* dense low shrublands	*SV19, *SVB007, *SVB008, SVB053 & SVB079	
S03	Wet sedgelands on sandy clays	*SV19, SVB006 & SVB050	
S09	*Banksia attenuata* woodlands over dense low shrublands	*360Q12 & *360Q25	
SCP02	Southern wet shrublands	*SVB011	TEC (EN)
SCP04	*Melaleuca preissiana* damplands	SV07, *SVB007 & *SVB008	
SCP05	Mixed shrub damplands	SVB042, SVB048, SVB056 & SVB094	
SCP06	Weed dominated wetlands on heavy soils	SV08, SV33 & SVB031	
SCP11	Wet forests and woodlands	360Q24, 360Q32, 360Q34, 360Q35, 360Q37, SV01, *SVB011, SVB018, SVB068, SVB076, SVB077, SVB078, SVB079A, SVB084, *SVB086, SVB091 & SVB098	
SCP12	*Melaleuca teretifolia* and/or *Astartea* aff. *fascicularis* shrublands	SVB005 & SVB045	
SCP13	Deeper wetlands on heavy soils	SVB002 & SVB044	
SCP14	Deeper wetlands on sandy soils	360Q20, SVB040, SVB041, SVB051 & SVB052	
SCP17	*Melaleuca rhaphiophylla – Gahnia trifida* seasonal wetlands	*SVB086	
SCP20a	*Banksia attenuata* woodlands over species rich dense shrublands	360Q03, 360Q39, *SVB001 & SVB016	TEC (EN)
SCP21a	Central *Banksia attenuata – Eucalyptus marginata* woodlands	SVB021	

FCT	Description	Quadrats	Significance (State)
SCP21c	Low lying *Banksia attenuata* woodlands or shrublands	360Q10, *360Q12, 360Q14, 360Q15, 360Q17, 360Q21, 360Q23, *360Q25, 360Q26, 360Q27, 360Q29, 360Q31, 360Q36, SV38, SVB004, SVB013, SVB023, SVB025, SVB035, SVB046, SVB047, SVB049 & SVB055	PEC (P3)
SCP22	*Banksia ilicifolia* woodlands	SV11	PEC (P2)
SCP23a	Central *Banksia attenuata – Banksia menziesii* woodlands	360Q04, 360Q06, 360Q22, SV09, *SVB001, SVB012, SVB019, SVB020, SVB030, SVB036, SVB037, SVB038, SVB039, SVB054 & SVB057	
SCP23b	Northern *Banksia attenuata – Banksia menziesii* woodlands	360Q28, SV05, SVB014A, SVB022, SVB024, SVB028, SVB029, SVB043, SVB092 & SVB093	PEC (P3)
SCP24	Northern Spearwood shrublands and woodlands	360Q30, SV18 & SVB003	PEC (P3)
SCP28	Spearwood *Banksia attenuata* or *Banksia attenuata – Eucalyptus* woodlands	360Q13. 360Q16 & SVB088	

* The site matches two FCTs.

5.5 Vegetation Significance

5.5.1 Poorly Protected Bioregions and Subregions

The bioregions and subregions are the reporting unit for assessing the status of native ecosystems and their level of protection in the National Reserve System. In this way, IBRA is used as a dynamic tool for monitoring progress towards building a comprehensive, adequate and representative (CAR) reserve system (DOTE, 2014a). Such information assists governments to prioritise funding to meet national protection targets.

According to the National Reserve System, the Swan Coastal Plain bioregion is not considered to be a bioregion with less than 10% protection. Both the Swan Coastal Plain bioregion and the Perth subregion have between 10 to 15% of their current area protected within IUCN Class I-IV Reserves (i.e. National Parks, Nature Reserves).

5.5.2 Threatened and Priority Ecological Communities

The four TECs (Mound Springs SCP, SCP02, SCP20a and Claypans on the SCP), and the four PECs (SCP21c, SCP22, SCP23b and SCP24) are described below in relation to the study area (Figure 11). The multivariate statistical analysis, review of the desktop assessment and review of the vegetation recorded within the study area, confirms that no other TEC or PEC occurs.

5.5.2.1 Threatened Ecological Communities

An occurrence of 1.5 ha of the **Mound Springs SCP** occurs within the study area and adjacent to the project area (Figure 11). The habitat of this community is characterised by the continuous discharge of groundwater in raised areas of peat. The peat and immediate surrounds provide a stable, permanently moist series of microhabitats.

Intact vegetated Tumulus springs are known from four locations (DEC, 2006), with the typical and common native vascular flora comprising *Banksia littoralis, Melaleuca preissiana, Eucalyptus rudis, Taxandria linearifolia, Astartea* spp. and *Pteridium esculentum*.

The Mound Springs TEC was not identified from statistical analysis; however, since 2007 the site has been the subject of several surveys to identify and delineate the boundary. A Level 1 flora and vegetation survey and hydrological investigation was conducted in July 2007 to support the realignment of the project area to avoid impacts (GHD 2007).

SCP02 (Southern wet shrublands) is listed as Endangered (EN) due to a limited distribution and only a few occurrences, with each being small or isolated and vulnerable to threatening processes. An occurrence of 1.4 ha of SCP02 was identified from one quadrat (SVB011) to the west of Hepburn Avenue near the intersection with Marshall Road (Figure 11).

The FCT determination of site SVB011 could not separate it between SCP02 and SCP11. The dendrogram listed the site as SCP11; the nearest neighbour had it with SCP11 and SCP03c; while the single site insertion could not separate between SCP02 and SCP11. The site does not represent SCP03c based on the known distribution and the floristic description of SCP03c.

The site is likely to be consistent with SCP11 (Wet forests and shrublands) based on the three analyses. SCP11 is not listed as a TEC or a PEC. For the purposes of the impact assessment, and following the precautionary principle, the site is considered TEC SCP02 to ensure maximum protection until further assessments can be completed to determine if the site represents TEC SCP02.

The vegetation at SVB011 is in very good condition (Figure 9) with impacts from introduced flora (nine introduced taxa) and fragmentation of the vegetation from the upgrade of Hepburn Avenue.

SCP20a (*Banksia attenuata* woodland over species rich dense shrublands) is listed as Endangered (EN) due to a limited distribution and only a few occurrences, with each being small or isolated and vulnerable to threatening processes. SCP20a was identified from three sites (360Q03, 360Q39 and SVB016) comprising 12.3 ha, all located south of Baal Road in Cullacabardee (Figure 11).

The sites 360Q03, 360Q39 are located within the project area, while SVB016 is located within the study area. The three sites have been mapped as two vegetation associations (including additional sites). Vegetation condition at the three sites was very good to excellent (Figure 9) with only minor disturbances associated with introduced taxa, uncontrolled access and dieback.

An additional site (SVB001) could not be distinguished between either SCP20a or SCP23a. SCP23a is not representative of a TEC or a PEC. Further sample work is required to confirm the affinity of the site.

Claypan on the SCP

Site SVB086 are representative of SCP11 or SCP17. However, based on the vegetation present and the location, this may be a misclassification due to the presence of introduced taxa.

The presence of *Casuarina obesa* in the upper storey may suggest the site is better placed within the P1 PEC *Casuarina obesa*. Alternatively, the presence of clay based soils and *Melaleuca lateritia* may also indicate that the site closely resembles the P1 PEC Claypans with mid dense shrublands of *Melaleuca lateritia* over herbs. This PEC is also classified as the TEC *Claypans of the Swan Coastal Plain* under the EPBC Act and is ranked as Critically Endangered comprising 9.8 ha (Figure 11).

The PEC occurs on claypans (predominantly basins) usually dominated by a shrubland of *Melaleuca lateritia* and can occur on both the coastal plain and the adjacent plateau. The claypans are characterized by aquatic (*Hydrocotyle lemnoides* – P4) and amphibious taxa (e.g. *Glossostigma diandrum, Villarsia capitata* and *Eleocharis keigheryi* – T).

Additional floristic surveys are required to accurately determine the presence of the Federal TEC. These surveys should be undertaken in early spring and late spring to target early and late flowering native taxa, including annuals and ephemerals.

5.5.2.2 Priority Ecological Communities

SCP21c (Low lying *Banksia attenuata* woodlands or shrublands) is a P3 PEC and is known numerous localities comprising 177.9 ha, with a significant number or area not currently under threat of habitat destruction or degradation. SCP21c was recorded from 23 sites (Figure 11, Table 19) located between Maralla Road in the north and Reid Highway in the south.

SCP21c occurs sporadically between Gingin and Bunbury and is largely restricted to the Bassendean system. The FCT tends to occupy lower lying wetter sites and is variously dominated by *Melaleuca preissiana, Banksia attenuata, Banksia menziesii, Regelia ciliata, Eucalyptus marginata* or *Corymbia calophylla*. Structurally, this FCT may be a woodland or occasionally shrubland.

SCP22 (*Banksia ilicifolia* woodlands) is a P2 PEC and is known from only few occurrences with a restricted distribution, with some locations under immediate threat of destruction or degradation. SCP22 was recorded from one site (SV11) comprising 3.4 ha which is located outside the project area to the northwest of the suburb of Ellenbrook (Figure 11).

SCP22 has been recorded from Low lying sites generally consisting of *Banksia ilicifolia – Banksia attenuata* woodlands, but *Melaleuca preissiana* woodlands are also recorded. The PEC occurs on the Bassendean and Spearwood systems in the central Swan Coastal Plain north of Rockingham. Typically has very open understorey, and is likely to be seasonally waterlogged.

SCP23b (Northern *Banksia attenuata – Banksia menziesii* woodlands) is a P3 PEC and is known from numerous localities, with a significant number or area not currently under threat of habitat destruction or degradation. SCP23b was identified from ten sites (Figure 11, Table 19) and 57.5 ha between Maralla Road in the north and Marshall Road in the south.

Banksia woodlands consistent with SCP23b occur in the Bassendean system, from Melaleuca Park to Gingin. The PEC occurs in extensive *Banksia* woodlands north of Perth with large areas protected within reserves and Bush Forever Sites. The identification of SCP23b within the study area extends the known range to the south.

SCP24 (Northern Spearwood shrublands and woodlands) is a P3 PEC and is known from numerous localities, with a significant number or area not currently under threat of habitat destruction or degradation. SCP24 was identified from three sites (360Q30, SV18 and SVB003) and 8.1 ha within the Rocla mine site and the Tonkin Highway and Reid Highway interchange (Figure 11).

SCP24 consists of heaths with scattered *Eucalyptus gomphocephala* occurring on deeper soils north from Woodman Point. Most sites occur on the Cottesloe unit of the Spearwood system. The heathlands in this group typically include *Banksia sessilis*, *Calothamnus quadrifidus* and *Schoenus grandiflorus*.

The three sites identified as SCP24 may be an anomaly and do not comprehensively match the PEC. Alternatively, the identification of the PEC on the eastern side of the Swan Coastal Plain may actually suggest a subset of SCP24 that occurs on the eastern side of the Swan Coastal Plain. The PEC determination was completed using single site insertion.

In addition to the above TECs and PECs, DPAW has listed '*Banksia dominated woodlands on the Swan Coastal Plain*' as a P3 PEC. Based on the description provided by DPAW, it is assumed that the relevant vegetation associations dominated by *Banksia attenuata and Banksia menziesii* represent the P3 PEC. As a result, the following vegetation associations also represent the PEC: Ba; BaBm[1]; BaBm[2]; BaBm[3]; BaBmMp;

Cc[3]; Cc[6]; Cc[7]; CcEm[1]; CcEm[2]; Em[1]; Et[1]; Et[2]; and Et[3]. The vegetation associations listed above represent *Banksia* dominated woodlands.

