ASSESSMENT OF FLORA AND VEGETATION OF PRIVATE PROPERTIES WITHIN THE BAUXITE MINE EXPANSION AREAS

Prepared for

South32 Worsley Alumina Pty Ltd

Prepared by

Mattiske Consulting Pty Ltd

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Mattiske Consulting Pty Ltd

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ABBREVIATIONS

The following abbreviations are used throughout this document:

BAM Act	*Biosecurity and Agriculture Management Act 2007*
BME	Bauxite Mine Expansion Areas
BOM	Commonwealth Bureau of Meteorology
DAFWA	Department of Agriculture and Food, Western Australia
DotEE	Department of the Environment and Energy
DPaW	Department of Parks and Wildlife, Western Australia
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ESA	Environmentally Sensitive Areas
ESCAVI	Executive Steering Committee for Australian Vegetation Information
Mattiske	Mattiske Consulting Pty Ltd
PBA	Primary Bauxite Area
PEC	Priority Ecological Community
SVT	Site-Vegetation Type
TEC	Threatened Ecological Community
TSSC	Threatened Species Scientific Committee
WAH	Western Australian Herbarium
WAOL	Western Australian Organism List
Worsley	South32 Worsley Alumina Pty Ltd

1. SUMMARY

Mattiske Consulting Pty Ltd (Mattiske) was commissioned in October 2016 by South32 Worsley Alumina Pty Ltd (Worsley) to undertake a flora and vegetation survey of extended private properties within the Bauxite Mine Expansion Areas, associated with the Worsley Alumina Expansion to 5.1Mtpa (MI 5.1), located from Hotham River to south of Mt Saddleback and near Quindanning Reserve, within the Bauxite Mine Expansion Areas. This assessment supplements earlier baseline flora and vegetation surveys of the Mt Saddleback area in the 1980's (Worsley Alumina Pty Ltd 1985) and more recent studies on the Quindanning Timber Reserve (Mattiske Consulting Pty Ltd 1993), Marradong Timber Reserve (Mattiske Consulting Pty Ltd 1990) and other nearby farmland areas from the southern end of the Boddington Gold Mine to the Quindanning Timber Reserves. South32 Worsley Alumina Pty Ltd is seeking an approval to extend their current mining areas.

2016 Survey

A total of 111 vascular plant taxa, representative of 80 plant genera and 37 plant families were recorded within the Private Properties of Bauxite Mine Expansion Areas. The majority of the taxa recorded were representative of the Poaceae (36 taxa), Fabaceae (35 taxa) and Asteraceae (21 taxa) families. Introduced species represented 35% of all recorded plant species within the Bauxite Mine Expansion Areas due to a large proportion of the BME areas having previously been exposed to agriculture and pastoral activities, with the vast majority of sites being rated as Completely Degraded.

No threatened flora pursuant to Schedule 1 of the *Wildlife Conservation Act 1950*, the *Environment Protection and Biodiversity Conservation Act 1999* and the Department of the Environment was recorded within the Bauxite Mine Expansion Areas.

A range of priority species have been recorded previously by Mattiske in survey areas nearby to the BME Areas; *Gastrolobium* sp. Prostrate Boddington (M. Hislop 2130) (P1), *Meionectes tenuifolia* (P3), *Lasiopetalum cardiophyllum* (P4) and *Parsonsia diaphanophleba* (P4). One priority flora species as listed by the Department of Parks and Wildlife (2017g) was recorded within the Bauxite Mine Expansion Areas. *Gastrolobium* sp. Prostrate Boddington (M. Hislop 2130) (Priority 1) has been recorded previously and two times within the current Survey area. Two previous records of *Lasiopetalum cardiophyllum* (P4), near the Hotham River, were extracted from Western Australian Herbarium datasets. *Lasiopetalum cardiophyllum* (P4) has been recorded extensively in previous eastern forest vegetation studies near Boddington in the P site-vegetation type (19JLc mapping code – Worsley Alumina Pty Ltd 1985).

A total of 39 introduced plant species were recorded within the Bauxite Mine Expansion Areas. One of these taxa, **Gomphocarpus fruticosus*, is listed as a Declared Plant species pursuant to section 22 of the *Biosecurity and Agricultural Management Act 2007* according to the Department of Agriculture and Food, Western Australia. **Gomphocarpus fruticosus* is a Category 3 (management) Declared Pest for the Shire of Boddington. This species has been recorded previously during vegetation surveys of Worsley's lease areas, and was only recorded in low numbers during the current survey in three survey quadrats of remnant vegetation.

Thirty site-vegetation types were defined and mapped within the Bauxite Mine Expansion Areas. These site-vegetation types are representative of Havel's site-vegetation types for the northern Jarrah forest. The majority of the vegetation within the BME Areas has been cleared for agriculture, however the dominant site-vegetation types of the remaining vegetation within the BME Areas were typed P and S (previous Worsley Alumina Pty Ltd 1985 Mapping Codes 19JLc and 19JBg). The P type is dominated by an overstorey of *Eucalyptus marginata - Allocasuarina fraseriana - Banksia grandis* over mixed shrub and low understorey species on sandy-gravel soils on slopes and ridges and the S type is dominated by an overstorey of *Eucalyptus marginata – Corymbia calophylla – Banksia grandis* over mixed shrubs and low understorey species on gravelly soils on slopes and ridges. Site-vegetation type G2 (previous Worsley Alumina Pty Ltd 1985 Code 21AAh - Mosaic of open woodland of *Allocasuarina huegeliana* and closed heath of Proteaceae - Myrtaceae spp. to Lithic Complex on exposed or shallow granite outcrops.) occurred the least, only being recorded as an isolated pocket in the southern extent of the survey area.

390000 415000 440000 465000 490000

6375000

6350000

6325000

Legend

2016 Assessment Areas

Client: SOUTH32

N

0 2 4 6km

Scale: 1:300,000
MGA94 (Zone 50)

CAD Ref: g1881_Veg_f08

Date: Mar 2017 | Rev: C | A3

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Worsley Alumina Expansion to 5.1 Mtpa (MI 5.1)

Mining Extension Areas

Locality

Figure: 1

2. BACKGROUND

Mattiske Consulting Pty Ltd (Mattiske) was commissioned in October 2016 by South32 Worsley Alumina Pty Ltd (South32) to undertake a flora and vegetation survey of private properties located from Hotham River to south of Mt Saddleback and near Quindanning Reserve, within the Bauxite Mine Expansion Areas. South32 Worsley Alumina Pty Ltd is seeking an approval to extend their current mining areas.

2.1 Location and Scope of Proposal

The Bauxite Mine Expansion Area is located approximately 120 km south east of Perth and is situated across multiple properties located between Boddington, the eastern edge of the Boddington Bauxite Mine (BBM) and just north of Quindanning, Western Australia.

2.2 Climate

Havel (1975a) characterised the climate of the Northern Jarrah Forest as typically Mediterranean with a predominance of winter rainfall. Beard (1990) subsequently described the climate of the Dale Botanical Subdistrict (within the Northern Jarrah Forest subregion) as somewhat drier than the Southern Jarrah Forest which has an average rainfall of 600 – 1200 mm per annum. The average maximum temperature for Wandering for November 2015 to October 2016 generally followed long term maxima trends, whilst the average monthly minimum temperatures were variable when compared with the long term average (LTA) maxima. Average rainfall for the year 2016 was 644.8 mm for Bannister.

