LandCorp

Denmark East Development Precinct
Eastern Section Flora and Fauna Survey

November 2016

Executive summary

Introduction

Through the Royalties for Regions “Growing our South” initiative, the Shire of Denmark has received funding to provide a second crossing of the Denmark River, to upgrade approximately 6.5 km of local roads and to support the delivery of an industrial estate adjacent to McIntosh Road.

GHD Pty Ltd (GHD) was commissioned by LandCorp to undertake a biological assessment of the project survey area. The purpose of the assessment was to identify and describe flora, vegetation and fauna within the survey area. The outcomes of the assessment will be used in the environmental assessment and approvals process and will identify the possible need for, and scope of, further field investigations will inform environmental impact assessment of the road upgrades. This report considers only the eastern portion of the proposed upgrade, with reporting on the western section, including the Denmark River crossing, being provided in a separate document. The survey area was approximately 36 ha in area and broadly includes the road reserve and adjacent land along East River Road and McIntosh Road between the Denmark Mt Barker Road and South Western Highway. A 200 m section north and south along the Denmark Mt Barker Road from East River Road was also surveyed.

The biological assessment involved a desktop review and three separate field surveys, including a winter flora and fauna survey, spring flora and fauna survey and spring nocturnal fauna survey. Fauna surveys also included the use of movement sensitive cameras in key locations.

Key biological aspects

The key biological aspects and constraints identified for the survey area are summarised in the following table.

Key biological aspects within the survey area

Biological values	Constraints identified
Remnant vegetation	The three pre-European vegetation types mapped by Beard (1979) are represented by at least 32% remaining at the Local Government, bioregional and Western Australian scales
Conservation significant vegetation types	No vegetation representative of Threatened or Priority Ecological Communities was recorded or is considered likely to be present.
Riparian vegetation	Vegetation associated with dampland zones was recorded within the survey area and includes: — *Melaleuca preissiana, Homalospermum firmum* and *Kunzea ericifolia* shrubland — *Evandra aristata, Anarthria prolifera* and *Leptocarpus tenax* sedgeland — *Tremulina tremula, Mesomelaena tetragona* and *Lepidosperma pubisquameum* sedgeland

Biological values	Constraints identified
Conservation significant flora species	One record of a Priority 4 flora species, *Laxmannia jamesii*, was recorded during the surveys. The likelihood of occurrence identified 24 conservation significant species which may occur within the survey area.
Conservation significant fauna species	The field surveys and camera trapping identified four conservation significant species: Baudin's and the Forest Red-tailed Black Cockatoos, the Southern Bush-tailed Phascogale (EPBC Act listed) the Southern Brown Bandicoot, a Priority 4 species. The likelihood of occurrence identified eight conservation significant species which are considered likely to occur within the survey area. Of these, two species are listed under the EPBC Act.
Black Cockatoo habitat	Suitable foraging and roosting habitat was recorded throughout the survey area in the Eucalyptus and *Allocasuarina* woodland habitats. 174 potential breeding trees were recorded within the survey area, with 9 of them supporting large hollows, 2 with medium hollows and 2 with small hollows. The timing of the September survey was within the breeding season of Baudin's and Carnaby's Black Cockatoo with no breeding events recorded in this area. One Forest Red-tailed Black Cockatoo hollow was recorded with chews consistent with a breeding tree. The hollow was inspected at not currently in use.
Southern Brushtailed Phascogale habitat	Species was recorded during the survey and is know from the local area and region. Primarily uses all of the woodland (20.57 ha) as habitat in the survey area. The remainder of the habitat may be utilised opportunistically as a foraging/hunting resource or for dispersal.

Environmental approvals and referrals

The following recommendations are provided based on a preliminary assessment of key biological constraints for the survey area (not the impact area):

Referral under the EPBC Act

Matters of National Environmental Significance	Species/ Community	Assessment of referral requirement
Threatened Species (flora) and Ecological Communities	None identified from July/September assessment	Not required
Threatened Species (fauna)	Baudin's Black Cockatoo were recorded feeding in the survey area	Foraging and breeding habitat present. Referral will depend on the final impact area and quality of impacted habitat.
Threatened Species (fauna)	Carnaby's Black-Cockatoo are likely to be present	Foraging habitat present. This species has not previously been recorded breeding in the Denmark area. Referral will depend on the final impact area and quality of impacted habitat.

Matters of National Environmental Significance	Species/ Community	Assessment of referral requirement
Threatened Species (fauna)	Forest Red-tailed Black-Cockatoo were recorded feeding in the survey area	Foraging and breeding habitat present. The timing of the September survey was within the breeding season for this species and one Forest Red-tailed Black Cockatoo was recorded sitting in the entrance to a hollow. Referral will depend on the final impact area and quality of impacted habitat.
Threatened Species (fauna)	Chuditch are likely to be present	Referral unlikely to be required. No Chuditch were recorded during either the field surveys or camera survey.
Listed Migratory Species	None present – no species were recorded from the survey area during the July or September 2016 surveys.	

