



## **FI Joint Venture Pty. Ltd.**

### Yogi Magnetite Project Flora and Vegetation Assessment

October 2019

# Executive summary

FI Joint Venture (FIJV) proposes to construct and operate a magnetite iron ore project (the Yogi Mine Project) located near Yalgoo in the Mid West Region of Western Australia (WA). The Yogi Mine Project proposal includes the mine and associated infrastructure as well as a magnetite slurry pipeline and a water pipeline to Geraldton Port, and a gas supply pipeline from the Dampier to Bunbury Natural Gas Pipeline network.

FIJV commissioned GHD Pty Ltd (GHD) to undertake a flora and vegetation assessment for the Yogi Mine Project. The purpose of the assessment was to identify key flora and vegetation constraints within the survey area. This report covers a survey area of 8,230 hectares (ha); a separate flora and vegetation survey of a pipeline alignment has been completed and is reported in GHD (2019).

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

## Key findings

- Nine vegetation types as well as cleared areas were identified and described for the survey area. The vegetation types included five types associated upland areas (BIF range, granite outcrops and low rises), three types associated with drainage areas and one type associated with gentle undulating floodplains.
- The vegetation condition within the survey area was rated from Excellent to Very Good, with cleared areas (i.e. Yalgoo-Mt Magnet Road) not rated. The majority of vegetation throughout the survey area was rated as Excellent. Whilst current grazing occurs over most of the survey area, areas with increased grazing impacts were rated Very Good.
- One PEC was identified within the survey area, the Yalgoo (Gnows Nest/Wolla Wolla and Woolgah-Wadgingarra) vegetation complexes (banded ironstone formation), which is listed as Priority 1 by Department of Biodiversity, Conservation and Attractions (DBCA). Vegetation communities mapped within the survey area occurring on the BIF range were considered representative of the Yalgoo vegetation complexes PEC. There is 1,041.09 ha of the Yalgoo vegetation complexes PEC in Excellent condition within the survey area.
- Two hundred and thirty three flora taxa (including subspecies and varieties) were recorded from the survey area during the field survey. This total comprised of 224 native taxa and nine introduced flora taxa. Of the introduced taxa, none are listed as Declared Pests under the *Biosecurity and Management Act 2007* and/or as a Weeds of National Significance.
- No *Environment Protection and Biodiversity Conservation Act 1999* or *Biodiversity Conservation Act 2016* (BC Act) listed flora were recorded within the survey area. Three DBCA Priority-listed flora species were recorded within the survey area during the field survey including:
  - *Acacia subsessilis* – Priority 3
  - *Acacia speckii* – Priority 4
  - *Dodonaea amplisemina* – Priority 4.
- All three species were restricted to the BIF range with the exception of *A. speckii* which was sporadically recorded from the granite areas.
- The likelihood of occurrence assessment post-field survey concluded that three species are known to occur, five taxa may possibly occur and the remaining ten taxa are unlikely or

highly unlikely to occur. The five taxa that may possibly occur have been recorded within the study area, suitable habitat is present within the survey area and the species can be cryptic.

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# 1. Introduction

## 1.1 Background

FI Joint Venture (FIJV) proposes to construct and operate a magnetite iron ore project (the Yogi Mine Project) located approximately 225 km east-northeast of Geraldton and 15 km northeast of Yalgoo in Mid West, Western Australia (WA) (Figure 1). The Yogi Mine Project proposal includes the mine and associated infrastructure as well as a magnetite slurry pipeline and a water pipeline to Geraldton Port, and a gas supply pipeline from the Dampier to Bunbury Natural Gas Pipeline network.

## 1.2 Purpose of this report

FIJV commissioned GHD to undertake a flora and vegetation assessment for the Yogi Mine Project. The purpose of the assessment was to identify key flora and vegetation constraints within the survey area. This report details the flora and vegetation results, which will be used to identify and assess key constraints and inform the environmental assessment and approvals process.

## 1.3 Project location

### 1.3.1 Survey area

The survey area intersects Carlaminda and Wagga Wagga Pastoral Stations and includes mining tenements M59/740, M59/637, P59/2133 and L59/156. The survey area covers 8,230 hectares (ha) and is mapped in Figure 1, Appendix A.

A separate flora and vegetation survey of a pipeline alignment has been completed and is reported in GHD (2019).

### 1.3.2 Study area

A study area was defined for the desktop based searches of the survey area and includes a 40 kilometre (km) buffer around the survey area.

## 1.4 Scope of works

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

- A desktop review of publically available information and relevant reports (as provided by FIJV) to determine the flora and vegetation values of the survey area
- A detailed and targeted flora and vegetation survey to identify:
  - Vegetation types present, including presence of any Threatened or Priority Ecological Communities (TECs or PECs) or other significant vegetation
  - Vegetation condition, including the location of any Weeds of National Significance (WONS) or Declared Weeds
  - Flora species present including introduced species
  - The presence or potential presence of any Threatened, Priority or other significant flora
- Preparation of technical report (this document) that documents the results of the desktop review and field surveys, including mapping.

## **1.5 Relevant legislation, conservation codes and background information**

In WA some ecological communities, flora and fauna are protected under both Federal 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 biological survey is provided in Appendix B.

## **1.6 Report limitations and assumptions**

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

GHD otherwise disclaims responsibility to any person other than FIJV 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 FIJV 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 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 vegetation values within the survey area, as shown in 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 identify environmental information relevant to the study area and to assist in survey design. The desktop assessment included a review of:

- The Department of the Environment and Energy (DEE) 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 (DEE 2018a) (Appendix C)
- The Department of Biodiversity, Conservation and Attractions (DBCAs) Threatened and Priority Ecological Community (TECs and PECs) database to determine the potential for TECs or PECs to be present within the study area
- The DBCA *NatureMap* database for flora species previously recorded within the study area (DBCAs 2007–) (Appendix C)
- The DBCA Threatened (Declared Rare) and Priority Flora (TPFL) and WA Herbarium (WAHEBR) databases for Threatened flora species listed under the *Biodiversity Conservation Act 2016* (BC Act) and listed as Priority by the DBCA, previously recorded within the study area
- Existing datasets including previous pre-European vegetation mapping of the survey area (Beard 1976), aerial photography, geology/soils and hydrology information to provide background information on the variability of the environment, likely vegetation units and to identify areas with potential to contain TECs, PECs, and Threatened and Priority listed flora species.
- Previous flora and vegetation survey reports and data including:
  - Flora and Vegetation Assessment Yalgoo Iron Project (ATA Environmental 2006)
  - Spring Flora and Vegetation Assessment Yalgoo Iron (ATA Environmental 2007)
  - Targeted Rare Flora Survey, Exploration Leases, Yalgoo Iron Project (Coffey 2010)
  - Western Haematite Deposit, Yalgoo Spring Flora Survey Final (Ecoscape 2008)
  - Ferrowest Limited: Yalgoo Iron Project (Tenements E59/1097 and M59740) (Maia Environmental Consultancy 2011)
  - Flora and vegetation of the banded iron formations of the Yilgarn Craton: Yalgoo (Markey and Dillon 2011).

### 2.2 Field survey

GHD botanists completed detailed and targeted flora and vegetation surveys of the surveys area between August and October 2018. A summary of survey effort is shown in Table 1 with survey effort shown on Figure 2, Appendix A. 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 or other significant ecological communities and flora taxa were also undertaken during the field surveys.

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



**Table 1 Survey effort**

Date	Survey effort	Personnel
6-14 August 2018	Detailed flora and vegetation, and targeted surveys	Two botanists and one ecologist
9-13 October 2018	Detailed flora and vegetation, and targeted surveys	One botanist and one ecologist

**Data collection**

Field survey methods involved a combination of sampling quadrats and transects located in identified vegetation units and traversing the survey area by vehicle and foot. Fifty five non-permanent quadrats and five transects were described throughout the survey area, which is deemed suitable for the size of the survey area and to ensure suitable spatial distribution and replication.

Quadrats (measuring 20 m x 20 m – area of 400 m<sup>2</sup>) were located within each identified vegetation unit. A minimum of three quadrats were located within each identified vegetation unit with the exception of vegetation type AiMsSa. For this vegetation type there was insufficient representation of the unit across the survey area to allow for additional sample locations. Field data at each quadrat was recorded on a pro-forma data sheet and included the parameters detailed in Table 2. Quadrat data is provided in Appendix D.