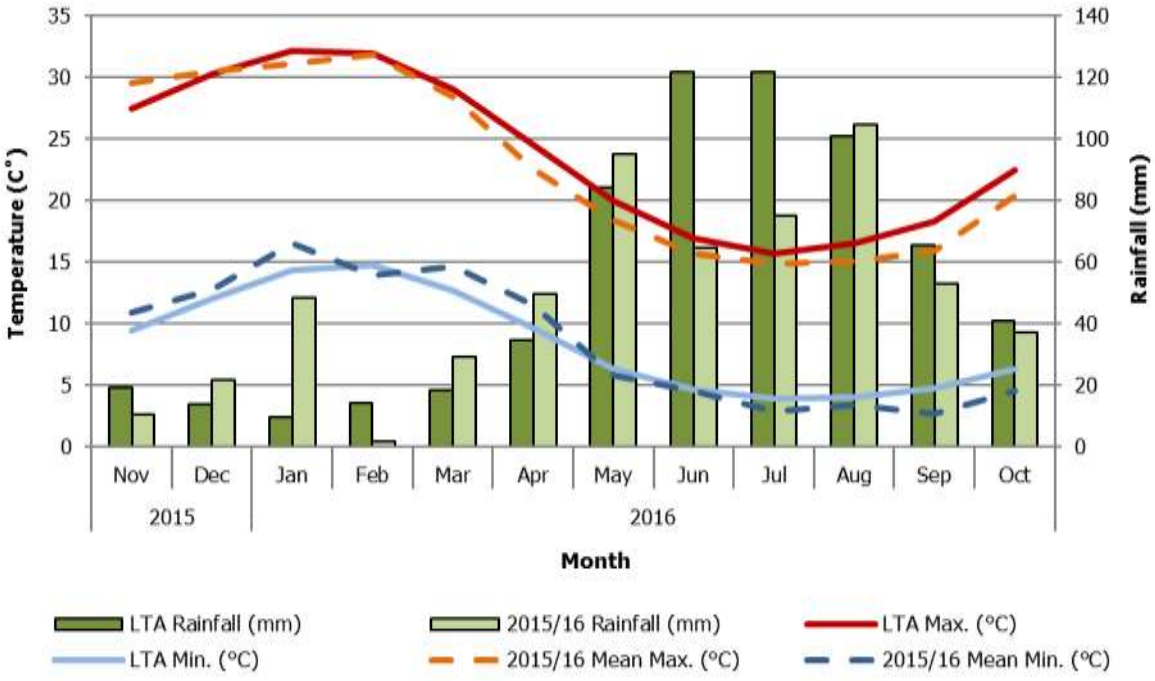

Figure 2: Rainfall and temperature data for the townships of Bannister and Wandering^
Long term average (LTA) rainfall (Bannister) and temperature (Wandering) data, together with monthly rainfall and average maximum and minimum temperature data for the period November 2015 to October 2016 are shown (Bureau of Meteorology 2016). ^Some temperature data unavailable on BOM.

2.3 Soils and Topography

The soils of the Dale Botanical Subdistrict can be broadly defined as lateritic gravels consisting of up to 5 m or more of ironstone gravels in a yellow, sandy matrix. Related to these are the lateritic podzolic soils with ironstone gravels in a sandy surface horizon, overlying a mottled yellow-brown clay subsoil (Beard 1990). The formation of these soils can be attributed to *in situ* weathering of igneous rock which underlies much of the Darling plateau (Vlahos *et al.* 1999). The region overlies an ancient plateau landform and has an average elevation of 300 m which is broken sporadically by nonconforming monadnocks such as Mt Cooke, Mt Dale and Mt Saddleback which reach up to 582 m (Havel 1975a; Beard 1990).

The lateritic soils which are specifically targeted in bauxite mining can be traced to iron-rich, greenstone volcanic "parent" rocks which represent an atypical variation of the granite-derived laterite that is commonplace within the region (Ball & Gilkes 1985).

2.4 Regional Vegetation

The Northern Jarrah Forest, specifically the Dale Botanical Subdistrict has been extensively described over the past 100 years by several authors (Diels 1906; Speck 1958; Havel 1975a; Beard 1990). Havel (1975a) summarised a number of the major ecological projects undertaken within the area, from Diels's original plant geography work in 1906 through to Kimber's study of the relationship between the root systems of the Jarrah plant and non-seasonal water loss in 1974. Beard (1990) again built on this framework and further defined the vegetation of this region in his botanical survey of Western Australia.

Diels (1906) and Speck (1958) both recognised that the Eastern range of the Jarrah forest (in which the Boddington Bauxite mine is located) contains a comparatively poorer range of species when compared to the Western reaches of the forest. This poorer range of species across the Eastern range can be related to a decrease in rainfall from West to East. Speck (1958) split the Jarrah forest into two broad vegetation systems; The Darling System and the Bannister System. The Darling System was described as "prime" Jarrah forest which covers the Darling Scarp and contains youthful streams with an average annual rainfall of over 890 mm. The Bannister System which covers the Eastern Jarrah forest, in comparison was associated with a mean annual rainfall of 520 – 1000 mm and no youthful streams.

Comparisons between climactic and edaphic factors and their relationships with trees within the region have been made since Lange (1960) attempted to relate these factors to the distribution of tree species within the Narrogin district. Additional work by Churchill (1961; 1968) addressed the influence of climatic conditions on the distribution of species, also undertaken more recently as part of the regional vegetation mapping program for the Regional Forest Agreement by Mattiske and Havel (1998). The latter studies relied on the conceptual climatic zoning developed by Gentilli (1989) for the Jarrah forest areas.

Beard (1990) described the Jarrah forest as one of only two forest formations in Western Australia. As would be expected, Jarrah (*Eucalyptus marginata*) is the dominant tree species within this area and is commonly found in association with Marri (*Corymbia calophylla*) in varying proportions. Maximum forest heights range from less than 25 m in the Eastern range of the Jarrah forest to heights of greater than 30 m in the Western range (Havel 1975a; Abbott & Loneragan 1986). Beard, as well as other researchers noticed that with the exception of creeklines and areas with significantly higher/lower than average rainfall amounts, no other tree species enters the canopy of the forest. Several smaller tree species (10 – 15 m tall) occur in the forest including, Bull Banksia (*Banksia grandis*), Sheoak (*Allocasuarina fraseriana*) and Snottygobble (*Persoonia longifolia*).

The forest understorey is comprised of a variety of shrub species which range from 1 – 2 m in height and have an average density of 185 plants/ha. Commonly occurring species include; *Adenanthos barbiger*, *Grevillea wilsonii*, *Trymalium ledifolium*, *Xanthorrhoea preissii*, *Macrozamia riedlei* and *Hypocalymma angustifolium*. Beard (1990) described the Eastern range of the Jarrah forest as being typically lower and more open woodland, with *Allocasuarina huegeliana* and *Acacia acuminata* occurring amongst the tree species. An association between tree species and the 500 mm isohyet line was also made obvious in this study with Beard noting the absence of Jarrah and the presence of Powderbark Wandoo (*Eucalyptus accedens*) east of this line. Understorey species also vary in these areas with *Gastrolobium spinosum*, *Calothamnus quadrifidus* and *Leptospermum erubescens* becoming more common.

Species which occur within the northern Jarrah forest were analysed by Havel (1975a and 1975b) and as a result a range of indicator species were delineated in relationship with particular site parameters that subsequently led to a classification of 21 site-vegetation types which are relevant for the northern Jarrah forest area.

The vegetation occurring within the South32 Worsley Alumina Pty Ltd tenements have been defined at different scales since 1981. The mining area of Mt Saddleback and the adjacent Marradong area fall into seven vegetation complexes (Appendix C1) as defined by Mattiske and Havel (1998). A range of site-vegetation types have been defined and mapped by Mattiske for Worsley Alumina Pty Ltd (Dames and Moore 1981, Worsley Alumina Pty Ltd 1985, E.M. Mattiske and Associates 1986, 1990 and 1993). These site-vegetation types have been related to the site-vegetation types as defined by Havel (1975b) (Appendix C2). The majority of the species which occur within the mining areas fall into the Proteaceae, Fabaceae, Myrtaceae and Asteraceae families (Worsley Alumina Pty Ltd 1985). With specific reference to trees, the areas in which the mining areas fall into are expected to have stand densities of approximately 300 trees/ha which increases to 500 – 600 trees/ha if seedlings are included.

2.4.1 Vegetation of the Bauxite Mine Expansion Areas

The BME Areas consists primarily of land cleared for agriculture, however the remaining areas occur within seven vegetation complexes as identified by Heddle *et al*. (1980) and Mattiske and Havel (1998), and are summarised below:

UPLANDS

Cooke (Ce): Mosaic of open forest of *Eucalyptus marginata* subsp. *marginata* – *Corymbia calophylla* (subhumid zone) and open forest of *Eucalyptus marginata* subsp. *thalassica* – *Corymbia calophylla* (semiarid and arid zones) and on deeper soils adjacent to outcrops, closed heath of Myrtaceae – Proteaceae species and lithic complex on granite rocks and associated soils in all climate zones, with some *Eucalyptus laeliae* (semiarid zone), and *Allocasuarina huegeliana* and *Eucalyptus wandoo* (mainly semiarid to perarid zone).

Dwellingup 4 (D4): Open forest to woodland of *Eucalyptus marginata* subsp. *thalassica* – *Corymbia calophylla* on lateritic uplands in semiarid and arid zones.

Yalanbee 5 (Y5): Mixture of open forest of *Eucalyptus marginata* subsp. *thalassica* – *Corymbia calophylla* and woodland of *Eucalyptus wandoo* on lateritic uplands in semiarid to perarid zones.

