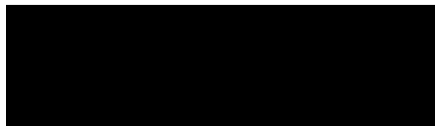


PROPOSED CLEARING OF NATIVE VEGETATION

LOTS 202 & 203 WANDENA ROAD AND
LOTS 204 & 205 GREAT NORTHERN HIGHWAY
CHITTERING

ENVIRONMENTAL ASSESSMENT

Prepared for



Report No. J19018c
8 October 2021

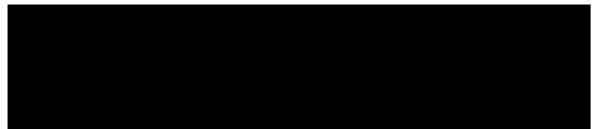


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1.0 INTRODUCTION

The owners of Lots 202 & 203 Wandena Road and Lots 204 & 205 Great Northern Highway, Chittering (the site) have applied to the Shire of Chittering for the lots to be rezoned from Agricultural Resource to General Industry. The draft Muchea Industrial Park Structure Plan 2019 (MIPSP; DPLH, 2019) shows Lots 204 and 205 as part of Precinct 2 (General Industry Core) and Lots 202 and 203 as part of Precinct 4 (Light Industry following completion of quarrying). Figure 1 shows the location of the site and its surroundings.

The total area of the rezoning is approximately 82 hectares. Figure 2 shows an aerial view of the site. The MIPSP concept for Precincts 2 and 4 is for industries with a minimum lot size of one hectare.

2.0 EXISTING ENVIRONMENT

2.1 Topography

The application area extends from a very gently sloping plain in the west to low hills in the east. The elevation ranges from 58m AHD in the south-west to 101m AHD on the eastern boundary. The north-eastern quarter of the site, comprising Lot 202 and the northern half of Lot 203, is significantly higher and steeper than the rest of the site.

The slope is generally to the south-west, with gradients ranging from less than 1% in the north-west to over 40% in places on the eastern boundary. Excavation in the quarry on Lots 202 and 203 has produced some steeper gradients, but these are expected to be reduced in the filling and rehabilitation of the quarry. Figure 3 shows the topography of the site.

2.2 Geology and Soils

The application area is located on the eastern edge of the Pinjarra Plain and the western colluvial outwash zone of the Dandaragan Scarp. The soils in the west are pebbly silts belonging to the Guildford Formation, which originated as alluvial deposits washed from the Dandaragan Plateau by rivers and streams. In the eastern part the soils are colluvium, colluvial sands and Leederville Formation siltstone eroded from the scarp. Figure 3 shows the site geology.

Drilling by BES at four sites on Lots 204 and 205 in March 2020 showed a pebbly silty sand to pebbly silty clay profile in the top 5.5m, which corresponds to the GSWA description for the Guildford Formation. Previous drilling by Bowman & Associates Pty Ltd (2016) at four sites on Lots 202 and 203 found a silty clay profile with ironstone commonly occurring at between 5m and 18m, which corresponds generally with the GSWA descriptions for Leederville Formation and colluvium.

2.3 Hydrology

2.3.1 Groundwater

Groundwater occurs at shallow depth across the lower-lying western parts of the site (Lots 204 and 205) in winter. The depth to groundwater in most years varies from over 18 metres in the east of the site to less than one metre in winter in the west. The DWER maps minimum groundwater levels at 48-53m AHD (13-48m below ground), flowing south-west towards Ellen Brook.

Groundwater measurements in 14 bores in and around the site in August 2020 (Figure 4), during a drier than average winter, gave the water depths and levels shown in Table 2.1.

Simultaneous measurements of DWER bores located 680m south (Swan GWA 2-98) and 800m north (Gnangara Monitoring GD20) enabled Average Annual Maximum (AAMGL) and Maximum (MGL) groundwater levels at the site to be calculated. Figure 4 shows the calculated AAMGL contours across the site.

Table 2.1 shows that the groundwater levels measured on 21 August 2020 were about 0.4m below the AAMGL. The winter of 2020 was drier than average, and the levels measured on 21 August are considered to approximate the peak for the year.

Table 2.1 Groundwater Depths and Levels 21 August 2020

<i>Bore</i>	<i>Depth (mbgl)</i>	<i>Level (m AHD)</i>	<i>AAMGL (m AHD)</i>	<i>MGL (m AHD)</i>	<i>Depth to AAMGL (m)</i>	<i>Depth to MGL (m)</i>
MW1	>17.44	<74.76	<75.19	<75.77	>17.01	>16.43
MW2	16.14	78.26	78.69	79.27	15.63	15.05
MW3	12.55	70.67	71.10	71.68	12.12	11.54
MW4	14.45	64.33	64.76	65.34	14.02	13.44
WB1	>4.68	<56.55	<56.98	<57.56	>4.25	>3.67
WB2	>4.98	65.89	<66.32	<66.90	>4.55	>3.97
WB3	1.58	67.51	67.94	68.52	1.15	0.57
WB4	2.34	59.53	59.96	60.54	1.91	1.33
TB7	1.14	57.26	57.69	58.27	0.71	0.13
TB8	1.11	64.14	64.57	65.15	0.68	0.10
TB9	0.56	74.24	74.67	75.25	0.13	-0.45
MB5	0.77	56.02	56.45	57.03	0.34	-0.24
MB7	0.65	54.86	55.29	55.87	0.22	-0.36
GD20	0.88	60.6	59.85	61.35	1.63	0.13
2-98	2.12	56.17	56.6	57.18	1.69	1.11

2.3.2 Surface Drainage

There are no natural defined drainage channels within the site, although several artificial drains have been cut in and around the quarry on Lots 202 and 203. The relatively low permeability of the soils would result in sheet flow across the ground surface during high rainfall events.

All drainage from the site flows eventually into Ellen Brook, the major drainage feature of the region. The Ellen Brook catchment is the largest sub-catchment of the Swan-Canning River system, contributing 6% of the total annual flow, and is the largest single contributor of nutrients to the system (WA Govt, 2011).

Ellen Brook has a surface catchment of 715km² (WRC, 2012). The Brook rises as Chandala Brook about 22km north-northwest of the site. The Brook is seasonal, flowing generally between May and November with an annual flow ranging from 2.1 to 48.6 GL (SRT, 2009).

2.4 Vegetation and Flora

The application area is largely cleared of native vegetation, consisting mostly of farm paddocks and current and former quarries. All of Lot 204, most of Lot 205 and the southern part of Lot 203 are cleared paddocks with some scattered mature trees, either native or planted. Native vegetation is present in the central east of Lot 205, the northern end of Lot 202 and the north of Lot 203.

Plantecology (2020) surveyed the vegetation and flora of the application area in November 2019. 360 Environmental (2015) undertook a vegetation survey of Lots 202 and 203 in March 2015. The full report of the Plantecology (2020) survey is attached in Appendix A. The descriptions below are based on the findings of both surveys.

2.4.1 Vegetation Types

The vegetation of the low-lying western part of the site is mapped by Heddle *et al.* (1980) as Coonambidgee Complex, ranging from a low open-forest and low woodland of pricklybark-banksia (*E. tottiana* - *B. attenuata* - *B. menziesii* – *B. ilicifolia*) with local admixtures of *B. prionotes*, to an open-woodland of marri-banksia. None of this complex remains in the application area.

The more elevated eastern part of the site is mapped by Heddle *et al.* (1980) as Reagan Complex, ranging from low open-woodland of *B. attenuata* – *B. menziesii* – *E. tottiana* to closed-heath, depending on the depth of soil. The vegetation on the site does not agree well with the descriptions of Reagan Complex in Heddle *et al.* (1980), notably in the presence and in some parts dominance of Wandoo and the absence of *E. tottiana* and Banksia tree species.

Beard (1981) mapped most of the application area as Pinjarra 4.30000: Medium woodland, marri and wandoo. The north-east corner (about 2.3ha) was mapped as Gingin 1020.09998: Mosaic of Medium forest, jarrah-marri and Medium woodland, marri-wandoo.

360 Environmental (2015) identified seven native vegetation associations within Lots 202 and 203, as shown on Figure 5:

- EaCcEm (4.15ha): Woodland of *Eucalyptus accedens*, *Eucalyptus wandoo*, *Corymbia calophylla*, *Eucalyptus marginata* and *Allocasuarina huegeliana* over *Xanthorrhoea preissii*, *Bossiaea eriocarpa*, *Hakea undulata*, *Acacia pulchella*, *Pultenaea reticulata*, *Hakea stenocarpa* and *Tetraria octandra*.

- Mps (0.1ha): Sedgeland of *Mesomelaena pseudostygia*, *Mesomelaena tetragona*, *Lepidosperma leptostachyum*, *Tetraria octandra*, *Hypocalymma robustum*, *Daucus glochidiatus* and *Acacia pulchella*.
- CcXp (1.17ha): Woodland of *Corymbia calophylla* over *Mesomelaena pseudostygia*, *Xanthorrhoea preissii*, *Bossiaea eriocarpa*, *Hibbertia hypericoides*, *Acacia pulchella*, *Banksia sessilis*, *Allocasuarina humilis* and *Banksia nivea*.
- EwMps (0.83ha): Low Open Woodland (young regrowth) of *Eucalyptus wandoo* over *Mesomelaena pseudostygia*, *Mesomelaena tetragona*, *Tetraria octandra*, *Bossiaea eriocarpa* and *Daucus glochidiatus*.
- Ea (0.08ha): *Eucalyptus accedens* woodland.
- Ew (2.14ha): *Eucalyptus wandoo* woodland.
- Cc (0.36ha): *Corymbia calophylla* scattered trees over pasture.

Plantecology (2020) identified two native vegetation communities within the site:

- Marri (*Corymbia calophylla*) Open Woodland over shrubland of *Xanthorrhoea preissii*, *Hibbertia hypericoides* subsp. *septentrionalis* and *Bossiaea eriocarpa* over herbland of *Mesomelaena pseudostygia*, *Caustis dioica* and *Banksia dallanneyi* var. *dallanneyi* on light brown clay loams on lower ground in the north-east of the site. Other common species include *Allocasuarina humilis*, *Acacia pulchella* subsp. *pulchella*, *Desmocladius fasciculatus*, *Lepidosperma asperatum* and *Conostylis aculeata* subsp. *aculeata*.
- Wandoo (*Eucalyptus wandoo*) Open Low Woodland over shrubland of *Xanthorrhoea preissii*, *Bossiaea eriocarpa* and *Hibbertia hypericoides* subsp. *septentrionalis* over herbland of *Tetraria octandra*, *Banksia dallanneyi* var. *dallanneyi* and *Lepidosperma pubisquameum* in brown gravelly clay loams on laterite on upper and middle slopes. Other common species include *Hakea stenocarpa*, *Gastrolobium acutum*, *Hakea lissocarpa* and *Desmocladius fasciculatus*.

Figure 6 shows the vegetation mapping by Plantecology (2020).

2.4.2 Vegetation Condition

The native vegetation ranges in condition from Completely Degraded to Excellent. The highest quality vegetation is located in the north of Lot 203, the east of Lot 205 and the north of Lot 202, in patches of 1.3ha or less. Figure 7 shows the vegetation condition.

Overall, the application area contains approximately 2.42ha of vegetation in Excellent condition, 2.33ha in Very Good condition, 0.48ha in Good condition and 0.86ha in Degraded condition. The remainder of the application area is in Completely Degraded condition, consisting of cleared paddocks with scattered mature native and introduced trees.

2.4.3 Flora

360 Environmental (2015) found 39 native flora taxa and seven introduced species in Lots 202 and 203. Plantecology (2020) found 86 native and nine introduced taxa across Lots 202-205, most of which were found in Lots 202 and 203. Appendix B presents a consolidated flora species list for the site, totalling 103 native taxa and 12 introduced species.

2.4.4 Rare and Significant Flora

The DBCA's Naturemap and Commonwealth databases of Threatened and Priority Flora list 42 plant taxa with the potential to occur within the site (Table 2.2). Of these, 19 are listed as Threatened under the *Biodiversity Conservation Act 2016*. Two species are listed as Priority 1, six as Priority 2, 11 as Priority 3 and six as Priority 4. One Priority 4 species (*Centrolepis caespitosa*) is also listed as Threatened under the EPBC Act. Table 2.2 summarises the likelihood of occurrence of these species at the site.

No Threatened Flora pursuant to the *Biodiversity Conservation Act 2016* or the *EPBC Act 1999* were recorded during the vegetation surveys. One species listed as Priority Flora by the DBCA was recorded by Plantecology (2020): *Haemodorum loratum* (P3) was recorded at two sites, M01 and M05, and in adjacent areas of the Wandoo open woodland in the south eastern part of the site and in the Marri woodland. One species of *Cyathochaeta* was recorded by 360 Environmental (2015) but, due to the timing of the survey, it could not be determined whether it was the Priority 3 species *C. teretifolia*.