**Table 2 Data collected during the flora and vegetation field survey**

Aspect	Measurement
Collection attributes	Site code, personnel/recorder, date, quadrat dimensions, photograph of the quadrat, marking method
Physical features	Landform, aspect, slope, soil attributes, ground surface cover, leaf and wood litter
Location	Coordinates recorded in GDA94 datum (Zone 50) using a hand-held Global Positioning System (GPS) tool to accuracy approximately ±5 m
Vegetation condition	Vegetation condition in accordance with the vegetation condition rating scale for the South-West Interzone Botanical Province (EPA 2016)
Disturbance	Level and nature of disturbances (e.g. weed presence, fire and time since last fire, impacts from grazing, exploration activities).
Flora	List of dominant flora from each structural layer, list of all species within the quadrat including stratum, average height and cover (using National Vegetation Information System (NVIS)).

A flora inventory was compiled from taxa listed in described quadrats, transects 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, field data/observations and statistical analyses.

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 NVIS and are consistent with NVIS Level V (Association). At Level V, three (or more) taxa per stratum are used to describe the association (NVIS Technical Working Group 2017).

**Statistical analyses**

PRIMER version 6 (Clarke and Gorley 2006) was used to examine the similarity between sites using collected data. A presence/absence matrix was created of all taxa (including perennials and annuals) present in GHD quadrats. The dissimilarity between quadrats was determined using the Bray-Curtis measure and the Resemblance function in PRIMER. A Cluster analysis (using Agglomerative Hierarchical Clustering technique) based on group average was

undertaken using the Bray-Curtis similarity matrix and results presented as a dendrogram. In addition, a nonmetric multi-dimensional scaling analysis (MDS) was undertaken using the Bray-Curtis similarity matrix and results presented as a two dimensional scatter plot. The analysis was repeated using removing all singleton taxa. The outputs of the PRIMER analysis were used to inform decisions on vegetation units.

### **Comparison with regional dataset**

The Yalgoo dataset from Banded Iron Formation and Greenstone survey data version 6 (accessed from *NatureMap*) includes quadrat data from 55 permanent quadrats established on the Gnows Nest Range, Wolla Wolla and Woolgah–Wadgingarra Hills during the spring season (August-September) of 2007. Of these quadrats, eight intersect the current survey area (WADG10, WADG11, WADG12, WADG14, WADG15, WADG16, WADG17 and WADG18).

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

It is noted that floristic analyses using presence/absence matrices can be limited in use as they are based on all species recorded in sites, and does not take into account dominance of species.

### **Vegetation condition**

The vegetation condition of the survey area was assessed and mapped in accordance with the vegetation condition rating scale for the South-West Interzone Botanical Province of WA (devised by Keighery (1994) and adapted by the EPA (2016)). The scales recognise the intactness of vegetation and consists of six rating levels as outlined in Appendix B.

### **Flora identification and nomenclature**

Species that were well known to the survey botanists were identified in the field; all other species were collected and assigned a unique collection number to facilitate tracking. Flora collections were made under SOPP licence no. SL012290. All specimens collected during the field assessment were dried and processed in accordance with the requirements of the Western Australian Herbarium. Species were identified by a qualified taxonomist using taxonomic literature, electronic keys and online electronic databases.

The conservation status of all recorded flora was compared against the current lists available on *FloraBase* (WA Herbarium 1998–) and the EPBC Act Threatened species database provided by DEE (2018b). Nomenclature used in this report follows that used by the WA 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, geology, soils and topography data, EPBC Act PMST, *NatureMap* search results and previous survey reports and data) was reviewed to determine conservation significant flora taxa potentially present within the survey area and locations. 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 for the presence of conservation significant flora. Targeted survey efforts focused on the Wadgingarra Hill area, where a number of Priority flora species had been previously recorded. In this area GHD employed a sampling method involving walking traverses spaced approximately 50 metres (m) apart. Traverse spacing equated to a 25 m search area either side of the walked traverse, which was deemed sufficient intensity for the taxa targeted and density of the vegetation present. Tracklogs of walked traverses were captured using handheld Garmin GPS and Samsung S2 tablets. Survey effort for the targeted flora survey is shown on Figure 2, Appendix A.

As the purpose of the targeted flora survey was to search for and record significant flora taxa, additional information along each traverse such as descriptive location, landform, aspect, soils and vegetation condition was not recorded. This information was already captured for the survey area as part of detailed vegetation and flora surveys completed by GHD.

Where individuals were identified, the location and number of plants present were recorded using handheld GPS units and Samsung S2 tablets. For each Priority listed species a representative sample was collected for verification and lodgement at the WA Herbarium. Additional data was also collected to support the lodgement of a Threatened and Priority Flora Report Form.

## **2.3 Limitations**

### **2.3.1 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 DBCA searches of Threatened and Priority flora provide more accurate information for the general area. However, some records of collections cannot be dated and only provide plain language locality descriptions which can misrepresent the current range of the species.

### **2.3.2 Field survey limitations**

The EPA (2016) Technical Guide states that flora survey reports for environmental impact assessment in WA should contain a section describing the limitations of the survey methods used. The limitations and constraints associated with this field survey are discussed in Table 3. Based on this assessment, the present survey effort has not been subject to any constraints which affect the thoroughness of the assessment and the conclusions which have been formed.

**Table 3 Field survey limitations**

Aspect	Constraint	Comment
Sources of information and availability of contextual information.	Nil	Adequate information is available for the survey area, this includes: <ul style="list-style-type: none"> <li>• Broad scale (1:250,000) mapping by Beard (1976) and digitised by Shepherd <i>et al.</i> (2002)</li> <li>• Regional biogeography (Desmond and Chant 2001)</li> <li>• Previous flora and vegetation survey reports and data (ATA 2006, 2007, Ecoscape 2008, Coffey 2010, Maia 2011, Markey and Dillon 2011)</li> </ul>
Scope (what life forms were sampled etc.)	Nil	Vascular flora were sampled during the survey. Non-vascular flora and aquatic fauna were not surveyed.
Proportion of flora collected and identified (based on sampling, timing and intensity)	Minor	The vegetation and flora assessment included multiple surveys within a single season, Spring 2018. The flora recorded from the field survey is detailed in section 4.4 and a full flora species list is provided in Appendix D. The portion of flora collected and identified was considered high based on survey effort and timing.
Flora determination	Minor	Flora determination was undertaken by the survey botanist and ecologist in the field and by a qualified taxonomist at the WA Herbarium. Two collections could be identified to family level only, five collections could be identified to genus level only and eight collections were uncertain species identifications due to lack of flowering and/or fruiting material required for identification. None of these collections were similar to known conservation significant flora (as identified in the desktop searches). The taxonomy and conservation status of the WA flora is dynamic. This report was prepared with reliance on taxonomy and conservation status current at the time report development, but it should be noted this may change in response to ongoing research and review of International Union for Conservation Nature criteria.
Completeness and further work which might be needed (e.g. was the relevant area fully surveyed)	Minor	Access to the survey area was made by vehicle tracks which extended throughout the survey area. The survey area was traversed by vehicle and on foot. 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 types and condition for the entire survey area.
Mapping reliability	Minor	The vegetation was mapped at a scale of 1:5,000 using high-resolution ESRI aerial imagery obtained from Landgate, topographical features, previous broad scale mapping and field data. Data was recorded in the field using hand-held GPS tools (e.g. 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 $\pm 5$ metres on average. Therefore the data points consisting of coordinates recorded from the GPS may contain inaccuracies.

Aspect	Constraint	Comment
Timing/weather/season/cycle	Minor	<p>The field surveys were conducted during spring from 6 August to 15 October 2018.</p> <p>The closest weather recording station to the survey area with long-term data is Mullewa (No. 008095) (Bureau of Meteorology (BoM) 2019). As shown in Plate 1 (section 3.1) during 2018 the area received lower amounts of rainfall in May and June, and greater amounts of rainfall in July and August compared with the long-term averages (LTA) for the same months. The temperature statistics indicate that the 2018 minimum and maximum temperatures were consistent with the LTAs.</p> <p>The weather conditions recorded during the survey periods are considered unlikely to have impacted upon the vegetation and flora survey. The survey timings were considered appropriate for the flora and vegetation field surveys.</p>
Disturbances (e.g. fire, flood, accidental human intervention)	Nil	No disturbances were experienced during the survey.
Intensity (in retrospect, was the intensity adequate)	Nil	The vascular flora of the survey area were sampled in accordance with EPA (2016). A minimum of three quadrats per vegetation type were established and described along with transects, opportunistic and traverse based searches to supplement the data. The survey area was sufficiently covered by the survey team during the survey.
Resources	Nil	Adequate resources were employed during the field survey. The survey team comprised a senior botanist (more than 12 years' experience), ecologist (8 years' experience) and a graduate ecologist (2 years' field experience).
Access restrictions	Nil	No access problems were encountered during the survey.
Experience levels	Nil	The team who executed the survey are practitioners suitably qualified and experienced in their respective fields. Jordan Tindiglia is a senior botanist with over 12 years' experience undertaking flora surveys in WA, Steven Petts is an ecologist with eight years' experience undertaking ecological surveys within WA, and Madison Roberts is a graduate ecologist with two years' experience assisting in ecological surveys within WA.