5.5.3 Vegetation Complexes

The study area is located across seven vegetation complexes: Bassendean Complex-Central and South, Bassendean Complex-North Transition, Bassendean Complex-North, Coonambidgee Complex, Reagan Complex, Southern River Complex and Yanga Complex (Figure 6). The extent remaining, including pre-European extent and current extent within formal protection (includes conservation estate, Bush Forever on conservation estate and Bush Forever in Regional Parks) is presented within Table 20.

Table 20 Native vegetation extent remaining on the Swan Coastal Plain

Vegetation complex	Pre-European extent (ha)[1]	2013 extent (ha)[1]	Pre-European extent remaining (%)[1]	Formal protection[2] (ha)	Pre-European extent with formal protection (%)[1]
Bassendean Complex-Central and South	87,392	24,206	27.70	6,350	2.57
Bassendean Complex-North Transition	17,640	16,126	91.42	11,480	64.16
Bassendean Complex-North	74,133	5,3518	72.19	30,302	35.67
Coonambidgee Complex	6,272	2,859	45.59	650	10.33
Reagan Complex	9080	3052	33.62	579	3.76
Southern River Complex	57,171	11,255	19.69	3,749	2.16
Yanga Complex	26,176	4,645	17.75	758	2.02

1 Perth Biodiversity Program (2013).
2 Formal protection includes DPAW conservation estates, Bush Forever on conservation estate and Bush Forever in Regional Parks.

The National Objectives and targets for Biodiversity Conservation 2001-2005 recognises that a retention of 30% or more of the pre-clearing extent of each ecological community is necessary if Australia's biological diversity is to be protected (ANZECC, 2000). In addition to the ANZECC 30% retention target, the EPA has adopted a 10% level of pre-clearing extent as representing 'endangered' (EPA, 2000).

The majority of the study area (excluding the portion located within the Shire of Chittering) is located within a constrained area. A constrained area is an area where there is an expectation that development will be able to proceed, this may include urban, urban deferred or industrial zoned land or land with existing development approvals (EPA, 2003). The Bush Forever Strategy identifies a retention target of at least 10% of pre-European vegetation complex extents within constrained areas (Government of Western Australia, 2000).

According to the extent remaining for each vegetation complex in Table 20, the Bassendean-North Transition and the Bassendean-North vegetation complexes have greater than 30% of their pre-European extent remaining within formal protection (which includes conservation estate, Bush Forever sites on conservation estate and Bush Forever sites in Regional Parks).

The pre-European extent remaining within formal protection for the Coonambidgee complex is above the 10% endangered level set by the EPA, while the remaining vegetation complexes (Bassendean-Central and South, Reagan, Southern River and Yanga) are below the 10% endangered level (Table 20).

Of the five vegetation complexes that have less than 30% of their pre-European extent remaining in formal protection, only the Coonambidgee and Reagan complexes have greater than 30% of their pre-European extent remaining. The remaining three vegetation complexes (Bassendean-Central and South, Southern River and Yanga) have below the 30% minimum threshold where species loss increases exponentially.

The three vegetation complexes, Bassendean-Central and South; Southern River; and Yanga, with lower than 30% of their pre-European extent remaining are also the three dominant (greater than 75%) vegetation complexes represented across the project area.

5.5.4 Ecological Corridors

The study area is located within the Perth subregion which has historically been cleared for urban development, industrial development and agriculture. As a result, only 42% (or 473,176 ha) of the pre-European extent for the Perth subregion (1,117,757 ha) remains intact (Government of Western Australia, 2013).

The Perth Biodiversity Project (PBP) has drafted a Regional Ecological Linkage Network that links protected regionally significant natural areas by retaining the best condition local natural areas (LNAs) available so they can act as stepping stones for flora and fauna (WALGA, 2004).

The study area is located across several key ecological linkages at the following locations (from north to south):

- Gaston Road, Bullsbrook. This linkage corridor incorporates the known TEC Tumulus Mounds Spring and connects Bush Forever Site No. 97 in the west with Bush Forever Site 292 in the east.
- Raphael Road, Bullsbrook near the proposed Cooper Road separation. This linkage corridor links Bush Forever Sites 6 and 399 in the west with Ellen Brook, which represents a northsouth corridor.
- Maralla Road Nature Reserve. This linkage corridor connects the State Forest (F 65) with Ellen Brook and represents a pinch point between the State Forest in the west and native vegetation on the eastern Swan Coastal Plain and the Darling Scarp.
- Rocla mine site. A northsouth ecological linkage corridor is located at the proposed Promenade grade separation in Ellenbrook. The corridor links the State Forest in the north with Whiteman Park in the south.
- Cullacabardee. The eastwest corridor links Lake Jandabup and Gnangara Lake in the northwest with Whiteman Park in the east.
- Reid Highway. The eastwest linkage corridor connects vegetation from the coastline east towards Bennett Brook at the southern end of Whiteman Park.

5.6 Flora Recorded

A total of 456 vascular taxa from 234 genera and 73 families were recorded during this survey (Appendix K). This included 357 native taxa (78%) and 99 introduced taxa (22%).

The number of vascular taxa recorded from this and previous surveys (GHD, 2013; 360 Environmental 2014), is 634, including 485 native and 149 introduced taxa. The list of vascular taxa recorded from all surveys is provided in Appendix L.

Eighteen specimens collected during the field survey could be identified to genus level only; a further two specimens could only be identified family level. Two specimens have tentatively been identified to species level due to inadequate material (not flowering or fruiting or the vegetative material had been disturbed ensuring the identification process was difficult).

The majority (30%) of the vascular taxa during this survey were members of the Myrtaceae, Fabaceae and Orchidaceae families (Table 21). Of the 67 families recorded, 27 families were only represented by one genus.

Table 21 Dominant families recorded from the study area

Family name	Common name	Number of native taxa	Number of introduced taxa
Myrtaceae	Eucalypts	46	1
Fabaceae	Acacias and Peas	33	14
Orchidaceae	Orchids	40	1
Cyperaceae	Sedges	23	4
Poaceae	Grasses	6	21
Asteraceae	Daisies	15	11

The dominant genera recorded from this study are listed in Table 22. Of the 234 genera, 142 genera were only represented by one taxon. The dominant six genera (*Stylidium*, *Acacia, Caladenia, Melaleuca, Drosera and Lomandra*) contributed approximately 12% of the total number of taxa.

Table 22 Dominant genera recorded from the study area

Genera	Common name	Native taxa	Introduced taxa
Stylidium	Trigger Plants	14	0
Acacia	Wattles	7	2
Caladenia	Spider Orchids	9	0
Melaleuca	Paperbarks	9	0
Drosera	Sundews	8	0
Lomandra	Mat Rush	8	0

5.6.1 Survey Adequacy

The total number of taxa recorded from this study was compared to other surveys undertaken in close proximity to the study area and previous studies completed for the project (360 Environmental, 2014) and (GHD, 2013a) (Table 23).

Table 23 Comparison with other surveys of the Swan Coastal Plain

Reference	Size of survey (ha)	No. of quadrats (& relevés)	Total no. of taxa recorded	Sampling intensity (sites/ha)*	Native taxa	Introduced taxa
This survey	**3061**	**93 (27)**	**456**	**0.04**	**357**	**99**
Mitchell Freeway extension (GHD, 2013b)	438	28	392	0.06	246	146
Lots 46 and 47 Maralla Road and Lexia Avenue, Ellenbrook (M.E. Trudgen and Associates, 1999)	~400	64	324	0.16	294	30
Swan Valley Bypass (360 Environmental, 2014)	937	39 (9)	283	0.05	230	53
Tonkin Highway definition study (GHD, 2013a)	1,659	24 (1)	248	0.02	178	74
North Ellenbrook (360 Environmental, 2012)	1,000	22	226	0.02	181	45
Victoria Road Bushland (Bennett Environmental Consulting Pty Ltd,2008)	21	6	156	0.29	134	22
Lot 5 Mornington Drive, Mariginiup (Monocot-Dicot Botanical Research, 2010)	8	10	154	1.25	133	21
M70/138 Hopkins Road, Nowergup (Coffey Environments, 2010)	8	8	141	1.00	119	22
Lot 154 Stockland (Ecoscape, 2009b)	4	Unknown	112	N/A	95	17
Lots 50 and 51 Stockland (Ecoscape, 2009a)	13	Unknown	97	N/A	80	17

* The higher the number, the more intense the sampling.

The total number of taxa in this survey is the highest of all surveys completed near the study area, due to the large size of the study area and the diversity of habitats along the corridor. Survey intensity, that is, the number of site per hectare, is lower than most surveys.

Completeness of survey was tested by performing a species accumulation curve (sample-based rarefaction), using Primer 6 (Clarke and Gorley, 2006), and comparing averages of seven estimators (Chao 1, Chao 2, Jacknife 1, Jacknife 2, Bootstrap, Michaelis Menton (MM) and Ugland Grey Ellingsen (UGE)) against actual observed richness from the flora sampling sites.

The species accumulation curve showed that 390 vascular taxa were recorded from the sampling sites, while 446 vascular taxa are expected to occur within the study area (Figure 12). In total, 456 vascular taxa (including 20 taxa which were identified to family or genus level only) were recorded in the quadrats,

relevés, mapping notes and opportunistic collections. This indicates that over 100% of the potentially occurring flora within the study area has been recorded.

Note that quadrats were sampled once only, that is, taxa potentially present at other times of the year may have been overlooked; some taxa identified to genus level only may actually be a species already recorded.

While the accumulation curve is still increasing, the rate of increase lessens with each additional quadrat and would eventually plateau.

5.7 Flora of Conservation Significance

During the September 2014 survey, two Threatened and eight Priority taxa were recorded in the study area (Figure 13) (Appendix M). The estimated populations and individuals recorded are provided in Table 24. The two known Threatened flora, *Caladenia huegelii* and *Grevillea curviloba* subsp. *incurva* and Priority taxa *Ornduffia submersa* (P4) and *Stylidium striatum* (P4) were not recorded in the project area.

Table 24 Threatened and Priority Flora

Species	Conservation Status	Number of Population		Number of individuals	
		within the study area	within the project area	within study area	within project area
Caladenia huegelii	T	1	0	1	0
Grevillea curviloba subsp. *incurva*	T	3	0	137	0
Millotia tenuifolia var. *laevis*	P2	4	2	7	3
Poranthera moorokatta	P2	2	1	7	1
Meeboldina decipiens subsp. *decipiens* ms	P3	2	2	11	11
Cyathochaeta teretifolia	P3	2	1	30	9
Anigozanthos humilis subsp. *chrysanthus*	P4	2	1	4	2
Hypolaena robusta	P4	3	3	25	17
Ornduffia submersa	P4	1	0	1	0
Stylidium striatum	P4	1	0	1	0

The remaining six Threatened taxa (*Darwinia foetida*, *Grevillea curviloba* subsp. *curviloba, Conospermum undulatum*, *Grevillea althoferorum* subsp. *fragilis, Trithuria occidentalis*, *Thelymitra stellata* and *Eleocharis keigheryi*) predicted to 'likely' or 'possible' to occur within the project area (Appendix G) were not recorded in the project area during the survey. Several known locations of threatened flora, for example *Darwinia foetida* and *Grevillea curviloba* subsp. *curviloba*, occur within or immediately adjacent to the study area.

5.7.1 Threatened Flora

A total of 25 Threatened flora species are known to occur in close proximity to the study area. Of these, five are considered 'likely' and four are considered 'possible' to occur within the study area. Of the five considered 'likely' to occur, only three (*Caladenia huegelii, Darwinia foetida* and *Grevillea curviloba* subsp. *incurva*) were recorded from within the study area. The *Darwinia foetida* record is a DPAW record and is not considered to be impacted from the project and is not discussed further. The DPAW record was visited and *Darwinia foetida* was confirmed as present at the known location.