Table 2.2 Significant Flora Potentially Occurring Within the Site

<i>Taxon</i>	<i>DBCA Cons Code</i>	<i>EPBC Cons Code</i>	<i>Recorded Habitat(s)</i>	<i>Closes Record</i>	<i>Likelihood of Occurrence</i>
<i>Acacia anomala</i>	DRF	VU	Western slopes of the Darling Range east of Perth, on shallow grey sands over laterite.	4km	Unlikely
<i>Acacia drummondii</i> ssp. <i>affinis</i>	P3		Lateritic gravelly soils.	5km	Likely
<i>Adenanthos cygnorum</i> ssp. <i>chamaephyton</i>	P3		Grey sand, lateritic gravel.	2km	Likely
<i>Andersonia gracilis</i>	DRF	EN	Known from the Badgingarra, Dandaragan and Kenwick areas. Seasonally damp, black sandy clay flats near swamps.	111km	Unlikely
<i>Anigozanthos viridis</i> ssp. <i>terraspectans</i>	DRF	VU	Winter-wet depressions on grey sandy clay loam or grey sand in low heath that is regenerating after fire.	111km	Unlikely
<i>Anthocercis gracilis</i>		VU	Sandy or loamy soils. Granite outcrops.	31km	Unlikely
<i>Caladenia huegelii</i>	DRF	EN	Mixed woodland of Jarrah, Banksia, Sheoak, marri from just north of Perth to Busselton, usually within 20m of the coast. Mostly deep grey-white sand of the Bassendean dune system.	16km	Unlikely
<i>Centrolepis caespitosa</i>	P4	EN	Winter-wet claypans dominated by low shrubs and sedges.	8km	Unlikely
<i>Chamaescilla gibsonii</i>	P3		Clay to sandy clay. Winter-wet flats, shallow water-filled claypans.	4km	Unlikely
<i>Chamelaucium</i> sp. <i>Gingin</i> (N.G. Marchant 6)	DRF	EN	White/yellow sand in woodland with <i>Eucalyptus todtiana</i> , <i>Banksia attenuata</i> and <i>Hibbertia</i> sp.	13km	Unlikely
<i>Conospermum densiflorum</i> ssp. <i>unicephalatum</i>	DRF	EN	Low-lying sandy clay soils with surface gravel, over 10km between Gingin and Moora.	75km	Unlikely
<i>Cyathochaeta teretifolia</i>	P3		Grey sand, sandy clay in swamps and creek edges.	3km	Unlikely
<i>Darwinia foetida</i>	DRF	CE	Grey-white sand on swampy, seasonally wet sites.	1.6km	Unlikely
<i>Diplolaena andrewsii</i>	DRF	EN	Loam, clay. Granite outcrops and hillsides.	17km	Possible
<i>Diuris micrantha</i>	DRF	VU	Seasonally wet flats among sedges and scattered shrubs.	73km	Unlikely

<i>Diuris purdei</i>	DRF	EN	Under dense shrubs in seasonally-wet swamps and drainage lines.	55km	Unlikely
<i>Drakaea elastica</i>	DRF	EN	Bare patches of grey-white sand in low-lying areas alongside winter-wet swamps, typically in banksia woodland or spearwood thicket.	32km	Unlikely
<i>Drosera occidentalis</i> ssp. <i>occidentalis</i>	P4		Sandy and clayey soils. Swamps and wet depressions.	1.2km	Unlikely
<i>Drosera sewelliae</i>	P1		Laterite and silica sand soils.	6km	Possible
<i>Eryngium pinnatifidum</i> ssp. <i>Palustre</i> (G.J. Keighery 13459)	P3		Winter-wet areas, damplands and claypans.	2km	Unlikely
<i>Eleocharis keigheryi</i>	DRF	VU	Clay, sandy loam. Emergent in freshwater: creeks, claypans.	10km	Unlikely
<i>Eucalyptus balanites</i>	DRF	EN	Gently sloping heathlands on light-coloured sandy soils over laterite.	64km	Unlikely
<i>Eucalyptus leprophloia</i>	DRF	EN	Known over 90km range from north of Badgingarra to the Mt Adams area. Range of habitats including slopes of hills in brown loam over laterite.	154km	Unlikely
<i>Grevillea althoferorum</i> ssp. <i>fragilis</i>	DRF	EN	Base of the Darling Scarp on greyish-yellow colluvial sand, in banksia woodland.	2.7km	Unlikely
<i>Grevillea christinae</i>	DRF	EN	Clay loam, sandy clay, often moist.	76km	Possible
<i>Grevillea corrugata</i>	DRF	EN	Known from two locations 10km south of Bindoon, on gravelly loam in partially-cleared eucalyptus woodland on roadsides.	16km	Unlikely
<i>Grevillea curviloba</i> ssp. <i>curviloba</i>	DRF	EN	Winter wet, deep peaty grey sands over limestone.	4km	Unlikely
<i>Grevillea curviloba</i> ssp. <i>incurva</i>	DRF	EN	Open heath in winter-wet areas on sand over limestone or ironstone.	2km	Unlikely
<i>Guichenotia tuberculata</i>	P3		Sandy clay over laterite, sand.	69km	Possible
<i>Haemodorum loratum</i>	P3		Grey or yellow sand, gravel.	63km	Present
<i>Hibbertia glomerata</i> ssp. <i>ginginensis</i>	P1		Sand, brown clay, laterite and near roadsides.	30km	Possible
<i>Oxymyrrhine coronata</i>	P4		Slopes and flats with dry gravel over laterite.	4km	Possible
<i>Persoonia rudis</i>	P3		White, grey or yellow sand, often over laterite.	4km	Possible
<i>Platysace ramosissima</i>	P3		Sandy soils.	2km	Possible
<i>Schoenus</i> sp. Bullsbrook (J.J. Alford 915)	P2		Grey peaty sand, low-lying flats.	13km	Unlikely

<i>Stenanthemum sublineare</i>	P2		Littered white sand on the Swan Coastal Plain.	13km	Unlikely
<i>Stylidium aceratum</i>	P2		Sandy soils, swamp heathland.	3km	Unlikely
<i>Stylidium longitubum</i>	P3		Sandy clay, clay. Seasonal wetlands.	14km	Unlikely
<i>Stylidium paludicola</i>	P3		Peaty sand over clay. Winter-wet habitats. Marri and melaleuca woodlands.	14km	Unlikely
<i>Stylidium squamellosum</i>			Brown to red-brown clay loam. Winter-wet depressions. Open woodland, shrubland.	2km	Unlikely
<i>Synaphea grandis</i>	P4		Laterite.	1km	Likely
<i>Tetraria</i> sp. Chandala (G.J. Keighery 17055)	P2		Mound springs, wetlands and peaty sands.	14km	Unlikely
<i>Thelymitra manginii</i> K. Dixon & Batty ms (<i>Thelymitra dedmaniarum</i>)	DRF	EN	Open wandoo woodlands on red-brown sandy loam associated with dolerite and granite outcrops.	18km	Unlikely
<i>Thelymitra stellata</i>	DRF	EN	Low heath and scrub in jarrah and wandoo woodland on ridges and slopes, also on river banks and breakaways, on red, brown, yellow or grey sandy loams, clay or gravel over laterite or gravel.	5km	Possible
<i>Trichocline</i> sp. Treeton (B.J. Keighery & N. Gibson 564)	P2		Sand over limestone, sandy clay over ironstone. Seasonally wet flats.	8km	Unlikely
<i>Verticordia lindleyi</i> ssp. <i>lindleyi</i>	P4		Sand, sandy clay. Winter-wet depressions.	5km	Unlikely
<i>Verticordia serrata</i> var. <i>linearis</i>	P4		White sand, gravel. Open woodland.	3km	Unlikely

2.4.5 Floristic Communities

360 Environmental (2015) tentatively assigned floristic community types (FCTs) to the vegetation associations on Lots 202 and 203 as follows:

- EaCcEm and EwMps **S8** – *Eucalyptus wandoo* woodlands
- CcXp and Mps **3c** – *Corymbia calophylla*-*Xanthorrhoea preissii* woodlands and shrublands / **S18** – *Eucalyptus marginata*-*Corymbia calophylla* woodlands on laterite

The vegetation of Lots 204 and 205, consisting mostly of isolated paddock trees, is too severely degraded to assign to any FCT except for the patch of Wandoo woodland in the east of Lot 204, which is tentatively assigned to FCT S8.

2.4.6 Threatened and Priority Ecological Communities

Floristic Community 3c is listed as Critically Endangered under the Western Australian *Biodiversity Conservation Act 2016* and as Endangered under the Commonwealth *EPBC Act 1999*.

The DBCA and EPBC Threatened and Priority Ecological Community databases list several other TECs and PECs within 5km of the application area:

- Muchea Limestone – Shrublands and Woodlands on Muchea Limestone (Endangered (DBCA) Endangered (EPBC));
- SCP07 – Herb rich saline shrublands in clay pans (Vulnerable (DBCA) Critically Endangered (EPBC));
- SCP3a – *Corymbia calophylla* - *Kingia australis* woodlands on heavy soils, Swan Coastal Plain (Critically Endangered (DBCA));
- Mound Springs – Communities of Tumulus Springs (organic mound springs, Swan Coastal Plain) (Critically Endangered (DBCA) Endangered (EPBC));
- SCP23b – Northern *Banksia attenuata* – *B. menziesii* woodlands (Priority 3 (DBCA));
- SCP25 – Southern *Eucalyptus gomphocephala* – *Agonis flexuosa* woodlands (Priority 3 (DBCA)); and
- SCP22 – *Banksia ilicifolia* woodlands (Priority 3 (DBCA)).

None of these floristic communities was found in the application area.

2.4.7 Local and Regional Representation

Table 2.3 summarises the status of the site vegetation types State-wide, in the Swan Coastal Plain Bioregion, the Shire of Chittering and within 15km of the site. The data in the table are sourced from the following:

- 2013 Native Vegetation extent by Vegetation complexes on the Swan Coastal Plain south of Moore River (Local Biodiversity Program, 2013).
- CAR Analysis Report 2009. WA Department of Environment & Conservation, Perth www2.landgate.wa.gov.au/slip/portal/services/files/carreserveanalysis2009.xls.
- Vegetation Extent-By-Type GIS database (Department of Agriculture, 2005).
- Swan Coastal Plain Vegetation Complexes GIS database (DPaW, 2016).
- CALM Estate GIS database (CALM, 2009).

Table 2.3 Remnant Vegetation Status

<i>Vegetation Unit</i>	<i>Pre-European Extent (km²)</i>	<i>Current Extent (km²)</i>	<i>% Remaining</i>	<i>% In Secure Reserves</i>
Remnant Vegetation				
Shire of Chittering	1,218	496	41	3
15km Radius	748	269	36	12
Reagan Complex (Heddlie <i>et al.</i>, 1980)				
Swan Coastal Plain	91	31	34	6
Shire of Chittering	20	10	51	
15km Radius	39	18	46	4
Pinjarra 4 (Beard, 1981)				
Statewide	106	14	13	1.4
Shire of Chittering	45	7	16	0.6
15km Radius	97	29	30	0.4
Gingin 1020 (Beard, 1981)				
Statewide	56	19	34	1.8
Shire of Chittering	36	12	34	0.5
15km Radius	56	24	43	2

The table shows that the vegetation types present in the application area are moderately to well represented both locally and regionally, but that their formal reservation status is generally poor. Figure 8 shows the local and regional representation and reservation.

2.5 Fauna

2.5.1 Species and Habitats

Most of Lots 204 and 205 is cleared apart from isolated paddock trees, and offers little habitat for native fauna. The exception is an area of about 1ha in the east of Lot 205, which supports wandoo woodland in excellent condition and offers good quality habitat for fauna.

Lots 202 and 203 support areas of native vegetation ranging in condition from Completely Degraded to Excellent, as well as fully cleared areas. The vegetation in Good, Very Good and Excellent condition offers good quality habitat for fauna.

Overall, the application area contains approximately 2.4ha in Excellent condition, 2.3ha in Very Good condition and 0.5ha in Good condition.

The following fauna habitats have been identified at the site:

- Marri and Wandoo woodlands with largely undisturbed understorey;
- Eucalypt woodlands with degraded understorey; and
- Cleared paddocks with isolated mature Marri, Wandoo and Jarrah trees.

The Marri and Wandoo woodlands offer a range of feeding and nesting habitats for native fauna including mature trees with hollows, shrubs, dense understorey, groundcover and ground litter. These are expected to support a wide range of reptile, mammal and bird species.

The Eucalypt woodlands with degraded understorey have little or no ground cover or shrub layer and are expected to offer low-quality habitat for birds and some disturbance-tolerant terrestrial species.

The cleared paddocks with isolated mature trees would provide grazing habitat for kangaroos, particularly in areas close to uncleared woodland in the east of Lot 205. Stock troughs in the paddocks are focal points for ducks (particularly Maned or Wood Duck, *Chenonetta jubata* and Mountain Duck or Shelduck, *Tadorna tadornoides*), which feed in small flocks in the paddocks around the troughs. The paddocks also support a large population of the introduced Long-Billed Corella (*Cacatua tenuirostris*), which is an agricultural pest in Western Australia.

The mature trees in the paddocks are mostly larger than 0.5m diameter at breast height (dbh), and a number contain hollows of various sizes that offer potential nesting sites for black cockatoos and other bird species. Results of a survey of potential nesting hollows are given in Section 2.5.3 below.

2.5.2 Significant Fauna

A search was made of relevant databases for the area surrounding the application area. The databases searched included:

- DBCA Naturemap (15km radius including the application area);
- DBCA Threatened Fauna Database (15km radius including the application area);
- EPBC Protected Matters Search Tool (10km radius including the application area); and
- Birds Australia Birddata database (1 degree/60nm square including the application area).

The searches produced an extensive list of Threatened Fauna species, Priority Fauna species and otherwise significant species from the search area. Many of those were marine or aquatic species for which no habitat exists in the application area. Species that might occur in the application area or its surrounds are summarised, and their likelihood of occurrence in the application area assessed, below:

- Carnaby's Black Cockatoo *Calyptorhynchus latirostris* (S1, EN) – Feeds and breeds in eucalypt and Banksia woodland from the lower Murchison to the lower south-west. Numerous records of occurrence near the application area. The application area contains food resources including Marri trees and potential nesting sites. Signs of feeding on Marri nuts, possibly by Carnaby's Black Cockatoo (or possibly by Twenty-Eight Parrots) were observed beneath trees in the south of Lot 203 during the site inspection in March 2020.
- Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso* (S1, VU) - Feeds and breeds in eucalypt and Banksia woodland from Gingin to the lower south-west. May occur in and around the application area. The application area contains food resources including Marri trees and potential nesting sites. A small group of 8-10 individuals was observed in Wandoo trees on the opposite side of Wandena Road during the site inspection March 2020.
- Black-striped Snake *Neelaps calonotos* (P3) - Inhabits dense leaf litter in Banksia and eucalypt woodlands with sandy soil from Lancelin south to Mandurah. Likely to be present in or around the application area.
- Black-flanked Rock Wallaby *Petrogale lateralis* subsp. *lateralis* (T, EN) – Restricted to parts of Cape Range, Little Sandy Desert, granite rocks in the Avon Wheatbelt, Kalbarri National Park and Barrow and Salisbury Islands. Occurs on rocky habitats with a preference for complex caves and crevices. Unlikely to be present in the application area due to the absence of suitable habitat.
- Woylie *Bettongia penicillata ogilbyi* (T, EN) - Formerly widespread species now restricted to six known sites in the south-west. Inhabits open eucalypt forest, open

mallee woodlands and shrublands. Unlikely to be present in the vicinity due to predation by foxes and cats.