# 3. Desktop assessment

## 3.1 Climate

The survey area is located within the Mid West Region of Western Australia. The climate of this region is classified as Mediterranean, semi-arid to arid and warm, with two distinct seasons: a hot and dry summer (December to February) and a mild wet winter (June to August) (Payne et al. 1998; Markey and Dillon 2008).

The region is characterised by a moderately variable rainfall, with rainfall events being restricted to local areas rather than being widespread. The majority of all rainfall received occurs during winter months and is a result of low pressure system associated with the westerly wind system. Summer rainfall occurs as result of thunderstorms and heavy downpours associated with remnant tropical cyclones (Markey and Dillon 2008). The BoM Mullewa station (site number 008095) is the nearest weather station to the survey area with continuous long-term data. Climatic data from this site including the long-term average, and from 2018 is summarised in Plate 1.

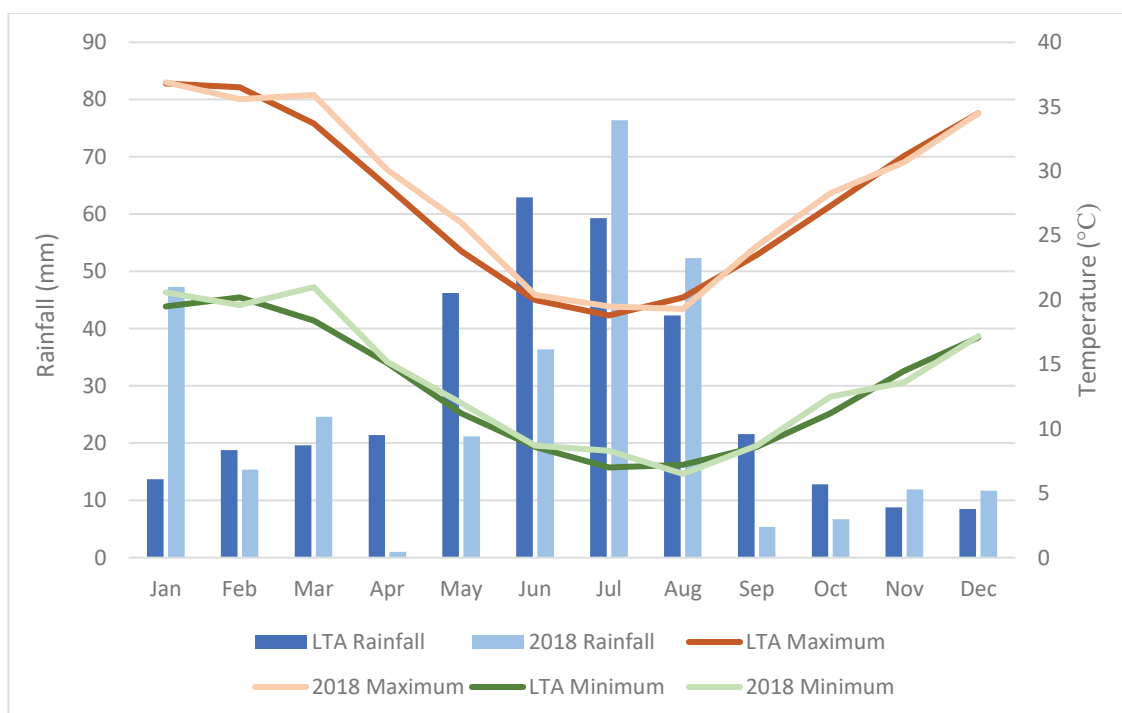


Plate 1 Climatic data from Mullewa (BoM 2019)

## 3.2 Geology and soils

### 3.2.1 Geology

The survey area is located within the Murchison Province of the Yilgarn Craton. The Yilgarn Craton is comprised of geological formation from the Archaean (2.5 billion years ago) to Cainozoic ages (66 million years ago to present) and bounded by the Murgoo Gneiss Complex of the Western Gneiss Terrane in the west and the Southern Cross Province in the east. The Archaean rocks of the Murchison and Southern Cross Provinces consists of linear to arcuate greenstone belts. The greenstones comprises volcanic rocks, felsic volcanic rocks and metasedimentary rocks including cherts and banded iron formation (BIF). The granitoid rocks contain adamellites, granite, gneiss and migamite (Payne et al. 1998).

### 3.2.1 Landforms and soil

The survey area is located within the Karrara Hills Plains and Lake, and Yalgoo Plains soil landscape zones in the Murchison Province:

- The Karrara Hills Plains and Lake Zone is described as hills and ranges, sandy plains, hardpan wash plains, stony plains and salt lakes (with some mesas and plains) on greenstone and granitic rocks of the Yilgarn Craton. Red shallow loams, Red loam earths, Red deep sands and Salt lake soils with some Red shallow sands, Stony soil and Red shallow sandy duplexes (Tille 2006).
- The Yalgoo Plain Zone is described as hardpan wash plains (with some sandplains, stony plains, mesas and granite outcrops) on granitic rocks (with some greenstone) of the Yilgarn Craton (Murchison Domain). Red loamy earths and Red shallow loams (often with hardpans) with Red deep sands and Red shallow sands and some shallow sandy complexes (Tille 2006).

### 3.3 Land systems

The Murchison Region has been surveyed by the Department of Agriculture and Food Western Australia (DAFWA) for the purpose of land classification, condition and resource evaluation (Payne et. al. 1998). The survey area intersects five land systems; details of each system is summarised in Table 4.

**Table 4 Land systems within the survey area**

Land system	Description	Land type
Gabanintha	Ridges, hills and footslopes of various metamorphosed volcanic rocks (greenstones), supporting sparse acacia and other mainly non-halophytic shrublands.	Hills and ranges with acacia shrublands
Violet	Gently undulating gravelly plains on greenstone, laterite and hardpan, with low stony rises and minor saline plains; supporting groved mulga and bowgada shrublands and patchy halophytic shrublands.	Stony plains with acacia shrublands and halophytic shrublands
Tindalarra	Near level hardpan wash plains, narrow drainage lines and moderately saline drainage floors; supporting tall mixed acacia shrublands with wanderrie grasses, also minor saltbush/bluebush low shrublands.	Wash plains on hardpan with mulga shrublands
Challenge	Gently undulating gritty-surfaced plains, occasional granite hills, tors and low breakaways, with acacia shrublands.	Gritty-surfaced plains and granite tors and domes with acacia shrublands
Hamilton	Hardpan plains, stony plains and incised drainage lines supporting mulga shrublands.	Wash plains on hardpan with mulga shrublands

### 3.4 Hydrology

#### 3.4.1 Drainage lines

Two ephemeral drainage lines intersect the survey area and are located in the western and eastern parts of the survey area. The unnamed watercourse that traverses the western part of the survey area is generally undefined in the north-west part of the survey area, and becomes more defined as it flows south east along the eastern side of the BIF. An alluvial floodplain with some distinct channels also recharge the watercourse and occur/intersect the central part of the survey area.

The second unnamed watercourse intersects the survey area in its north-east part and generally flows south both within and adjacent to the survey area. This watercourse is predominately ill defined.

### **3.4.2 Wetlands**

No wetlands are located within or adjacent to the survey area.

## **3.5 Land use**

### **3.5.1 DBCA managed lands**

No DBCA managed lands are located within the survey area or study area.

### **3.5.2 Environmentally Sensitive Areas**

No Environmental Sensitive Areas (ESA) occur within the survey area or study area.

## **3.6 Regional biogeography**

The survey area is situated in the Eremaean Botanical Province, within the Yalgoo bioregion and Talling sub-region as described by the Interim Biogeographic Regionalisation of Australia (IBRA).

The Yalgoo bioregion represents an interzone between south western bioregions and the Murchison bioregion. The bioregion is characterised by low woodlands to open woodlands of *Eucalyptus*, *Acacia* and *Callitris* on red sandy plains of the Western Yilgarn Craton and Southern Carnarvon Basin. The Western Yilgarn Craton comprises mulga, *Callitris-E. salubris*, and Bowgada open woodlands and scrubs on earth to sandy-earth plains. The Southern Carnarvon Basin has a basement of Phanerozoic sediments. The subregion is particularly rich in ephemerals (Desmond and Chant 2001).

## **3.7 Vegetation**

### **3.7.1 Broad vegetation mapping**

Broad scale (1:1,000,000) pre-European vegetation mapping of the Murchison region was completed by Beard (1976) at an association level. The mapping indicates there are two vegetation associations present within the survey area:

- Low woodland; mulga (*Acacia aneura*) (association 18)
- Shrublands; bowgada & jam scrub (association 420).