5.7.1.1 *Caladenia huegelii* (Grand Spider Orchid)

During the September 2014 survey, one plant was recorded near the Ellenbrook suburb (Figure 13) (Plates 1 and 2). Additional searches around the plant were undertaken; however, none were located. The plant was confirmed by Mr Andrew Brown, a leading orchid taxonomist with DPAW. *C. huegelii* is a cryptic species and additional plants may occur close to the known plant. Not all plants flower each year (DEC, 2009) and the flowers are the key feature for identification.

Plate 1 ***Caladenia huegelii* flowering**

Plate 2 ***Caladenia huegelii* flowering**

C. huegelii is a tall orchid, with a flower stem to 60 cm high but occasionally as tall as 1 m. It has a single erect, pale green, hairy leaf 10 to 18 cm long by 7 to 12 mm wide; the basal third usually irregularly blotched with red-purple. Plants have one or two (rarely three) predominantly pale greenish-cream flowers 7 to 10 cm across, with variable suffusions, lines and spots of red maroon. The sepals end in slender light brown to yellow clubs 6 to 40 mm long (DEC, 2009). The large labellum is prominently two-coloured with a pale greenish-cream basal lamina and a uniformly dark maroon recurved apex (Hopper and Brown 2001). The labellum contains particularly long, fine, often split fringes, which extend well above the column (Brown et al. 1998).

C. huegelii was declared as Rare Flora as *Caladenia* sp. (Coastal Plain) SD Hopper 3400 in September 1987 and as *C. huegelii* in November 1990, under the Western Australian WC Act. It is Critically Endangered (CR)

under World Conservation Union (IUCN 2001) criterion B2ab(i,ii,iii,iv) due to the severe fragmentation of populations and the continuing decline in the extent of occurrence, quality of habitat and number of locations. *C. huegelii* is also listed as Endangered under the EPBC Act.

Based on the Recovery Plan for the Grand Spider Orchid (DEC, 2009) and the Critically Endangered listing under the WC Act, critical habitat includes all known habitat for wild and translocated populations. All known wild and translocated populations are important populations (DEC, 2009).

Habitat critical to the survival of *C. huegelii* includes:

- The area supporting important populations;
- Areas of similar habitat surrounding important populations (i.e. jarrah/banksia woodland on Bassendean sands) – as these areas provide potential habitat for natural range extension and are necessary to support viable populations of the symbiotic mycorrhizal fungus and the pollinating wasps crucial to the orchid's survival, and to allow pollinators to move between populations; and
- Additional occurrences of similar habitat that may contain important populations of the species or be suitable sites for future translocations or other recovery actions intended to create important populations.

The vegetation surrounding the known location is critical habitat for the survival of *Caladenia huegelii* (Figure 13). The critical habitat for *Caladenia huegelii* extends from Maralla Road in the north, where an individual was previously recorded (Figure 8), to vegetation association Pr (located west of Ellenbrook) within Nature Reserve R46920.

An additional population of *Caladenia huegelii* is known to occur near the Whiteman Park Archery Range (located immediately adjacent to the study area (Figure 8). The vegetation on the eastern side of Beechboro Road North, near the archery range is considered to be critical habitat.

The total area of critical habitat for *Caladenia huegelii* within the study area is 228.3 ha, which includes approximately 39.3 ha within the project area (Figure 13).

5.7.1.2 *Grevillea curviloba* subsp. *incurva* (Narrow Curved-leaf Grevillea)

During the September 2014 survey, the known population of *Grevillea curviloba* subsp. *incurva* (Plates 3 and 4) along the Brand Highway was re-visited: the population was identified (Figure 13) and appeared healthy. No additional plants or populations were recorded.

Plate 3

***Grevillea curviloba* subsp. *incurva* flowering**

Plate 4

***Grevillea curviloba* subsp. *incurva* habitat (note the high density of introduced grasses)**

Grevillea curviloba subsp. *incurva* is a vigorous, sprawling shrub to 2.5 m high and wide, with greyish-green leaves 1.8 to 5.2 cm long with 3 to 5 strongly incurved, weakly pungent, narrowly-linear lobes, 7 to 20 mm long. Inflorescences occur on short stalks and are 1 to 3 cm long by 3 cm wide. They usually occur in the leaf axils. Individual flowers are creamy white, 7 to 10 mm long and 0.5 m across. Shrubs flower from September to October. The subspecies differs from *Grevillea curviloba* subsp. *curviloba* in having prominently incurved, narrowly linear leaf lobes 0.8 to 1.2 mm wide (Brown *et al*. 1998; Olde and Marriott 1995).

The interim recovery plan for the Narrow Curved-leaf Grevillea (Phillimore and English, 2000) has identified habitat that is critical for the survival of the threatened taxon. Critical habitat is defined as:

- The area of occupancy of the known populations;
- Areas of Muchea Limestone or the Perth to Gingin Ironstone with remnant vegetation within 200 m of known populations (these provide potential habitat for natural range extension);
- The local catchment for the surface and ground waters that provide the wetland habitat of the subspecies (the subspecies occurs in seasonal wetland areas and is dependent on maintenance of local hydrology);
- Corridors of remnant vegetation that link populations , thus allowing pollinators to move between populations, e.g. road and rail verges); and

- Additional occurrences of the ecological communities 'Shrublands and Woodlands on Muchea Limestone of the Swan Coastal Plain' and 'Shrublands and Woodlands of the Perth to Gingin Ironstone' that do not currently contain the subspecies, as they represent possible translocation sites.

As a result, the vegetation located along the verge of the Brand Highway and the adjacent rail reserve (Figure 13), is considered critical habitat. The total area of critical habitat for *Grevillea curviloba* subsp. *incurva* within the study area is 182.7 ha, which includes approximately 5.7 ha within the project area (Figure 13). Based on the observation of this shrub in disturbed areas, this taxon may be a disturbance specialist.

5.7.2 Priority Flora

Three Priority taxa, *Cyathochaeta teretifolia* (P3)*, Eryngium pinnatifidum* subsp. Palustre (G. J. Keighery 13459) (P3) and *Hypolaena robusta* (P4), occur within the study area. The known locations were visited during the September 2014 survey; however, only *Hypolaena robusta* (P4) was re-recorded. Plants at the known locations for *Cyathochaeta teretifolia* (P3) and *Eryngium pinnatifidum* subsp. Palustre (G. J. Keighery 13459) (P3) could not be re-located at the known locations.

The previously known location of *Cyathochaeta teretifolia* is located within a cleared area and it is assumed that the clearing has included the individuals of *Cyathochaeta teretifolia*. The population previously recorded (360 Environmental, 2014) within site 360Q24 was not re-identified during the September 2014 survey. This may be a result of sterile material (i.e. no inflorescence) resulting in a misidentification of the plant during this survey, or is now locally extinct within the sample site.

The record of *Eryngium pinnatifidum* subsp. Palustre (G.J. Keighery 13459) was not re-located during the survey. The priority taxon may not have been flowering at the time of the survey which is required for a positive identification or it may be locally extinct in the study area.

In addition to the three Priority taxa discussed above, *Verticordia lindleyi* subsp. *lindleyi,* a P4 taxon, was recorded near Beechboro Road North in the Whiteman area (GHD, 2013). During the September 2014 survey the population was not recorded. No *Verticordia lindleyi* subsp. *lindleyi* were recorded in the project area.

An additional seven Priority flora were recorded during the September 2014 survey, including:

- *Millotia tenuifolia* var. *laevis* (P2);
- *Poranthera moorokatta* (P2);
- *Cyathochaeta teretifolia* (P3) (new locations);
- *Meeboldina decipiens* subsp. *decipiens* (P3);
- *Anigozanthos humilis* subsp. *chrysanthus* (P4);
- *Hypolaena robusta* (P4);
- *Ornduffia submersa* (P4); and
- *Stylidium striatum* (P4).

Information on each of the Priority taxon, is detailed below, while locations are shown in Figure 13.

5.7.2.1 *Millotia tenuifolia* var. *laevis* (P2)

The daisy *Millotia tenuifolia* var. *laevis* was recorded from eight quadrats (Figure 13) located in the Cullacabardee bushland and Maralla Nature Reserve. *M, tenuifolia* var. *laevis* is an ascending to erect

annual herb that grows to from 0.02 to 0.1 m high. It produces yellow flowers between September and October and occurs on granite or lateritic soils (DPAW, 2014). Seven specimens have previously been lodged at WAH, while Australia's Virtual Herbarium (AVH) has ten records.

In contrast to typical soil preferences, the plants in the study area occur on deep Bassendean Sands (Plates 5 and 6). Importantly, the taxon has never been recorded from the Swan Coastal Plain bioregion and represents a range extension of over 50 km from the Jarrah Forest bioregion, and is therefore locally and regionally significant.

Plate 5

Habitat supporting *Millotia tenuifolia* var. *laevis*

Plate 6

Habitat supporting *Millotia tenuifolia* var. *laevis*

5.7.2.2 *Poranthera moorokatta* (P2)

The herb *Poranthera moorokatta* is a monoecious, erect annual with sparsely branched stems growing to a height of 50 mm (Plate 7). It produces flowers in short dense, terminal umbel-like racemes which are pale-pink to white (Barrett, 2012).

Plate 7

***Poranthera moorokatta* (Barrett, 2012)**

P. moorokatta was discovered from Kings Park in 2005 and subsequently described (Barrett, 2012). It is only known from two locations, Kings Park and bushland west of Ellenbrook, and the discovery of additional plants is considered to be significant.

The new populations were identified in bushland west of Ellenbrook and expand the known population previously identified in 1999 by Trudgen & Associates (1999). *P. moorokatta* was recorded from seven quadrats near Ellenbrook and within Maralla Nature Reserve (Figure 13).

Due to the small stature of the plant, it is quite feasible that *P. moorokatta* is more widespread in bushland west of Ellenbrook and within Maralla Nature Reserve. However, due to the site being only one of two known locations for *P moorokatta*, vegetation supporting the Priority species is significant in a local and regional context.

5.7.2.3 *Cyathochaeta teretifolia* (P3)

The sedge *Cyathochaeta teretifolia* is a rhizomatous, clumped, robust perennial and grows to 2 m high and 1 m wide. *C. teretifolia* produces brown flowers and occurs on grey sand and/or sandy clay in swamps and creek edges (DPAW, 2014).

C. teretifolia was recorded from two quadrats (Figure 13) (Plates 8 and 9) within bushland at Gaston Road, Bullsbrook and Victoria Road, Beechboro. The previous record identified from the desktop assessment is located in a cleared area and may have been destroyed.

Plate 8

***Cyathochaeta teretifolia* habitat (Gaston Road)**

Plate 9

***Cyathochaeta teretifolia* habitat (Victoria Road)**

C. teretifolia is widespread, occurring from Chittering in the north to Pemberton in the south and Denmark in the southeast (CHAH, 2014). The sedge has been recorded from numerous locations on the Swan Coastal Plain. The WAH has 37 specimens (DPAW, 2014), while AVH has 42 records (CHAH, 2014). The record at the end of Gaston Road is located within a TEC.

5.7.2.4 *Meeboldina decipiens* subsp. *decipiens* (P3)

Meeboldina decipiens subsp. *decipiens* is an erect, open perennial sedge that grows to a height of 60 cm. The sedge flowers in October and occurs on sand and sandy peat within swamps (DPAW, 2014).

M. decipiens subsp. *decipiens* was recorded from two quadrats within the Victoria Road Bushland (Figure 13) (Plates 10 and 11). The sedge is widespread from Nannup in the south to Gosnells in the north. The locations within the Victoria Road bushland represent a range extension (approximately 15 km) to the north and the most northerly extent. These records represent the most northerly known location, and as such are considered locally and regionally significant. A sample of *Meeboldina decipiens* has been recorded from the Vines area (east of Ellenbrook); however, the specimen has not been identified to subspecies level and therefore cannot be considered as this taxon until further review.