- Douglas' Broad-headed Bee *Hesperocolletes douglasi* (T, CR) – Recently rediscovered in Banksia woodland at Pinjar in 2019 after being presumed extinct. Only previous sighting was on Rottnest Island in 1938. Unlikely to be present in the application area.
- Chuditch *Dasyurus geoffroyi* (S3, VU) - Occurs in a wide range of habitats including woodlands, dry sclerophyll forests and riparian vegetation. The application area provides foraging habitat and the species is likely to be an occasional visitor to the application area.
- Peregrine Falcon *Falco peregrinus* (S4) - A wide-ranging species that prefers nesting in cliff faces. Likely to overfly the application area but would not be resident.
- Rainbow Bee-eater *Merops ornatus* (S3, MI) - A common and widespread migratory species that utilises a wide range of habitats, with a preference for nesting in open sandy ground. The application area has few open sandy areas and is unlikely to provide habitat for the species.
- Fork-tailed Swift *Apus pacificus* (S3, MI) - A widespread and almost entirely aerial species. Likely to overfly the application area but would not be resident or dependent upon it.
- A short-tongued bee *Leioproctus douglasiellus* (CR) - Known from only three locations within the Perth metropolitan area in association with two plant species: *Goodenia filiformis* and *Anthotia junciforme*, neither of which are present at the site.
- Brush-tailed Phascogale *Phascogale tapoatafa* (P3) - Inhabits dry sclerophyll forests and open woodlands with hollow-bearing trees and sparse ground cover between Perth and Albany. A specimen was captured in open Tuart woodland in Baldivis, 23km south-west of the application area, in 2017 (Australian Ecological Services, 2017). Unlikely to be present at the site due to its scarcity and the absence of its preferred habitat.
- Graceful Sunmoth *Synemon gratiosa* (P4) - Inhabits coastal heathland on Quindalup dunes and banksia woodland on Spearwood and Bassendean dunes, in association with two species of mat-rush, *Lomandra maritima* and *L. hermaphrodita*. Neither plant species was found in significant numbers in the application area so the moth is unlikely to be present.
- Inornate Trapdoor Spider *Euoplos inornatus* (northern Jarrah Forest) (P3) – Known from several locations in the northern Jarrah forest, the closest 6.5km south-east of the site. May be present in uncleared areas at the site.

- A short-tongued Bee *Leioproctus contrarius* (P3) – Occurs on the Swan Coastal Plain in association with *Scaevola repens* var. *repens* and *Lechenaultia* spp, neither of which are present at the site.
- Quenda *Isodon obesulus fusciventer* (P4) - Inhabits dense ground cover in forests, woodlands and heaths, preferring areas around wetlands and damplands. May be present in uncleared parts of the application area although no evidence of presence (e.g. diggings) were observed.
- Grey Wagtail *Motacilla cinerea* (MI) – Breeds in northern Europe and migrates to the southern hemisphere, mostly Africa and Asia. Two Western Australian records from near Pemberton and Northcliffe. Unlikely to be present at the site.

2.5.3 Black Cockatoo Habitat Assessment

Feeding Habitat

The application area contains nine species recorded by Valentine & Stock (2008) as food resource species for Carnaby's Cockatoo: *Corymbia calophylla*, *Eucalyptus marginata*, *Xanthorrhoea preissii*, *Hakea lissocarpha*, *Mesomelaena pseudostygia*, *M. tetragona*, *Allocasuarina fraseriana*, *Banksia sessilis* and *Lambertia multiflora*. In most cases (except *C. calophylla*), these species are present at low density over small areas, so the site offers limited food resources for black cockatoos. The large Marri trees in the cleared areas would be expected to provide food for black cockatoos. Limited evidence of Carnaby's Cockatoo feeding (in the form of chewed nuts) was observed in the south of Lot 203 during the site inspection.

Roosting Habitat

The EPBC Act Referral Guidelines for Black Cockatoos (DSEWPC, 2012) define black cockatoo roosting sites as tall trees or groups of tall trees, usually close to an important water source and within an area of quality feeding habitat.

The application area contains no significant water sources and limited feeding habitat. It is therefore unlikely that black cockatoos will roost in the area.

Breeding Habitat

The DSEWPC (2012) defines black cockatoo breeding habitat as follows:

- Current breeding habitat - Trees of suitable species (including Marri, Jarrah and Wandoo) with suitably-sized hollows (generally minimum 140mm opening, 200mm internal width, 450mm depth).
- Potential breeding habitat - Trees of suitable species of size at least 500mm diameter at breast height (dbh) (or 300mm for Wandoo).

360 Environmental (2015) found 126 Marri, Jarrah and Wandoo trees in Lots 202 and 203 that met the DSEWPC (2012) definition of future breeding habitat. None of the

trees contained visible hollows potentially suitable for black cockatoo nesting. BES (2020) found 122 trees across Lots 202-205 that met the DSEWPC (2012) size criteria, including 56 that contained hollows or potential hollows, of which eight appeared to be of a suitable size for black cockatoos. Across the two surveys, a total of 190 trees met the DEWA size criteria for potential nesting habitat.

BES inspected all potential hollows in October 2020 with a pole-mounted camera (Cocky Cam) supplied by Birdlife Australia. The inspection found nine hollows in use by Corellas, two by Australian Kestrels and one by Kookaburras. No evidence of current or previous black cockatoo nesting was found. A large number of hollows (approximately 15 of 56 examined) contained feral bee hives.

Figure 9 shows a consolidated map of all potential nesting trees identified by 360 Environmental (2015) and BES (2020).

3.0 CLEARING METHOD

Clearing will be undertaken by bulldozer or wheeled loader. The cleared vegetation will be mulched and stockpiled for future use in landscaping. Larger trees (over 50cm dbh) will be retained within large lots and road reserves where feasible.

Prior to clearing, a fauna capture and relocation exercise will be undertaken by a qualified specialist consultant to relocate any sedentary animals (e.g. snakes and lizards) from the application area. During and after clearing, monitoring of debris will be carried out to locate and salvage any fauna caught within the clearing operation.

Fauna captured or salvaged during this operation will be relocated to parks or reserves in consultation with and by permission of the DBCA. Any injured fauna found after clearing will be taken to a refuge where possible. Any feral animals captured, as well as native animals that are too badly injured to recover, will be euthanased.

4.0 ASSESSMENT AGAINST THE CLEARING PRINCIPLES

Development of the project area as proposed will involve the clearing of approximately 2.42ha of Marri and Wandoo woodland in Excellent condition, 2.33ha in Very Good condition, 0.48ha in Good condition and 0.86ha in Degraded condition. In addition, up to approximately 110 isolated native paddock trees (Marri, Wandoo and Jarrah) may be removed where they cannot be retained.

a) Native vegetation should not be cleared if it comprises a high level of biological diversity.

Summary: Proposal is not likely to be at variance to this principle.

The wording of this principle suggests that, to be regarded as having a “high level” of biological diversity, then the diversity of the vegetation should be relatively high compared to other vegetation, either of the same type or of different types.

The vegetation surveys by 360 Environmental (2015) and Plantecology (2020) found a total of 103 native species within the 5.2ha of Good to Excellent vegetation in the application area. These included one Priority 3 species and one possible Priority 3 species (which could not be identified to species level).

The five 100m² vegetation quadrats surveyed by Plantecology (2020), all within Very Good or Excellent vegetation, had species richness ranging from 24 to 39 species per 100m², with an average and median of 31 spp/100m². Little comparative data is available in the literature, but Gibson *et al.* (1994) found a mean species richness of 48 spp/100m² for FCT 3C (possibly present at the site). 360 Environmental (2015) concluded that the species richness of the site was broadly typical of the vegetation types present.

In summary, the biological diversity of the application area is similar to or somewhat below what would be expected for undisturbed vegetation of this type.

b) Native vegetation should not be cleared if it comprises the whole or part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.

Summary: Proposal is not likely to be at variance to this principle.

The application area contains about 5.2ha of vegetation in Good to Excellent condition, which provides high-quality habitat for native fauna. The remainder of the site is Degraded to Completely Degraded and provides poor quality habitat for disturbance-tolerant fauna.

The site contains potential habitat for several significant fauna species: Carnaby's Black Cockatoo, Forest Red-tailed Black Cockatoo, Black-Striped Snake, Chuditch, Inornate Trapdoor Spider and Quenda. Of these, only the Forest Red-tailed Black Cockatoo was observed near the site, while possible evidence of Carnaby's Black Cockatoo feeding was found in the south of the site.

Surveys by 360 Environmental (2015) and BES (2020) found a total of 190 trees that met the DEWA size criteria (0.5m dbh) for potential black cockatoo nesting habitat. Of these, 56 contained visible hollows, of which eight appeared to be of a suitable size for black cockatoos.

BES inspected all potential hollows in October 2020 with a pole-mounted camera (Cocky Cam) supplied by Birdlife Australia. The inspection found nine hollows in use by Corellas, two by Australian Kestrels and one by Kookaburras. No evidence of current or previous black cockatoo nesting was found. A large number of hollows (approximately 15 of 56 examined) contained feral bee hives. Figure 9 shows a consolidated map of all potential nesting trees identified by 360 Environmental (2015) and BES (2020).

Most of the land within 3km of the site is cleared farmland. Further afield, there are large areas of publicly-owned intact native vegetation in the Gngangara-Moore River State Forest (3km west) and in the Avon Valley National Park (9km east).

In summary, the application area contains high quality habitat for terrestrial fauna and a usable food resource for black cockatoos, but its small size and isolation mean that it is unlikely to be a key habitat for any species.

- c) Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.**

Summary: Proposal is not likely to be at variance to this principle.

360 Environmental (2015) and Plantecology (2020) found no Declared Rare Flora (DBCA) or Threatened Flora (EPBC) species in the application area. One Priority 3 species was identified and another may be present but could not be identified to species level. It is concluded that the application area is unlikely to be significant as a habitat for rare flora.

- d) Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a threatened ecological community.**

Summary: Proposal may be at variance to this principle.

360 Environmental (2015) identified two vegetation communities (CcXp and Mps) totalling 1.27ha as possibly belonging to Floristic Community SCP 3c, which is listed as Critically Endangered at State level and Endangered at Commonwealth level. The alternative assignment, FCT S18, is not listed as threatened by the State or Commonwealth. The majority of the vegetation, composed of Wandoo woodlands (EaCcEm and EwMps), was assigned to FCT S8, which similarly is not listed as threatened.

A small area in the north of Lots 202 and 205 is mapped by DAWE (Commonwealth of Australia, 2016) as part of the Threatened Ecological Community *Banksia Woodlands of the Swan Coastal Plain*. However, the application area contains no *Banksia* woodland, and none of the species described by DAWE as defining the community (*Banksia attenuata*, *B. menziesii*, *B. prionotes* and *B. ilicifolia*) are present.

- e) Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.**

Summary: Proposal is not likely to be at variance to this principle.

Table 2.3 shows that the vegetation types present in the application area, and remnant vegetation overall, are generally well represented in the Swan Coastal Plan, the Shire of Chittering and within a 15km radius of the site. All except the Beard Pinjarra 4 vegetation community have more than 30% of their pre-European extent remaining locally, regionally and State-wide. In most cases the level of secure reservation is low, with overall remnant vegetation within 15km the only category that exceeds 10% reservation. Nonetheless, the level of representation and the relatively small area subject to this application suggest that the site is not a significant remnant in a heavily cleared landscape.

- f) Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland.**

Summary: Proposal is not likely to be at variance to this principle.

The application area is located on elevated dry land. The nearest mapped wetlands are palusplains in cleared paddocks located 160m to the south-west and 170m to the north-east. The application area contains no wetland-dependent or riparian vegetation.

- g) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.**

Summary: Proposal is not likely to be at variance to this principle.

Land degradation may be taken to mean erosion, salinisation, nutrient leaching or other events that reduce the capability of the land or other areas downgradient to support biological production.

The application area is situated on elevated soils with no significant risk of salinisation. After clearing, the area will be developed for industrial use with low nutrient inputs and drainage management in line with water-sensitive urban design principles.

- h) Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.**

Summary: Proposal is not likely to be at variance to this principle.

There are no conservation areas near the application area. The closest DBCA-managed lands are the Bullsbrook Nature Reserve, located 2.2km south of the application area, and an unnamed flora reserve located 2.8km north-west. The proposed clearing will have no effect on either of these reserves.

- i) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.**

Summary: Proposal is not likely to be at variance to this principle.

After clearing, the land will be developed for industry. The draft *Muchea Industrial Park Structure Plan* (DPLH, 2019) identifies the application area as part of Precinct 2, the general industry core of the Muchea Industrial Park. Given the limited availability of groundwater in the industrial park, industries that establish are likely to be low water-use industries that generate little waste water.

Drainage in the industrial park will be designed and managed in accordance with water-sensitive urban design principles under the auspices of a Local Water Management Strategy and Urban Water Management Plans. These will ensure that the quantity and quality of surface and groundwater are maintained after development. With the removal of cattle and horse grazing from the site, the quality of surface runoff and groundwater is expected to improve.

- j) **Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding.**

Summary: Proposal is not likely to be at variance to this principle.

The application area is situated on elevated ground which is not at risk of flooding. As described above, the development of the site will be in line with an LWMS and UWMPs that will ensure that drainage is managed to avoid flooding.