The mapping by Beard (1976) was built upon by Pringle (1998) for the wider Sandstone – Yalgoo – Paynes Find area. Pringle (1998) described 50 major habitats split into 10 habitat groups across the area. Habitats were based upon dominant vegetation structure, perennial taxa and land surface (Pringle 1998).

### **3.7.2 Vegetation extent and status**

The pre-European vegetation mapping has been adapted and digitised by Shepherd *et al.* (2002). The extents of the vegetation associations have been determined by the State-wide vegetation remaining extent calculations maintained by the DBCA (current as of March 2019 – Government of WA (GoWA) 2019). As shown in Table 5, the current extents remaining of all vegetation associations are greater than 90 per cent (%) of their pre-European extents at all scales (e.g. State, IBRA Bioregion, IBRA Subregion and Local Government Area (LGA)).



**Table 5 Extents of vegetation associations mapped with the survey area (GoWA 2018)**

Vegetation association	Scale	Pre-European extent (ha)	Current extent (ha)	Remaining (%)	% Current extent in all DBCA managed lands
YAL IBRA bioregion		5,057,325.85	4,923,840.47	97.36	31.18
Tallering IBRA sub-region		3,498,943.53	3,387,092.96	96.80	23.66
18	State: WA	19,892,306.46	19,843,148.07	99.75	6.62
	IBRA bioregion: Yalgoo (YAL)	101,331.17	101,232.93	99.90	19.45
	IBRA sub-region: Tallering (YAL02)	101,278.46	101,180.22	99.90	19.41
	LGA: Shire of Yalgoo	548,671.48	548,555.14	99.98	19.88
420	State: WA	859,632.11	830,216.12	96.58	14.11
	IBRA bioregion: Yalgoo (YAL)	621,396.05	620,265.57	99.82	16.41
	IBRA sub-region: Tallering (YAL02)	615,816.17	614,685.69	99.82	16.56
	LGA: Shire of Yalgoo	549,363.05	548,343.13	99.81	12.89

### 3.7.3 Conservation significant ecological communities

The EPBC Act PMST did not identify any federally listed TECs potentially occurring within the study area (DEE 2018a) (Appendix C). The DBCA TEC and PEC database searched identified eight PECs and/or their buffers occurring within the study area (Table 6 and Figure 3, Appendix A). Five of these PECs represent unique assemblages of invertebrates associated with groundwater calcretes. One PEC intersects the survey area, the Yalgoo (Gnows Nest/Wolla Wolla and Woolgah-Wadgingarra) vegetation complexes (banded ironstone formation) PEC.

**Table 6 PECs identified in the desktop searches occurring within the study area**

ID and status	Description	Location
Yalgoo BIF Priority 1	Yalgoo (Gnows Nest/Wolla Wolla and Woolgah-Wadgingarra) vegetation complexes (banded ironstone formation)	Intersects western portion of survey area
Wagga and Yalgoo Calcrete Priority 1	Wagga Wagga and Yalgoo calcrete groundwater assemblage type on Yalgoo palaeodrainage on Wagga Wagga Station and Moore Palaeodrainage on Yoweragabbie Station	Located 14 km south-west of survey area
Gabyon Calcrete Priority 1	Gabyon calcrete groundwater assemblage type on Moore palaeodrainage on Gabyon Station	Located 26 km north of survey area
Gullewa BIF Priority 1	Gullewa vegetation complexes (banded ironstone formation)	Located 38 km south-west of survey area
Muralgarra Calcrete Priority 1	Muralgarra calcrete groundwater assemblage type on Murchison palaeodrainage on Muralgarra Station	Located 36 km south-west of the survey area
Bunnawarra Calcrete Priority 1	Bunnawarra calcrete groundwater assemblage type on Moore palaeodrainage on Bunnawarra Station	Located 37 km south-west of the survey area
Minjar and Chulaar Hills Priority 1	Minjar and Chulaar Hills vegetation complexes (banded ironstone formation)	Located 39 km south-west of the survey area
Badja Calcrete Priority 1	Badja calcrete groundwater assemblage type on Moore palaeodrainage on Badja Station	Located 36 km south of the survey area

## 3.8 Flora

### 3.8.1 Flora diversity

The *NatureMap* database identified 454 vascular plant taxa, representing 60 families, which have previously been recorded within the study area (Appendix C). This total comprises 438 native flora taxa and 16 naturalised (non-native) flora taxa. Dominant families included:

- Fabaceae (72 taxa)
- Asteraceae (57 taxa)
- Poaceae (39 taxa)
- Chenopodiaceae (33 taxa)
- Scrophulariaceae (28 taxa).

### **3.8.2 Conservation significant flora**

Desktop searches of the EPBC Act PMST, *NatureMap*, DBCA TPFL and WAHERB databases identified the presence/potential presence of 18 conservation significant flora taxa within the study area. The desktop searches recorded:

- Two taxa listed as Endangered under the EPBC Act and Threatened under the BC Act
- One Priority 1 (P1) flora taxon
- One Priority 2 (P2) flora taxon
- Eight Priority 3 (P3) flora taxa
- Six Priority 4 (P4) flora taxa.

The locations of the conservation significant species registered on the DBCA databases are mapped in Figure 3, Appendix A.

### **3.9 Previous studies**

A number of vegetation and flora studies have been previously undertaken within or intersecting parts of the survey area. These studies have been completed by various environmental consultants and staff from the Department of Environment and Conservation (DEC – now DBCA), between 2005 and 2011. A summary of the key findings from these previous studies is provided in Table 7.

**Table 7 Summary of previous studies**

Study	Location	Methodology	Key findings
Maia Environmental Consultancy (2011)	The Maia survey area included three polygons (Area 1, Area 2 and Laydown Area) within E59/1097 and E59/740. Area 1 intersects the western part of the current survey area.	Targeted flora survey completed between 2 and 7 November 2011. Transects at 100 m spacing both along and across the polygons were walked. Transects at 50 m spacing (i.e. between wider transects) were walked in areas where conservation significant flora were found.	<ul style="list-style-type: none"> <li>• Twelve vegetation associations (VA) were described, none of the vegetation associations were considered conservation significant.</li> <li>• 229 taxa from 109 genera and 42 families were recorded. Dominant families included Fabaceae (37 species), Asteraceae and Chenopodiaceae (22 species each) and Poaceae (18).</li> <li>• Five priority species recorded including: <ul style="list-style-type: none"> <li>– <i>Acacia subsessilis</i> (P3) – 2,025 plants from 1,638 locations</li> <li>– <i>Gunniopsis rubra</i> (now delisted)</li> <li>– <i>Acacia speckii</i> (P4) – 776 plants from 739 locations</li> <li>– <i>Dodonaea amplisemina</i> (P4) – 478 plants from 272 locations</li> <li>– <i>Verticordia penicillaris</i> (P4) – 734 plants from 24 locations</li> </ul> </li> <li>• Six species considered range extensions including <i>Acacia macrocarpa</i> [now <i>A. macraneura</i>], <i>A. minyura</i>, <i>A. wiseana</i>, <i>*Sagina procumbens</i>, <i>Solanum ashbyae</i> and <i>Verticordia penicillaris</i>.</li> <li>• 15 introduced species including one Declared plant, <i>*Emex australis</i> (Double-gee).</li> </ul>
Coffey Environments (2010)	The Coffey survey area includes four separate areas (1, 2, 3 and 4) within E59/1097, E59/740 and E59/1348. Coffey area 2 is within the current survey area.	Targeted flora survey completed from 29 August to 1 September 2007. Survey methodology consistent with EPA Guidance Statement No. 51 (2004). Survey included sampling within 19 releves located in vegetation types and intensive traverses of other areas. Survey area traversed by vehicle and foot.	<ul style="list-style-type: none"> <li>• Ten vegetation types were identified, with none representative of conservation significant vegetation.</li> <li>• Vegetation condition was assessed using the disturbance ratings adapted from the DEC Salinity Action Plan Wheatbelt Vegetation Surveys. The vegetation was given rating 1, no effective disturbance other than grazing by hooved animals.</li> <li>• 63 species including 60 native and three introduced were recorded. Dominant families were Fabaceae (12 species), Scrophulariaceae (7 species and Chenopodiaceae (7 species).</li> <li>• Two priority species recorded including: <ul style="list-style-type: none"> <li>– <i>Acacia speckii</i> (P4) – 27 individuals from 7 locations</li> <li>– <i>Acacia subsessilis</i> (P3) – 8 individuals from 1 location</li> </ul> </li> </ul>
Ecoscope (2008)	The Ecoscope survey area includes an area within E59/1097. The north-east part of the Ecoscope survey area	Level 1 Survey and targeted flora survey completed from 6 to 9 October 2008. Survey included selective, low intensity sampling of flora and	<ul style="list-style-type: none"> <li>• Six vegetation types were described within the survey area based on six sites.</li> <li>• Vegetation condition was assessed using the disturbance ratings adapted from the DEC Salinity Action Plan Wheatbelt Vegetation Surveys. The vegetation was given rating 1, no</li> </ul>