Plate 10

Habitat supporting *Meeboldina decipiens* subsp. *decipiens*

Plate 11

Habitat supporting *Meeboldina decipiens* subsp. *decipiens*

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

The Golden Catspaw *Anigozanthos humilis* subsp. *chrysanthus* is a rhizomatous, perennial herb, growing to a height from 20 to 80 cm. The taxon produces yellow-golden flowers in July to October and occurs on grey or yellow sand (DPAW, 2014).

The subspecies differs from the common subspecies *Anigozanthos humilis* subsp. *humilis* in the golden more erect inflorescence (Plates 12 and 13).

Anigozanthos humilis subsp. *chrysanthus* was recorded from two locations near the Ellenbrook interchange and within Cullacabardee (Figure 13). In the field it is difficult to differentiate between *chrysanthus* subspecies and *humilis* subspecies as flower colour depends on the age of the inflorescence, and the golden or yellow flowers may already be grading into darker 'red' colours as they die-off.

Therefore, the significance of the two records is not high, in addition, the taxon occurs throughout the northern Swan Coastal Plain and Northern Sandplains bioregions.

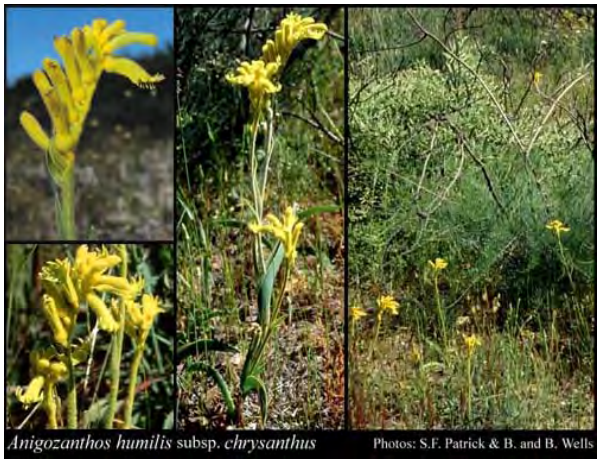

Plate 12

Anigozanthos humilis* subsp. *chrysanthus

Photography by S.F. Patrick, & B. and B. Wells. Image used with the permission of the Western Australian Herbarium, Department of Parks and Wildlife (https://florabase.dpaw.wa.gov.au/help/copyright). Accessed on Wednesday, 3 December 2014.

Plate 13

Habitat supporting *Anigozanthos humilis* subsp. *chrysanthus*

5.7.2.6 *Hypolaena robusta* (P4)

Hypolaena robusta is a dioecious rhizomatous, perennial rush growing to 50 cm high. It flowers in September and October and occurs on white sand on consolidated dunes and sandplains (DPAW, 2014). *Hypolaena robusta* occurs along the Swan Coastal Plain and Northern Sandplains from Eneabba in the north to Perth in the south, with two disjunct locations near Collie and Augusta in the southwest (CHAH, 2014).

Hypolaena robusta (Plates 14 and 15) was recorded from two quadrats (Figure 13), one of these was from a previously known location identified during the desktop assessment and the second record expands the known population (Figure 8). The populations identified during the September 2014 survey represent an increase in the known distribution of *Hypolaena robusta* within the Perth Metropolitan Region. From a regional perspective, the records from the study area are not significant. Locally, the records are significant as they increase the known distribution within the Perth Metropolitan Region.

Plate 14

Close-up of the inflorescence on *Hypolaena robusta*

Plate 15

Habit and habitat for *Hypolaena robusta*

5.7.2.7 *Ornduffia submersa* (P4)

Ornduffia submersa (formerly *Villarsia submersa* is an aquatic, extremely slender perennial herb with white flowers in August to November (Plate 16). The herb occurs in freshwater pools, lakes, swamps, winter-wet depressions and claypans. The depth of the water rarely exceeds half a metre.

Ornduffia submersa was recorded from one location in the north of the study area (Figure 13). The specimen was taken from a small flowing ephemeral creek that flowed into Ellen Brook.

Plate 16

Ornduffia submersa

Photography by M. Sowry. Image used with the permission of the Western Australian Herbarium, Department of Parks and Wildlife (https://florabase.dpaw.wa.gov.au/help/copyright). Accessed on Wednesday, 3 December 2014.

The specimen recorded in the north of the study area represents the most northerly record for *Ornduffia submersa* on the Swan Coastal Plain (DPAW, 2014). The location is considered to be locally and regionally

significant as it expands upon the known distribution of *Ornduffia submersa* in the South West of Western Australia. It is feasible that additional plants are located along the tributary and the Ellen Brook.

5.7.2.8 *Stylidium striatum* (P4)

The Fan-leaved Triggerplant *Stylidium striatum* is a rosette perennial herb growing to a height of 15 to 55 cm. The herb produces yellow flowers from October to November and occurs on brown clay loam over laterite on hillslopes in Jarrah/Marri forests and Wandoo woodlands (DPAW, 2014) (Plates 17 and 18).

Plate 17

Stylidium striatum

Photography by J. Wege. Image used with the permission of the Western Australian Herbarium, Department of Parks and Wildlife (https://florabase.dpaw.wa.gov.au/help/copyright). Accessed on Wednesday, 3 December 2014.

Plate 18

Habitat of *Stylidium striatum* in the study area

The triggerplant was recorded from one location in the north of study area on the slopes of the Dandaragan Plateau (Figure 13). The location is within the MRS referral boundary and may be directly impacted.

S. striatum has not previously been recorded from the Chittering region, with most populations located from Kalamunda to Armadale and east to York (DPAW, 2014). However, AVH has an additional record located 5 km to the northeast of the study area (CHAH, 2014).

5.7.3 Significant Flora of the Perth Metropolitan Region

The native taxa recorded from the study area were compared against the list of significant flora of the Perth Metropolitan Region detailed in the Bush Forever Strategy (Government of Western Australia, 2000b).

A total of 16 native taxa are significant, based on their conservation status and geographical variation or regional ecological preferences (Table 25).

Although *Aotus cordifolia* was considered a significant flora of the PMR (Government of Western Australia, 2000b), it is now no longer listed as a Priority taxon and is now considered to be well reserved. However, an updated list of significant flora in the PMR has not been prepared, therefore, *Aotus cordifolia* is treated as significant flora of the PMR.

Table 25 Significant Flora of the Perth Metropolitan Region

Taxa	Family	Federal conservation rating	State conservation rating	Significance code[1]	Presence in project area
Aotus cordifolia	Fabaceae			p, s	
Boronia purdieana	Rutaceae			r, s	
Caladenia huegelii	Orchidaceae	EN	CR	p, s, e	
Conospermum incurvum	Proteaceae			r, s	
Conostephium minus	Ericaceae			p, s, e	
Conostylis aculeata subsp. *cygnorum*	Haemodoraceae			e	
Croninia kingiana (formerly *Leucopogon kingianus*)	Ericaceae			s	
Cyathochaeta teretifolia	Cyperaceae		P3	p, s	
Dielsia stenostachya	Restionaceae			e	
Eremaea purpurea	Myrtaceae			d, p	
Hensmania turbinata	Haemodoraceae			r, s	
Macarthuria apetala	Molluginaceae			s	
Ornduffia submersa (formerly *Villarsia submersa*)	Menyanthaceae		P4	p, s	
Pithocarpa pulchella var. pulchella	Asteraceae			r, s	
Pterostylis sp. cauline leaves (N. Gibson & M.N. Lyons 1490)	Orchidaceae			d, s	
Verticordia nitens	Myrtaceae			s	

1 Table 13 from the Bush Forever Strategy Volume 2 (Government of Western Australia, 2000b).
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 Perth Metropolitan Region.
e – taxa endemic to the Swan Coastal Plain.
E – taxa endemic to the Swan Coastal Plain in the Perth Metropolitan Region.

5.7.4 Range Extensions

Four species, *Amperea simulans, Conostylis teretiuscula, Histiopteris incisa* and *Melaleuca amydra*, located in the study area represent range extensions.

Amperea simulans, a perennial herb, has not previously been recorded north of the Swan River. A sample was collected from the Rocla mining tenement (360Q29) and represents a range extension of over 70 km. The nearest known record is from Midgegoroo National Park, southeast of Jarrahdale. The new record of *Amperea simulans* is located within the proposed Drumpellier Drive intersection, near Ellenbrook.

Conostylis teretiuscula, a perennial herb, has not previously been recorded in the Perth Metropolitan Region. A sample was collected from the Rocla mining tenement (SVB037) and represents a range extension of 70 km to the south. The nearest known location of *Conostylis teretiuscula* is from near Boonanarring Nature Reserve.

Histiopteris incisa, a fern, was recorded from Bush Forever Site 97 near Gaston Road, Bullsbrook. The record from the Bush Forever site is on the northern margins of its range in Western Australia. The specimen was collected from the Tumulus Springs which does not support the usual habitat, namely wet rock face of a gorge, (DPAW, 2014).

Melaleuca amydra, a shrub, is known from the Northern Sandplains bioregion, with the nearest known record to the Perth Metropolitan Region just south of Dandaragan (100 km to the north of the project area). This represents a range extension in excess of 120 km to the south. *Melaleuca amydra* was recorded from Maralla Nature Reserve.

5.7.5 Unique and Unusual Taxa

Five taxa displayed unique or unusual characteristics which may warrant further investigation by taxonomists and WAH in the future, including *Allocasuarina campestris, Bossiaea eriocarpa, Calytrix fraseri, Monotaxis occidentalis* and *Tetratheca hirsuta*.

A collection of *Allocasuarina campestris* displayed atypical large fruit. Although not considered a separate entity, the specimen will be vouchered to WAH for further investigation.

The *Bossiaea eriocarpa* group in the southwest of Western Australia shows considerable variation, which may warrant further investigation to determine if there are separate entities. The specimens collected from the study area appear to be a form of *Bossiaea eriocarpa*; based on the specimens vouchered at WAH, they are not rare.

Calytrix fraseri displays considerable variation in the southwest of Western Australia and may warrant further investigation to determine if they represent several entities. The specimens collected from the study area show considerable variation to the type specimen and have been identified as *Calytrix fraseri* Ellenbrook Form.

A sample of *Monotaxis occidentalis* collected from the Cullacabardee area may represent a Swan Coastal Plain form of this species. The specimen will be vouchered with WAH and may warrant further review to determine if it represents a new taxon, a variety or subspecies of *Monotaxis occidentalis*.

A specimen of *Tetratheca hirsuta* was an atypical glabrous form of the typical hairy form. The specimen will be vouchered with WAH; however it is not considered to warrant further investigation to determine if it is a new taxon, variety or subspecies.

5.8 Introduced Flora

A total of 99 introduced taxa were recorded, including three WONS and five Declared Plants.

5.8.1 Weeds of National Significance

The three WONS, including **Asparagus asparagoides, *Opuntia stricta* and **Rubus fruticosus aggregate* were recorded from several locations (Figure 9, Appendix O). In addition to the three WONS recorded in this survey, 360 Environmental (2014) identified **Eichhornia crassipes* from a paddock north of Neaves Road within the project area.

5.8.1.1 Bridal Creeper (**Asparagus asparagoides*)

Bridal Creeper (**Asparagus asparagoides*) (Plate 19) is a climbing herb or vine to 3 m, arising from a short rhizome attached to tuberous roots. The above-ground portion can die back annually or under unfavourable conditions. The adult foliage are not true leaves but flattened leaf-like appendages called cladodes or phylloclades that arise from the base of the true leaves, which are reduced to scales (DOTE, 2014). It is regarded as one of the worst weeds in Australia because of its invasiveness, potential for spread, and economic and environmental impacts and unlike most environmental weeds can establish in undisturbed native vegetation (DOTE, 2014b).

This WONS was recorded at six locations, mainly in degraded habitats (Figure 9). It is know from numerous locations in the SCP.