Yalanbee 6 (Y6): Woodland of *Eucalyptus wandoo* – *Eucalyptus accedens*, less consistently open forest of *Eucalyptus marginata* subsp. *thalassica* – *Corymbia calophylla* on lateritic uplands and breakaway landscapes in arid and perarid zones.

VALLEYS

Coolakin (Ck): Woodland of *Eucalyptus wandoo* with mixtures of *Eucalyptus patens*, *Eucalyptus marginata* subsp. *thalassica* and *Corymbia calophylla* on the valley slopes in arid and perarid zones.

Michibin (Mi): Open woodland of *Eucalyptus wandoo* over *Acacia acuminata* with some *Eucalyptus loxophleba* on valley slopes, with low woodland of *Allocasuarina huegeliana* on or near shallow granite outcrops in arid and perarid zones.

VALLEY FLOOR SWAMPS

Williams (Wi): Mixture of woodland of *Eucalyptus rudis* – *Melaleuca rhaphiophylla*, low forest of *Casuarina obesa* and tall shrubland of *Melaleuca* spp. on major valley systems in arid and perarid zones.

There are no threatened or priority ecological communities defined on the Bauxite Mine Expansion Areas or in the immediate area (Department of the Environment 2017b; Department of Parks and Wildlife 2017d, 2017e, and 2017f). While the majority of the survey area has been cleared for agriculture, there is remnant vegetation on some ridges, hill slopes, swamps and creeklines.

2.5 Western Australia's Flora – A Legislative Perspective

Western Australia has a unique and diverse flora, and is recognised as one of the world's 34 biodiversity hotspots (Myers et al. 2000). In this context, Western Australia possesses a high degree of species richness and endemism. This is particularly pronounced in the south-west region of the state. The Department of Parks and Wildlife (DPaW) flora statistics indicate that there are currently over 12,000 native plant species known to occur within Western Australia (DPaW 2017a). Scientific knowledge of many of these species is limited.

The legislative protection of flora within Western Australia is principally governed by four Acts. These are:

- *The Biodiversity Conservation Act 2016*
- *The Wildlife Conservation Act 1950;*
- *The Environmental Protection Act 1986;* and
- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

The unique flora of Western Australia is potentially under threat due to historical clearing practices associated with agricultural, mining and human habitation activities. As a consequence of these historical clearing practices a number of flora species have become threatened or have the potential to become threatened as their habitat is impacted by human activity. In addition, some areas of the State have been affected by past clearing practices such that entire ecological communities are under threat. The following sections describe these threatened and priority flora and ecological communities, and outline the legislative protection afforded to them.

At the State level, the Wildlife Conservation Act 1950 provides for taxa of native flora (and fauna) to be specially protected because they are subject to identifiable threats. Protection of these taxa has been identified as being warranted because they may become extinct, are threatened, or are otherwise in need of special protection. Ecological communities that are deemed to be threatened are afforded protection under the *Environmental Protection Act 1986*. Listings of threatened species and communities are reviewed annually by the Western Australian Threatened Species Scientific Committee (TSSC), which is a body appointed by the Minister for the Environment and supported by the DPaW. The TSSC reviews threatened and specially protected flora (and fauna) listings on an annual basis. Recommendation for additions or deletions to the listings of specially protected flora (and fauna) is made to the Minister for the Environment by the TSSC, via the Director General of the DPaW, and the WA Conservation Commission. Under Schedule 1 of the *Wildlife Conservation Act 1950*, the Minister for the Environment may declare a class or description of flora to be threatened flora throughout the State, by notice published in the *Government Gazette* (DPaW 2017b).

At the Commonwealth level, under the *Environment Protection and Biodiversity Conservation Act 1999*, a nomination process exists to list a threatened species or ecological community. Additions or deletions to the lists of threatened species and communities are made by the Minister for the Environment, on advice from the Federal Threatened Species Scientific Committee. *Environment Protection and Biodiversity Conservation Act 1999* lists of threatened flora and ecological communities are published on the Department of the Environment and Energy (DotEE) website (2017a, 2017b).

2.5.1 Threatened and Priority Flora

In December 2016, several parts of the new *Biodiversity Conservation Act 2016* were proclaimed. The *Biodiversity Conservation Act 2016* is ultimately intended to replace the *Sandalwood Act 1929* and the *Wildlife Conservation Act 1950*. At the time of compiling this report, the *Biodiversity Conservation Act 2016* does not fully replace the *Sandalwood Act 1929* and the *Wildlife Conservation Act 1950*. Specifically, with respect to flora, threatened species listings and controls over the taking and keeping of native species are still covered under the *Wildlife Conservation Act 1950*. Whilst throughout this document reference is made to the *Biodiversity Conservation Act 2016*, this should be read so as to include the *Wildlife Conservation Act 1950*.

Flora within Western Australia that is considered to be under threat may be classed as either threatened flora or priority flora. Where flora has been gazetted as threatened flora under the *Wildlife Conservation Act 1950*, it is an offence "to take" such flora without the written consent of the Minister. The *Wildlife Conservation Act 1950* states that "to take" flora includes to gather, pluck, cut, pull up, destroy, dig up, remove or injure the flora or to cause or permit the same to be done by any means.

Priority flora constitute species which are considered to be under threat, but where there is insufficient information available concerning their distribution and/or populations to make an evaluation of their conservation status. Such species are considered to potentially be under threat, but do not have legislative protection afforded under the *Wildlife Conservation Act 1950*. The Department of Parks and Wildlife (DPaW) categorises priority flora according to their conservation priority, using four categories, P1 to P4, to denote the conservation priority status of such species, with P1 listed species being the most threatened, and P4 the least. Priority flora species are regularly reviewed, and may have their priority status changed when more information on the species becomes available. Appendix A1 sets out definitions of both threatened and priority flora (DPaW 2017a).

At the Commonwealth level, under the *Environment Protection and Biodiversity Conservation Act 1999,* (*EPBC Act*) threatened species can be listed as extinct, extinct in the wild, critically endangered, endangered, vulnerable, or conservation dependent, by the Commonwealth Minister for the Environment and Energy. Refer to Appendix A2 for a description of each of these categories of threatened species. Under the EPBC Act, a person must not take an action that has or will have a significant impact on a listed threatened species without approval from the Commonwealth Minister for the Environment and Energy, unless those actions are not prohibited under the Act.

The current *EPBC Act* list of threatened flora may be found on the Department of the Environment and Energy website (DotEE 2017).

2.5.2 Threatened and Priority Ecological Communities

An ecological community is defined as a naturally occurring biological assemblage that occurs in a particular type of habitat composed of specific abiotic and biotic factors. At the State level, ecological communities may be considered as threatened once they have been identified as such by the Western Australian Threatened Ecological Communities Scientific Advisory Committee. A threatened ecological community is defined, under the *Environmental Protection Act 1986*, as an ecological community listed, designated or declared under a written law or a law of the Commonwealth as threatened, endangered or vulnerable. There are four State categories of threatened ecological communities, or TECs: presumed totally destroyed (PD); critically endangered (CR); endangered (EN); and vulnerable (VU) (DPaW 2017d). A description of each of these categories of TECs is presented in Appendix A3. Threatened ecological communities are gazetted as such (DPaW 2017e).

At the Commonwealth level, some Western Australian TECs are listed as threatened, under the *Environment Protection and Biodiversity Conservation Act 1999*. Under the *Environment Protection and Biodiversity Conservation Act 1999*, a person must not take an action that has or will have a significant impact on a listed threatened ecological community without approval from the Commonwealth Minister for the Environment, unless those actions are not prohibited under the Act. A description of each of these categories of TECs is presented in Appendix A4. The current *Environment Protection and Biodiversity Conservation Act 1999* list of threatened ecological communities can be located on the DotEE (2017b) website.

Ecological communities identified as threatened, but not listed as threatened ecological communities, can be classified as priority ecological communities (PECs). These communities are under threat, but there is insufficient information available concerning their distribution to make a proper evaluation of their conservation status. The DPaW categorises priority ecological communities according to their conservation priority, using five categories, P1 to P5, to denote the conservation priority status of such

ecological communities, with P1 communities being the most threatened and P5 the least. Appendix A5 sets out definitions of priority ecological communities (DPaW 2017d). A list of current priority ecological communities can be viewed at the DPaW (2017f) website

2.5.3 Clearing of Native Vegetation

Under the *Environmental Protection Act 1986*, the clearing of native vegetation requires a permit to do so, from the Department of Environment Regulation or the Department of Mines and Petroleum, unless that clearing is exempted under specific provisions listed in Schedule 6 of the Act, or are prescribed in the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. Under the *Environmental Protection Act 1986*, "native vegetation" means indigenous aquatic or terrestrial vegetation, and includes dead vegetation unless that dead vegetation is of a class declared by regulation to be excluded from this definition but does not include vegetation in a plantation. Under the *Environmental Protection Act 1986*, Section 51A, "clearing" means the killing or destruction of, the removal of, the severing or ringbarking of trunks or stems of, or the doing of any other substantial damage to, some or all of the native vegetation in an area, and includes the draining or flooding of land, the burning of vegetation, the grazing of stock, or any other act or activity, that causes any of the aforementioned consequences or results.