Study	Location	Methodology	Key findings
	intersects the western part of the current survey area.	vegetation. Targeted searching for conservation significant flora was also completed.	<p>effective disturbance other than grazing by hoofed animals and rating 2, limited clearing.</p> <ul style="list-style-type: none"> <li>• 39 native species were recorded with dominant families including Chenopodiaceae (6 species), Amaranthaceae (5 species) and Fabaceae (5 species).</li> <li>• Three priority flora species recorded including <i>Acacia speckii</i> (P4) (54 individuals), <i>Acacia subsessilis</i> (P3) (26 individuals) and <i>Gunniopsis rubra</i> (now delisted).</li> </ul>
Markey and Dillon (2008)	The Yalgoo survey area extends over Muralgarra, Badja, Bunnawarra, Wagga Wagga and Carlaminda Stations. The current survey area intersects Wagga Wagga and Carlaminda Stations.	Level 2 Flora and Vegetation survey conducted during August and September 2007. 55 permanent quadrats were established over the survey area and strategically placed across the topological profile of ranges. Of the 55 quadrats, eight are located with the current survey area.	<ul style="list-style-type: none"> <li>• Five community types were derived from the site classification analysis. Community types 2, 3b, 4 and 5 were recorded on the Woolgah-Wadgingarra Hills.</li> <li>• 243 taxa and four hybrids from 51 families were recorded within or adjacent to the quadrats. This included 234 native taxa and nine naturalised taxa. Dominant families included Asteraceae, Fabaceae, Chenopodiaceae, Poaceae and Scrophulariaceae.</li> <li>• Five priority species were recorded including <i>Acacia subsessilis</i> (P3), <i>Acacia speckii</i> (P4), <i>Dodonaea amplisemina</i> (P4), <i>Calytrix uncinata</i> (now delisted) and <i>Calotis</i> sp. Perrinvale Station (R.J. Cranfield 7096) (P3).</li> <li>• Two taxa were identified as having affinities to known taxa, but were morphologically distinct enough to be considered as potentially new taxa. An additional taxon (<i>Hibiscus</i> cf. <i>solanifolius</i>) was also considered a range extension.</li> </ul>
ATA Environmental (2007)	The ATA survey area included E59/642, P59/1397 and P59/1508. The northern part of the ATA survey area intersects the south-west part of the current survey area.	Level 2 Flora and Vegetation survey conducted from 6-9 September 2006. Survey methodology consistent with EPA Guidance Statement No. 51 (2004). Survey included re-visiting 14 permanent quadrats and traversing area on foot to search for conservation significant flora.	<ul style="list-style-type: none"> <li>• The key findings were consistent with the ATA (2006) report including five vegetation types, no locally or regionally significant vegetation and condition predominately rated Very Good to Good.</li> <li>• 99 species including 94 native and 5 introduced were recorded. Dominant families were Fabaceae (15 species), Poaceae (11 species) and Asteraceae (10 species).</li> <li>• One Priority species recorded, <i>Acacia speckii</i> (P4) with 138 individuals from four locations.</li> </ul>
ATA Environmental (2006)	The ATA survey area included E59/642, P59/1397 and P59/1508. The northern part of the ATA survey area	Initial flora and vegetation survey conducted between 29 May and 2 June 2006.	<ul style="list-style-type: none"> <li>• Five vegetation types were described within the survey area. None of the types were considered locally or regionally significant.</li> <li>• Vegetation condition was predominately Very Good to Good with no areas of significant weed invasion.</li> </ul>

Study	Location	Methodology	Key findings
	intersects the south-west part of the current survey area.	<p>Survey methodology consistent with EPA Guidance Statement No. 51 (2004).</p> <p>Survey included establishing 15 permanent quadrats and traversing area on foot to describe and map major vegetation types.</p>	<ul style="list-style-type: none"> <li>• 78 species including 74 native and 4 introduced were recorded. Dominant families were Fabaceae (14 species), Poaceae (8 species) and Amaranthaceae (7 species).</li> <li>• One Priority species recorded, <i>Acacia speckii</i> (P4) from one location.</li> </ul>

## 4. Field survey results

### 4.1 Vegetation types

Nine vegetation types as well as cleared areas were identified and described for the survey area (Table 8 and Figure 5, Appendix A). The vegetation types included five types associated upland areas (BIF range, granite outcrops and low rises), three types associated with drainage areas and one type associated with gentle undulating floodplains.

The most dominant vegetation type is mixed *Acacia* shrublands on floodplains (APoEc) which covers approximately 68% of survey area. This vegetation type was variable (in vegetation structure and cover) with areas of dense *Acacia* woodland, open shrubland and sparsely vegetated areas distributed in a mosaic like pattern across the survey area. Vegetation types associated with the BIF range included ArrTdHc on upper slope and crests, AtEgCd on mid to lower slopes and hills, and AEgRc on lower slopes and colluvial flats. Collectively these vegetation types covered approximately 12% of the survey area and were restricted to the BIF range. The northern and eastern parts of the survey area supported granite outcrops which were described as AuEeBs. These outcrop areas were generally characterised by low, sparse shrubland and shallow soils, and covered approximately 10% of the survey area. The most restricted vegetation type was AiMsSa, which was recorded from a single laterite rise in the eastern part of the survey area.

Vegetation types associated with drainage areas included AbCaPd in major drainage lines, AtSePd in minor drainage lines and gullies, and AeFsEd on broad clay flats adjacent to drainage areas. Two main ephemeral drainage lines intersect the survey area with numerous minor ephemeral drainage lines and gullies associated with the BIF and granite areas. Vegetation type AeFsEd was restricted to the central part of the survey area and supported low shrubland dominated by chenopods which formed a mosaic with vegetation type APoEc in parts.

#### *Statistical analyses*

The similarity between the GHD quadrats and transects were examined using PRIMER. Analysis was run using three scenarios, all species, no singles (i.e. species that occur only once removed from the dataset) and perennial taxa only. The cluster analysis and resulting dendrograms showed similar results with general groupings of quadrats for all vegetation types. The vegetation types that most closely grouped included ArrTdHc, AtEgCd, AeFsEd, AtSePd and AbCaPd. Vegetation types AuEeBs APoEc also largely grouped, however several quadrats/quadrat groupings representative of these types occurred across multiple clades. A two dimensional MDS scatter plot was also produced and largely reflected the dendrogram. The stress value (0.27) was the same for both scenarios and indicates a poor fit/random representation. The outputs from the statistical analysis are presented in Appendix D.

The GHD quadrats and transects were compared to the Yalgoo dataset using PRIMER. The cluster analysis and resulting dendrogram showed the all DBCA quadrats grouped on their own clade with the exception of quadrat WADG14, adjacent to a clade with GHD quadrats from type ArrTdHc (a BIF vegetation type). It was concluded that overall the GHD quadrats showed some similarity/affinities to the Yalgoo dataset, with relevant communities described by Markey and Dillon (2008) noted in Table 8. The outputs from the statistical analysis are presented in Appendix D.



### ***Comparison with previous vegetation mapping***



A comparison with previous vegetation mapping completed within or intersecting parts of the survey area (as outlined in section 3.9) is provided below. Broadly the previous vegetation mapping aligns with that described during the GHD survey.




- The ATA (2006, 2007) surveys assessed an area that intersects the south-west part of the current survey area. The ATA vegetation type mapping was based on relevé sampling with one (or occasionally two relevés) described per vegetation type and no statistical analysis. Two vegetation types were described in the current survey area which broadly align with those described during the GHD survey.
- The north-east part of the Ecoscape (2008) survey area intersects the current survey area. Ecoscape described six vegetation types based on single sites, with the vegetation types not mapped as part of reporting.
- The Markey and Dillon (2008) survey assessed eight quadrats in the current survey area as part of their floristic survey of BIF in the Yalgoo area. The eight quadrats are representative of three community types including 2, 3b and 4 as described by Markey and Dillon (2008). The GHD vegetation types described on the BIF range show affinities to and broadly align with those communities described by Markey and Dillon (2008).
- The Coffey (2010) survey assessed an area (area 2) within the western part of the current survey area. Area 2 is a narrow, linear polygon that extends along the BIF range. The Coffey vegetation type mapping was based on relevé sampling with one (or occasionally two relevés) described per vegetation type and no statistical analysis. The Coffey vegetation type mapping indicates seven vegetation types intersect the current survey area. The vegetation types identified by Coffey broadly align with those described during the GHD survey.
- The Maia (2011) survey assessed three areas, with area 1 intersecting the western part of the current survey area. Twelve vegetation associations were noted in the areas surveyed by Maia with no corresponding mapping provided. The vegetation types identified by Maia broadly align with those described during the GHD survey.