Plate 19

****Asparagus asparagoides***

Photography by J.P. Pigott & R. Randall. Image used with the permission of the Western Australian Herbarium, Department of Parks and Wildlife (https://florabase.dpaw.wa.gov.au/help/copyright). Accessed on Tuesday, 11 November 2014.

5.8.1.2 Prickly Pear (**Opuntia stricta*)

Prickly Pears belong to the genus *Opuntia*, several species of which are weeds or potential weeds in most states of Australia. The stem segments of **Opuntia stricta* (Plate 20) often thicken at the base and form a trunk. The flattened stem segments are elliptic to egg-shaped and are dull green to grey-green with a whitish waxy bloom. The leaves are very small and drop off. The flowers are 5 to 8 cm diameter, the petaloid lobes are yellow but the outer smaller ones are often greenish to pinkish. The almost rounded to pear-shaped fruits have scattered prominent tufts of glochids. They are succulent and purple with a white waxy bloom at maturity (adapted from DOTE, 2014c).

**Opuntia stricta* is an aggressive, drought tolerant weed that is easily dispersed by fragmentation. Dense infestations can impede movement of stock, lay waste to agricultural and pastoral lands (DOTE, 2014c).

Prickly Pear was recorded in one location, within the former Ellenbrook settlement near the Rocla mine site (Figure 9).

Plate 20

***Opuntia stricta**

Photography by AgWA. Image used with the permission of the Western Australian Herbarium, Department of Parks and Wildlife (https://florabase.dpaw.wa.gov.au/help/copyright). Accessed on Tuesday, 11 November 2014.

5.8.1.3 Blackberry (**Rubus fruticosus* aggregate)

Blackberries (**Rubus* spp.) (Plate 21) are mostly evergreen, but sometimes partially deciduous, sprawling woody shrubs, often forming mounds. Its leaves mostly consist of 5 distinct leaflets, arranged as in a hand (palmately). The lower surfaces of the leaflets are variable but often felt-like and there are down-curved spines on the main veins (DOTE, 2014d).

The **Rubus fruticosus* aggregate consists of hundreds of different named species in Europe, of which at least 16 of these species have been introduced to Australia (DPI, 2009), including **Rubus laudatus.*

**Rubus laudatus* was recorded from seven locations across the study area with a higher prevalence north of Maralla Road in association with degraded vegetation (Figure 9).

It is regarded as one of the worst weeds in Australia because of its invasiveness, potential for spread, and economic and environmental impacts (DOTE, 2014d). Blackberry forms impenetrable thickets and mounds that fill gullies, block access to waterways and alienate productive pasture, orchards and forestry land. These thickets can also reduce the natural attraction of the bush as well as hindering recreational opportunities by preventing access to natural features. Control costs are high and a sustained effort is needed to attain success (DOTE, 2014d).

Plate 21

***Rubus laudatus**
(*Rubus fruticosus* aggregate)

Photography by S.M. Armstrong. Image used with the permission of the Western Australian Herbarium, Department of Parks and Wildlife (https://florabase.dpaw.wa.gov.au/help/copyright). Accessed on Tuesday, 11 November 2014.

5.8.1.4 Water Hyacinth (*_Eichhornia crassipes_)

Water Hyacinth (*_Eichhornia crassipes_) (Plate 22) is an erect, free-floating (sometimes attached to the mud and creeping), aquatic perennial herb, varying from 10 cm to 1 m in height where nutrient levels are high. It has horizontal stems (stolons) which root at the joints (nodes) to form daughter plants (DOTE, 2015).

It is regarded as one of the worst weeds in Australia because of its invasiveness, potential for spread, and economic and environmental impacts. Water Hyacinth is declared as a noxious plant in all states and territories of Australia and is on the World Conservation Union's list of the world's 100 worst invasive alien species. It is a highly invasive aquatic plant that has become a pest of waterways around the world. It grows aggressively in nutrient-rich stationary or slow-moving freshwater to quickly form dense mats (DOTE, 2015).

*_Eichhornia crassipes_ was previously recorded from one location north of Neaves Road in Bullsbrook (360 Environments, 2014) within the project area.

Plate 22

Eichhornia crassipes

Photography by R. Knox & WA Herbarium. Image used with the permission of the Western Australian Herbarium, Department of Parks and Wildlife (https://florabase.dpaw.wa.gov.au/help/copyright). Accessed on Friday, 13 March 2015.

5.8.2 Declared Pests

A total of five Declared Plants were recorded, three of these: Bridal Creeper (*_Asparagus asparagoides_), Prickly Pear (*_Opuntia stricta_) and Blackberry (*_Rubus laudatus_) are WONS and were described in Section 5.8.1. The remaining two Declared Plants are Arum Lily (*_Zantedeschia aethiopica_) and One-leaf Cape Tulip (*_Moraea flaccida_). Water Hyacinth (*_Eichhornia crassipes_) is listed as Prohibited under Section 12 of the BAM Act, however is considered to be a Declared Plant for the remainder of this report.

Organisms are grouped into four main classifications:

- Declared pests (under Section 22 of the Act).
- Permitted (under Section 11 of the Act).
- Prohibited (under Section 12 of the Act).
- Permitted requiring a permit (under Section 73 of the BAM Regulations 2013).

Under the BAM Act, all declared pests are placed in one of three categories:

- C1 (exclusion) – not currently established in WA and control measures including border control are to be taken;

- C2 (eradication) – Present in WA in sufficiently limited areas that eradication is still feasible; or
- C3 (management) – established in WA but is feasible or desirable to manage in order to limit damage.

Bridal Creeper and Prickly Pear are listed C3 (management) for the state, Blackberry is listed as C1 (exclusion) for the Shire of Chittering and the City of Swan. Water Hyacinth is listed as C2 (eradication) for the state.

Paterson's Curse (**Echium plantagineum*) was previously recorded near Beechboro Road North in Bennett Springs (2014). Paterson's Curse is listed as a Declared Plant but not for the City of Swan where the plant was recorded.

5.8.2.1 Arum Lily (**Zantedeschia aethiopica*)

Arum Lily (Plate 23) is categorised as a C3 declared pest for the whole of WA. Arum lily is a robust, dark green, succulent herb. It was introduced to Western Australia from South Africa as a garden plant and subsequently became established as a weed. It is found in creeks, irrigation ditches and areas of summer-moist land in the higher rainfall southwest of WA, often forming large dense clumps.

Arum Lily was recorded from 22 locations spread throughout the study area (Figure 9). The majority of the records were from highly modified areas north of Maralla Road in association with wetlands (the Ellen Brook floodplain, UFI 15732).

Plate 23

Zantedeschia aethiopica

Photography by K. Dean, R. Knox & AGWA. Image used with the permission of the Western Australian Herbarium, Department of Parks and Wildlife (https://florabase.dpaw.wa.gov.au/help/copyright). Accessed on Tuesday, 11 November 2014.

5.8.2.2 One-leaf Cape Tulip (**Moraea flaccida*)

One-leaf Cape Tulip (Plate 24) is categorised as a C3 declared pest for numerous local governments in the southwest, which does not include the Shire of Swan and the Shire of Chittering. One-leaf cape tulip previously *Homeria flaccida*) is a native of South Africa. Perennial herb to 70 cm high, distinguished by fibrous-sheathed corm at the base of the plant, orange to salmon pink flowers that are yellow in the centre; single leaves and presence of seeds in capsules. One-leaf Cape Tulip spreads by seed and movement of corms.

It was recorded at 21 locations (Figure 9), mainly in degraded wetland habitats and were illegal access is high (bushland west of Ellenbrook).

Plate 24

Moraea flaccida

Department of Agriculture and Food Western Australia (https://www.agric.wa.gov.au/declared-plants/one-leaf-cape-tulip-declared-pest). Accessed on Tuesday, 11 November 2014.

5.8.3 Environmental Weeds and Weed Prioritisation Process

According to the EWSWA and review of the 99 introduced taxa recorded from the study area, 17 were rated High, 47 were rated Moderate, eight were rated Mild, 16 were rated Low and 11 have not been rated (Appendix N).

According to the weed prioritisation process, nine introduced taxa were ranked as High, 11 were ranked as Medium, 41 were ranked as Low, 28 were ranked as Negligible and the remaining ten are awaiting further assessment or have not been identified within the DPAW weed prioritisation process (DPAW 2013b) (Appendix N).

6 DISCUSSION

In accordance with the ESD, a Level 2 flora and vegetation survey consistent with the EPA guidance statements (EPA, 2004a) and policies (EPA, 2000 and 2002) was undertaken to identify:

- Loss of flora and vegetation through clearing for road construction;
- Loss of fauna habitat (vegetation loss) short and long term;
- Spread of weed and *Phytophthora* Dieback; and
- Fragmentation.

6.1 Vegetation

The vegetation types included dryland, wetland and transitional vegetation (between dryland and wetland) with additional vegetation units being degraded or completely degraded. Eighteen dryland vegetation associations, 31 wetland vegetation associations, five transitional vegetation associations and 11 disturbed/altered/degraded vegetation associations (including simple mapping units, for example 'Cleared') were identified.

The vegetation associations were described from 93 quadrats and 27 relevés and ten quadrats established and sampled in 2013 (360, Environmental, 2014). Of the 93 quadrats, 64 were new sites established and sampled in 2014, while the remaining 29 sites were quadrats established and sampled in 2013 and resampled in 2014 (360, Environmental, 2014).

6.1.1 Vegetation Condition

Vegetation condition ranged from Pristine to Completely Degraded, with the majority Completely Degraded due to the high proportion of cleared or highly modified areas, including paddocks and infrastructure (highways, roads and industry).

Significant portions of native vegetation in the Ellenbrook, Cullacabardee areas and further south of Hepburn Avenue supported vegetation in Very Good to Pristine condition. The project area will impact 121.1 ha of native vegetation in very good or better condition.

The condition of vegetation is frequently reduced, especially of small and linear remnants that have a large perimeter relative to their size, as a result of edge effects. The quality and condition of the vegetation in the study area can be compromised by the invasion of weeds, changed hydrology, increased accessibility and other anthropogenic impacts.

The presence of weeds, changes in hydrology, uncontrolled access and other anthropogenic disturbances have, and continue to impact on the fragmented vegetation present within the study area. This is most evident north of Maralla Road, where the prevalence of introduced significant weeds (WONS and Declared Pests) was high.

In addition, the largely contiguous area of good or better condition vegetation near the suburb of Ellenbrook was showing the effects of uncontrolled access, resulting in the dumping of rubbish, introduction and spread of introduced weeds and dieback and the degradation of vegetation through off-road activities.

The project may or may not increase the level of uncontrolled access in the Ellenbrook area. The level of uncontrolled access will be dependent on the design of the project. For example, fences, barriers and walls will block access to the native vegetation. The restriction on uncontrolled access is considered vital to

maintaining the integrity of the large, contiguous areas of vegetation located in close proximity to the project, including the Cullacabardee and Whiteman Park areas.

6.1.2 Vegetation Associations

Sixty vegetation associations and five additional mapping units (disturbed/altered areas) (Table 18) were described and mapped within the study area. This included 18 dryland communities, 31 wetland communities, five transitional communities and six disturbed/altered communities. The five mapping units are highly disturbed or modified (i.e. rehabilitated sites, cleared areas, open paddocks).

The study area supports 20 FCTs, with several of the FCTs considered to be representative of two State listed TECs and five State listed PECs. The significance of the TECs and PECs is discussed in Section 6.1.3.1.