Western Australian approvals

Referral under Part IV of Environmental Protection Act, 1986 is not considered necessary, as the impacts are primarily associated with flora and fauna, which can be considered under Part V of the Act (Native Vegetation Clearing Permit).

The Federal and Western Australian governments have entered into a bilateral agreement under the EPBC Act relating to environmental assessment (assessment bilateral agreement). Specifically, this agreement now includes the clearing permit assessment process under Part V Division 2 of the EP Act. Under the assessment bilateral agreement, if a native vegetation clearing permit is required and the clearing will have or is likely to have an impact on a MNES, the assessment of the clearing application including the potential impacts to the MNES can be conducted by the DER or Department of Minerals and Petroleum under delegation.

Four fauna species listed under the EPBC Act (MNES) and Wildlife Conservation Act were recorded within the survey area during the field surveys, and a further seven fauna species listed under the Acts were considered likely to occur as they are known from the area and suitable habitat is present for them.

As such, any clearing permit application should assess the significance of any potential impacts of the proposed clearing area on these aspects, and the assessment of the potential impacts to the MNES can be can be assessed by DER under the bilateral agreement.

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1. Introduction

1.1 Background and purpose of this report

Through the Royalties for Regions “Growing our South” initiative, the Shire of Denmark has received funding to provide a second crossing of the Denmark River, to upgrade approximately 6.5 km of local roads and to support the delivery of an industrial estate adjacent to McIntosh Road.

GHD Pty Ltd (GHD) was commissioned by LandCorp to undertake a biological assessment of the project survey area. The purpose of the assessment was to identify and describe flora, vegetation and fauna within the survey area. The outcomes of the assessment will be used in the environmental assessment and approvals process and will identify the possible need for, and scope of, further field investigations will inform environmental impact assessment of the road upgrades. This report considers only the eastern portion of the proposed upgrade, with reporting on the western section, including the Denmark River crossing, being provided in a separate document.

1.2 Location

1.2.1 Survey area

The survey area is approximately 36 ha in area and broadly includes the road reserve and adjacent land along East River Road and McIntosh Road between the Denmark Mt Barker Road and South Western Highway. A 200 m section north and south along the Denmark Mt Barker Road from East River Road was also surveyed.

The location of the survey area is shown in Figure 1, Appendix A.

1.2.2 Study area

A study area has been defined for the desktop based searches for the biological assessment and includes a 10 km buffer around the survey area. This area provides local context for the assessment.

1.3 Scope of works

The scope of works, as detailed in the LandCorp Request for Service was to:

- Undertake a desktop assessment of the study area
- Undertake a biological survey of the survey area to provide:
  - Description and mapping of vegetation units and vegetation condition
  - Assessment of plant species diversity, density, composition, structure and weed cover in quadrats
  - Location and extents of any Threatened or Priority Flora
  - Inventory of flora and fauna species
  - Description and mapping of fauna habitat
  - Identification and mapping of trees / areas which are potential Black Cockatoo or Western Ringtail Possum habitat (i.e. >500 mm diameter at breast height, DBH), or with suitable hollows or known possum habitat species

- Prepare a biological survey report that documents the results of the desktop assessment and field survey, assesses (and where applicable recommends) the requirement for referral to statutory authorities or other clearances for the project.

1.4 Relevant legislation, conservation codes and background information

In Western Australia some ecological communities, flora and fauna are protected under both Australian and State Government legislation. In addition, regulatory authorities also provide a range of guidance and information on expected standards and protocols for environmental surveys.

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

1.5 Report limitations and assumptions

This report has been prepared by GHD for LandCorp and may only be used and relied on by LandCorp for the purpose agreed between GHD and the LandCorp as set out in section 1.1 of this report.

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

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

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

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

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

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

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

Site conditions may change after the date of this report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change. This report has assessed the flora and fauna within the survey area (Figure 1, Appendix A). Should the survey area change or be refined, further assessment may be required.

2. Methodology

2.1 Desktop assessment

Prior to the commencement of the field survey a desktop assessment was undertaken to identity relevant environmental information pertaining to the study area and to assist in survey design. This included a review of:

- Available and relevant reports of the survey area and surrounds
- The Department of the Environment (DotE) Protected Matters Search Tool (PMST) to identify communities and species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) potentially occurring within the study area (DotE 2016a) (Appendix C)
- The Department of Parks and Wildlife (DPaW) Threatened Ecological Communities (TEC) and Priority Ecological Communities (PEC) database to determine the potential for TECs or PECs to be present within the study area
- The DPaW's NatureMap database for flora and fauna species previously recorded within the study area (DPaW 2007–) (Appendix C)
- The DPaW Threatened and Priority Flora database (TPFL) and Western Australian Herbarium database (WAHERB) for Threatened and Priority flora species listed under the *Wildlife Conservation Act 1950* (WC Act) and listed as Priority by DPaW, previously recorded within the study area
- Existing datasets including previous vegetation mapping of the study area (Beard 1979), to provide background information on the variability of the environment, likely vegetation units and fauna habitats and to identify areas with potential to contain TECs, PECs, and Threatened and Priority listed flora and fauna species.