**Table 8 Vegetation types recorded within the survey area**

Vegetation type	Description	Extent (ha)	Landform, sample locations and notes	Representative photograph
<b>BIF</b>				
ArrTdHc (1c)	<p><i>Acacia ramulosa</i> var. <i>ramulosa</i>, <i>A. umbraculiformis</i> tall sparse shrubland over <i>Thryptomene decussata</i>, <i>Philotheca brucei</i> subsp. <i>brucei</i>, <i>Aluta aspera</i> subsp. <i>hesperia</i> mid sparse to open shrubland over <i>Helipterum craspedioides</i>, <i>Erodium cygnorum</i>, <i>Wurmbea densiflora</i> isolated herbs.</p> <p><u>Indicator species:</u> <i>Acacia ramulosa</i> var. <i>ramulosa</i>, <i>Thryptomene decussata</i>, <i>Philotheca brucei</i> subsp. <i>brucei</i>, <i>Aluta aspera</i> subsp. <i>hesperia</i>.</p>	65.72	<p>Landform: Upper slopes and crests of BIF</p> <p>Sample locations: Q04, Q15, Q16, Q34, Q38.</p> <p>Similar to VT12 described by Maia (2011).</p> <p>Aligns with Community 2 described by Markey and Dillon (2008).</p>	
AtEgCd (1b)	<p><i>Acacia tetragonophylla</i>, <i>A. ramulosa</i> var. <i>ramulosa</i>, <i>A. pteraneura</i> mid to tall sparse shrubland over <i>Eremophila galeata</i>, <i>Ptilotus obovatus</i>, <i>Maireana carnososa</i>, <i>Solanum lasiophyllum</i> low sparse shrubland over <i>Cephalopterum drummondii</i>, <i>Roebuckiella ciliocarpa</i>, <i>Helipterum craspedioides</i> isolated herbs.</p> <p><u>Indicator species:</u> <i>Acacia tetragonophylla</i>, <i>Eremophila galeata</i>, <i>Ptilotus obovatus</i>, <i>Maireana carnososa</i>, <i>Solanum lasiophyllum</i>.</p>	833.66	<p>Landform: lower and mid slopes, low crests and hills of BIF</p> <p>Sample locations: Q01, Q03, Q05, Q35, Q44.</p> <p>Mapped as TSAa, TSAqEf by Coffey (2010)</p> <p>Mapped as TSAaAa in the southern part of the survey area by ATA (2006, 2007)</p> <p>Similar to Community 3b and 4 described by Markey and Dillon (2008).</p>	

Vegetation type	Description	Extent (ha)	Landform, sample locations and notes	Representative photograph
AEgRc (1a)	<p><i>Acacia</i> spp. mid to tall sparse shrubland over <i>Eremophila galeata</i>, <i>Ptilotus obovatus</i>, <i>Maireana carnososa</i> low sparse shrubland over, <i>Roebuckiella ciliocarpa</i>, <i>Lemooria burkittii</i>, <i>Helipterum craspedioides</i> sparse herbland.</p> <p><u>Indicator species:</u> <i>Acacia</i> spp., <i>Eremophila galeata</i>, <i>Ptilotus obovatus</i>, <i>Maireana carnososa</i>, <i>Roebuckiella ciliocarpa</i>.</p>	141.70	<p>Landform: low slopes, colluvial flats around BIF ranges</p> <p>Sample locations: Q06, Q37, Q39</p> <p>Similar to VT7 described by Maia (2011).</p> <p>Similar to Community 3b described by Markey and Dillon (2008).</p>	
<b>Floodplains</b>				
APoEc (2)	<p><i>Acacia</i> spp. (<i>Acacia tetragonophylla</i>, <i>A. burkittii</i>, <i>A. ramulosa</i> var. <i>ramulosa</i>, <i>A. pteraneura</i>, <i>A. caesaneura</i>), <i>Hakea recurva</i> subsp. <i>recurva</i> mid to tall open shrubland over <i>Eremophila forrestii</i> subsp. <i>forrestii</i>, <i>Ptilotus obovatus</i>, <i>Solanum lasiophyllum</i>, <i>Sida</i> sp. dark green fruits (S. van Leeuwen 2260), <i>Maireana planifolia</i> low sparse shrubland over <i>Erodium cygnorum</i>, <i>Chthonocephalus pseudevax</i>, <i>Helipterum craspedioides</i> sparse herbland.</p> <p><u>Indicator species:</u> <i>Acacia tetragonophylla</i>, <i>A. burkittii</i>, <i>Eremophila forrestii</i> subsp. <i>forrestii</i>, <i>Ptilotus obovatus</i>, <i>Solanum lasiophyllum</i>, <i>Maireana planifolia</i>, <i>Erodium cygnorum</i>.</p>	5,587.38	<p>Landform: floodplains</p> <p>Sample locations: Q02, Q07, Q08, Q17, Q19, Q20, Q21, Q22, Q24, Q25, Q27, Q28, Q30, Q33, Q36, Q43, Q45, Q47, Q48, Q49, Q50, Q51, Q54, Q55.</p> <p>Mapped as TSAAtAa in the southern part of the survey area by ATA (2006, 2007)</p> <p>Mapped as TSAcAgAtAb and TSAbAtAcAa by Coffey (2010).</p>	
Mosaic between APoEc and AeFsEd (3)	APoEc and AeFsEd formed a mosaic in areas adjacent to one of the major drainage lines. This has been mapped as Mosaic between APoEc and AeFsEd (3).	93.48	<p>Landform: floodplains and seasonal inundated areas</p> <p>Sample locations: Q42</p>	

Vegetation type	Description	Extent (ha)	Landform, sample locations and notes	Representative photograph
<b>Drainage areas</b>				
AeFsEd (4)	<p><i>Acacia eremaea</i> mid to tall sparse shrubland over <i>Frankenia setosa</i>, <i>Maireana tomentosa</i>, <i>Ptilotus obovatus</i> low open shrubland over <i>Eragrostis dielsii</i>, <i>Helipterum craspedioides</i>, <i>Chthonocephalus pseudevax</i> isolated grasses and herbs.</p> <p><u>Indicator species:</u> <i>Acacia eremaea</i>, <i>Frankenia setosa</i>, <i>Maireana tomentosa</i>, <i>Eragrostis dielsii</i>.</p>	391.26	<p>Landform: floodplains and seasonal inundated areas</p> <p>Sample locations: Q09, Q10, Q41, Q46</p>	
AtSePd (5)	<p><i>Acacia tetragonophylla</i> mid to tall sparse shrubland over <i>Sida ectogama</i>, <i>Solanum lasiophyllum</i>, <i>Eremophila galeata</i> low sparse shrubs over <i>Cymbopogon ambiguus</i> mid isolated tussock grasses over <i>Pluchea dentex</i>, <i>Roebuckiella ciliocarpa</i>, <i>Helipterum craspedioides</i> isolated herbs.</p> <p><u>Indicator species:</u> <i>Acacia tetragonophylla</i>, <i>Sida ectogama</i>, <i>Solanum lasiophyllum</i>, <i>Cymbopogon ambiguus</i>, <i>Pluchea dentex</i>.</p>	99.77	<p>Landform: minor drainage lines and gullies</p> <p>Sample locations: T01, T03, T04, T05</p> <p>Mapped as TSTOSAtAnAs in the southern part of the survey area by ATA Environmental (2006)</p>	
AbCaPd (6)	<p><i>Acacia burkittii</i>, <i>A. tetragonophylla</i> mid to tall open shrubland over <i>Ptilotus obovatus</i>, <i>Solanum lasiophyllum</i> low sparse shrubs over <i>Cymbopogon ambiguus</i> mid isolated tussock grasses over <i>Pluchea dentex</i>, <i>Lysimachia arvensis</i>, <i>Cyperus ?alterniflorus</i>, <i>Euphorbia drummondii</i> isolated herbs and sedges.</p> <p><u>Indicator species:</u> <i>Acacia burkittii</i>, <i>A. tetragonophylla</i>, <i>Cymbopogon ambiguus</i>, <i>Pluchea dentex</i>, <i>Lysimachia arvensis</i>, <i>Cyperus ?alterniflorus</i>, <i>Euphorbia drummondii</i>.</p>	157.48	<p>Landform: major drainage lines</p> <p>Sample locations: Q12, Q29, Q40, Q53, T02</p> <p>Mapped as TSAAbAtAcAa in the western part of the survey area by Coffey (2010)</p>	