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Figures

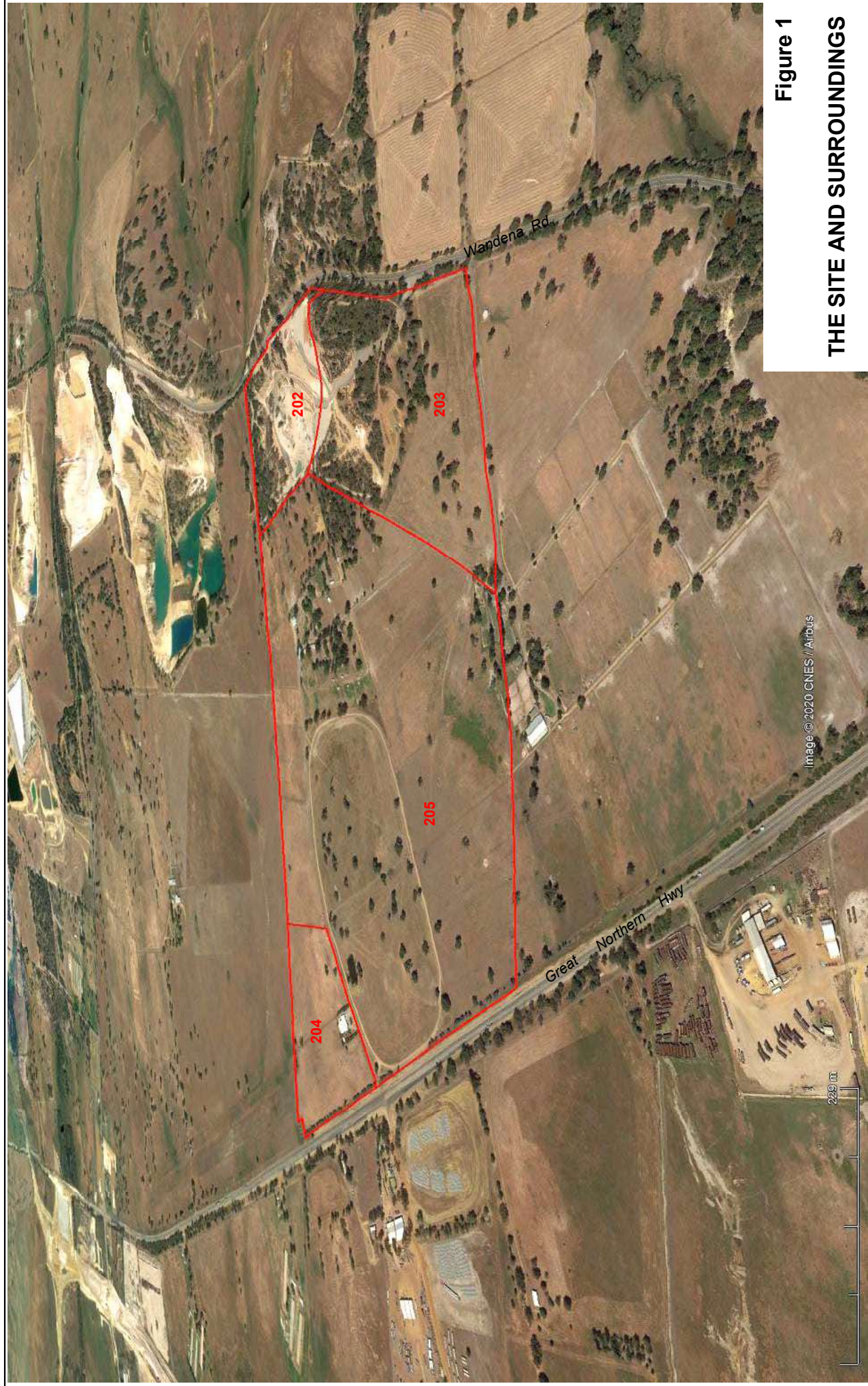


Figure 1

THE SITE AND SURROUNDINGS

Figure 2

AERIAL VIEW



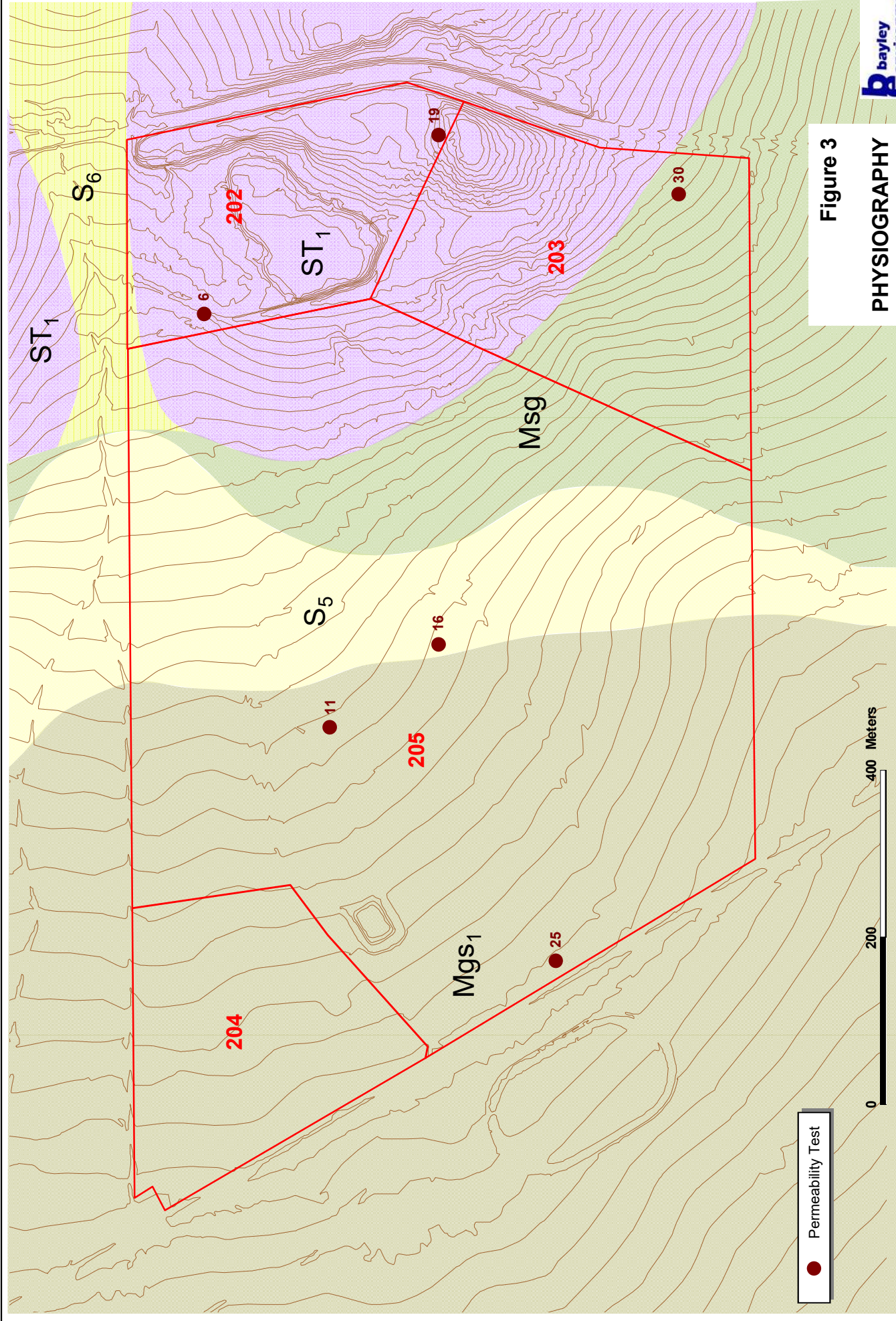


Figure 3

PHYSIOGRAPHY

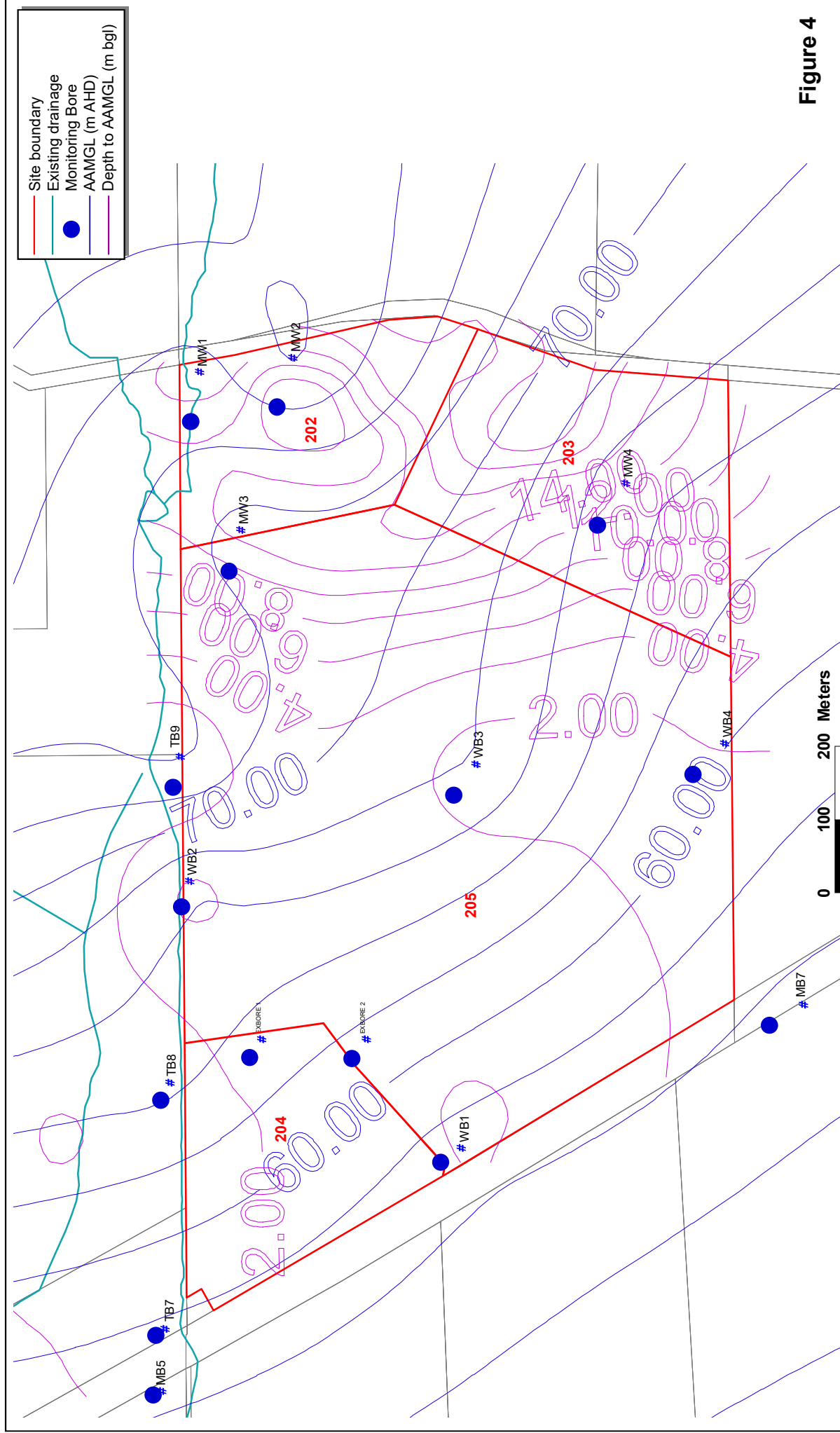
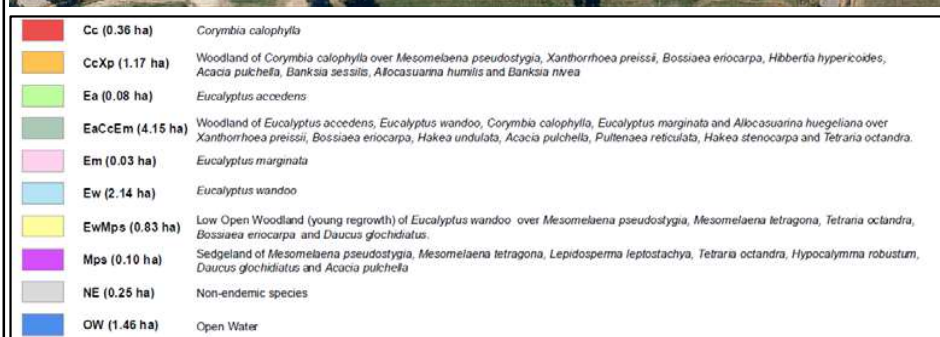