Under the *Environmental Protection Act 1986*, ten principles are set out, under which native vegetation should not be cleared. These principles state that native vegetation should not be cleared, if:

a. it comprises a high level of biological diversity;
b. it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia;
c. it includes, or is necessary for the continued existence of, threatened flora;
d. it comprises the whole or a part of, or is necessary for the maintenance of, a threatened ecological community;
e. it is significant as a remnant of native vegetation in an area that has been extensively cleared;
f. it is growing in, or in association with, an environment associated with a watercourse or wetland;
g. the clearing of the vegetation is likely to cause appreciable land degradation;
h. the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area;
i. the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water; or
j. the clearing of the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding.

The *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*, under Regulation 5, sets out prescribed clearing actions that do not require a clearing permit, as defined in Section 51C of the *Environmental Protection Act 1986*. However, exemptions under these Regulations do not apply in Environmentally Sensitive Areas (ESA's).

Under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*, under Regulation 6 – "Environmentally sensitive areas" include "the area covered by vegetation within 50 m of threatened flora, to the extent to which the vegetation is continuous with the vegetation in which the threatened flora is located". Similarly, "the area covered by a threatened ecological community" is listed as an environmentally sensitive area under Regulation 6.

2.5.4 Declared (Plant) Pest Organisms

The *Biosecurity and Agriculture Management Act 2007* (BAM Act), Section 22, makes provision for a plant taxon to be listed as a declared pest organism in respect to parts of, or the entire State. According to the BAM Act, a declared pest is defined as a prohibited organism (Section 12), or an organism for which a declaration under section 22 (2) of the Act is in force.

Under section 26 (1) of the BAM Act, a person who finds a declared plant pest must report, in accordance with subsection (2), the presence or suspected presence of the declared pest to the Director General or an inspector of the Department of Agriculture and Food Western Australia.

Under the *Biosecurity and Agriculture Management Regulations 2013*, declared plant pests are placed in one of three control categories, C1 (exclusion), C2 (eradication) or C3 (management), which determines the measures of control which apply to the declared pest (Appendix A6). According to section 30 (3) of the BAM Act, the owner or occupier of land, or a person who is conducting an activity on the land, must take the prescribed control measures to control the declared pest if it is present on the land.

The current listing of declared pest organisms and their control category is available on the Western Australian Organism List (WAOL), at the Biosecurity and Agriculture Management website of the Department of Agriculture and Food Western Australia (DAFWA 2017).

2.6 Local and Regional Significance

Flora or vegetation may be locally or regionally significant in addition to statutory listings by the State or Federal Government.

In regards to flora; species, subspecies, varieties, hybrids and ecotypes may be significant other than as threatened flora or priority flora, for a variety of reasons, including:

- a keystone role in a particular habitat for threatened species, or supporting large populations representing a significant proportion of the local regional population of a species;
- relic status;
- anomalous features that indicate a potential new discovery;
- being representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- the presence of restricted subspecies, varieties, or naturally occurring hybrids;
- local endemism/a restricted distribution; and
- being poorly reserved (Environmental Protection Authority 2004).

Vegetation may be significant because the extent is below a threshold level and a range of other reasons, including:

- scarcity;
- unusual species;
- novel combinations of species;
- a role as a refuge;
- a role as a key habitat for threatened species or large populations representing a significant proportion of the local to regional total population of a species;
- being representative of the range of a unit (particularly, a good local and/or regional example of a unit in "prime" habitat, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- a restricted distribution (Environmental Protection Authority 2004).

Vegetation communities are locally significant if they contain Priority Flora species or contain a range extension of a particular taxon outside of the normal distribution. They may also be locally significant if they are very restricted to one or two locations or occur as small isolated communities. In addition, vegetation communities that exhibit unusually high structural and species diversity are also locally significant.

Vegetation communities are regionally significant where they are limited to specific landform types, are uncommon or restricted plant community types within the regional context, or support populations of threatened Flora.

Determining the significance of flora and vegetation may be applied at various scales, for example, a vegetation community may be nationally significant and governed by statutory protection as well as being locally and regionally significant.

3. OBJECTIVES

The aim of this survey was to define the flora and vegetation values of the private properties located within South32 Worsley Alumina's Bauxite Mining Expansion (BME) Areas. Specifically, the objectives include:

- Undertake a desktop assessment to evaluate the botanical values of the local and broader area associated with the BME areas to identify any matters of botanical or conservation significance;
- Review previous literature and current databases associated with the BME Areas;
- On the basis of the reviews, provide summaries to assist in the assessment of the potential range of values and the potential for conservation significant species and communities;
- Undertake botanical data collection in quadrats that are representative of all potential vegetation communities within the BME Areas of sufficient detail to permit appropriate statistical analyses;
- Collect and identify the vascular plant species present in vegetation survey quadrats, as well as opportunistically, within the BME Areas;
- Record visual observations on the fire regimes, grazing pressures and overall health of the vegetation to allow for an assessment of the overall condition of the flora and vegetation within the BME Areas;
- Identify and record the locations of any Declared Organisms within the BME Areas;
- Review the conservation status of the vascular plant species recorded by reference to current literature and current listings by the DPaW (2017g) and plant collections held at the Western Australian State Herbarium, and listed by the Department of the Environment (DotEE 2017a) under *the Environment Protection and Biodiversity Conservation Act 1999;*
- Define and prepare a vegetation map of the vegetation communities within the BME Areas;
- Assess the condition of the vegetation communities within the BME Areas;
- Evaluate the distributions of any conservation significant flora recorded within the BME Areas; and evaluate their regional significance;
- Provide descriptions of the vegetation communities present within the BME Areas; and evaluate their regional significance; and
- Prepare a report summarising the findings.

4. METHODS

4.1 Desktop Survey

The desktop assessment for the BME Areas was conducted using the DPaW (1998-; 2007-; 2017b; 2017e; 2017f) and DotEE (2017a and 2017b) databases. A 20 km search radius about the approximate central point between Boddington and Quindanning (32°54'10" S, 116°27'33" E) was used as a search reference point. These databases were utilised to identify the possible occurrence of threatened and priority flora, threatened and priority ecological communities and any other significant environmental matters within the vicinity of the BME Areas assessment areas. In addition to data which was accessed through NatureMap (DPaW 2007-), results from previous vegetation assessments conducted by Mattiske (Mattiske Consulting Pty Ltd 2012a; 2012b; 2012c) and (Mattiske Consulting Pty Ltd 2014a; 2014b) were reviewed to provide more detailed information on the local flora and vegetation. The currency of all plant taxa nomenclature was verified using FloraBase (DPaW 1998-).

4.2 Field Survey

The assessment of the flora and vegetation of the BME Areas (Figure 3) was undertaken by two experienced botanists from Mattiske, from 15th to 18th November 2016. All botanists held valid collection licences to collect flora for scientific purposes, issued under the *Wildlife Conservation Act 1950*. Aerial photographic maps at a 1:17,500 scale of the BME Areas were prepared by CAD Resources of Carine, Western Australia. Additional maps and information of local property owners was supplied by South32 Worsley Alumina Pty Ltd.

To sample all of the apparent vegetation types across the BME Areas, the location of vegetation survey sites was selected primarily on the basis of aerial photographic maps. Additional survey sites were selected *in situ*, based on observations of vegetation types during the field survey. Wherever possible, a minimum of three vegetation survey sites were established in the same, but discontinuous vegetation site type to enable replication. This enabled the visual confirmation of site type boundaries during the field survey, in addition to providing the opportunity to record species that were not located within established survey sites. The sampling sites were selected to sample all vegetation types within the BME Areas.

The flora and vegetation was described and sampled systematically at each survey site, and additional opportunistic collecting was undertaken wherever previously unrecorded plants were observed. At each site the following floristic and environmental parameters were recorded:

- GPS location (GDA94 datum);
- soil type, colour and any additional observations;
- local site topography;
- presence of any outcropping rocks and their type;
- aspect of the hill-slopes;
- percentage of litter cover (logs, twigs and/or leaves);
- percentage of bare ground;
- time since fire;
- dieback presence and impact;
- condition of the vegetation, based on Keighery's (1994) condition ratings (Appendix A7); and
- alive and dead percentage of foliage cover and average height of each species recorded.