Vegetation type	Description	Extent (ha)	Landform, sample locations and notes	Representative photograph
<b>Granite outcrops</b>				
AuEeBs (7)	<p><i>Acacia umbraculiformis</i>, <i>A. tetragonophylla</i>, <i>A. ramulosa</i> var. <i>linophylla</i> tall to mid-sparse shrubland over <i>Eremophila exilifolia</i>, <i>E. forrestii</i> subsp. <i>forrestii</i> mid- isolated shrubs over <i>Borya sphaerocephala</i>, <i>Ptilotus obovatus</i>, <i>Solanum lasiophyllum</i> low isolated shrubs over <i>Hyalosperma glutinosum</i> subsp. <i>venustum</i>, <i>Pogonolepis muelleriana</i> isolated herbs.</p> <p><u>Indicator species:</u> <i>Acacia umbraculiformis</i>, <i>Eremophila exilifolia</i>, <i>E. forrestii</i> subsp. <i>forrestii</i>, <i>Borya sphaerocephala</i>, <i>Hyalosperma glutinosum</i> subsp. <i>venustum</i>, <i>Pogonolepis muelleriana</i>.</p>	824.77	<p>Landform: granite outcrops with shallow soils.</p> <p>Sample locations: Q13, Q14, Q18, Q23, Q26, Q31, Q32, Q52</p>	
<b>Low rises</b>				
AiMsSa (8)	<p><i>Acacia incognita</i> mid isolated shrubs over <i>Micromyrtus sulphurea</i>, <i>Ptilotus obovatus</i>, <i>Eremophila latrobei</i> subsp. warty leaves (M. Officer 230) low isolated shrubs over <i>Stenopetalum anfractum</i>, <i>Gnephosis brevifolia</i>, <i>Goodenia ?pinnatifida</i> isolated herbs.</p> <p><u>Indicator species:</u> <i>Acacia incognita</i>, <i>Micromyrtus sulphurea</i>, <i>Ptilotus obovatus</i>, <i>Stenopetalum anfractum</i>, <i>Gnephosis brevifolia</i>.</p>	1.04	<p>Landform: low lateritic rise</p> <p>Sample locations: Q11</p>	No photo available
<b>Cleared areas</b>				
Cleared (0)	Cleared areas including the Yalgoo – Mt Magnet Road	33.57		

## 4.2 Vegetation condition

The vegetation condition within the survey area was rated from Excellent to Very Good, with cleared areas (i.e. Yalgoo-Mt Magnet Road) not rated. The majority of vegetation throughout the survey area was rated as Excellent. In these areas the vegetation structure was intact with limited signs of damage/disturbances observed and non-aggressive weeds present. Whilst current grazing occurs over most of the survey area, it was concentrated in vegetation type AeFsEd which supported low shrubland dominated by chenopods on sandy soils. These areas were rated Very Good due to the increase in grazing impacts observed.

The extents of the vegetation condition ratings mapped within the survey area are detailed in Table 9 with vegetation condition mapping shown on Figure 6, Appendix A.

**Table 9 Vegetation condition ratings**

Vegetation condition ratings	Extent (ha)
Excellent	7,711.20
Very Good	484.74
Not rated	33.57

## 4.3 Significant vegetation

One PEC was identified within the survey area during the field survey, the Yalgoo (Gnows Nest/Wolla Wolla and Woolgah-Wadgingarra) vegetation complexes (banded ironstone formation) listed as Priority 1 by DBCA. This community was listed following surveys conducted by Markey and Dillon (2008) in the Yalgoo area (as part of flora and vegetation surveys of BIF of the Yilgarn Craton). Markey and Dillon (2008) noted that although the Yalgoo survey area did not have as many restricted communities and endemic and uncommon taxa as other areas (e.g. Central Tallering Land system) the area still supports taxa of conservation significance and distinctive floristic communities.

Vegetation communities mapped within the survey area occurring on the BIF range include ArrTdHc on upper slopes and crests, AtEgCd on mid to lower slopes and hills, and AEgRc on lower slopes and colluvial flats. These three vegetation types are considered representative of the Yalgoo vegetation complexes PEC. There is 1,041.09 ha of the Yalgoo vegetation complexes PEC within the survey area; a breakdown of the PEC by vegetation type is provided in Table 10 and the extent shown in Figure 7.

**Table 10 Extent of Yalgoo vegetation complexes PEC within the survey area**

Vegetation type	Condition rating	Extent in the survey area (ha)
ArrTdHc	Excellent	65.72
AtEgCd	Excellent	833.66
AEgRc	Excellent	141.70

## 4.4 Flora diversity

Two hundred and thirty three flora taxa (including subspecies and varieties) representing 50 families and 122 genera were recorded from the survey area during the field survey. This total comprised of 224 native taxa and nine introduced flora taxa.

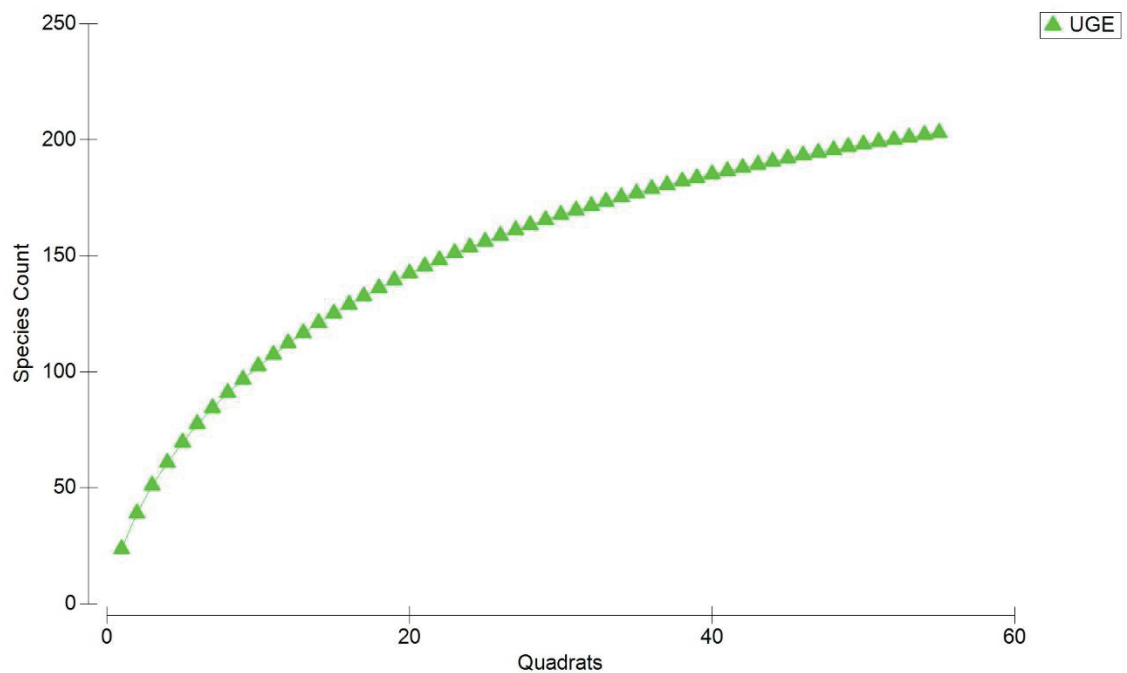
Dominant families recorded from the survey area included:

- Fabaceae (44 taxa)
- Asteraceae (26 taxa)
- Chenopodiaceae (19 taxa)

- Scrophulariaceae (18 taxa).

Based on described quadrats, species diversity ranged from 15 to 44 (average 23.8) taxa per 400 m<sup>2</sup>; the highest floristic diversity was recorded in vegetation type APoEc.

A species accumulation curve was generated using PRIMER to assess adequacy of sampling effort within the survey area. The species accumulation curve for the survey area, based on flora recorded within quadrats, is approaching an asymptote, which suggests that the current survey effort is sufficient. Furthermore, the bootstrap estimate of species richness generated from this data indicates that 229.21 species could be expected from the survey area based on the diversity recorded within quadrats. The total species recorded from the survey area was 233 flora species, which is near equal with the predicted species diversity estimate. The survey area is considered representative of the floristic diversity in the area.



## Plate 2 Species accumulation curve

### 4.5 Significant flora

No EPBC Act or BC Act listed flora were recorded within the survey area. Three DBCA Priority-listed flora species were recorded within the survey area during the field survey. The locations of the DBCA Priority-listed flora recorded within the survey area are mapped in Figure 8, Appendix A.

No other significant flora such as taxa representing range extensions, taxa endemic to the survey area or otherwise anomalous taxa were recorded within the survey area.