Figure 4

HYDROLOGY



VEGETATION MAPPING
- 360 ENVIRONMENTAL



Figure 6

VEGETATION MAPPING - PLANTECOLOGY

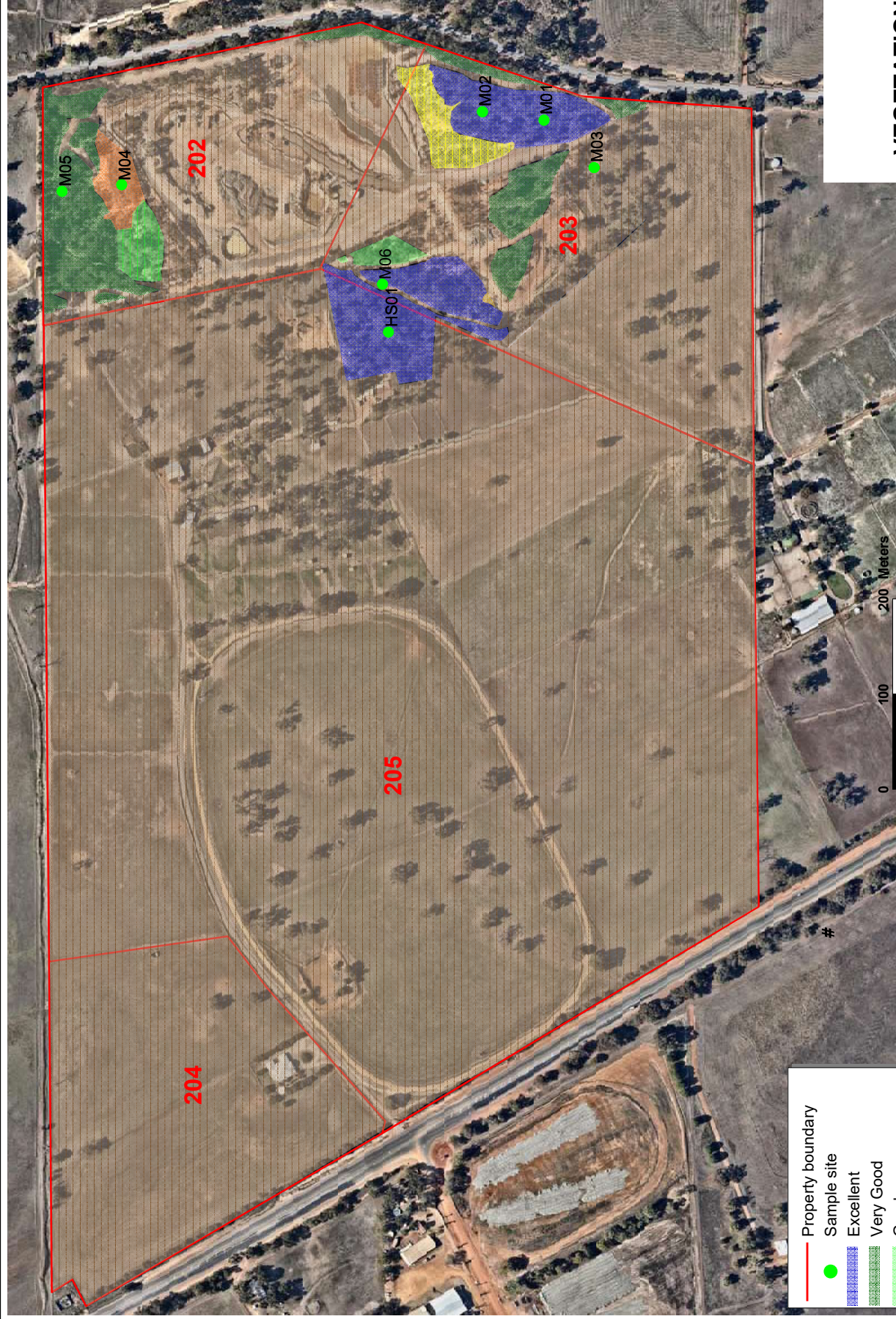


Figure 7

VEGETATION CONDITION

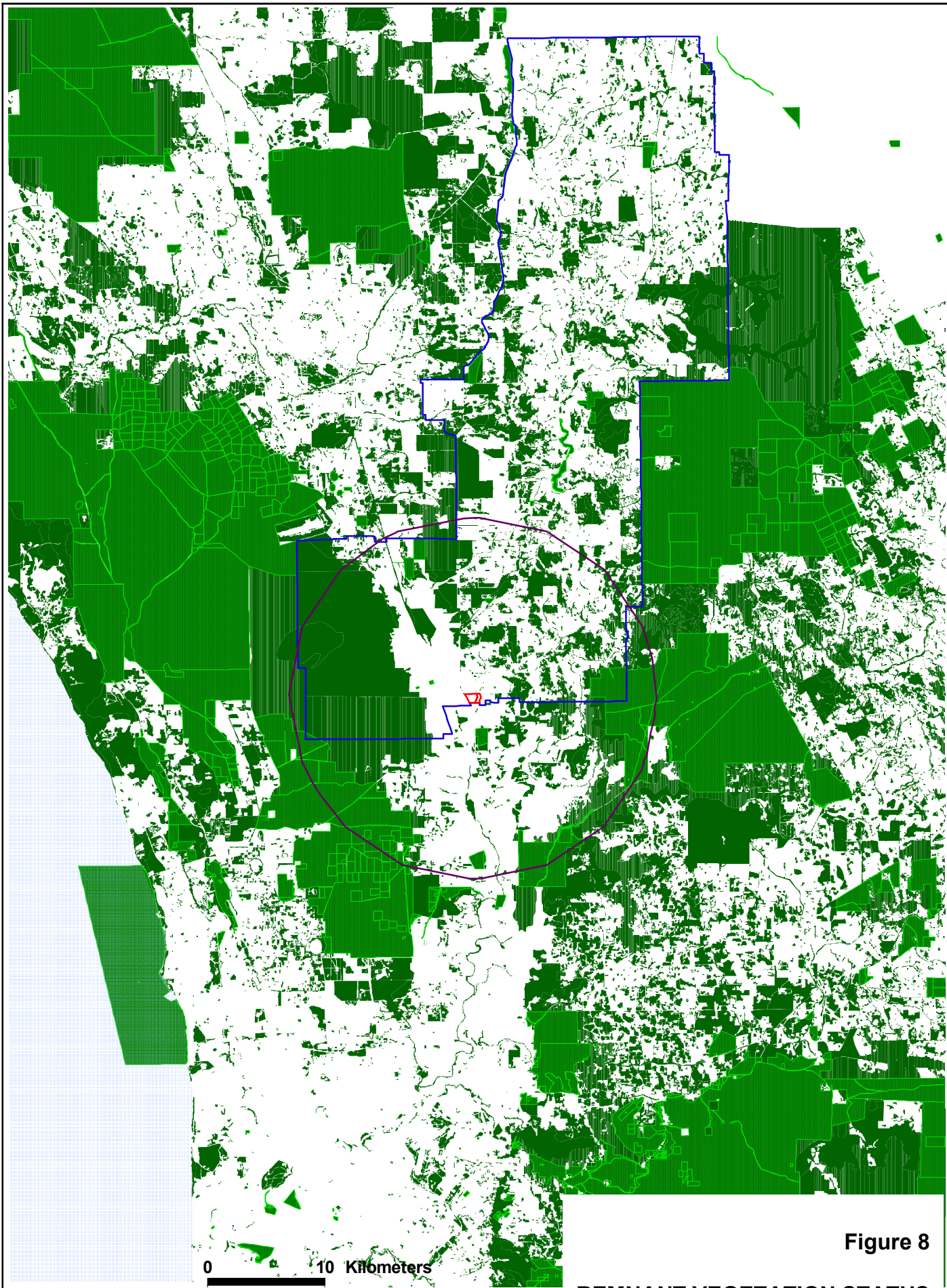


Figure 8

REMNANT VEGETATION STATUS

- | | |
|---------------------|----------------------------|
| Site boundary | Remnant vegetation present |
| 15km radius | DBCA estate |
| Shire of Chittering | Ocean |



Figure 9

**POTENTIAL BLACK COCKATOO
BREEDING HABITAT**

Site boundary
Tree >0.5m dbh
Tree >0.5m dbh with occupied hollow

Appendix A

**Botanical Survey Report
(Plantecology, 2020)**

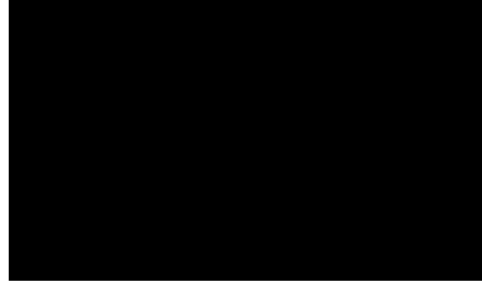
Lots 202, 203, 204 & 205
Wandena Rd
Muchea
Flora and Vegetation Survey



PREPARED FOR BAYLEY ENVIRONMENTAL SERVICES



FEBRUARY 2020



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Executive Summary

Plantecology Consulting was commissioned by Bayley Environmental Services to undertake a detailed flora and vegetation survey at Lots 202, 203, 204 and 205, Wandena Rd, Muchea, (the site), in the Shire of Chittering. The site covers approximately 82 ha, of which approximately 15 ha is within Lots 202 and 203. Lots 202 and 203 are currently used for extractive industry, while Lots 204 and 205 support a horse stud.

The field survey was conducted by a botanist from Plantecology Consulting on the 13th November 2019. The site was traversed on foot and search made for conservation significant flora. A detailed survey of the vegetation was undertaken at five 100 m² sampling plots (10m x 10m quadrats) and two recce plots, which are used to record the structure, condition and dominants in a patch. The sampling plots were selected to adequately sample the flora within a stand (Figure 2). Plots were positioned to sample a representative and homogeneous (i.e. not located in transitional areas between communities) area of each community. The location of each corner of a plot was recorded with a hand-held GPS unit and a photograph of the plot taken looking inward to the quadrat. All vascular plant species were recorded and an estimate of the Foliage Cover (FC) percentage was made for each species.

A total of 86 native and 9 non-native (exotic) taxa were recorded within the site, representing 31 families and 69 genera. The dominant families containing mostly native taxa were Fabaceae (11 native taxa, one exotic taxon), Myrtaceae (7 native taxa), Cyperaceae (7 native taxa), and Proteaceae (10 native taxa). Most exotic species were grasses (Poaceae, three exotic taxa).

No Threatened Flora pursuant to the *Biodiversity Conservation Act* (2016) nor the *EPBC Act* (1999) were recorded during the survey. One species listed as Priority Flora by the PWS was recorded during the survey. *Haemodorum loratum* (P3) was recorded at two sites, M01 and M05, and in adjacent areas of the *Eucalyptus wandoo* open woodland in the south eastern part of the site and the *Corymbia calophylla* woodland.

The survey identified two native plant communities within the site:

Corymbia calophylla open woodland

Woodland of *Corymbia calophylla* over shrubland of *Xanthorrhoea preissii*, *Hibbertia hypericoides* subsp. *septentrionalis* and *Bossiaea eriocarpa* over herbland of *Mesomelaena pseudostygia*, *Caustis dioica* and *Banksia dallanneyi* var. *dallanneyi* on light brown clay loams.

This unit occurs in the lower ground in the northern part of the site. Other common species include *Allocasuarina humilis*, *Acacia pulchella* subsp. *pulchella*, *Desmocladius fasciculatus*, *Lepidosperma asperatum* and *Conostylis aculeata* subsp. *aculeata*.

Eucalyptus wandoo open low woodland

Low open woodland of *Eucalyptus wandoo* subsp. *wandoo* over shrubland of *Xanthorrhoea preissii*, *Bossiaea eriocarpa* and *Hibbertia hypericoides* subsp. *septentrionalis* over herbland of *Tetraria octandra*, *Banksia dallanneyi* var. *dallanneyi* and *Lepidosperma pubisquameum* in brown gravelly clay loams on laterite.

This unit occurs on upper and mid-slopes within the site. Other common species include *Hakea stenocarpa*, *Gastrolobium acutum*, *Hakea lissocarpha* and *Desmocladius fasciculatus*.

The vegetation condition within the site reflects past and current pastoral and quarrying activity within the site with the vegetation adjacent to the quarry area in poorer condition than that within vegetation remnants. Pastured areas, infrastructure areas for the horse stud and

extractive industries, formed tracks and stands where the understorey has been replaced by exotic species have been rated as 'Completely Degraded'. The largest stand in this category is approximately 66 ha of Lots 204 and 205, which are used for pastures with paddock trees of *Corymbia calophylla* and the supporting infrastructure of the horse stud. Also rated as 'Completely Degraded' is the area at the southern extremity of Lots 202 and 203 where an open tree layer of *Eucalyptus wandoo* and *Corymbia calophylla* remains but the understorey consists almost entirely of **Ehrharta calycina* and **Avena barbata*. Stands where the vegetation structure has been significantly altered but retain more native species are rated as 'Degraded' and occur on the southern edge of the quarry area. Adjacent to an area undergoing rehabilitation in the northern part of Lots 202 and 203 is a stand of 'Good' vegetation where the vegetation is sparser from previous disturbance but still retains its basic structure.

Nine of the taxa recorded during the survey are exotics (weeds), none of which are Declared Pests under the *Biosecurity and Agriculture Management Act 2007*. The most abundant weeds were **Ehrharta calycina* and **Avena barbata*, recorded in the more degraded areas of the site.

The search of DBCA's databases for Threatened and Priority communities showed that the Commonwealth-listed Endangered community 'Banksia-dominated woodlands of the Swan Coastal Plain IBRA region' or its buffer zone is mapped as occurring within the site. To be considered a part of this community, a vegetation stand must include at least one of the diagnostic species *Banksia attenuata*, *Banksia menziesii*, *Banksia prionotes* or *Banksia ilicifolia*. None of these species were recorded within the site and neither the *Corymbia calophylla* woodland nor the *Eucalyptus wandoo* woodland can be considered part of the 'Banksia-dominated woodlands of the Swan Coastal Plain IBRA region' community. Neither the *Corymbia calophylla* woodland nor the *Eucalyptus wandoo* woodland are listed as PECs or TECs.

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1 Introduction

Plantecology Consulting was commissioned by Bayley Environmental Services to undertake a detailed flora and vegetation survey at Lots 202, 203, 204 and 205, Wandena Rd, Muchea, (the site), in the Shire of Chittering (Figure 1). The site covers approximately 82 ha, of which approximately 15 ha is within Lots 202 and 203. Lots 202 and 203 are currently used for extractive industry, while Lots 204 and 205 support a horse stud.

1.1 Purpose

The purpose of the survey was to provide a detailed assessment of botanical values within the site, which could then inform the proposed rezoning of the site from rural to industry

The objectives of the survey were to:

- Undertake a detailed flora and vegetation survey in accordance with the Environmental Protection Authority's (EPA) Technical Guidance: Flora and Vegetation Survey for Environmental Impact Assessment (2016).
- Identify the presence of any Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs);
- Undertake a systematic search for all vascular plant taxa present; and
- Record the locations and numbers present of any Threatened Flora and Priority Flora.