2.2 Field survey

2.2.1 Vegetation and flora

GHD botanist (Gaynor Owen) conducted the first phase of the Level 2 vegetation and flora assessment of the survey area from 27 to 29 July 2016. Megan Dilly (GHD Botanist) conducted the second phase of the Level 2 survey from the 5 to 7 September 2016. The field surveys were undertaken to verify the results of the desktop assessment, identify and describe the dominant vegetation units, assess vegetation condition and identify and record vascular flora taxa present at the time of survey. Searches for conservation significant ecological communities and flora taxa were also undertaken.

The survey methodology employed by GHD was undertaken in accordance with the Environmental Protection Authority (EPA) *Guidance Statement No. 51 Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004a)

Data collection

Field survey methods involved sampling quadrats and releves located in identified vegetation units and traversing the survey area by foot and vehicle. Nine quadrats (measuring 10 m x 10 m – area of 100 m^2) were utilised for data collection within the survey area. Field data at each quadrat was recorded on a pro-forma data sheet and included the parameters detailed in Table 1.

Table 1 Data collected in quadrats

Aspect	Measurement
Collection attributes	Personnel/recorder; date, quadrat dimensions, photograph of the quadrat.
Physical features	Aspect, soil attributes, ground surface cover, leaf and wood litter.
Location	Coordinates recorded in GDA94 datum using a hand-held Global Positioning System (GPS) tool to accuracy approximately ± 5 m.
Vegetation condition	Vegetation condition was assessed using the Bushland Vegetation Condition rating scale (EPA/DPAW 2015)
Disturbance	Level and nature of disturbances (e.g. weed presence, fire and time since last fire, impacts from grazing, exploration activities).
Flora	List of dominant flora from each structural layer. List of all species within the quadrat including average height and cover (using a modified Braun-Blanquet scale)

A flora inventory was compiled from taxa listed in described quadrats and from opportunistic floristic records throughout the survey area.

Vegetation units

Vegetation units were identified and boundaries delineated using a combination of aerial photography, topographical features and field data/observations.

Vegetation units were described based on structure, dominant taxa and cover characteristics as defined by quadrat data and field observations. Vegetation unit descriptions follow the National Vegetation Information System (NVIS) and are consistent with NVIS Level V (association), and are grouped within NVIS Level III (broad floristic formation). At Level V up to three taxa per stratum are used to describe the association (Executive Steering Committee for Australian Vegetation Information (ESCAVI) 2003)).

Vegetation mapping has been undertaken at a scale of 1:6,000; this is considered a suitable scale for this project.

Vegetation condition

The vegetation condition of the survey area was assessed and mapped in accordance with the vegetation condition rating scale published by EPA/DPaW 2015. The scale recognises the intactness of vegetation, level of disturbance and weeds and the inherent ability of the remnant to be returned to a natural state without intensive intervention and consists of seven rating levels as outlined in 0.

Flora identification and nomenclature

Species that were well known to the survey botanist were identified in the field; all other species were collected and assigned a unique collection number to facilitate tracking. Flora identification was undertaken by Megan Dilly. Plant species were identified by the use of local and regional flora keys and by comparison with the named species held at the Western Australian Herbarium.

The conservation status of all recorded flora was compared against the current lists available on *FloraBase* (WA Herbarium 1998–) and the EPBC Act List of Threatened Flora (DotE 2016b).

Nomenclature used in this report follows that used by the Western Australian Herbarium as reported on *FloraBase* (WA Herbarium 1998–).

Surveys for conservation significant flora

Prior to the field survey, information obtained from the desktop assessments (e.g. aerial photography, EPBC Act PMST, TPFL, *NatureMap* and the WAHERB databases search results) was reviewed to determine conservation significant flora taxa potentially present within the survey area. Additionally, ecological information (e.g. habitat, associated flora taxa and phenology) was sourced from *FloraBase* (WA Herbarium 1998–) and other relevant publications where available, to provide further details.

Potential habitats were searched by transect sampling and opportunistic sampling. Locations within the survey area with differing hydrology, fire or disturbance history to the surrounding areas were also searched, where identified.

2.3 Fauna

GHD ecologist (Glen Gaikhorst) undertook a Level 1 fauna survey (reconnaissance survey) of the survey area from 27 to 28 July and again from the 5 to 7 September 2016. The fauna surveys were undertaken in conjunction with the vegetation and flora assessment and with reference to EPA *Guidance Statement No. 56* T*errestrial Fauna Survey for Environmental Impact Assessment in Western Australia* (EPA 2004b). The purpose of the reconnaissance survey was to verify the accuracy of the desktop study, and to delineate and characterise the fauna and faunal assemblages present in the survey area.