Tree species assessments were undertaken within a 20 m radius from the observation point, with each tree species present being ranked by abundance:

0 absent;

1 one or two trees;

2 three to five trees;

3 more than five trees, but contributing less than one third of the total stand;

4 between one third and one half of the total stand; and

5 more than one half of the total stand.

Understorey species assessments were undertaken within a 5 m radius from the observation point, with each understorey species being ranked by abundance:

0 absent;

1 very rarely seen, only after careful search;

2 present, observable, but in small numbers only;

3 common locally, but not uniformly over the whole area;

4 common over the whole area; and

5 completely dominating the understorey.

The physiological stress was determined for each species within a 5m and 20 m radius for understorey and tree species respectively) from the observation point and ranked according to the following scale. This stress assessment system has been previously used in the northern Jarrah forest.

0 healthy, no evidence of stress;

1 odd plant showing signs of stress, not dead;

2 one or two stressed plants, near death;

3 scattered stressed, (2 – 4) dead plants around plot;

4 susceptible plants dying or dead (> 4 plants); and

5 "graveyard" death.

All plant specimens collected during the field survey were dried and fumigated in accordance with the requirements of the Western Australian Herbarium. Plant species were identified through comparisons with pressed specimens housed either at the Mattiske Consulting internal herbarium or the Western Australian Herbarium. Where required, specialist plant taxonomists were consulted. Nomenclature of species recorded is in accordance with the Western Australian Herbarium (1998-).

4.3 Statistical Analysis of Data and Vegetation Mapping

Due to the high level of disturbance related to pastoral activities within the BME Areas, site- vegetation types were defined based on key indicator species, overstorey species and local site parameters (i.e. soil, outcropping, landscape position) to minimise confusion caused by the high numbers of introduced species dominating the understorey. The descriptions of plant communities within the survey area are based on the structural forms of Australian vegetation developed by Beard (1990; Appendix A8) and then integrated into the site-vegetation types as defined and mapped in the eastern Jarrah forests near Mt Saddleback by Mattiske based on the earlier studies by Havel (1975a, 1975b).

4.4 Survey Limitations and Constraints

An assessment of the survey against a range of factors which may have had an impact on the outcomes of the present survey is presented in Table 1. Based on this assessment, the BME Areas have only been subject to minor constraints which would affect the thoroughness of the survey and the conclusions which have been formed. These minor constraints were related to the lack of access to a few properties at the time of the assessments.

Table 1: Potential Flora and Vegetation Survey Limitations for the Bauxite Mine Expansion Areas

Potential Survey Limitation	Impact on Survey
Sources of information and availability of contextual information (i.e. pre-existing background versus new material).	**Not a constraint:** Multiple surveys have previously been conducted by Mattiske within the surrounding area. This, together with reference to resources such as Havel (1975a; 1975b), Heddle *et al.* (1980) and Mattiske and Havel (1998), previous mapping of site-vegetation types by Mattiske for the Worsley sites, online flora and vegetation information, has provided an appropriate amount of information for the current survey.
Scope (i.e. what life forms, etc., were sampled).	**Not a constraint:** Due to the timing of the survey, all life forms were sampled adequately during the survey. All site characteristics were adequately sampled during the survey.
Proportion of flora collected and identified (based on sampling, timing and intensity).	**Not a constraint:** The survey was conducted during Spring which is considered an appropriate time to assess flora and vegetation within the Jarrah forest due to the flowering period for a large majority of species.
Completeness and further work which might be needed (i.e. was the relevant survey area fully surveyed).	**Minor constraint:** With the exception of two small properties, the rest of the survey area was accessible from roads and tracks and was adequately surveyed by foot traverse.
Mapping reliability.	**Not a constraint:** Supplied aerial photographic maps and outlines of private properties were utilised in the selection of sites to ensure coverage of all perceived vegetation communities.
Timing, weather, season, cycle.	**Not a constraint:** The survey was conducted during Spring which is considered to be the ideal sampling period for the Jarrah Forest as it allows maximum coverage of annual species after winter rains.
Disturbances (fire flood, accidental human intervention, etc.).	**Not a constraint:** No disturbances impacted upon the survey.
Intensity (in retrospect, was the intensity adequate).	**Minor constraint:** With the exception of two small properties, the rest of the survey area was accessible from roads and tracks and was adequately surveyed by foot traverse.
Resources (i.e. were there adequate resources to complete the survey to the required standard).	**Not a constraint:** Adequate resources were provided for the completion of the survey work.
Access problems (i.e. ability to access survey area).	**Minor constraint:** Access was not granted by owners for two properties, however the rest of the survey area was accessible and was surveyed accordingly.
Experience levels (e.g. degree of expertise in plant identification to taxon level).	**Not a constraint:** Both field personnel have the appropriate training in sampling and identifying the flora of the region. Plants not identifiable in the field were collected and identified by specialist Taxonomists.

5. RESULTS

5.1 Desktop Survey

A desktop survey was conducted prior to the field assessment to identify threatened and priority flora and ecological communities that have been previously recorded in the area.

5.1.1 Flora

The desktop survey for threatened and priority flora which may potentially occur within the BME Areas was undertaken using the resources of NatureMap (DPaW 2007-), the WAH (DPaW 2017g), and the DotEE (2017a; 2017b). Within the 20 Km search radius about the vicinity of the BME Areas, there were two threatened and seventeen known priority flora.

An assessment of the likelihood of recording any of the listed threatened and priority taxa within the BME Areas, based on factors including known soil type, topography and distribution, is set out in Table2. Based on this assessment, one taxon – *Gastrolobium* sp. Prostrate Boddington (P1) – was ranked as being highly likely to be recorded as it is known to occur within the vicinity of the BME Areas. The remaining taxa, were ranked as having low to medium likelihood of being recorded within the BME Areas.

Table 2: Potential Threatened and Priority Flora occur within the Bauxite Mine Expansion Areas

Species	SCC[1]	Family	Likelihood to Record
Caladenia dorrienii	T	Orchidaceae	unlikely
Caladenia hopperiana	T	Orchidaceae	unlikely
Calytrix simplex subsp. *simplex*	P1	Myrtaceae	Low
Gastrolobium sp. Prostrate Boddington	P1	Fabaceae	High
Hemigenia rigida	P1	Lamiaceae	Medium
Isopogon sp. Canning Reservoir (M.D. Tindale 121 & B.R. Maslin)	P1	Proteaceae	Medium
Papistylus intropubens	P1	Rhamnaceae	Low
Synaphea panhesya	P1	Proteaceae	Low
Banksia subpinnatifida var. *imberbis*	P2	Proteaceae	Low
Banksia subpinnatifida var. *subpinnatifida*	P2	Proteaceae	Low
Asteridea gracilis	P3	Asteraceae	Low
Byblis gigantea	P3	Byblidaceae	Medium
Goodenia katabudjar	P3	Goodeniaceae	Low
Meionectes tenuifolia	P3	Haloragaceae	Low
Stylidium marradongense	P3	Stylidiaceae	Medium
Tetratheca pilifera	P3	Elaeocarpaceae	Low
Acacia alata var. *platyptera*	P4	Fabaceae	Low
Boronia tenuis	P4	Rutaceae	Medium
Senecio leucoglossus	P4	Asteraceae	Medium

5.12 Introduced (Exotic) Plant Species

A total of 21 introduced (exotic) plant species were recorded from the desktop assessment utilising a 20 km search buffer about the BME Area prospect (Table 5). None of the species are listed as Declared Pest species pursuant to Section 22 of the *Biosecurity and Agriculture Management Act 2007*. None of the species are listed as a Prohibited Organism pursuant to Section 12 of the *Biosecurity and Agriculture Management Act 2007* or listed as a Weed of National Significance (DotEE 2017e).

5.2 Field Survey

The field survey consisted of a detailed assessment of all remnant vegetation occurring within the Bauxite Mine Expansion Areas (Figure 1). A total of 25 survey quadrats were used to assess the flora and vegetation of the BME Areas. Refer to Appendix D for a list of the geographical locations for each of the survey quadrats.

5.2.1 Flora

A total of 111 vascular plant taxa which are representative of 81 plant genera and 37 plant families in addition to 39 introduced plant species were recorded across 25 vegetation sites within the BME Areas during November 2016. The majority of the taxa recorded were representative of the Poaceae (36 taxa), Fabaceae (35 taxa) and Asteraceae (21 taxa) families. A total of 56 and 39 introduced species was recorded within the expansion areas in 2014 and 2016 respectively. A list of taxa recorded within each site-vegetation site type is presented in Appendix C.