6.1.3 Significant Vegetation

6.1.3.1 Threatened and Priority Ecological Communities

Eight TECs and four PECs occur within or near the study area (Section 5.1.1.3). The statistical analysis of the floristic data collected from the sampling sites, in comparison with the floristic data of Gibson et al. (1994) and the floristic survey of the Swan Coastal Plain (Keighery et al., 2012), identified two TECs and four PECs within the study area. An additional PEC (Banksia dominated woodlands of the Swan Coastal Plain) is considered to occur within the study area, while there is a high likelihood that an additional PEC (*Casuarina obesa* association or Claypans with mid dense shrublands of *Melaleuca lateritia* over herbs), that is listed as a TEC under the EPBC Act, occurs within the study area. The TECs and PECs recorded from the study area include:

- Clay Pans on the Swan Coastal Plain; *Casuarina obesa* association (PEC; P1)/Claypans with mid dense shrublands of *Melaleuca lateritia* over herbs (PEC; P1 and Critically Endangered under the EPBC Act), inferred from one quadrat totalling approximately 9.8 ha.
- Mound Springs TEC (CR) known to occur within the study area with one quadrat sampled and totalling approximately 1.5 ha.
- SCP02 (Southern wet shrublands): TEC (EN) identified from one quadrat totalling approximately 1.4 ha.
- SCP20a (*Banksia attenuata* woodlands over species rich dense shrublands): TEC (EN), identified from three quadrats totalling approximately 12.3 ha.
- SCP21c (Low lying *Banksia attenuata* woodlands or shrublands): PEC (P3), identified from 23 quadrats totalling approximately 177.9 ha.
- SCP22 (*Banksia ilicifolia* woodlands): PEC (P2), identified from one quadrat (not sampled in this survey) totalling approximately 3.4 ha.
- SCP23b (Northern *Banksia attenuata* – *Banksia menziesii* woodlands): PEC (P3), identified from 10 quadrats totalling approximately 57.5 ha.
- SCP24 (Northern Spearwood shrublands and woodlands): PEC (P3), identified from three quadrats totalling approximately 8.1 ha.

In addition, the P3 PEC *Banksia* dominated woodlands of the Swan Coastal Plain occurs across the majority of the study area, especially south of Maralla Road. Fourteen of the 60 vegetation associations either have an upper stratum dominated or co-dominated by *Banksia attenuata* and *Banksia menziesii*. *Banksia attenuata* and *Banksia menziesii* were recorded from 67 and 68 sampling sites, respectively. Consequently, the 14 vegetation associations are considered to be representative of the *Banksia* dominated PEC. The approximate area covered by the Banksia dominated PEC is 483 ha within the study area.

The TECs and PECs were mostly recorded from native vegetation located between Maralla Road in the north and the Reid Highway in the south (Figure 11). The inferred identification of the Commonwealth TEC, *Claypans on the Swan Coastal Plain*, was identified from one location in the north of the study area, on the eastern side of the Great Northern Highway, north of Brand Highway, and the Mound Springs TEC is located near Gaston Road in Bullsbrook (Figure 11).

The Commonwealth listed TEC *Claypans on the Swan Coastal Plain* was inferred in association with sampling sites SVB086, while SVB085 was not included in the analysis, however it is also inferred to represent the Commonwealth listed TEC based on the presence of clay based soils and the vegetation recorded within the sampling site. The analysis of the floristic data collected from the sampling site (SVB086) was compromised due to the presence of introduced species, which resulted in the sites incorrectly assigned to either SCP11 (Wet forests and woodlands) or SCP17 (*Melaleuca rhaphiophylla – Gahnia trifida* seasonal wetlands). The sampling sites more accurately align with either the PEC (Priority 1) *Casuarina obesa* association or the PEC (Priority 1) Claypans with mid dense shrublands of *Melaleuca lateritia* over herbs. The latter is considered to represent the Commonwealth TEC *Claypans on the Swan Coastal Plain*.

The vegetation associations (Mp^{10} and Co) which are consistent with the Commonwealth TEC covers approximately 9.8 ha of the study area. The project area will impact on 0.23 ha of the Claypans on the Swan Coastal Plain TEC. It is anticipated that the TEC can be avoided through the design of the project. The Mound Springs TEC is known to occur within Bush Forever Site 97. The extent of the TEC is approximately 1.5 ha with the extent based on the vegetation associations. The mound is vegetated by closed low woodland of *Melaleuca preissiana* over a tall sedgeland of *Cyathochaeta teretifolia* (P3). The project area has been previously re-aligned to avoid impacts to the TEC (GHD, 2008).

The TEC SCP02 was identified from one sampling site mapped as vegetation association Mp^{3}. The TEC covers approximately 1.4 ha of the study area, with approximately 1.1 ha within project area. The identification of SCP02 within the study area is considered to be significant, as most occurrences are located south of Perth, generally on the Pinjarra Plains landform. The occurrence within the study area was identified from the Bassendean Dunes landform, north of Perth.

The accurate identification and delineation of the TEC SCP02 has been discussed in Section 5.5.2 and as previously mentioned, the precautionary principle has been applied to the identification of the TEC until further information can be collected and obtained.

The State listed TEC SCP20a was recorded from three locations within the study area, totalling approximately 12.3 ha. Of which, approximately 4.3 ha occurs within the project area, equating to approximately 34.9%. The area of occupancy for the TEC is considered to be indicative only, as the vegetation between Maralla Road in the north and Reid Highway in the south consists of numerous TECs and PECs and is dominated by *Banksia attenuata* and *Banksia menziesii* over the vast majority of this area. As such, it is considered this area represents several TECs and PECs and is therefore significant vegetation.

The State listed PEC SCP21c was recorded from 10 occurrences in the study area and 63.65 ha will be impacted by the project area. The State listed PEC SCP 22 was recorded from one occurrence of approximately 3.4 ha, 0.13 ha will be impacted by the project area. The State listed PEC SCB23b is known from eight occurrences from the study area and 11.64 ha will be impacted by the project area. State listed PEC SCP24 was located from 3 occurrences in the study area, 7.77 ha will be impacted by the project area.

The study area includes approximately 494 ha of conservation significant vegetation, including TECs and PECs, and which often supports conservation-significant flora. Of the 494 ha of conservation significant vegetation, approximately one-third (147 ha) is located within the project area. The conservation significant vegetation is sensitive to anthropogenic stresses, including:

- Altered surface water regimes caused by linear infrastructure such as roads, and the construction of culverts;
- Altered groundwater regimes resulting from the lowering water table associated with the project;
- Invasion of pathogens, including *Phytophthora* dieback, which affects members of the Proteaceae family, especially *Banksia,* and *Xanthorrhoea* particularly. The plant pathogens has the potentially to alter the structure of the vegetation through the removal of key species;
- Invasion of weeds, which displace native flora, especially small herbaceous flora and prevent the germination of native taxa by competing for light and nutrients. This is amplified along "edges" of the project area and native vegetation;
- The degradation of the vegetation through uncontrolled access; and
- The introduction and proliferation of feral animals impacting native fauna (which is discussed further in Coffey (2015)).

In order to conserve the significant vegetation located within the study area, the direct and indirect impacts of the project on the vegetation and the surrounding catchment need to be minimised. The impact of the project and some management and mitigation measures considered necessary to maintain the value of the vegetation is discussed in Chapter 7.

6.1.3.2 Regional Representation

The study area corresponds to seven vegetation complexes (Heddle *et al*., 1980) (Sections 3.10.2 and 5.5.3). The pre-European extent remaining, available through the Perth Biodiversity Program (2013) was reviewed to determine the regional representation and protection of the seven vegetation complexes (Table 26). The SCP portion of PMR is recognised to be a 'constrained' area and as such the Bush Forever Strategy (Government of Western Australia, 2000) and the State Planning Policy 2.8 (WAPC, 2003) recognise a retention target of 10%, compared to the 30% identified by ANZECC (2000) and adopted by the EPA (2000) for areas outside of constrained areas (i.e. the SCP portion of PMR and the Greater Bunbury region).

Following the review of pre-European extent remaining, the following vegetation complexes have greater than 30% of their pre-European extent remaining:

- Bassendean Complex-North Transition;
- Bassendean Complex-North;
- Coonambidgee Complex; and
- Reagan Complex.

The ecological impact on these four vegetation complexes is considered to be minor. Three complexes have between 10% and 30% of their pre-European extent remaining and the ecological impact on these is considered to be moderate:

- Bassendean Complex-Central and South;
- Southern River Complex; and
- Yanga Complex.

Although these vegetation complexes are all above the 10% target for constrained areas for pre-European extent remaining, three have greater than 10% of their pre-European extent within formal protection (i.e. conservation estate, Bush Forever on conservation estate and Bush Forever in Regional Parks). The

remaining four vegetation complexes have less than 10% of their pre-European extent within formal protection:

- Reagan Complex.
- Bassendean Complex-Central and South;
- Southern River Complex; and
- Yanga Complex.

The retention of vegetation good or better condition representative of the four under-protected vegetation complexes is important to maintaining the ecological integrity of the native vegetation and the fauna values that they support.

Overall, the project will have minor to intermediate ecological impact; however any impact should be placed in a cumulative context, taking historic, present and future developments into account. Where vegetation representative of the Bassendean-Central and South, Reagan, Southern River and Yanga complexes occurs in conservation estate and current Bush Forever sites along the project area, the clearing of this vegetation may potentially represent a significant impact depending on the amount of clearing within conservation estate and Bush Forever sites.

In determining the regional representation of the vegetation complexes and the significance of the impact on the regional representation, the extent of native vegetation within the project area for each vegetation complex was removed from the current pre-European extent values to revise their extent remaining (Table 26).

The clearing of native vegetation within the project area is not considered to significantly reduce the pre-European extent remaining on the Swan Coastal Plain of the seven vegetation complexes. The project will result in the reduction of the pre-European extents by less than 0.2% for all the vegetation complexes. From a regional perspective, this is considered to be a minor impact.

Table 26 Reduction in pre-European extent of vegetation complexes

Vegetation complex	Pre-European extent (ha)[2]	2013 extent (ha)[2]	Pre-European extent remaining (%)[2]	Formal protection[1] (ha)	Pre-European extent with formal protection (%)	Extent to be disturbed (ha)	Revised extent remaining (ha)	Revised extent with remaining (%)
Bassendean Complex-Central and South	87,392	24,206	27.70	6,350	7.27	99.9	24,106	27.58
Bassendean Complex-North Transition	17,640	16,126	91.42	11,480	65.08	11.2	16,115	91.35
Bassendean Complex-North	74,133	53,518	72.19	30,302	40.87	71.4	53,447	72.10
Coonambidgee Complex	6,272	2,859	45.59	650	10.37	0	2,859	45.58
Reagan Complex	9,080	3,052	33.62	579	6.37	0	3,052	33.61
Southern River Complex	57,171	11,255	19.69	3,749	6.56	88.4	11,167	19.53
Yanga Complex	26,176	4,645	17.75	758	2.90	24.9	4,620	17.65

1 Formal protection includes conservation estate, Bush Forever on conservation estate and Bush Forever in Regional Parks.
2 Perth Biodiversity Program (2013).

6.1.4 Fragmentation

The vegetation of the study area was highly fragmented, which is consistent with the remaining native vegetation on the SCP. The native vegetation recorded from the Cullacabardee and Ellenbrook region is large (comparatively) contiguous areas of native vegetation; however, they are still fragmented by urban development, infrastructure corridors and highly modified native vegetation (i.e. open disturbed paddocks in the Whiteman Park area).

The construction of the project will further fragment a highly fragmented landscape, including the areas surrounding Maralla Road, Cullacabardee and Whiteman. It is anticipated that consideration will be given to maintaining ecological corridors during the design of the project and the revegetation and rehabilitation of project within the landscaping strategy. The project area is considered to be a narrow (ranging from 100 to 200 m, excluding proposed interchanges) linear corridor and the impacts from fragmentation are not considered to be significant.