1.2 Existing Environment

Much of the site currently being used for extractive industry has been developed for that purpose. Some areas have been revegetated after the end of quarrying while two areas of native vegetation remain in the northern and southern parts of the site. The vegetated remnants are dissected by tracks and firebreaks, while the northern remnant is also dissected by some drainage channels. The majority of the horse stud have been cleared to create pasture and farm infrastructure with only a small patch of remnant vegetation remaining adjacent to the extractive industry lots.

1.3 Climate

The Muchea area experiences a dry Mediterranean climate of hot dry summers and cool wet winters. Long-term climatic averages indicate the site is located in an area of moderate to high rainfall, receiving 655.1 mm on average annually (data for Pearce RAAF, station number 9053, the nearest currently reporting station; Bureau of Meteorology 2019) with the majority of rainfall received between May and August. The area experiences rainfall on an average of 107 days per year. Mean maximum temperatures range from 17.9 °C in July to 33.5 °C in January. Mean minimum temperatures range from 8.2 °C in August to 17.5 °C in February.

1.4 Soils

The Atlas of Australian Soils maps the soils for the majority of the site as Map Unit Wd9 (Natural Resource Information Centre 1991). Map Unit Wd9 comprises broad valleys and undulating interfluvial areas with some discontinuous breakaways and occasional mesas. Lateritic materials mantle the area and the chief soils are sandy acidic yellow mottled soils containing

much ironstone gravel in the A horizons. The western portion of the horse stud is mapped as Sp2, which comprises gently sloping terraces of the Ridge Hill Shelf. The main soils are hard acidic yellow soils containing ironstone gravels and associated brown sands, often containing ironstone gravels at depth.

1.5 Conservation Significant Flora

Under the *Biodiversity Conservation Act 2016* ('BC Act'), the Minister for the Environment produces a gazetted list of Threatened Flora under three categories: Critically Endangered, Endangered and Vulnerable. The Parks and Wildlife Service (PWS) also produces a list of Priority Flora that have not been assigned statutory protection under the BC Act but may be under some degree of threat (PWS 2019a). The PWS recognises four Priority Flora levels. The definitions for each category of Threatened and Priority Flora are shown in Appendix E.

As well as protection under State legislation, selected flora are also afforded statutory protection at a Federal level pursuant to the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPBC Act provides for the protection of Threatened species, pursuant to Schedule 1 of the Act, and are defined as "Critically Endangered", "Endangered", "Vulnerable" or "Conservation Dependent" under Section 179. Definitions of these categories are shown in Appendix E. Any action likely to have a significant impact on a species listed under the EPBC Act requires approval from the Commonwealth Minister for Agriculture, Water and the Environment.

A search of the DBCA and Commonwealth databases of Threatened and Priority Flora as well as NatureMap returned a list of 49 taxa with the potential to occur within the site (Table 1). Of these taxa, 11 are listed as Threatened under the BC Act. *Diuris drummondii* is an orchid of winter-wet depressions and swamps that flowers from November through to January. *Thelymitra stellata* is an orchid that occurs in gravel and lateritic loams and flowers from October to November. *Eleocharis keigheryi* is a freshwater emergent that flowers from August to November. The remaining Threatened Flora on the list are perennial shrubs and should be observable at all times of the year. The timing of the survey should, therefore, be appropriate to detect the Threatened Flora on the list.

Table 1: Threatened and Priority Flora potentially occurring within the survey area based on database searches. (VU = Vulnerable; EN = Endangered; CR = Critically Endangered; T = Threatened; 1 – 4 = Priority Flora Category)

Taxa	PWS Rating	EPBC Act Category	Flowering Period
<i>Acacia anomala</i>	T	VU	Aug-Sep
<i>Acacia cummingiana</i>	3		May – Jun, Aug
<i>Acacia drummondii</i> subsp. <i>affinis</i>	3		Jul - Aug
<i>Acacia pulchella</i> var. <i>reflexa</i> acuminate bracteole variant (R.J. Cumming 882)	3		Jul - Sep
<i>Adenanthos cygnorum</i> subsp. <i>chamaephyton</i>	3		Jul, Sep - Jan
<i>Anigozanthos humilis</i> subsp. <i>chrysanthus</i>	4		Jul – Oct
<i>Caustis gigas</i>	2		May
<i>Chamaescilla gibsonii</i>	3		Sep
<i>Chamaelaucium</i> sp. Gingin (N.G. Marchant 6)	T	VU	
<i>Cyathochaeta teretifolia</i>	3		
<i>Darwinia foetida</i>	T	CR	
<i>Diuris drummondii</i>	T	VU	Nov - Jan
<i>Drosera occidentalis</i>	4		Oct - Jan
<i>Drosera sewelliae</i>	1		Oct
<i>Eleocharis keigheryi</i>	T	VU	Aug – Nov
<i>Eryngium pinnatifidum</i> subsp. <i>palustre</i>	3		
<i>Gastrolobium crispatum</i>	1		Sep - Oct
<i>Gastrolobium nudum</i>	2		Feb
<i>Grevillea althoferorum</i> subsp. <i>fragilis</i>	T	CR	
<i>Grevillea candolleana</i>	2		Aug - Sep
<i>Grevillea corrugata</i>	T	EN	?Aug - Sep
<i>Grevillea curviloba</i> subsp. <i>curviloba</i>	T	EN	Oct
<i>Grevillea curviloba</i> subsp. <i>incurva</i>	T	EN	Aug - Sep
<i>Guichenotia tuberculata</i>	3		Aug - Oct
<i>Hydrocotyle lemnoides</i>	4		Aug - Oct
<i>Hydrocotyle striata</i>	1		
<i>Hibbertia glomerata</i> subsp. <i>ginginensis</i>	2		Jul - Sep
<i>Hypocalymma sylvestre</i>	T		Aug
<i>Hypolaena robusta</i>	4		Sep - Oct
<i>Isotropis cuneifolia</i> subsp. <i>glabra</i>	3		Sep
<i>Leucopogon squarrosus</i> subsp. <i>trigynus</i>	2		
<i>Millotia tenuifolia</i> var. <i>laevis</i>	2		Sep - Oct
<i>Ornduffia submersa</i>	4		
<i>Oxymyrrhine coronata</i>	4		
<i>Persoonia rudis</i>	3		Sep -Jan
<i>Platysace ramosissima</i>	3		Oct - Nov
<i>Schoenus capillifolius</i>	3		Oct - Nov
<i>Schoenus griffinianus</i>	3		Sep – Oct
<i>Stylidium aceratum</i>	3		Oct – Nov
<i>Stylidium paludicola</i>	3		Oct – Dec

Taxa	PWS Rating	EPBC Act Category	Flowering Period
<i>Stylidium squamellosum</i>	2		Oct – Nov
<i>Synaphea grandis</i>	4		Oct - Nov
<i>Tetraria</i> sp. Chandala (G.J. Keighery 17055)	2		Aug - Oct
<i>Tetratheca pilifera</i>	3		Aug - Oct
<i>Thelymitra stellata</i>	T	EN	Oct – Nov
<i>Thysanotus</i> sp. Badgingarra (E.A. Griffin 2511)	2		Dec
<i>Verticordia lindleyi</i> subsp. <i>lindleyi</i>	4		May, Nov – Jan
<i>Verticordia rutilastra</i>	3		Sep - Nov
<i>Verticordia serrata</i> var. <i>linearis</i>	1		Sep - Oct

1.6 Conservation Significant Communities

The PWS defines an ecological community as “a naturally occurring assemblage that occurs in a particular type of habitat” (PWS 2019b). A Threatened Ecological Community (TEC) is one that has declined in area or was originally limited in distribution. Uncommon ecological communities that do not strictly meet TEC defined criteria, or are inadequately defined, are listed by the PWS as a Priority Ecological Community (PEC). Definitions of the categories of Threatened and Priority Ecological Communities are given in Appendix E.

As well as protection under State legislation, selected ecological communities are also afforded statutory protection at a Federal level pursuant to the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The EPBC Act provides for the protection of TECs, which are listed under section 181 of the Act, and are defined as “Critically Endangered”, “Endangered” or “Vulnerable” under Section 182. Similar to flora listed under the EPBC Act, any action likely to have a significant impact on a TEC listed under the EPBC Act requires Commonwealth approval.

A search of the DBCA databases of Threatened and Priority Ecological Communities (TECs and PECs) identified five conservation-coded community types with the potential to occur within the site. These were:

- The Critically Endangered ‘Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain)’;
- The Vulnerable ‘Herb rich saline shrublands in clay pans (SCP 7)’;
- The Endangered ‘Shrublands and woodlands on Muchea Limestone of the Swan Coastal Plain’;
- The Priority 3 ‘Southern *Eucalyptus gomphocephala* – *Agonis flexuosa* woodlands’; and
- The Priority 3 ‘Banksia-dominated woodlands of the Swan Coastal Plain IBRA region’, listed as Endangered under Commonwealth legislation and includes the State-listed PECS:
 - Swan Coastal Plain *Banksia attenuata* – *Banksia menziesii* woodlands (FCT 23b); and
 - Banksia woodland of the Gingin area restricted to soils dominated by yellow to orange sands.

The ‘Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain)’ and the Shrublands and woodlands on Muchea Limestone of the Swan Coastal Plain’ are both listed by the Commonwealth as Endangered communities, while the ‘Herb rich saline shrublands in clay pans (SCP 7)’ is listed as Critically Endangered.

1.7 Ecological Linkages

Ecological linkages are important conservation tools that allow the movement of fauna, flora and genetic material between areas of remnant habitat. The movement of fauna and the exchange of genetic material between vegetation remnants improves the viability of those remnants by allowing greater access to breeding partners, food sources, refuge from disturbances such as fire and maintains the genetic diversity of plant communities and populations. Local ecological linkages seek to improve the viability of local natural areas by providing connections to other local or regionally significant natural areas and regional ecological linkages. The vegetation stands within the site is not part of either a regional or local ecological linkage (Shire of Chittering 2010).

1.8 Vegetation Complexes

Vegetation complexes are a series of plant communities forming a regularly repeating pattern associated with a particular soil unit (Government of Western Australia 2000). Two vegetation complexes have been mapped as potentially occurring within the site: Reagan Complex, which is described as varying from a low open woodland of *Banksia* species and/or *Eucalyptus tottiana* (Pricklybark) to a closed heath, depending on the depth of soil; and Coonambidgee Complex, which ranges from a low open forest and low woodland of *Eucalyptus tottiana* (Pricklybark) - *Banksia attenuata* - *Banksia menziesii* - *Banksia ilicifolia* with localised occurrences of *Banksia prionotes* to an open woodland of *Corymbia calophylla* - *Banksia* species (Webb et al. 2016). Reagan Complex has been mapped as a Swan Coastal Plain vegetation complex and has 33.8% of its original 9 180 ha pre-European extent remaining (Webb et al. 2016). Only 3.7% of its original extent is protected for conservation (Webb et al. 2016). Coonambidgee Complex has 45% of its original 6272 ha remaining, with 650 ha currently protected in the reserve system (Webb et al. 2016).

2 Methods

2.1 Field Survey

The field survey was conducted by a botanist from Plantecology Consulting on the 13th November 2019. The site was traversed on foot and search made for conservation significant flora. A detailed survey of the vegetation was undertaken at five 100 m² sampling plots (10m x 10m quadrats) and two recce plots, which are used to record the structure, condition and dominants in a patch. The sampling plots were selected to adequately sample the flora within a stand (Figure 2). Plots were positioned to sample a representative and homogeneous (i.e. not located in transitional areas between communities) area of each community. The location of each corner of a plot was recorded with a hand-held GPS unit and a photograph of the plot taken looking inward to the quadrat. All vascular plant species were recorded and an estimate of the Foliage Cover (FC) percentage was made for each species.

Environmental data recorded included topographic position, aspect, slope, soil colour and texture class, rock outcropping, litter cover as well as the degree of disturbance and an estimate of the time since the last fire event. The condition of the vegetation of the site was assessed to assist in determining the conservation values of the site. The vegetation condition was rated according to Keighery (1994), a vegetation condition scale commonly used in the metropolitan and southwest regions. The categories are listed and defined in Table 2. Data on the vegetation structure was also recorded and included the height of the three main strata and the dominant species within each stratum. The vegetation structural description follows that of the National Vegetation Information System (Thackway *et al.* 2006).

All plant specimens collected during the field survey were dried, pressed and then sorted in accordance with requirements of the Western Australian Herbarium. Identification of specimens occurred through comparison with named material and through the use of taxonomic keys. Taxonomic determinations were made using reference material at the Western Australian State Herbarium. Taxa names utilise the current terminologies from FloraBase (2019). Family names utilise the revised phylogeny of the Angiosperm Phylogeny Group - APGIII (FloraBase 2019).

2.1 Study Limitations and Survey Effort

Various factors can limit the effectiveness of a vegetation survey. Pursuant to EPA Technical Guidance: Flora and Vegetation Survey for Environmental Impact Assessment (EPA 2016), these factors have been identified and their potential impact on the effectiveness of the survey has been assessed (Table 3).

The survey was undertaken in mid-November 2019 and would likely have intercepted the flowering period of most annuals of conservation concern with the potential to occur within the site. However, the spring of 2019 was much drier than normal, which may have affected the flowering of some species.