5.2.2 Threatened and Priority Flora

No threatened flora pursuant to Schedule 1 of the *Wildlife Conservation Act 1950* and as listed by the DPaW (2016b) were recorded within the BME Areas. No threatened flora pursuant to *the Environment Protection and Biodiversity Conservation Act 1999* and as listed by the DotEE (2016a) were recorded within BME Areas. Two priority flora species *Gastrolobium* sp. Prostrate Boddington (M. Hislop 2130) (P1) and *Lasiopetalum cardiophyllum* (P4), as listed by DPaW (2016g), were recorded in additional areas within the BME Areas.

The *Gastrolobium* sp. Prostrate Boddington (M. Hislop 2130) (P1) species was recorded on lower slopes in site-vegetation types AX, D, DG, L and Y as defined in the vegetation mapping (see Figures 3.1. to 3.32) and near Hotham River in substantial numbers from previous studies for the Newmont Boddington Gold Mine and also the Friends .

The *Lasiopetalum cardiophyllum* (P4) was recorded on lower slopes near Hotham Road, Figure 3.23 and Table 3. These two records are from the Western Australian Herbarium database. This species has been recorded in larger number on sandy-gravelly soils (mainly P site-vegetation type – Worsley Alumina Pty Ltd 1985 Mapping Code 19JLc) in the Boddington area and southwards towards the Stene State forest block. This species is relatively restricted to the Boddington area. Further this species has been recorded in rehabilitation areas in recent decades.

Table 3: GPS location of *Gastrolobium* sp. Prostrate Boddington (P1) and *Lasiopetalum cardiophyllum* (P4) within the Bauxite Mine Expansion Areas

Species	Geographic Location (GDA94_Z50H)		Population
	Easting	Northing	
Gastrolobium sp. Prostrate Boddington (M Hislop 2130) (P1)	443812	6363802	One
Gastrolobium sp. Prostrate Boddington (M Hislop 2130) (P1)	443747	6363355	Eight
Lasiopetalum cardiophyllum (P4)	446315	6352662	-
Lasiopetalum cardiophyllum (P4)	446393	6352632	-

5.2.3 Introduced Plant Species

A total of 39 introduced (exotic) plant species were recorded within the Study area (Appendix B). One of these taxa were listed as a Declared Plant species pursuant to section 22 of the *Biosecurity and Agricultural Management Act 2007* according to the Department of Agriculture and Food, Western Australia (2017).

Gomphocarpus fruticosus **Narrow Leaf Cotton Bush** **Apocynaceae**

According to the Western Australian Organism List (DAFWA 2017), **Gomphocarpus fruticosus* is a Category 3 Declared Pest for the Shire of Boddington. This species has been recorded previously during vegetation surveys of Worsley's lease areas, and was recorded in low numbers during the current survey.

An erect perennial shrub growing 0.5 – 1.5 m high, producing white/cream flowers between February and July. This species is known to occur in disturbed sites and is capable of forming dense thickets (Department of Parks and Wildlife 1998-).

Table 4: GPS location of *Gomphocarpus fruticosus within the Bauxite Mine Expansion Areas

Site	SVT	Geographic Location (GDA94_Z50H)		Population
		Easting	Northing	
Site 03	AX	443527	6363353	2-5
Site 17	Y	443826	6363366	2-5
Site 18	Y	443904	6363395	2-5

5.2.4 Vegetation

The site-vegetation types which enable the definition of the vegetation at a local level are based on the initial work of Havel (1975a; 1975b) and the later work developed and expanded by Mattiske based on extensive studies in the northern Jarrah forest since 1976 for Worsley Alumina Pty Ltd in the Boddington area (Worsley Alumina Pty Ltd 1985; E.M. Mattiske and Associates 1986 to 1993; Mattiske Consulting Pty Ltd 2012a to 2012c).

Table 5: Summary of Site-Vegetation Types Occurring in the Bauxite Mine Areas
(** designates previous Worsley Alumina Pty Ltd 1985 mapping code; note some mapping codes not included in former Mt Saddleback and Refinery 1985 report).

SVT Code	Previous Mapping Code**	Description
A		Tall shrubland of *Melaleuca lateritia*, *Hakea varia*, *Melaleuca viminea* and *Melaleuca incana* subsp. *incana* on clay-loams in seasonally wet valley floors.
A1		Mixed tall shrubland of *Melaleuca viminea*, *Melaleuca lateritia*, *Taxandria linearifolia*, *Astartea scoparia* over *Baumea juncea* and *Lepidosperma tetraquetrum* with occasional patches of *Banksia littoralis* and *Melaleuca rhaphiophylla* over low herbs on seasonally water-logged clays and clay loams on valley floors.
A2		Low open woodland of *Melaleuca rhaphiophylla* over *Astartea scoparia* and low herbs on seasonally water-logged clays and clay loams in seasonally wet valley floors.
A3		Open woodland of *Eucalyptus rudis*, *Eucalyptus patens* and *Eucalyptus wandoo* over *Melaleuca lateritia*, *Hakea varia*, *Taxandria linearifolia* and *Hypocalymma angustifolium* over herbs and sedges on clay-loams in seasonally wetter valley floors.
AC		Open woodland of *Eucalyptus wandoo* and *Eucalyptus rudis* over *Juncus pallidus*, *Astartea scoparia*, *Taxandria linearifolia* and *Lepidosperma tetraquetrum* over herbs on clay loams in seasonally wet valley floors.
AD		Low open woodland of *Eucalyptus rudis* and *Eucalyptus marginata* over *Banksia littoralis*, *Hakea prostrata* and *Pericalymma ellipticum* over low shrubs and herbs on leached sands over sandy-gravel on lower slopes.
AX		Open woodland of *Eucalyptus rudis* over *Acacia saligna*, *Melaleuca incana* subsp. *incana* and *Hypocalymma angustifolium* on clay- loams on valley floors.
AY		Open woodland of *Eucalyptus rudis* and *Eucalyptus wandoo* over *Acacia saligna*, *Hakea prostrata* and *Hypocalymma angustifolium* on clay- loams on valley floors.
AY/D		Mosaic of AY and D
B		Open woodland of *Eucalyptus marginata* and *Corymbia calophylla* over *Mesomelaena tetragona*, *Adenanthos obovatus and Babingtonia camphorosmae* on lower sandier soils on fringes of swamps and valley floors.
CL	CL	Cleared Land
		DAM
D	19JHl	Open forest of *Corymbia calophylla* and *Eucalyptus marginata* over *Hakea lissocarpha*, *Macrozamia riedlei*, *Acacia alata*, *Babingtonia camphorosmae*, *Hypocalymma angustifolium* and *Phyllanthus calycinus* on clay-loams on lower slopes.
DG	19JHl/23HDc	Open forest of *Corymbia calophylla* and *Eucalyptus marginata* over *Hakea lissocarpha*, *Macrozamia riedlei*, *Pericalymma ellipticum, Grevillea bipinnatifida*, *Allocasuarina humilis*, *Acacia alata*, *Babingtonia camphorosmae*, *Hypocalymma angustifolium* and *Phyllanthus calycinus* on clay-loams on lower slopes with localized patches of outcropping.
E		Open woodland of *Eucalyptus marginata* and *Corymbia calophylla* over *Mesomelaena tetragona*, *Kingia australis*, *Leptospermum erubescens* and *Babingtonia camphorosmae* on sandy to sandy-loam soils on slopes.
G	23H Dc	Open Heath of *Grevillea bipinnatifida*, *Hakea undulata*, *Banksia squarrosa* subsp. *squarrosa*, *Hakea incrassata*, *Hakea undulata* and *Petrophile serruriae* over *Borya sphaerocephala* on shallow soils and outcrops.
G1		Mosaic of open heath of Proteaceae - Myrtaceae spp. with emergent patches of *Eucalyptus drummondii* on shallow soils on slopes.
G2	21A Ah	Mosaic of open woodland of *Allocasuarina huegeliana* and closed heath of Proteaceae Myrtaceae spp. to Lithic Complex on exposed or shallow granite outcrops.
G3	23H Dc	Open heath of *Banksia squarrosa* subsp. *squarrosa*, *Hakea incrassata*, *Hakea undulata*, *Petrophile heterophylla* and *Petrophile serruriae* on shallow soils over granite outcrops on slopes with occasional emergent *Eucalyptus drummondii*.
G4		Open scrub and tall shrubland of *Hakea trifurcata* and *Hakea undulata* with admixtures of mallee species including *Eucalyptus latens* and *Eucalyptus aspersa* on clay to clay-loam soils over outcrops on slopes.