6.2 Overview of Flora

A total of 456 vascular taxa from 73 families and 234 genera were recorded. The high number of taxa is a function of the large size and linear shape of the study area, traversing numerous landforms and geological soil types, including wetlands and large remnant *Banksia* woodlands with a diverse understorey in Very Good or better condition. It is also a function of suitable seasonal conditions (spring survey), survey intensity and observer quality.

The number of vascular taxa has been augmented by previous surveys completed in spring 2012 and 2013 that covered wholly or partially the length of the study area. In total, three flora and vegetation surveys have been completed for the project area, with all surveys undertaken in the optimal flowering period for the majority of flowering species on the Swan Coastal Plain, which is spring (September to November).

Based on statistical analysis (Species Accumulation Curves), the vascular taxa recorded from the study area represents 102% of the taxa expected to occur.

6.2.1 Conservation Significant Flora

A total of 25 Threatened (Declared Rare-Extant) and 44 Priority (two P1; nine P2; 21 P3; and 12 P4) taxa potentially occur within the study area (Appendix G).

Five Threatened and 11 Priority taxa have previously been recorded within or near (within 500 m) to the project area (Section 5.1.1). This includes three Priority taxa (*Cyathochaeta teretifolia, Eryngium pinnatifidum* subsp. Palustre (G. J. Keighery 13459) and *Hypolaena robusta*) located within the project area.

During the September 2014 survey, two Threatened and eight Priority taxa were recorded in the study area (Figure 13) (Appendix M):

- *Caladenia huegelii* (T);
- *Grevillea curviloba* subsp. *incurva* (T);
- *Millotia tenuifolia* var. *laevis* (P2);
- *Poranthera moorokatta* (P2);
- *Cyathochaeta teretifolia* (P3);
- *Meeboldina decipiens* subsp. *decipiens* (P3);
- *Anigozanthos humilis* subsp. *chrysanthus* (P4);

- *Hypolaena robusta* (P4);
- *Ornduffia submersa* (P4); and
- *Stylidium striatum* (P4).

The two threatened flora recorded, *Caladenia huegelii* and *Grevillea curviloba* subsp. *incurva*, do not occur within the project area. However, the vegetation supporting the known locations are considered to be critical habitat and the protection of the vegetation within 50 m of each record should be maintained to ensure the individuals do not become locally extinct through vegetation degradation and the loss of soil stored seeds.

Several records of *Millotia tenuifolia* var. *laevis*, *Poranthera moorokatta, Anigozanthos humilis* subsp. *chrysanthus* and *Hypolaena robusta* occur within the project area, while both records of *Meeboldina decipiens* subsp. *decipiens* ms occur within the project area.

The retention and protection of records outside the project area, along with a 50 m vegetated buffer helps to ensure the survival of the individual species within the region. Two populations of *Poranthera moorokatta* (P2) and one population of *Millotia tenuifolia* subsp. *laevis* (P2) identified during the survey were recorded from Nature Reserves R46875 and R46919, located near Maralla Road and the suburb of Ellenbrook.

Additional targeted surveys should be undertaken to locate new populations and to further define the known extents to ensure the impact on the priority listed flora is reduced through the identification of new populations outside of the project area.

A further 16 taxa of significance (range extension, unusual or unique morphological characteristics) were recorded:

- *Allocasuarina campestris* (unusual/unique);
- *Amperea simulans* (range extension);
- *Aotus cordifolia* (significant flora of the PMR);
- *Boronia purdieana* (significant flora of the PMR);
- *Bossiaea eriocarpa* (unusual/unique);
- *Caladenia huegelii* (T) (significant flora of the PMR);
- *Calytrix fraseri* (unusual/unique);
- *Conospermum incurvum* (significant flora of the PMR);
- *Conostephium minus* (significant flora of the PMR);
- *Conostylis aculeata* subsp. *cygnorum* (significant flora of the PMR);
- *Conostylis teretiuscula* (range extension);
- *Croninia kingiana* (formerly *Leucopogon kingianus*) (significant flora of the PMR);
- *Cyathochaeta teretifolia* (P3) (significant flora of the PMR);
- *Dielsia stenostachya* (significant flora of the PMR);
- *Eremaea purpurea* (significant flora of the PMR);
- *Hensmania turbinata* (significant flora of the PMR);

- *Histiopteris incisa* (range extension);
- *Macarthuria apetala* (significant flora of the PMR);
- *Melaleuca amydra* (range extension);
- *Monotaxis occidentalis* (unusual/unique);
- *Ornduffia submersa* (formerly *Villarsia submersa*) (P4) (significant flora of the PMR);
- *Pithocarpa pulchella* var. *pulchella* (significant flora of the PMR);
- *Pterostylis* sp. cauline leaves (N. Gibson & M.N. Lyons 1490) (significant flora of the PMR);
- *Tetratheca hirsuta* (unusual/unique); and
- *Verticordia nitens* (significant flora of the PMR);

In addition, the nine Threatened and Priority flora identified from the study area (excluding *Caladenia huegelii*) during the survey not listed above are considered significant for the broader PMR. Although not specifically protected through the WC Act (threatened flora) or by DPAW (priority listed flora), these additional conservation significant flora are considered to be locally significant on the SCP portion of the PMR. The project area will impact on several locally significant species; however, they are also located outside of the project area, ensuring their persistence in the immediate region.

6.2.1.1 Vegetation Supporting Conservation Significant Flora

Vegetation associations that support habitat for conservation significant flora (Threatened and Priority flora) are locally significant for the continual survival of those taxa. The relevant vegetation associations are summarised in Table 27.

There are 13 vegetation associations supporting conservation significant flora, with two vegetation associations supporting threatened flora, which are particularly significant. By protecting the habitats for this flora, the survival of this flora will be assisted and ecological and landscape functions of these areas will be maintained.

Table 27 Locally significant vegetation associations supporting threatened and priority taxa

Vegetation association	Threatened and priority taxa supported
AsMlEvCl	*Meeboldina decipiens* subsp. *decipiens* ms
BaBm[1]	*Poranthera moorokatta*
BaBm[2]	*Anigozanthos humilis* subsp. *chrysanthus; Hypolaena robusta;* and *Millotia tenuifolia* var. *laevis*
Bl	*Poranthera moorokatta*
Cc/Mp	*Millotia tenuifolia* var. *laevis;* and *Poranthera moorokatta*
CcEm[2]	*Millotia tenuifolia* var. *laevis*
CcMpMr	*Grevillea curviloba* subsp. *incurva*
Em[2]	*Stylidium striatum*
Er[3]	*Poranthera moorokatta*
Er[6]	*Ornduffia submersa*

Vegetation association	Threatened and priority taxa supported
Et[2]	*Anigozanthos humilis* subsp. *chrysanthus; Caladenia huegelii; Hypolaena robusta;* and *Poranthera moorokatta*
Mp[1]	*Cyathochaeta teretifolia*
Mp[6]	*Cyathochaeta teretifolia*

6.2.2 Introduced Flora

A total of 99 introduced Flora were recorded including four WONS (**Asparagus asparagoides, *Eichhornia crassipes, *Opuntia stricta* and *Rubus laudatus*) and six Declared Pests (**Moraea flaccida, *Zantedeschia aethiopica* and the four WONS).

Landowners and land managers at all levels are responsible for managing WONS and Declared Pests. The management and control categories for each of the WONS and Declared Pest are provided in Appendix I.

Weed invasion was relatively high across the majority of the study area, in particular where clearing and urban development is high (Rocla, Ellenbrook and Cullacabardee) and in association with disturbed waterways and wetlands (Ellen Brook, the palusplain zone north of Warbrook Road). Weeds such as, Kikuyu grass (**Cenchrus clandestinus*) occurred throughout the open paddocks and disturbed waterways and wetlands north of Maralla Road. In other areas, there were scattered patches of non-invasive weeds in the large, resilient remnants of native vegetation (i.e. in the Ellenbrook region and Cullacabardee).

The proposed development will need to implement effective weed hygiene measures to prevent the spread of these species and the introduction of new species to the area. This is particularly important for adjacent areas that have vegetation associations in Very Good to Pristine condition, including the Ellenbrook region, Cullacabardee and the Tonkin Highway and Reid Highway interchange. In addition, weed management and control is required within the vegetation associated with the Mound Springs located adjacent to the project area. Arum Lily and Blackberry was recorded in high densities within this ecologically significant community.

7 IMPACT ASSESSMENT

7.1 Methods and Approach

The criteria used in determining the level of impact on vegetation (vegetation associations) and conservation significant flora are provided in Table 28 and Table 29, respectively. The impact on vegetation has been determined based on the National Objectives and Targets for Biodiversity Conservation 2001–2005 (ANZECC, 2000) and the values adopted by the EPA (EPA, 2000). Retention of 30% or more of the pre-clearing extent (the extent of a vegetation complex existing in Western Australia pre-European settlement) of each vegetation complex is necessary for the protection of Australia's biological diversity. Biodiversity loss increases exponentially when less than 30% of the ecological community remains (EPA, 2000; ANZECC, 2000). The EPA has adopted a 10% target of the pre-clearing extent below which vegetation is 'endangered' (EPA, 2000).

Therefore, a loss of greater than or equal to 90% of the vegetation association (VA) existing within the study area was considered to be a high impact, while a loss of 70 to 89% of the VA was considered to be a moderate impact. A loss of 11 to 69% of the VA was considered to be a low impact while a loss of less than 10% was negligible (Table 28). In addition to the percentage loss of vegetation associations in determining the impact, the presence of PECs or TECs will increase the impact rating.

Table 28 Impact assessment rating for vegetation associations

Impact rating	% loss of vegetation associations
Negligible	<10% loss of individual vegetation associations and does not support any known TECs or PECs
Low	11 to 69% loss of individual vegetation associations and does not support any known TECs or PECs
Moderate	70 to 89% loss of individual vegetation associations or is known to support a known PEC
High	>90 loss of individual vegetation associations or is known to support a known TEC

Impact to vegetation on a regional scale (the Swan Coastal Plain bioregion and the Perth subregion) was determined using the broad-scale mapping undertaken by Heddle et al. (1980). To determine regional significance, the current extent remaining of the mapped vegetation complexes (Heddle et al., 1980) will be updated to include the loss of vegetation within the study area. The values adopted by the EPA (2000) will be utilised to determine regional significance.

For the purposes of this assessment, clearing of a vegetation community (i.e. vegetation associations mapped from the study area) supporting greater than 30% of the known conservation significant flora population within the study area is considered a high impact. Clearing of 11 to 30% of the known population is considered to be a moderate impact, while clearing less than 10% of the known population low impact. If none of the known conservation significant flora populations within the study area are cleared then the impact is negligible (Table 29).

However, these classifications may be adjusted if the population is of local and regional significance (Table 29). For example, if the entire population of significant flora recorded from the study area occurs within the project area and that population represents a new record in a subregion with all other records

located more than 100 km away, then the loss of that population is considered to impact on the local significance of the taxa (i.e. local extinction) and the impact would be considered to be moderate. The impact ratings are arbitrary and open to change where appropriate.

Table 29 Impact assessment rating for conservation significant flora

Impact rating	Impact assessment
Negligible	No clearing and/or impact on conservation significant taxa
Low	Clearing and/or impact on less than 10% of the conservation significant flora population within the study area. Or No impact on the local and regional significance.
Moderate	Clearing and/or impact on 11 to 30% of the conservation significant flora population within the study area. Or Loss of local significance but not the regional significance.
High	Clearing and/or impact on greater than 31% of the conservation significant flora population within the study area. Or Loss of both regional and local significance.

7.2 Vegetation

Approximately 296 ha of intact native vegetation occur within the project area. This equates to approximately 39% of native vegetation of the project area. The remaining 61% (or 469 ha) of the project area consists of either open paddocks with scattered paddock trees, infrastructure or roads and areas considered to be cleared. The overall impact on the vegetation of the project area is considered to be low based on the criteria detailed in Table 28.