Table 2: Vegetation Condition Scale (Keighery 1994)

Vegetation Condition	Definition
Pristine (1)	Pristine or nearly so, no obvious signs of disturbance.
Excellent (2)	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
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
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. 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.
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.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Table 3: Potential limitations affecting the vegetation survey

Potential limitations	Constraint	Comment
Availability of contextual information	No	Sufficient regional and local information was available to place the survey site in its environmental context.
Competency and experience of the botanists undertaking the survey	No	The survey was undertaken by botanists with a comprehensive knowledge of Southwestern Western Australia vegetation, with at least 15 years' experience in vegetation surveys in Western Australia.
Seasonality	Minor	The survey was undertaken in spring 2019. The rainfall in the three months prior to the survey was well below average for the area, especially in September. Maximum and minimum temperatures were approximately 2 ^o higher than the mean.
Adequate ground coverage and intensity of survey effort	No	The survey area was traversed on foot. It is considered the survey quadrats and mapping points provided adequate coverage given the degraded nature of most of the site.
Proportion of Flora identified	No	The survey recorded an estimated 77% (chao2 estimator) of the plant taxa present, although this still represents fewer species than could be expected from an undisturbed system.
Disturbance	Minor	Part of the site has and is being used for quarrying. Formed access tracks and firebreaks dissect the remnant patches and some historic tracks are still evident. Drainage channels have also been constructed in the northern part of the site. The historic disturbances may have had an impact on the species richness and structure of the vegetation and limit some of the conclusions that may be drawn from the data.
Resources	No	Adequate resources were available to conduct the survey.
Access restrictions	No	All parts of the site were accessible

3 Results

3.1 Flora

3.1.1 Floristic Summary

A total of 86 native and 9 non-native (exotic) taxa were recorded within the site, representing 31 families and 69 genera. The dominant families containing mostly native taxa were Fabaceae (11 native taxa, one exotic taxon), Myrtaceae (7 native taxa), Cyperaceae (7 native taxa), and Proteaceae (10 native taxa). Most exotic species were grasses (Poaceae, three exotic taxa). For a complete species list and the individual site data refer to Appendix A and Appendix B, respectively.

3.1.2 Threatened and Priority Flora

No Threatened Flora pursuant to the *Biodiversity Conservation Act* (2016) nor the *EPBC Act* (1999) were recorded during the survey.

One species listed as Priority Flora by the PWS was recorded during the survey. *Haemodorum loratum* (P3) was recorded at two sites, M01 and M05, and in adjacent areas of the *Eucalyptus wandoo* open woodland in the south eastern part of the site and the *Corymbia calophylla* woodland (Table 4). Approximately 50 individuals were counted in each habitat. A more accurate count was not possible as *Haemodorum discolor* was also recorded during the survey, and non-flowering individuals are difficult to discern with certainty. The described upper limit of leaf width for *Haemodorum discolor* is similar to the lower limit for *Haemodorum loratum*.

Table 4: Locations of sampling plots with *Haemodorum loratum* (P3) present (GDA94, Zone 50).

Plot	Easting	Northing
M01	406871	6503674
M05	406796	6504183

3.2 Vegetation

3.2.1 Plant Associations

The survey identified two native plant communities within the site (Figure 2):

Corymbia calophylla open woodland (Plates 2 and 3)

Woodland of *Corymbia calophylla* over shrubland of *Xanthorrhoea preissii*, *Hibbertia hypericoides* subsp. *septrionalis* and *Bossiaea eriocarpa* over herbland of *Mesomelaena pseudostygia*, *Caustis dioica* and *Banksia dallanneyi* var. *dallanneyi* on light brown clay loams.

This unit occurs in the lower ground in the northern part of the site. Other common species include *Allocasuarina humilis*, *Acacia pulchella* subsp. *pulchella*, *Desmocladius fasciculatus*, *Lepidosperma asperatum* and *Conostylis aculeata* subsp. *aculeata*.

Eucalyptus wandoo open low woodland (Plate 4)

Low open woodland of *Eucalyptus wandoo* subsp. *wandoo* over shrubland of *Xanthorrhoea preissii*, *Bossiaea eriocarpa* and *Hibbertia hypericoides* subsp. *septentrionalis* over herbland of *Tetraria octandra*, *Banksia dallanneyi* var. *dallanneyi* and *Lepidosperma pubisquameum* in brown gravelly clay loams on laterite.

This unit occurs on upper and mid-slopes within the site. Other common species include *Hakea stenocarpa*, *Gastrolobium acutum*, *Hakea lissocarpa* and *Desmocladius fasciculatus*.

3.2.2 Vegetation Condition

The vegetation condition within the site reflects past and current pastoral and quarrying activity within the site with the vegetation adjacent to the quarry area in poorer condition than that within vegetation remnants (Figure 3). Pastured areas, infrastructure areas for the horse stud and extractive industries, formed tracks and stands where the understorey has been replaced by exotic species have been rated as 'Completely Degraded'. The largest stand in this category is approximately 66 ha of Lots 204 and 205, which are used for pastures with paddock trees of *Corymbia calophylla* and the supporting infrastructure of the horse stud. Also rated as 'Completely Degraded' is the area at the southern extremity of Lots 202 and 203 where an open tree layer of *Eucalyptus wandoo* and *Corymbia calophylla* remains but the understorey consists almost entirely of **Ehrharta calycina* and **Avena barbata* (Plate 3). Stands where the vegetation structure has been significantly altered but retain more native species are rated as 'Degraded' and occur on the southern edge of the quarry area. Adjacent to an area undergoing rehabilitation in the northern part of Lots 202 and 203 (Plate 4) is a stand of 'Good' vegetation where the vegetation is sparser from previous disturbance but still retains its basic structure.

The *Corymbia calophylla* woodland in the north-eastern part of the site has been rated as 'Very Good', largely due to the disturbance from drainage channels constructed through it. The shrub layer in this community is lower and sparser than could be expected in undisturbed vegetation.

Areas of 'Excellent' condition vegetation occur in the *Eucalyptus wandoo* woodland in the south-eastern part of the site. These stands have retained most of their vertical structure and native species richness (e.g. 36 native taxa at Plot M01).

3.2.3 Weeds

Nine of the taxa recorded during the survey are exotics (weeds), none of which are Declared Pests under the *Biosecurity and Agriculture Management Act* 2007. The most abundant weeds in native remnants were **Ehrharta calycina* and **Avena barbata*, recorded in the more degraded areas of the site.

4 Discussion

4.1 Flora

No species of Threatened Flora were recorded during the survey. One species of Priority Flora was recorded from two plots, one each in the *Corymbia calophylla* and the *Eucalyptus wandoo* woodlands. *Haemodorum loratum* (P3) occurs from Eneabba to Perth on the eastern side of the Swan Coastal Plain and adjacent slopes of the Dandaragan Plateau. Its usual habitat is in grey and yellow sands in low heath, and eucalypt and banksia woodlands. The soil within the *Corymbia calophylla* woodland was generally a light brown clay loam, and in the *Eucalyptus wandoo* woodland a brown loamy clay. The local population was difficult to count accurately as *Haemodorum discolor* was also recorded for the site and the upper limit of leaf width for this species is similar to the lower limit for *Haemodorum loratum*. Non-flowering individuals, therefore, could not consistently be identified to species level.

4.2 Plant Communities

The search of DBCA's databases for Threatened and Priority communities showed that the Commonwealth-listed Endangered community 'Banksia-dominated woodlands of the Swan Coastal Plain IBRA region' or its buffer zone is mapped as occurring within the site. To be considered a part of this community, a vegetation stand must include at least one of the diagnostic species *Banksia attenuata*, *Banksia menziesii*, *Banksia prionotes* or *Banksia ilicifolia*. None of these species were recorded within the site and neither the *Corymbia calophylla* woodland nor the *Eucalyptus wandoo* woodland can be considered part of the 'Banksia-dominated woodlands of the Swan Coastal Plain IBRA region' community. The species assemblages recorded for each community type within the site also do not match the other conservation-coded communities that are known to occur nearby.

The *Corymbia calophylla* woodland shows some similarity to the *Corymbia calophylla* – *Xanthorrhoea preissii* woodlands and shrublands TEC, but *Bossiaea eriocarpa* is present in this unit within the site and that species is a contra-indicator for this particular TEC.

Corymbia calophylla woodland is generally in 'Very Good' condition with few exotic species present. The condition of the *Eucalyptus wandoo* woodland ranged from 'Degraded' to 'Excellent'. The poorer condition areas were mostly adjacent to tracks or active work areas and been disturbed previously or were experiencing weed invasion.

Mapping of vegetation complexes for the Swan Coastal Plain places much of the site within the Reagan Complex, which is described as varying from a low open woodland of Banksia species and/or *Eucalyptus tottiana* (Pricklybark) to a closed heath, depending on the depth of soil (Webb *et al.* 2016). This description does not accurately describe the vegetation for the site and is likely due to variance from the scale of mapping as the site is situated on the lower Gingin Scarp and near the boundary between the vegetation complex mapping for the Swan Coastal Plain and that of the southwest forests.

5 Summary

One species of Priority Flora was recorded from within the site. The local population of *Haemodorum loratum* (P3) is estimated to be approximately 50 plants. Neither the *Corymbia calophylla* woodland nor the *Eucalyptus wandoo* woodland are listed as PECs or TECs. The vegetation condition of the site varies from 'Completely Degraded' in cleared areas and tracks, to 'Excellent' in intact woodland patches that support few invasive weed species.

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Figures

Figure 1: Locality Plan Wandena Rd Flora and Vegetation Survey

Figure 2: Plant Communities Wandena Rd Flora and Vegetation Survey

Figure 3: Vegetation Condition Wandena Rd Flora and Vegetation Survey



Figure 1

LOCATION



- Property boundary
- Sample site
- Corymbia calophylla* open woodland
- Eucalyptus wandoo* open low woodland
- Rehabilitation
- Tracks and clearings
- Infrastructure
- Pasture and Paddocks

Figure 2

PLANT COMMUNITIES



- Property boundary
- Sample site
- Excellent
- Very Good
- Good
- Degraded
- Completely Degraded
- Rehabilitation

Figure 3

VEGETATION CONDITION

Plates



Plate 1: View of Eucalyptus wandoo woodland (Plot M01).



Plate 2: Another view of Eucalyptus wandoo woodland at Plot 2.



Plate 3: View of 'Completely Degraded' at Plot M03.



Plate 4: View of rehabilitation area in the northern section of the site.



Plate 5: View of *Corymbia calophylla* woodland at Plot M05.



Plate 6: View of *Eucalyptus wandoo* woodland at Plot M06.



Plate 7: View of *Eucalyptus wandoo* woodland at Plot HS01.

Appendix A

List of flora recorded within the survey area

NB: * indicates introduced flora

Family	Taxon Name
Zamiaceae	<i>Macrozamia riedlei</i>
Lauraceae	<i>Cassytha glabella</i>
Colchicaceae	<i>Burchardia congesta</i>
Iridaceae	* <i>Gladiolus caryophyllaceus</i> <i>Patersonia juncea</i> * <i>Romulea rosea</i>
Xanthorrhoeaceae	<i>Xanthorrhoea preissii</i>
Asparagaceae	<i>Laxmannia ramosa</i> subsp. <i>ramosa</i> <i>Lomandra caespitosa</i> <i>Lomandra hermaphrodita</i> <i>Lomandra preissii</i> <i>Lomandra sericea</i>
Hemerocallidaceae	<i>Agrostocrinum hirsutum</i> <i>Agrostocrinum scabrum</i> <i>Tricoryne elatior</i>
Haemodoraceae	<i>Anigozanthos manglesii</i> <i>Conostylis aculeata</i> subsp. <i>aculeata</i> <i>Conostylis</i> sp. <i>Haemodorum discolor</i> <i>Haemodorum loratum</i> (P3)
Cyperaceae	<i>Caustis dioica</i> <i>Lepidosperma asperatum</i> <i>Lepidosperma pubisquameum</i> <i>Mesomelaena graciliceps</i> <i>Mesomelaena pseudostygia</i> <i>Mesomelaena tetragona</i> <i>Tetraria octandra</i>
Restionaceae	<i>Desmocladius fasciculatus</i> <i>Desmocladius flexuosus</i>
Poaceae	? <i>Amphipogon debilis</i> <i>Austrostipa</i> ? <i>hemipogon</i> <i>Austrostipa elegantissima</i> * <i>Avena barbata</i> * <i>Briza maxima</i> * <i>Ehrharta calycina</i> <i>Neurachne alopecuroidea</i> <i>Rytidosperma setaceum</i>

Family	Taxon Name
Proteaceae	<i>Banksia armata</i> var. <i>armata</i> <i>Banksia bipinnatifida</i> subsp. <i>multifida</i> <i>Banksia dallanneyi</i> var. <i>dallanneyi</i> <i>Banksia sessilis</i> <i>Grevillea synapheae</i> <i>Hakea lissocarpa</i> <i>Hakea stenocarpa</i> <i>Hakea undulata</i> <i>Petrophile striata</i> <i>Stirlingia latifolia</i>
Dilleniaceae	<i>Hibbertia hypericoides</i> <i>Hibbertia</i> sp. <i>Hibbertia spicata</i> subsp. <i>spicata</i> <i>Hibbertia hypericoides</i> subsp. <i>septentrionalis</i>
Halorogaceae	<i>Glischrocaryon aureum</i> <i>Gonocarpus cordiger</i>
Fabaceae	<i>Acacia applanata</i> <i>Acacia lasiocarpa</i> subsp. <i>sedifolia</i> <i>Acacia pulchella</i> var. <i>pulchella</i> <i>Bossiaea eriocarpa</i> * <i>Chamaecytisus palmensis</i> <i>Cristonia biloba</i> subsp. <i>biloba</i> <i>Daviesia decurrens</i> <i>Daviesia hakeoides</i> subsp. <i>hakeoides</i> <i>Daviesia preissii</i> <i>Dillwynia laxiflora</i> <i>Gastrolobium acutum</i> <i>Gompholobium marginatum</i>
Polygalaceae	<i>Comesperma ciliatum</i>
Rhamnaceae	<i>Trymalium angustifolium</i>
Casuarinaceae	<i>Allocasuarina fraseriana</i> <i>Allocasuarina humilis</i>
Elaeocarpaceae	<i>Tetratheca nuda</i>
Phyllanthaceae	<i>Phyllanthus calycinus</i>
Proteaceae	<i>Isopogon asper</i>
Myrtaceae	<i>Calothamnus sanguineus</i> <i>Corymbia calophylla</i> <i>Eucalyptus marginata</i> <i>Eucalyptus wandoo</i> subsp. <i>wandoo</i> <i>Hypocalymma angustifolium</i>

Family	Taxon Name
Myrtaceae	<i>Lambertia multiflora</i> var. <i>darlingensis</i> <i>Melaleuca clavifolia</i>
Malvaceae	<i>Thomasia foliosa</i>
Thymeleaceae	<i>Pimelea imbricata</i> var. <i>piligera</i>
Primulaceae	* <i>Lysimachia arvensis</i>
Rubiaceae	<i>Opercularia vaginata</i>
Stylidiaceae	<i>Stylidium affine</i> <i>Stylidium piliferum</i> <i>Stylidium purpureum</i>
Goodeniaceae	<i>Dampiera linearis</i> <i>Goodenia caerulea</i> <i>Lechenaultia biloba</i> <i>Scaevola glandulifera</i>
Asteraceae	* <i>Hypochaeris glabra</i> <i>Trichocline spathulata</i> * <i>Ursinia anthemoides</i>
Pittosporaceae	<i>Billardiera ?variifolia</i> <i>Marianthus drummondianus</i>

Appendix B

Sampling plot raw data

NB: Only taxa recorded within sampling plots included in table.