Table 5: Summary of Site-Vegetation Types Occurring in the Bauxite Mine Expansion Areas (continued)

SVT Code	Previous Mapping Code**	Description
G5		Low woodland of Eucalypt mallee species including *Eucalyptus aspersa*, *Eucalyptus latens*, *Eucalyptus longicornis* and *Eucalyptus drummondii* with occasional *Eucalyptus wandoo* over low shrubs of *Allocasuarina humilis*, *Hakea incrassata*, *Synaphea damopsis* and herbs on clay loams and sandy-loams on slopes.
H	19J Ps	Open forest to woodland of *Eucalyptus marginata* and *Corymbia calophylla* over *Petrophile striata*, *Daviesia decurrens*, *Daviesia longifolia* and *Daviesia rhombifolia* on sandy loam to sandy gravels on slopes and ridges.
H1	Variant of 19JPs	Open forest to woodland of *Eucalyptus marginata* and *Corymbia calophylla* over *Petrophile striata*, *Daviesia decurrens* and *Daviesia longifolia* on sandy-gravel soils of slopes and less undulating hills.
H2	Variant of 19JPs	Open forest to woodland of *Eucalyptus marginata* and *Corymbia calophylla* with occasional admixtures of *Banksia grandis* and *Persoonia longifolia* over *Acacia celastrifolia*, *Daviesia preissii*, *Leucopogon capitellatus* and *Styphelia tenuiflora* on gravel and sandy-gravel soils of slopes and less undulating hills.
HG	19JPs / 23HDc	Open forest to woodland of *Eucalyptus marginata* and *Corymbia calophylla* over *Petrophile striata*, *Lepidosperma squamatum*, *Styphelia tenuiflora*, *Daviesia preissii* and *Daviesia decurrens. Grevillea bipinnatifida*, *Allocasuarina humilis* and *Hakea undulata* on shallower sandy-gravel soils over granites or secondary laterisation areas on slopes and less undulating hills.
J		Open woodland of *Eucalyptus marginata* and *Corymbia calophylla* over *Conospermum stoechadis*, *Patersonia rudis* and *Babingtonia camphorosmae* on sandier soils on lower to mid slopes.
L	Variant of 11W2	Open woodland of *Eucalyptus patens* with some *Eucalyptus wandoo* over *Xanthorrhoea preissii*, *Macrozamia riedlei*, *Trymalium ledifolium*, *Acacia saligna* and *Hakea prostrata* on clay and clay loam soils on lower slopes.
LG	11W3/23HDc	Open woodland of *Eucalyptus patens* and *Eucalyptus wandoo* over *Hypocalymma angustifolium*, *Xanthorrhoea preissii*, *Grevillea bipinnatifida*, *Allocasuarina humilis* and *Babingtonia camphorosmae* over herbs and sedges on clay-loams on seasonally moister lower slopes underlain by outcrops.
M	11W1	Open woodland of *Eucalyptus wandoo* over *Trymalium ledifolium*, *Macrozamia riedlei* and *Hakea lissocarpha* on clay loams with some gravel on mid to upper slopes and ridges.
M2	Variant of 11W1	Woodland to open woodland of *Eucalyptus accedens*, *Eucalyptus wandoo*, *Eucalyptus marginata*, *Corymbia calophylla* over *Hakea lissocarpha*, *Macrozamia riedlei*, *Banksia squarrosa* subsp. *squarrosa*, *Hypocalymma angustifolium*, *Babingtonia camphorosmae*, *Grevillea bipinnatifida* and *Allocasuarina humilis* on clay-loams over shallow granites on mid to upper slopes.
MG	11W1/23HDc	Open woodland of *Eucalyptus wandoo* over *Trymalium ledifolium*, *Macrozamia riedlei, Pericalymma ellipticum*, *Hypocalymma angustifolium*, *Grevillea bipinnatifida*, *Allocasuarina humilis* and *Hakea lissocarpha* on clay-loams over shallow granite on mid to upper slopes and ridges.
		No Access
O		Open forest to woodland of *Eucalyptus marginata* and *Corymbia calophylla* over *Daviesia decurrens*, *Daviesia preissii* and *Bossiaea ornata* on sandy-gravels on slopes.
P	19JLc	Open forest of *Eucalyptus marginata* and *Allocasuarina fraseriana* with admixtures of *Corymbia calophylla* and *Banksia grandis* over *Lasiopetalum cardiophyllum* (P4), *Lasiopetalum floribundum*, *Lechenaultia biloba* and *Ptilotus drummondii* var. *drummondii* on sandy gravels on slopes and ridges.
PL	PL	Plantation and Planted Trees
PS	19JLc/19JBg	Open forest of *Allocasuarina fraseriana*, *Eucalyptus marginata*, *Corymbia calophylla* and *Banksia grandis* over *Adenanthos barbiger*, *Leucopogon capitellatus* on gravels and sandy gravels on slopes and ridges.
PW	19JLc/19JHl	Open forest of *Allocasuarina fraseriana*, *Eucalyptus marginata*, *Corymbia calophylla*, *and Banksia grandis* with scattered understorey, including *Adenanthos barbiger*, *Leucopogon capitellatus* and *Hypocalymma angustifolium* on seasonally moister and sandy gravels on slopes.
R		Open woodland of *Eucalyptus marginata* and *Corymbia calophylla* over *Trymalium ledifolium*, *Phyllanthus calycinus* and *Hypocalymma angustifolium* on sandy-gravels associated with nearby shallow outcropping.
RE	RE	Rehabilitation Areas
S	19JBg	Open forest of *Eucalyptus marginata* and *Corymbia calophylla* with admixtures of *Allocasuarina fraseriana*, *Banksia grandis* and *Persoonia longifolia* over *Acacia celastrifolia*, *Hovea chorizemifolia*, *Daviesia preissii*, *Leucopogon capitellatus* and *Styphelia tenuiflora* on sandy-gravels on slopes and ridges.
SP	19JBg/19JLc	Open forest of *Eucalyptus marginata*, *Corymbia calophylla* and *Allocasuarina fraseriana* with admixtures of *Banksia grandis* over *Lasiopetalum cardiophyllum*, *Acacia celastrifolia*, *Styphelia tenuiflora*, *Daviesia decurrens* and *Trymalium ledifolium* on sandy-gravel to gravel soils on slopes and ridges.
ST	19JSd	Open forest of *Eucalyptus marginata* and *Corymbia calophylla* with admixtures of *Allocasuarina fraseriana*, *Persoonia longifolia* and *Banksia grandis* over *Stylidium dichotomum*, *Acacia urophylla*, *Acacia celastrifolia*, *Leucopogon verticillatus*, *Clematis pubescens* and *Leucopogon capitellatus* on sandy-loam gravel soils on slopes and ridges.

Table 5: Summary of Site-Vegetation Types Occurring in the Bauxite Mine Expansion Areas (continued)

SVT Code		Description
SW		Open forest of *Eucalyptus marginata* and *Corymbia calophylla* over *Hypocalymma angustifolium*, *Babingtonia camphorosmae*, *Acacia celastrifolia*, *Hovea chorizemifolia*, *Daviesia preissii*, *Leucopogon capitellatus* and *Styphelia tenuiflora* on seasonally moister sandy-gravels on slopes.
T		Open Forest of *Eucalyptus marginata* - *Corymbia calophylla* with scattered understorey, including *Leucopogon verticillatus*, *Pteridium esculentum*, *Clematis pubescens* and *Bossiaea aquifolium* subsp. *aquifolium* on sandy-loam gravelly soils on slopes and ridges.
W		Open forest of *Corymbia calophylla*, *Eucalyptus marginata* and *Eucalyptus patens* over *Hakea lissocarpha*, *Hypocalymma angustifolium*, *Acacia extensa* and *Synaphea petiolaris* on loam soils on lower slopes.
Y	11W2	Open woodland of *Eucalyptus wandoo* over *Gompholobium marginatum*, *Acacia nervosa*, *Babingtonia camphorosmae*, *Hypocalymma angustifolium*, *Macrozamia riedlei*, *Phyllanthus calycinus* and *Gastrolobium calycinum* on clay and clay-loam soils on lower slopes.
YG	11W3/23HDc	Open woodland of *Eucalyptus wandoo* over *Gompholobium marginatum*, *Acacia nervosa*, *Babingtonia camphorosmae*, *Hypocalymma angustifolium*, *Macrozamia riedlei*, *Pericalymma ellipticum*, *Grevillea bipinnatifida*, *Allocasuarina humilis*, *Phyllanthus calycinus* and *Gastrolobium calycinum* on clay and clay-loam soils with localized outcropping on lower slopes.
Z	19JMr	Open forest of *Eucalyptus marginata* and *Corymbia calophylla* over *Macrozamia riedlei*, *Xanthorrhoea preissii*, *Hakea lissocarpha* and *Phyllanthus calycinus* on sandy-loam to sandy loam gravel soils on slopes.