The majority of the survey area was traversed on foot and by vehicle over the course of five days (in total) to identify and describe the dominant fauna habitat types present and their condition, assess habitat connectivity, identify and record fauna species within the survey area. An assessment of the likelihood of conservation significant fauna and their habitats occurring within the survey area was also undertaken.

Following the reconnaissance surveys a targeted night-time survey was undertaken over three nights from the 4 to 6 October by GHD Senior Ecologist Craig Grabham.

Habitat assessment

A fauna habitat assessment was undertaken to document the type, condition and extent of habitats within the survey area. The following information was recorded:

- Habitat structure (e.g. vegetation type, presence/absence of structural layers such as ground cover and mid storey)
- Presence/absence of refuge including: density of ground covers, fallen timber (coarse woody debris), hollow-bearing trees and stags and rocks/boulder piles, and the type and extent of each refuge
- Presence/absence of waterways including type, extent and habitat quality within waterways
- Location of the habitat within the survey area in comparison to the habitat within the surrounding landscape
- Habitat connectivity and identification of wildlife corridors within and immediately adjacent to the survey area
- Current land use and disturbance history
- Evaluation of key habitat features and types identified during the desktop assessment relevant to fauna of conservation significance
- Evaluation of the likelihood of occurrence of conservation significant fauna within the habitat (based on presence of suitable habitat)

- A representative photograph of each habitat type.

Opportunistic fauna searches

Opportunistic fauna searches were also conducted across the survey area. Opportunistic searches involved:

- Searching the survey area for tracks, scats, bones, diggings and feeding areas for both native and feral fauna
- Searching through microhabitats including turning over logs or rocks, turning over leaf litter and examining tree hollows and hollow logs
- Visual and aural surveys, which accounted for many bird species potentially utilising the survey area
- Establishing three, movement sensitive cameras within the survey area for a total survey period of 120 nights. The cameras were set up at locations which were potential usage areas for Southern Brush-tailed Phascogale and Western Ringtail Possum. These cameras were deployed to supplement the species inventory list and to assist in verifying the presence/absence of conservation significant fauna species.
- Recording GPS locations of any conservation significant fauna species.

Black Cockatoos

A targeted survey for Black Cockatoo was conducted in accordance with the EPBC Act referral guidelines for three threatened black cockatoo species: Carnaby's Cockatoo (endangered) *Calyptorhynchus latirostris*, Baudin's Cockatoo (vulnerable) *Calyptorhynchus baudinii*, Forest Red-tailed Black Cockatoo (vulnerable) *Calyptorhynchus banksii naso*, (Department of Sustainability, Environment, Water, Populations, and Communities (DSEWPaC 2012). The assessment included:

- The identification and recording (via GPS) of the locations of potential and actual breeding habitat within the survey area (relevant tree species with a DBH of >500 mm)
- Identifying, describing and recording the size of existing tree hollows and any evidence of use by Black Cockatoos within the survey area
- Identifying, describing and recording the diameter at breast height (DBH) of trees with existing hollows within the survey area.
- Identifying, recording and describing the locations of potential night roosting habitat
- Identifying, recording and describing the locations of potential foraging habitat.

The survey distinguished between actual and potential breeding habitat as per the following:

1) Actual nest trees: Evidenced as currently being used or have been used in the past

2) Potential habitat: Trees with available hollows that do not show evidence of use now or in the past

3) Potential habitat: Trees with hollows that do not show evidence of use now or in the past where the hollow is not available (e.g. hollows are occupied by bees or galahs)

4) Potential habitat: Those trees without hollows but which have the potential to develop hollows in the future, and which have DBH >500 mm for Jarrah, Marri and Karri.

Targeted nocturnal animal survey

Spotlighting surveys were conducted to target the Southern Brush-tailed Phascogale, Western Western Ringtail Possum and other nocturnal fauna. Two ecologists using hand held spotlights

walked seven pre-determined transects (totalling 2.2 km) each night for three consecutive nights. All fauna observed or heard were recorded including the following details: species; GPS point; approximate distance from the observer and habitat.

In addition to the pre-determined transect walks, random spotlighting searches were undertaken of areas located between the transects to increase survey effort within the survey area. Spotlighting surveys were also undertaken in the western precinct along the length of the Denmark River to increase survey effort and understand the local extent of the target species. All fauna observed or heard were recorded including species and GPS point.

Fauna species identification

Identification of fauna species was made in the field using available field guides and electronic guides (e.g. Morcombe 2014). Where identification was not possible, photographs of specimens were collected to be later identified.

Nomenclature used in this report follows that used by the Western Australian Museum and the DPaW NatureMap database (DPaW 2007–) with the exception of birds, whereby Christidis and Boles (2008) was used.

2.4 Limitations

2.4.1 Desktop limitations

The EPBC Act PMST is based on bioclimatic modelling for the potential presence of species. As such, this does not represent actual records of the species within the area. The records from the DPaW searches of threatened flora and fauna provide more accurate information for the general area. However, some records of collections, sightings or trappings can be dated and often misrepresent the current range of threatened species.