Taxon Name	Plot						
	M01	M02	M03	M04	M05	M06	HS01
<i>?Amphipogon debilis</i>	0.1	0.1	0	0	0	0	0
<i>Acacia applanata</i>	0.2	0.1	0	0	0	0.2	0
<i>Acacia pulchella</i> var. <i>pulchella</i>	0.4	0.5	0	0	0.3	0	0.5
<i>Agrostocrinum hirsutum</i>	0.3	0.2	0	0	0	0	0
<i>Agrostocrinum scabrum</i>	0	0	0	0	0	0	0.1
<i>Allocasuarina fraseriana</i>	1	0	0	0	0	0	0
<i>Allocasuarina humilis</i>	0.5	0	0	0	0.5	0	0
<i>Austrostipa ?hemipogon</i>	0	0.1	0	0	0	0	0
<i>Austrostipa elegantissima</i>	0	0.1	0	0	0	0	0
<i>Avena barbata</i>	0	0	10	0	0	0	0
<i>Banksia armata</i> var. <i>armata</i>	1	0	0	0	0	0.3	0
<i>Banksia bipinnatifida</i> subsp. <i>multifida</i>	0.2	0.3	0	0	0	0	0.5
<i>Banksia dallanneyi</i> var. <i>dallanneyi</i>	0.3	0.5	0	0	5	1	1
<i>Billardiera ?variifolia</i>	0	0	0	0	0	0	0.1
<i>Bossiaea eriocarpa</i>	1	1	0	0	4	2	1
<i>Briza maxima</i>	0.1	0	0	0	0	0.1	0.3
<i>Burchardia congesta</i>	0	0	0	0	0.3	0	0
<i>Calothamnus sanguineus</i>	0	0	0	0	0	0.5	0
<i>Cassytha glabella</i>	0.1	0.1	0	0	0.1	0	0.1
<i>Caustis dioica</i>	0	0	0	0	2	0	0
<i>Chamaecytisus palmensis</i>	0	0	3	0	0	0	0
<i>Conostylis aculeata</i> subsp. <i>aculeata</i>	0	0	0	0	0.2	0	0
<i>Conostylis</i> sp.	0	0	0	0	0.1	0	0
<i>Corymbia calophylla</i>	0	0	1	0	20	1	5
<i>Daviesia decurrens</i>	0	0	0	0	0.3	0	0
<i>Daviesia hakeoides</i> subsp. <i>hakeoides</i>	0.2	0.3	0	0	0	0	0
<i>Desmocladus fasciculatus</i>	0.7	0.3	0	0	0.5	0.3	0.5
<i>Desmocladus flexuosus</i>	0	0.2	0	0	0.5	0	0
<i>Ehrharta calycina</i>	0.1	0	20	0	0	0	0.5
<i>Eucalyptus marginata</i>	0	0	0	0	0	0.5	0
<i>Eucalyptus wandoo</i> subsp. <i>wandoo</i>	11	10	5	10	0	8	15
<i>Gastrolobium acutum</i>	2	0	0	0	0	0.3	8
<i>Gladiolus caryophyllaceus</i>	0.1	0	0	0	0.2	0.2	0.1
<i>Gompholobium marginatum</i>	0.2	0.2	0	0	0	0.2	0
<i>Goodenia caerulea</i>	0.1	0.1	0	0	0	0.1	0
<i>Grevillea synapheae</i>	0	0.2	0	0	0	0	0
<i>Haemodorum loratum</i> (P3)	0.2	0	0	0	0.3	0	0
<i>Hakea lissocarpa</i>	0.2	0.5	0	0	0.3	0.3	2
<i>Hakea stenocarpa</i>	0.5	0	0	0	0	0.5	0.5
<i>Hakea undulata</i>	0.7	1	0	0	0	0	0
<i>Hibbertia hypericoides</i>	0.5	1	0	0	0	0	0.3
<i>Hibbertia</i> sp.	0.2	0.3	0	0	0	0	0
<i>Hibbertia spicata</i> subsp. <i>spicata</i>	1	0	0	0	0	0	0
<i>Hibbertia hypericoides</i> subsp. <i>septentrionalis</i>	1	1	0	0	1	1	1
<i>Hypocalymma angustifolium</i>	0	0	0	0	0	0.2	0
<i>Hypochaeris glabra</i>	0	0	0	0	0	0	0.1
<i>Isopogon asper</i>	0.3	0	0	0	0	0	0
<i>Lambertia multiflora</i> var. <i>darlingensis</i>	0	0	0	0	0.1	0	0
<i>Laxmannia ramosa</i> subsp. <i>ramosa</i>	0.1	0	0	0	0	0	0
<i>Lechenaultia biloba</i>	0	0.2	0	0	0	0.3	0.1

Taxon Name	Plot						
	M01	M02	M03	M04	M05	M06	HS01
<i>Lepidosperma asperatum</i>	0.1	0.2	0	0	1	0	0
<i>Lepidosperma pubisquameum</i>	0.3	0.5	0	0	0	1	0.5
<i>Lomandra caespitosa</i>	0	0	0	0	0	0	0.1
<i>Lomandra hermaphrodita</i>	0.2	0	0	0	0	0	0
<i>Lomandra preissii</i>	0	0	0	0	0	0	0.1
<i>Lomandra sericea</i>	0	0	0	0	0	0	0.1
<i>Melaleuca clavifolia</i>	0.2	0	0	0	0	0.3	0
<i>Mesomelaena graciliceps</i>	0	0	0	0	0.1	0	0
<i>Mesomelaena pseudostygia</i>	0	0	0	0	8	0	0
<i>Mesomelaena tetragona</i>	0.3	0	0	0	0	0	0
<i>Neurachne alopecuroidea</i>	0	0.1	0	0	0.1	0	0.1
<i>Opercularia vaginata</i>	0	0.1	0	0	0	0	0
<i>Petrophile striata</i>	0	0	0	0	0	0.3	0
<i>Phyllanthus calycinus</i>	0	0	0	0	0.2	1	0
<i>Pimelea imbricata</i> var. <i>piligera</i>	0	0.3	0	0	0	0	0
<i>Stirlingia latifolia</i>	0	0	0	0	0.3	0	0
<i>Stylidium affine</i>	0.1	0.1	0	0	0	0	0
<i>Stylidium piliferum</i>	0	0	0	0	0	0.1	0
<i>Stylidium purpureum</i>	0	0.1	0	0	0	0	0
<i>Tetraria octandra</i>	0.2	0.3	0	0	0	0.5	0.3
<i>Tetratheca nuda</i>	0	0	0	0	0	0	0.1
<i>Trichocline spathulata</i>	0.1	0.2	0	0	0	0.1	0.5
<i>Tricoryne elatior</i>	0	0	0	0	0	0.1	0.1
<i>Trymalium angustifolium</i>	0	0	0	0	0	0.1	0
<i>Ursinia anthemoides</i>	0	0	0	0	0	0	0.2
<i>Xanthorrhoea preissii</i>	4	6	2	0	4	5	2

Appendix C

Sampling Plot Environmental Data and Vegetation Structural Data

Plot	Date	Latitude	Longitude	Easting	Northing	UTM Zone	Aspect (classes)
M01	13/11/2019	-31.598258	116.0183277	406871.7153	6503674.938	50	S
M02	13/11/2019	-31.597675	116.0184214	406880.0246	6503739.64	50	SSW
M03	13/11/2019	-31.5987326	116.0177956	406821.7069	6503621.879	50	S
M04	13/11/2019	-31.5942336	116.017641	406802.5598	6504120.429	50	N/A
M05	13/11/2019	-31.5936641	116.0175812	406796.3191	6504183.503	50	N/A
M06	13/11/2019	-31.5967054	116.0165093	406697.6536	6503845.483	50	S
HS01	13/11/2019	-31.5967634	116.0159869	406648.1499	6503838.608	50	SW

Plot	Placement strategy	Plot Type	Plot Size (m ²)	Plot Width (m)	Plot Length (m)	Stand Age	Slope (%)
M01	Preferential	Quadrat	100	10	10	>3	3
M02	Preferential	Quadrat	100	10	10	>3	5
M03	Preferential	Recce	100	10	10	N/A	2
M04	Preferential	Recce	N/A	N/A	N/A	>3	0.5
M05	Preferential	Quadrat	100	10	10	>3	0
M06	Preferential	Quadrat	N/A	N/A	N/A	>3	3
HS01	Preferential	Quadrat	100	10	10	>3	3

Plot	Bare Ground (%)	Bare Rock (%)	Litter (%)	Landform	Soil Colour	Soil Texture	Rock Type
M01	2	N/A	35	Mid slope	Brown	Clay Loam	N/A
M02	5	N/A	40	Upper slope	Light brown	Loamy clay	N/A
M03	N/A	N/A	N/A	Lower slope	Brown	Gravelly loam	N/A
M04	50	N/A	25	Rehabilitation	Light brown	Loamy clay	N/A
M05	1	N/A	35	Flat	Light brown	Clay Loam	N/A
M06	5	N/A	25	Upper slope	Brown	Gravelly clay loam	N/A
HS01	1	N/A	55	Mid slope	Brown	Loam	N/A

Plot	Vegetation Condition	Cover Trees (%)	Cover Shrubs (%)	Cover Ground Layer (%)	Remarks
M01	Excellent	12	35	10	
M02	Excellent	10	30	15	
M03	Completely Degraded	N/A	N/A	N/A	
M04	Rehabilitation	N/A	N/A	N/A	
M05	Very Good	20	20	40	Some influence from drains
M06	Excellent	18	50	20	
HS01	Excellent	20	50	15	

Appendix B

Consolidated Flora Species List

Lots 202-203 Wandena Rd and Lots 204-205 Great Northern Highway, Muchea
Consolidated Flora Species List

From 360 Environmental (2015) and Plantecology (2020)

Native Taxa

Acacia applanata
Acacia lasiocarpa subsp. sedifolia
Acacia pulchella var. pulchella
Acacia saligna
Agrostocrinum hirsutum
Agrostocrinum scabrum
Allocasuarina fraseriana
Allocasuarina huegeliana
Allocasuarina humilis
?Amphipogon debilis
Anigozanthos manglesii
Austrostipa ?hemipogon
Austrostipa elegantissima
Banksia armata var. armata
Banksia bipinnatifida subsp. multifida
Banksia dallanneyi var. dallanneyi
Banksia nivea
Banksia sessilis
Billardiera ?variifolia
Billardiera fraseri
Bossiaea eriocarpa
Burchardia congesta
Calothamnus sanguineus
Cassutha glabella
Caustis dioica
Comesperma ciliatum
Conostylis aculeata subsp. aculeata
Conostylis sp.
Corymbia calophylla
Cristonia biloba subsp. biloba
Cyathochaeta sp.
Dampiera alata
Dampiera linearis
Daucus glochidiatus
Daviesia decurrens
Daviesia hakeoides subsp. hakeoides
Daviesia preissii
Daviesia triflora
Desmocladius fasciculatus
Desmocladius flexuosus
Dillwynia laxiflora
Eucalyptus accedens
Eucalyptus marginata
Eucalyptus wandoo subsp. wandoo
Gastrolobium acutum
Gastrolobium capitatum

Glischrocaryon aureum
Gompholobium marginatum
Gonocarpus cordiger
Goodenia caerulea
Grevillea synapheae
Haemodorum discolor
Haemodorum loratum (P3)
Hakea lissocarpa
Hakea stenocarpa
Hakea undulata
Hibbertia hypericoides subsp. septentrionalis
Hibbertia sp.
Hibbertia spicata subsp. spicata
Hypocalymma angustifolium
Hypocalymma robustum
Isopogon asper
Lambertia multiflora var. darlingensis
Laxmannia ramosa subsp. ramosa
Lechenaultia biloba
Lechenaultia sp.
Lepidosperma asperatum
Lepidosperma leptostachyum
Lepidosperma pubisquameum
Lepidosperma sp.
Lomandra caespitosa
Lomandra hermaphrodita
Lomandra preissii
Lomandra sericea
Lomandra sonderi
Macrozamia riedlei
Marianthus drummondianus
Melaleuca clavifolia
Melaleuca sp.
Mesomelaena graciliceps
Mesomelaena pseudostygia
Mesomelaena tetragona
Neurachne alopecuroidea
Opercularia vaginata
Patersonia juncea
Petrophile macrostachya
Petrophile striata
Phyllanthus calycinus
Pimelea imbricata var. piligera
Pultenaea reticulata
Rytidosperma setaceum
Scaevola glandulifera
Stirlingia latifolia
Stylidium affine
Stylidium piliferum
Stylidium purpureum
Tetraria octandra
Tetratheca nuda
Thomasia foliosa
Trichocline spathulata

Tricoryne elatior
Trymalium angustifolium
Xanthorrhoea preissii

Introduced Taxa

*Avena barbata
*Briza maxima
*Chamaecytisus palmensis
*Cynodon dactylon
*Ehrharta calycina
*Eragrostis curvula
*Gladiolus caryophyllaceus
*Hypochaeris glabra
*Lupinus sp.
*Lysimachia arvensis
*Romulea rosea
*Ursinia anthemoides