5.2.5 Site Vegetation Type (SVT) Coverage

The total area mapped across the Bauxite Mine Expansion Areas was 17148.18 ha and is summarised in Table 6. Areas with no access accounted for 13% of the total survey area. The majority of the 2016 survey and assessment area has been highly modified from previous agricultural and mining areas, namely:

. cleared for agriculture and farming and dams – 38.07%, and
. plantation and rehabilitation areas – 39.18%.

The dominant site-vegetation types within the BME Areas were types P (or 19JLc) and S (19JBg) (504.20 and 551.35ha respectively). The P type is dominated by an overstorey of *Eucalyptus marginata* - *Allocasuarina fraseriana* - *Banksia grandis* over mixed shrub and low understorey species on sandy-gravel soils on slopes and ridges and the S type is dominated by an overstorey of *Eucalyptus marginata – Corymbia calophylla – Banksia grandis* over mixed shrubs and low understorey species on gravelly soils on slopes and ridges (see Table 5). Site-vegetation type G2 was the least occurring, accounting for 0.01% of the BME Areas, and was only recorded as an isolated pocket in the southern extent of the BME Areas. Site-vegetation type G2 is broadly defined as a mosaic of open woodland of *Allocasuarina huegeliana* and closed heath of Proteaceae, Myrtaceae spp. to Lithic Complex on exposed or shallow granite outcrops.

Table 6: Coverage of each Site-Vegetation Type within the Bauxite Mine Expansion Areas

Site-Vegetation Types	Area_ha	Total Mapped Area
A	67.16	0.39
A1	2.88	0.02
AX	286.28	1.67
AY	92.91	0.54
AY/D	1.95	0.01
D	138.88	0.81
DG	5.03	0.03
G	18.70	0.11
G1	1.91	0.01
G2	0.97	0.01
H	361.22	2.11
H1	4.68	0.03
H2	10.95	0.06
L	8.68	0.05
M	492.37	2.87
M2	8.29	0.05
MG	30.28	0.18
P	504.20	2.94
S	551.35	3.22
ST	56.11	0.33
Y	223.76	1.3
Z	265.59	1.55
Dam	1.02	0.01
Cleared	6527.08	38.06
No Access	767.64	4.48
Rehab	6679.66	38.95
Plantation	38.63	0.23
Total	17148.18	100.00

5.2.6 Condition of the Vegetation

The condition of the vegetation within the BME areas ranged from Completely Degraded to Excellent in different sections of the BME survey areas. The condition ratings are based on the Keighery scale (Keighery 1994; Appendix A; Figures 4.01 to 4.32, Table A7). The BME Areas are primarily used for agriculture, and as such, a large proportion of the survey area has previously been cleared. However, small sections of remnant vegetation and forest areas still remain within the survey area, with the vast majority of sites were rated as Completely Degraded to Good. Vegetation sites that were rated as being in excellent condition were primarily located within Area G2 (Figure 4.13), in site-vegetation types M, part of A and Y. These sites supported higher levels of species richness, with little to no infestation of introduced species. These areas that have been rated as being in Good to Excellent condition warrant management for their biodiversity values.

6. DISCUSSION

A total of 111 vascular plant taxa which are representative of 81 plant genera and 37 plant families in addition to 39 introduced plant species were recorded across 25 vegetation sites within the Bauxite Mine Expansion Areas during November 2016.

No threatened flora pursuant to Schedule 1 of the *Wildlife Conservation Act 1950*, the *Environment Protection and Biodiversity Conservation Act 1999* and the Department of the Environment was recorded within the Bauxite Mine Expansion Areas.

A range of priority species have been recorded previously by Mattiske in survey areas nearby to the BME Areas; *Gastrolobium* sp. Prostrate Boddington (M. Hislop 2130) (P1), *Meionectes tenuifolia* (P3), *Lasiopetalum cardiophyllum* (P4) and *Parsonsia diaphanophleba* (P4). One priority flora species as listed by the Department of Parks and Wildlife (2017g) was recorded within the Bauxite Mine Expansion Areas. *Gastrolobium* sp. Prostrate Boddington (M.Hislop 2130) (Priority 1) has been recorded previously and two times within the current Survey area. Two previous records of *Lasiopetalum cardiophyllum* (P4), near the Hotham River, were extracted from Western Australian Herbarium datasets. *Lasiopetalum cardiophyllum* (P4) has been recorded extensively in previous eastern forest vegetation studies near Boddington in the P site-vegetation type (19JLc mapping code – Worsley Alumina Pty Ltd 1985).

A total of 39 introduced species, one of which is listed as a declared plant pest, were recorded during the current survey. The vast majority of these introduced species are considered to be pasture weeds and as such it is expected that there would be high numbers of introduced species. There is a need to be vigilant in vehicle hygiene efforts, particularly in remnant areas that are less disturbed. The introduced species recorded includes **Gomphocarpus fruticosus*, which is listed as a declared plant pest and has been given the control category C3 (management). This category requires that the owner or occupier of the land in which a declared pest is recorded must take control measures to alleviate the harmful impacts of the declared pest (Appendix A6). **Gomphocarpus fruticosus* were recorded in three survey quadrats during the current survey and in low numbers, however it is capable of forming dense thickets (Department of Parks and Wildlife 1998-).

Thirty site-vegetation types were defined and mapped within the Bauxite Mine Expansion Areas. These site-vegetation types are representative of Havel's site-vegetation types for the northern Jarrah forest. The majority (77.25%) of the vegetation within the BME Areas has been cleared for agriculture or mining activities. The dominant site-vegetation types of the remaining vegetation within the BME Areas were typed P and S (previous Worsley Alumina Pty Ltd 1985 Mapping Codes 19JLc and 19JBg). Site-vegetation type G2 (previous Worsley Alumina Pty Ltd 1985 Code 21AAh - Mosaic of open woodland of *Allocasuarina huegeliana* and closed heath of Proteaceae Myrtaceae spp. to Lithic Complex on exposed or shallow granite outcrops.) occurred the least, only being recorded as an isolated pocket in the southern extent of the survey area.

Overall, the vegetation communities mapped and species recorded in the Bauxite Mine Expansion Areas are consistent with the historical mapping of Mattiske as reflected in the earlier work of Havel (1975a and 1975b) in the northern Jarrah forest and also the more recent mapping by Mattiske since the Phase Two studies on the Mt Saddleback area (Worsley Alumina Pty Ltd 1985; E.M. Mattiske and Associates 1986 to 1993; Mattiske Consulting ty Ltd 2012a to 2012c). As the majority of the Bauxite Mine Expansion Areas are either completely degraded or degraded the potential impact on local flora values should be minimal. Any areas supporting remnant vegetation in good to excellent condition or threatened or priority flora should be avoided if possible.

7. CONCLUSIONS AND RECOMMENDATIONS

In response to the proposed Bauxite Mine Expansion Areas located across private properties, it is recommended to:

- Avoid the location of the previously recorded threatened and priority flora species and the current and previous recordings of the priority species *Gastrolobium* sp. Prostrate Boddington (M. Hislop 2130) (P1) wherever feasible within the BME Areas;
- Limit ground disturbance and clearing of vegetation to designated areas and access routes wherever possible;
- Maintain existing drainage systems, ensuring tracks and other infrastructure areas do not disrupt or divert historic water flow patterns; and
- Remove and stockpile topsoil, log debris and leaf litter where possible for use in future rehabilitation programs; particularly in the areas where the vegetation is less disturbed) If possible, stockpiled topsoil should be treated for introduced species before being directly replaced on disturbed areas.

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9. PERSONNEL

The following Mattiske Consulting Pty Ltd personnel were involved in this project:

Name	Position	Project Involvement	Flora Collection Permit
Dr E.M. Mattiske	Managing Director & Principal Ecologist	Planning, management, data interpretation & reporting	N/A
Mr R. Dharmarajan	Experienced Botanist	Planning, fieldwork, data interpretation and report preparation	SL012022
Mr C. Blackburn	Experienced Botanist	Fieldwork	SL012021
Mr B. Ellery	Taxonomist	Plant identification	N/A
Mr A. Barrett	Botanist	Plant Identification	N/A

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