New Wildlife Conservation (Rare Flora) and Wildlife Conservation (Specially Protected Fauna) Notices were gazetted on 3 November 2015. The format of these Notices has been changed to align with the EPBC Act threatened species lists. To date information contained in publically available databases such as *NatureMap* does not reflect these newly gazetted Notices. This report has been updated to reflect the conservation status of flora and fauna listed in these Notices. However, the outputs of database searches contained in this report such as *NatureMap*, does not reflect the conservation status of flora and fauna listed in these Notices.

2.4.2 Field survey limitations

Guidance Statements No. 51 and No. 56 (EPA 2004a, 2004b) state that flora and fauna survey reports for environmental impact assessment in Western Australia should contain a section describing the limitations of the survey methods used. The limitations and constraints associated with this field survey are discussed in Table 2.

Table 2 Survey limitations

Aspect	Constraint	Comment
Sources of information and availability of contextual information.	Minor	Adequate information is available for the survey area, this includes: • Broad scale (1:250,000) mapping by Beard (1979) and digitised by Shepherd et al. (2002) • Hearn et al., 2002
Scope (what life forms were sampled etc.)	Nil	Vascular flora and terrestrial vertebrate fauna were sampled during the survey. Non-vascular flora, invertebrate and aquatic fauna were not surveyed.
Proportion of flora collected and identified (based on sampling, timing and intensity) Proportion of fauna identified, recorded and/or collected	Moderate	The vegetation and flora survey was undertaken over two phases for a Level 2 flora survey, undertaken in winter and spring 2016. The winter assessment was undertaken in July 2016 and the spring assessment was undertaken in early September 2016. The flora recorded from the field survey is detailed in Section 3.3.4 and a full flora species list is provided in Appendix D. The portion of flora collected and identified was considered moderate; and it is likely that the survey under-recorded some grass species (Poaceae), herbs and orchids due to an early spring field assessment. Annuals and orchids were observed during the spring assessment as coming into flower, however were not identifiable, and as such, are likely to be underrepresented in the flora collected. The fauna survey was undertaken in winter and spring 2016 and was a reconnaissance survey only. The fauna assessment sampled those species that can be easily seen, heard or have distinctive signs, such as tracks, scats, diggings, etc. Many cryptic species would not have been identified during a reconnaissance survey and seasonal variation within species often requires targeted surveys at a particular time of the year. Of the fauna species recorded during the survey, all species were identified to species level. The fauna assessment was aimed at identifying habitat types and terrestrial vertebrate fauna utilising the survey area. No sampling for invertebrates or aquatic species occurred. The information available on the identification, distribution and conservation status of invertebrates is generally less extensive than that of vertebrate species.
Flora determination	Moderate	Flora determination was undertaken by GHD ecologists in the field and by Megan Dilly at the WA Herbarium. Seven taxa could only be identified to family level only, 33 taxa could be identified to genus level only, and 13 taxa could be tentatively identified to species level, due to lack of flowering and fruiting material required for identification. Some species, particularly grasses, sedges and herbs, may have been overlooked due to lack of material. A small number of potential conservation significant sedge, herbs and orchid species were not observed during the spring 2016 assessment.

Aspect	Constraint	Comment
		The taxonomy and conservation status of the Western Australian flora is dynamic. This report was prepared with reliance on taxonomy and conservation status current at the time report development, but it should be noted this may change in response to ongoing research and review of International Union for Conservation Nature (IUCN) criteria.
Completeness and further work which might be needed (e.g. was the relevant area fully surveyed)	Minor	The majority of the survey area was accessed on foot or traversed by vehicle. The access tracks created as a result of infrastructure development (road, water and electrical services) allowed access to the majority of the survey area. Information gained from the survey was extrapolated across those sections of the survey area not accessed on foot during the field survey to assist with determining the vegetation and habitat types for the entire survey area.
Mapping reliability	Minor	The vegetation was mapped at a scale of 1:6,000 using high resolution ESRI aerial imagery obtained from Landgate, topographical features, previous broad scale mapping (Beard 1979) and field data. Data was recorded in the field using hand-held GPS tools (e.g. Nomad Juno and Garmin GPS). Certain atmospheric factors and other sources of error can affect the accuracy of GPS receivers. The Garmin GPS units used for this survey are accurate to within ±5 metres on average. Therefore the data points consisting of coordinates recorded from the GPS may contain inaccuracies.
Timing/weather/ season/cycle	Moderate	The field surveys were conducted during winter (27 to 29 July 2016) and spring (5 to 7 September 2016). In the three months prior to the winter survey (April-June), Denmark weather recording station (No. 09531, BoM 2016) recorded a total of 417.4 mm of rainfall. This total is approximately 15% higher than the long term average for the same period (April - June; 362.2 mm) (BoM 2016). The weather conditions (when recorded) during the winter field survey included: • Daily maximum temperature ranging from 17.7 to 20.3 °C (Albany weather station No. 09999; 41 km from survey area). • Daily minimum temperature ranging from 6.6 to 10.0 °C (Albany weather station No. 09999) • Daily rainfall 0.8 mm. In the three months prior to the spring survey (June-August), Denmark weather recording station (No. 09531, BoM 2016) recorded a total of 439.6 mm of rainfall. This total is approximately 7% lower than the long term average for the same period (June-September; 471.6 mm) (BoM 2016). The weather conditions (when recorded) during the winter field survey included: • Daily maximum temperature ranging from 16.6 to 19.8 °C (Albany weather station No. 09999; 41 km from survey area). • Daily minimum temperature ranging from 4.3 to 9.2 °C (Albany weather station No. 09999) • Daily rainfall 0.2 to 9.2 mm.