#### *Acacia subsessilis* – Priority 3

*Acacia subsessilis* is a spreading shrub 1-2 m high with pungent phyllodes and golden flowers. The species grows in shallow red loam, sand or clay often on rocky slopes and over ironstone. Associated species include *Acacia grasbyi*, *A. tetragonophylla*, *A. quadrimarginea*, *A. umbraculiformis* and *A. ramulosa*. *Acacia subsessilis* has been recorded from the Murchison and Yalgoo IBRA bioregions (WA Herbarium 1998–).

*Acacia subsessilis* was recorded from three locations with 218 individuals identified within the survey area. The species was restricted to the BIF range recorded from (vegetation types

ArrTdHc and AtEgCd). Based on field observations and other studies (see section 3.9) *A. subsessilis* extends beyond the survey area, occurring outside of the survey area.



**Plate 3 *Acacia subsessilis* in-situ and close up of phyllodes and flowers**

#### ***Acacia speckii* – Priority 4**

*Acacia speckii* is a bushy shrub to c. 2 m tall, maturing to a gnarled tree c. 3 m tall. It is characterised by rigid, erect phyllodes and moniliform pods. The species grows in rocky soils on slopes of low hills with underlying basalt, granite or dolerite in shrubland or open scrub. *Acacia speckii* has been recorded from the Gascoyne, Murchison and Yalgoo IBRA bioregions (WA Herbarium 1998–).

*Acacia speckii* was recorded along the BIF hill with 890+ individuals identified within the survey area. The species was recorded on the BIF hill (vegetation types ArrTdHc, AtEgCd and AEgRc) with sporadic records from the granite areas (vegetation type AuEeBs). Based on field observations and other studies (see section 3.9) *A. speckii* occurs outside of the survey area, recorded in large numbers on neighbouring BIF rises.



**Plate 4 *Acacia speckii* in-situ**

#### ***Dodonaea amplisemina* – Priority 4**

*Dodonaea amplisemina* is a woody, multi-stemmed shrub 0.3-1 m high. It is characterised by broad and narrow leaves clusters at nodes and fruit with triangular appendages. The species commonly grows in red-brown sandy clay soils on rocky basalt and gabbro or banded ironstone. *Dodonaea amplisemina* has been recorded from the Avon Wheatbelt, Gascoyne, Murchison and Yalgoo IBRA bioregions (WA Herbarium 1998–).

*Dodonaea amplisemina* was recorded from one location with five individuals identified within the survey area (vegetation type AtEgCd). Markey and Dillon (2008) also recorded the individuals at this location.



**Plate 5 *Dodonaea amplissima* in-situ and close up of fruit**

#### **Likelihood of occurrence assessment**

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

The likelihood of occurrence assessment post-field survey concluded that three species are known to occur, five taxa may possibly occur and the remaining ten taxa are unlikely or highly unlikely to occur. The five taxa that may possibly occur have been recorded within the study area, suitable habitat is present within the survey area and the species can be cryptic. The taxa known or considered possibly to occur are summarised in Table 11.

**Table 11 Summary of likelihood of occurrence assessment**

Taxon	Status	Likelihood
<i>Acacia speckii</i>	P4	Known
<i>Acacia subsessilis</i>	P3	Known
<i>Dodonaea amplisemina</i>	P4	Known
<i>Gunniopsis divisa</i>	P3	Possible
<i>Calotis</i> sp. Perrinvale Station (R.J. Cranfield 7096)	P3	Possible
<i>Rhodanthe collina</i>	P3	Possible
<i>Goodenia berringbinensis</i>	P4	Possible
<i>Goodenia neogoodenia</i>	P4	Possible

#### **4.6 Introduced flora**

Nine introduced flora taxa were recorded in the survey area including:

- *\*Brassica tournefortii* (Mediterranean Turnip)
- *\*Cuscuta epithymum* (Lesser Dodder)
- *\*Lysimachia arvensis* (Pimpernel)
- *\*Mesembryanthemum nodiflorum* (Slender Iceplant)
- *\*Pentameris airoides* (False Hairgrass)
- *\*Rostraria pumila*
- *\*Sisymbrium erysimoides* (Smooth Mustard)
- *\*Sonchus oleraceus* (Common Sowthistle)
- *\*Zaluzianskya divaricata* (Spreading Night Phlox)



Of the introduced taxa, none are listed as Declared Pests under the *Biosecurity and Management Act 2007* and/or as a Weeds of National Significance. All of the introduced flora have been previously recorded from the Yalgoo IBRA bioregion.

## 5. Discussion

Nine vegetation types as well as cleared areas were identified and described for the survey area. The vegetation types included five types associated upland areas (BIF range, granite outcrops and low rises), three types associated with drainage areas and one type associated with gentle undulating floodplains. The vegetation types mapped within the survey area broadly align with previous vegetation mapping of the area by Beard (1976) (digitised by Shepherd (2001)), ATA (2006, 2007), Ecoscape (2008), Marley and Dillon (2008), Coffey (2010) and Maia (2011).

Locally, the vegetation types identified within the survey area are considered to be well represented outside the survey area based on a review of the aerial photography surrounding the survey area. Furthermore, the vegetation within the survey area is part of a contiguous, largely intact area of remnant vegetation within a largely intact LGA, IBRA sub-region and IBRA bioregion. The vegetation associations mapped by Beard (1976) within survey area are not restricted to the Yalgoo IBRA bioregion, nor considered regionally significant.

One PEC was identified within the survey area, the Yalgoo (Gnows Nest/Wolla Wolla and Woolgah-Wadgingarra) vegetation complexes (banded ironstone formation), which is listed as Priority 1 by DBCA. The vegetation types associated with this PEC may be considered local significant as they are restricted to the BIF range and support Priority-listed flora. However, it is noted that whilst the Yalgoo vegetation complexes PEC is restricted to the Yalgoo area, it extends west and south of the survey area and has been mapped from four separate occurrences covering approximately 38,000 ha.

Two hundred and thirty three flora taxa (including subspecies and varieties) were recorded from the survey area during the field survey. This total comprised 224 native taxa and nine introduced flora taxa. The floristic diversity recorded within the survey area was similar to that recorded in previous surveys of the area (notably Maia (2011) and Markey and Dillon (1998)). The flora composition recorded within the survey area is considered typical for the Midwest region and for the landforms present within the survey area. The flora composition reflected the dominant families and genera reported by Pringle (1998), Maia (2011) and Markey and Dillon (2008).

No EPBC Act or BC Act listed Threatened flora species were recorded within the survey area. However, three DBCA listed Priority species were recorded, *Acacia subsessilis* (Priority 3), *Acacia speckii* (Priority 4) and *Dodonaea amplisemina* (Priority 4). All three species were restricted to the BIF range with the exception of *A. speckii* which was sporadically recorded from the granite areas. None of these Priority listed species are endemic to the Yalgoo IBRA bioregion. Although numerous individuals (ca. 1,185 and 450) of *Acacia speckii* and *A. subsessilis* were recorded within the survey area, both species occur outside of the survey area occurs in adjacent areas (and likely beyond). No other significant flora such as taxa representing range extensions, taxa endemic to the survey area or otherwise anomalous taxa were recorded within the survey area.

The likelihood of occurrence assessment post-field survey concluded that three species are known to occur, five taxa may possibly occur and the remaining ten taxa are unlikely or highly unlikely to occur. The five taxa that may possibly occur have been recorded within the study area, suitable habitat is present within the survey area and are annual/ephemeral (or cryptic) taxa that can be difficult to detect depending on conditions.

## 6. Conclusions and recommendations

### 6.1 Key findings

The survey area comprised nine vegetation types as well as cleared areas. The vegetation types included five types associated upland areas, three types associated with drainage areas and one type associated with gentle undulating floodplains. One PEC was identified within the survey area, the Yalgoo (Gnows Nest/Wolla Wolla and Woolgah-Wadgingarra) vegetation complexes (banded ironstone formation), which is listed as Priority 1 by DBCA. The vegetation condition within the survey area was rated from Excellent to Very Good, with cleared areas not rated.

No EPBC Act or BC Act listed Threatened flora species were recorded within the survey area. However, three DBCA listed Priority species were recorded, *Acacia subsessilis* (Priority 3), *Acacia speckii* (Priority 4) and *Dodonaea amplisemina* (Priority 4). The likelihood of occurrence assessment post-field survey concluded that three species are known to occur, five taxa may possibly occur and the remaining ten taxa are unlikely or highly unlikely to occur.

### 6.2 Recommendation

*Acacia speckii* was recorded along the BIF hill with sporadic records from the granite areas (vegetation type AuEeBs). Systematic traverse based searches were undertaken in BIF area, with non-systematic meandering searches completed in the granite areas (north east parts of the survey area). Should disturbance for mining infrastructure be proposed in the granite areas, systematic searches should be undertaken to confirm the locations and counts of *A. speckii* present within the survey area.

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