7.2.1 Regional Significance

The pre-European extent remaining for each of the vegetation complexes occurring within the project area is detailed in Table 26.

The clearing of native vegetation of the project area will not reduce the current extent remaining to levels near the 10% endangered level set by the EPA (2000). Of the seven vegetation complexes occurring within the project area, only the Bassendean-Central and South, Southern River and Yanga complexes are below the minimum 30% threshold for pre-European extent remaining on the Swan Coastal Plain.

The PMR of the Swan Coastal Plain is considered to be a 'constrained area' (Government of Western Australia, 2000) and as such the minimum target for retention in constrained areas is 10%. Therefore, the pre-European extent remaining for each of the vegetation complexes is above the 10% minimum level, including the proposed clearing within the project area. As a result, the clearing associated with the project is considered to have a negligible impact on the pre-European extent of each of the vegetation complexes occurring within the project area.

7.2.2 Local Significance

In determining the impact of the proposed project area on the local significance of the vegetation associations recorded from the study area, the percentage extent of each vegetation association was calculated (Table 30) based on the total disturbance area of 765 ha (Table 30).

Table 30 Extent of the mapped vegetation associations proposed to be cleared

Unit code	Area (ha)		% disturbance	Presence of relevant TEC/PEC	Impact
	Study area	Project area			
As	3.4	1.9	55.9		Low
AsMlEvCl	5.4	5.4	100.0		High
Ba	3.7	3.7	100.0	SCP21c	High
BaBm[1]	41.7	11.2	26.9	SCP23b; SCP21c	Moderate
BaBm[2]	147.6	26.7	18.1	SCP20a; SCP23b; SCP21c	High
BaBm[3]	41.9	28.8	68.7	SCP24; SCP23b; SCP21c	Moderate
BaBmMp	7.5	7.2	96.0	SCP21c	High
Bl	4.8	0.0	0.0		Negligible
BlMp	8.2	0.0	0.0		Negligible
Cc[1]	263.2	62.1	23.6		Low
Cc[2]	7.6	1.7	22.4		Low
Cc[3]	3.7	3.0	81.1		Moderate
Cc[4]	13.4	1.5	11.2		Low
Cc[5]	45.1	23.1	51.2		Low
Cc[6]	16.9	0.0	0.0		Negligible
Cc[7]	4.9	2.6	53.1	SCP21c	Moderate
Cc/Mp	15.8	0.4	2.5	SCP21c	Moderate
CcEm[1]	3.9	0.0	0.0	SCP21c	Negligible
CcEm[2]	92.5	27.0	29.2	SCP23b; SCP21c	Moderate
CcEr[1]	9.3	2.2	23.7		Low
CcEr[2]	20.6	12.1	58.7		Low
CcMp	1.0	0.9	90.0	SCP21c	High
CcMpMr	11.1	1.1	9.9		Negligible
Co	5.2	0.2	3.8	Claypan TEC	High
Em[1]	7.6	3.7	48.7	SCP24; SCP21c	Moderate
Em[2]	30.4	0.0	0.0		Negligible
Ep	4.8	0.0	0.0	SCP21c	Negligible
EpRi	0.9	0.9	100.0		High

Unit code	Area (ha)		% disturbance	Presence of relevant TEC/PEC	Impact
	Study area	Project area			
Er[1]	8.3	1.7	20.5		Low
Er[2]	4.8	0.0	0.0		Negligible
Er[3]	12.8	0.0	0.0		Negligible
Er[4]	3.5	0.0	0.0		Negligible
Er[5]	0.9	0.0	0.0		Negligible
Er[6]	51.8	5.7	11.0		Low
Er[7]	4.4	0.1	2.3		Negligible
Er[8]	6.2	0.7	11.3		Low
ErCo	4.7	2.0	42.6		Low
ErMp	11.7	7.6	65.0		Low
ErMrMc	2.3	0.0	0.0		Negligible
Et[1]	13.8	3.6	26.1	SCP20a; SCP23b	High
Et[2]	81.9	24.4	29.8	SCP23b; SCP21c	Moderate
Et[3]	20.5	4.8	23.4		Low
Mp[1]	1.5	0.0	0.0	Mound Springs SCP	Negligible
Mp[2]	8.5	0.1	1.2	SCP22	Moderate
Mp[3]	5.3	1.1	20.8	SCP02	High
Mp[4]	12.5	0.8	6.4		Negligible
Mp[5]	1.4	1.2	85.7		Moderate
Mp[6]	2.7	1.3	48.1		Low
Mp[7]	3.1	0.1	3.2		Negligible
Mp[8]	9.4	5.2	55.3		Low
Mp[9]	0.9	0.0	0.0		Negligible
Mp[10]	4.6	0.1	2.2	Claypan TEC	High
MpAl	4.3	2.4	55.8		Low
MpBl	5.4	0.0	0.0		Negligible
MpCc	1.3	0.3	23.1		Low
MpMr	7.1	1.4	19.7		Low
PeAsMtMl	8.4	0.0	0.0		Negligible
Xp[1]	8.4	1.3	15.5		Low
Xp[2]	35.3	17.1	48.4		Low

Unit code	Area (ha)		% disturbance	Presence of relevant TEC/PEC	Impact
	Study area	Project area			
CcEr[3]	665.5	99.3	14.9		Low
Pr	8.6	3.4	39.5	SCP21c	Moderate
Pp	74.6	49.2	65.0		Negligible
R	35.9	7.0	19.5		Negligible
Rehab	11.2	1.7	15.2		Negligible
Cl	1,109.1	294.1	26.5		N/A
Total	**3,061.3**	**765**	**25.0**		

N/A – Not applicable

The impact on vegetation is:

- High for ten vegetation associations (49.8 ha or 6.5% of the project area).
- Moderate for 11 vegetation associations (105.8 ha or 13.8% of the project area).
- Low for 21 vegetation associations (255.4 ha or 33.4% of the project area).
- Negligible for 22 vegetation associations (60.0 ha or 7.8% of the project area).

Five associations (Co, Mp[3], Mp[10], Et[1] and BaBm[2]) rated as highly impacted are a result of the presence of a TEC (Claypans, SCP02 and SCP20a) within the project area. The remaining five vegetation associations rated as a high impact are due to the expected clearing of more than 90% within the project area.

Three sites, SVB011, 360Q03 and 360Q39 represent a TEC and are located within the project area, resulting in the direct loss of TEC SCP20a (360Q03 and 360Q39) and the potential direct loss of TEC SCP02 (SVB011) (dependent on further sampling and analysis as discussed in Section 5.5.2 and Section 6.1.3).

The impact to vegetation associations Co and Mp[10] are considered high due to the presence of the Claypans on the Swan Coastal Plain TEC, however, it is anticipated that the design of the project can avoid the known location of the TEC. However, due to the current expected disturbances, the impact remains high.

The vegetation recorded from flora sampling site SVB016 is consistent with the TEC SCP20a but is located outside of the project area. Therefore this TEC is not directly impacted in this location.

Only two (Cc[3] and Mp[5]) of the 11 vegetation associations rated moderately impacted are due to the clearing of 70 to 89% of the mapped extent. The remaining nine vegetation associations are below 70%; however, several PECs (SCP21c, SCP22, SCP23b and SCP24) are located within the mapped extent of the vegetation associations (Mp[2], Cc/Mp, BaBm[1], CcEm[2], Et[2], Pr, Em[1], Cc[7] and BaBm[3]).

The remaining 46 vegetation associations will experience low or negligible impact, with one mapping unit ('Cleared') not relevant as it is already cleared.

7.2.3 Fragmentation of Ecological Corridors

The clearing of native vegetation and the construction of the highway will impact on the known ecological linkage corridors that traverse across the project area (Section 5.5.4). The key area of concern occurs in the Cullacabardee and Whiteman Park region, where the project area will further fragment the large areas of remnant native vegetation, including the six regional ecological linkages traversing the project area. The current project area alignment occurs along the western edge of the Ellenbrook suburb, which will have minimal fragmentation.

The impacts to fauna have been addressed within a separate Fauna Assessment report prepared by Coffey (2015). Fauna underpasses and dual use culverts have been proposed at strategic locations along the project area to assist with the movement of fauna.

The fragmentation of the vegetation may impact on the condition and integrity of the vegetation as a result of edge effects. Where possible, the project area has been designed to avoid creating 'pockets' of native vegetation that are isolated from larger areas. Small fragments of native vegetation have a higher propensity to degrade quicker from introduced weeds, uncontrolled access and dumping of refuse as a result of edge effects.

Small fragmented areas of native vegetation will occur in the Tonkin Highway and Reid Highway interchange, east of Rocla mine near Drumpellier Drive, Ellenbrook area and near Gaston Road. The fragmentation of these small pockets of native vegetation should be managed appropriately to ensure vegetation degradation is minimised.

7.3 Native Flora

Two Threatened taxa (*Caladenia huegelii* and *Grevillea curviloba* subsp. *incurva*) and eight Priority taxa(*Millotia tenuifolia* var. *laevis* (P2), *Poranthera moorokatta* (P2), *Cyathochaeta teretifolia* (P3), *Meeboldina decipiens* subsp. *decipiens* (P3), *Anigozanthos humilis* subsp. *chrysanthus* (P4), *Hypolaena robusta* (P4), *Ornduffia submersa* (P4) and *Stylidium striatum* (P4)) were recorded. Of the ten conservation significant taxa occur in the study area, only five Priority flora (*Anigozanthos humilis* subsp. *chrysanthus, Hypolaena robusta, Meeboldina decipiens* subsp. *decipiens* ms, *Millotia tenuifolia* var. *laevis* and *Poranthera moorokatta*) are located within the project area. The remaining five taxa are located outside of the project area and will not be directly impacted.

The key potential impacts on conservation significant flora include:

- Local extinction of conservation significant taxa through the direct clearing of individual/populations and the loss of habitat.
- Habitat fragmentation.
- Habitat degradation via the introduction of weeds and *Phytophthora* Dieback.

The direct impact to the ten conservation significant flora species and the populations recorded within the study area has been assessed from a regional scale in Table 31. Excluding *Millotia tenuifolia* var. *laevis* and *Meeboldina decipiens* subsp. *decipiens* ms, the regional impact on the proportion of individuals for the remaining eight conservation significant species is considered to be negligible with between 0 and 1% impacted by the project.

Based on available information, the project will impact on approximately 20% of the known individuals of *Millotia tenuifolia* var. *laevis* and 50% of the known individuals of *Meeboldina decipiens* subsp. *decipiens* ms.

Table 31 Impacts on Threatened and Priority Flora

Species	Conservation Status	Total Number of Known Populations[1]	Number of populations known within the study area	Number of populations to be impacted within the project area	Proportion of populations to be impacted (%)	Total minimum number of known Individuals	Number of Individuals within study area	Number of known individuals to be impacted within project area	Proportion of known individuals within project area to be impacted (%)
Caladenia huegelii	T	19	1	0	0	355	1	0	0
Grevillea curviloba subsp. *incurva*	T	24	3	0	0	682	137	0	0
Millotia tenuifolia var. *laevis*	P2	11	4	2	18.2	15	7	3	20.0
Poranthera moorokatta	P2	4	2	1	25.0	2508	7	1	0.04
Meeboldina decipiens subsp. *decipiens ms*	P3	12	2	2	16.7	22	11	11	50.0
Cyathochaeta teretifolia	P3	30	2	1	3.3	1375	30	9	0.65
Anigozanthos humilis subsp. *chrysanthus*	P4	18	2	1	5.6	1334	4	2	0.15
Hypolaena robusta	P4	30	3	3	10.0	17,742	25	17	0.10
Ornduffia submersa	P4	43	1	0	0	10,297	1	0	0
Stylidium striatum	P4	24	1	0	0	2965	1	0	0

[1] DPAW Threatened and priority flora search and Florabase.