Aspect	Constraint	Comment
		The weather conditions recorded during the survey period are considered unlikely to have impacted upon the vegetation and flora survey. The survey timings were considered appropriate for the flora and fauna field survey.
Disturbances (e.g. fire, flood, accidental human intervention)	Nil	Much of the survey area has been subjected to historical disturbance events (e.g. clearing, grazing); however, these disturbances did not impact the survey.
Intensity (in retrospect, was the intensity adequate)	Nil	The vascular flora of the survey area was sampled in accordance with EPA (2004a) and terrestrial fauna sampled in accordance to EPA (2004b) for Level 2 surveys. The survey area was sufficiently covered by a GHD zoologist and botanist during the survey.
Resources	Nil	Adequate resources were employed during the field survey. A total of 11 person days was spent undertaking the survey using a dedicated zoologist and botanist.
Access restrictions	Nil	No access problems were encountered during the survey.
Experience levels	Nil	The zoologist and botanist who executed the survey are practitioners suitably qualified and experienced in their respective fields. Glen Gaikhorst (zoologist) has over 20 years' experience undertaking fauna surveys within Western Australia. Craig Grabham (zoologist) has over 18 years undertaking fauna surveys. Gaynor Owen (botanist) has over 9 years' experience within Western Australia.

3. Desktop assessment

3.1 Regional biogeography

The Survey area is situated in the South-West Botanical Province (Beard 1990), within the Warren bioregion and Warren sub-region as described by the Interim Biogeographic Regionalisation of Australia (IBRA) (DotE 2015c).

The Warren subregion is a "dissected undulating country of the Leeuwin Complex, Southern Perth Basin (Blackwood Plateau), South-West intrusions of the Yilgarn Craton and western parts of the Albany Orogen with loamy soils supporting Karri forest, laterites supporting Jarrah–marri forest, leached sandy soils in depressions and plains supporting low Jarrah woodlands and paperbark/sedge swamps, and Holocene marine dunes with *Agonis flexuosa* and *Banksia* woodlands and heaths. The climate is moderate Mediterranean. The bioregion is not further divided into subregions and the area is 1, 027, 639 hectares (ha)." (Hearn et al., 2002).

Many of the region's plants and animals are endemic, especially in plant groups such as Myrtaceae, Rutaceae, Proteaceae, Papilionaceae, Restionaceae, Stylidiaceae and Sterculiaceae. The bioregion is a biodiversity hotspot with hundreds of taxa of vascular plants per square kilometre (Department of Conservation and Land Management (McKenzie et al. 2002).

3.2 Hydrology

No defined rivers or wetlands are mapped within the survey area, however, a minor creekline/low lying area is present near the junction of the Mt Barker Denmark Road and East River Road.

A summary of the Geographic Data Atlas queries for the survey area is provided in Table 3.

Table 3 Department of Water geographic atlas queries for the Survey area

Aspect	Details	Result
Groundwater areas	Groundwater areas proclaimed under the *Rights in Water and Irrigation Act 1914* (RIWI Act).	None present
Surface water areas	Surface water areas proclaimed under the RIWI Act.	None present
Irrigation district	Irrigation Districts proclaimed under the RIWI Act.	None present
Rivers	Rivers proclaimed under the RIWI Act.	None present
Public Drinking Water Source Areas (PDWSA)	PDWSA is a collective term used for the description of Water Reserves, Catchment Areas and Underground Pollution Control Areas declared (gazetted) under the provisions of the *Metropolitan Water Supply, Sewage and Drainage Act 1909* (MWSSD) or the *Country Area Water Supply Act 1947* (CAWS).	None present
Waterway Management Areas	Areas proclaimed under the *Waterway Conservation Act 1976*.	Wilson Inlet Management Area

3.3 Vegetation and flora

3.3.1 Broad vegetation associations and extent

Mapping of pre-European vegetation associations at a broad scale (1:250,000) was undertaken by Beard (1979). The mapping indicates that the following three vegetation associations are present within the survey area:

- Tall forest; karri (*Eucalyptus diverscolor*) (association 1) – intersects the western part of the survey area
- Medium forest; jarrah-marri (association 3) – intersects the eastern and central part of the survey area
- Mosaic: Medium forest; jarrah-marri / Low forest; jarrah (association 969) – intersects the western of the survey area.

The pre-European mapping has been adapted and digitised by Shepherd *et al.* (2002). The extent of the vegetation associations has been determined by the State-wide vegetation remaining extent calculations maintained by the DPaW (latest update June 2014 – Government of Western Australia (GoWA) 2015). As shown in Table 4, the current extents remaining of vegetation associations 1, 3 and 969 are greater than 32 % of their pre-European extents at all scales [e.g. State, IBRA bioregion, IBRA subregion and (Local Government Authority) LGA)], and are therefore above the 30 per cent threshold level[1].

Table 4 Broad vegetation association extents

Vegetation association	Scale	Pre-European extent (ha)	Current extent (ha)	Remaining (%)	% Current extent in all DPaW managed lands
1	State	72,410.18	56,300.61	77.75	83.52
	IBRA bioregion	69,118.21	53,821.56	77.87	83.86
	IBRA subregion	69,118.21	53,821.56	77.87	83.86
	LGA	12,550.36	6,032.08	48.06	25.7
3	State	2,661,405.06	1,810,489.41	68.03	81.09
	IBRA bioregion	250,262.66	195,368.73	78.07	86.96
	IBRA subregion	250,262.66	195,368.73	78.07	86.96
	LGA	76,437.34	60,628.97	79.32	85.80
969	State	27,711.96	9,054.79	32.67	10.53
	IBRA bioregion	19,159.43	7,600.29	39.67	9.47
	IBRA subregion	19,159.43	7,600.29	39.67	9.47
	LGA	17,721.25	7,271.22	41.03	10.62

3.3.2 Previous surveys

A vegetation and flora survey of part of McIntosh Road and adjacent areas was undertaken in October 2015 by AECOM for the proposed industrial area and access. This survey included McIntosh Road from South Western Highway up to the northern end of the McIntosh Road

[1] The 30 per cent threshold level is the level below which species loss appears to accelerate exponentially at an ecosystem level (EPA 2000).

Nature Reserve as well as a strip of that Reserve. The vegetation communities identified and species recorded were included in this report where relevant.

3.3.3 Conservation significant ecological communities

A search of the EPBC PMST identified one Commonwealth listed Threatened Ecological Community (TEC) within the study area:

- Subtropical and Temperate Coastal Saltmarsh: The ecological community consists of organisms associated with saltmarsh in coastal regions of subtropical and temperate Australia. The physical environment for the ecological community is coastal areas under regular or intermittent tidal influence. The coastal saltmarsh ecological community consists mainly of salt-tolerant vegetation (halophytes) including: grasses, herbs, sedges, rushes and shrubs (EPBC Act 1999).

A search of the DPaW TEC and PEC database identified one PEC within the study area:

- *Melaleuca spathulata /Melaleuca viminea* Swamp Heath (Priority 1): Seasonally wet heath dominated by *Melaleuca spathulata* and *Melaleuca viminea* in the upper stratum over an open sedgeland characterised by *Meeboldina roycei*; occurs on brown to orange brown loam overlying clay in winter-wet sumplands (DPaW 2015).

3.3.4 Flora diversity

A search of the *NatureMap* database identified 1065 plant taxa, representing 123 families and 403 genera, which have previously been recorded within 10 km of the survey area. This total comprised 918 native flora taxa and 147 naturalised (non-native) flora taxa. Dominant families included Fabaceae (123 taxa), Orchidaceae (81 taxa) and Myrtaceae (78 taxa).

3.3.5 Conservation significant flora

Desktop searches of the EPBC Act PMST database, *NatureMap* database, and the DPaW TPFL and WAHERB databases identified the presence/potential presence of 43 conservation significant flora taxa within the study area.

The desktop searches recorded:

- Ten taxa listed as Threatened under the EPBC Act and/or as Declared Rare Flora under the WC Act
- One taxa listed as Declared Rare Flora under the WC Act
- Two Priority 1 taxa
- Seven Priority 2 taxa
- Eleven Priority 3 taxa
- Twelve Priority 4 taxa.

The location of conservation significant flora registered on the DPaW databases is provided in Figure 2.

3.4 Fauna

3.4.1 Fauna diversity

A search of the *NatureMap* identified 213 fauna species that have been previously recorded within 10 km of the study area. This total included 156 birds, 24 reptiles, 12 amphibians and 21 mammals. The total number recorded in the search was 643 however a majority of these were invertebrates and were not assessed in this survey. Additionally the report includes previous

species names as well as the new synonym. The old names and invertebrates were excluded from the above results.

3.4.2 Conservation significant fauna

Searches of the EPBC Act PMST and *NatureMap* database identified the presence, or potential presence, of 27 conservation significant fauna species (Appendix C). Species identified by the PMST as marine or migratory/marine and migratory wetland were excluded from this assessment as no marine or wetland habitat was present within or nearby the survey area.

In addition to the 27 species identified by the database searches, three species were considered for this assessment as a result of a review of the species listed under Schedules 1-4 of the WC Act (revised 3 November 2015) to occur within the DPaW Warren and South Coast regions (DPaW 2015).

3.5 Land use

3.5.1 Conservation reserves and estate

A search of the Department of Environment Regulation (DER) Native vegetation map viewer (DER 2016) indicates a number of DPaW managed lands/ Nature Reserves within the study area. These are:

- McIntosh Road Nature Reserve – adjoining the eastern side of McIntosh Road within the survey area
- Denmark Catchment State Forest – approximately 1.5 km north of the survey area.
- Scotsdale Road Nature Reserve – approximately 2.3 km west of the survey area
- Un-named Timber Reserve – approximately 2.7 km east of the survey area

3.5.2 Environmentally sensitive areas

A search of the Department of Environmental Regulation's map viewer did not identify any Environmentally Sensitive Areas within the study area (DER 2016).

4. Field survey results

4.1 Vegetation

4.1.1 Vegetation types

Eight vegetation types (VT) (not including highly disturbed areas and planted trees) were identified and described from the survey area (Table 5 and Figure 3). The survey area is dominated by eucalypt woodlands and forests; mixed *Eucalyptus marginata, Eucalyptus staeri, Corymbia calophylla, Agonis flexuosa* and *Allocasuarina fraseriana* woodlands to open forests. Myrtaceous shrublands and sedgelands occur throughout the survey area in lower lying areas. The soil types for the survey area range from dark loamy and grey sandy soils in the lower lying areas of the survey area to lateritic outcrops in higher areas of the survey area. The vegetation types are closely allied with the landform feature in which they occur. Vegetation types VT2, VT7 and VT8 are associated with plains; VT4 is associated with lateritic stony rises; and VT5 and VT6 are associated with lower lying areas.

VT7 may align with vegetation association 3 (Medium forest; jarrah-marri); and VT2, VT4 and VT8 may align with vegetation association 969 **(**Mosaic: Medium forest; jarrah-marri / Low forest; jarrah).

Vegetation types are presented in Table 5 mapped in Figure 3, Appendix A.

Table 5 Recorded vegetation types

Vegetation type	Vegetation Type Description	Landform and Substrate	Extent (ha)	Notes and quadrat reference	Photograph
Eucalyptus marginata, Eucalyptus staeri and Allocasuarina fraseriana woodland VT2	*Eucalyptus marginata, Eucalyptus staeri and Allocasuarina fraseriana* woodland over *Banksia* spp., and *Taxandria parviceps* tall shrubland over *Beaufortia decussata, Agonis theiformis* and *Adenanthos obovatus* mid sparse shrubland over *Xanthosia rotundifolia* and *Pultenaea reticulata* sparse low shrubland over *Anarthria spp. Dasypogon bromeliifolius and Cyathochaeta avenacea* sedgeland over *Drosera* spp. and *Dampiera leptoclada* sparse herbland	Plains with grey sands	14.81	Q4, Q7, Q9	
Eucalyptus marginata, Allocasuarina fraseriana and *Banksia grandis* open forest VT4	*Eucalyptus marginata, Allocasuarina fraseriana* and *Banksia grandis* open forest over *Agonis theiformis, Bossiaea linophylla* and *Persoonia longifolia* mid to tall shrubland over *Hovea chorizemifolia*, *Acacia browniana* var. *browniana* and *Xanthosia rotundifolia* low sparse shrubland over *Desmocladus fasciculatus*, *Anarthria prolifera* and *Lepidosperma* aff. *squamatum* open sedgeland over *Patersonia umbrosa* var. *umbrosa, Lomandra* spp. and *Drosera* spp. sparse herbland	Lateritic stony rises	323	Q2, Q3	

Vegetation type	Vegetation Type Description	Landform and Substrate	Extent (ha)	Notes and quadrat reference	Photograph
Melaleuca preissiana, *Homalospermum firmum* and *Kunzea ericifolia* shrubland VT5	*Melaleuca preissiana*, *Homalospermum firmum* and *Kunzea ericifolia* mid to tall shrubland over *Evandra aristata, Anarthria* spp., *Leptocarpus scariosa* and **Cyperus congestus* open sedgeland	Low lying damplands with dark loamy soils	1.77	This vegetation type creates a mosaic throughout the survey area with vegetation types VT4, VT6 and VT2.	
Evandra aristata, *Anarthria prolifera* and *Leptocarpus tenax* sedgeland VT6	*Evandra aristata*, *Anarthria prolifera* and *Leptocarpus tenax* sedgeland with an emergent shrubland of *Kunzea ericifolia, Taxandria parviceps* and *Beaufortia sparsa*	Low lying damplands with dark loamy soils	1.26	Q1