Mason’s Darwinia (Darwinia masonii) IUCN Criteria Assessment

Iron Hill Deposits Proposal

Prepared for
Mount Gibson Mining

1 March 2016
Mason’s Darwinia (Darwinia masonii) IUCN Criteria Assessment

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Plate 1 & 2: *D. masonii*. Photo credit: Eco Logical Australia 2014, 2015. .............................................. 4

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<tr>
<td>AHD</td>
<td>Australian Height Datum</td>
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<tr>
<td>AOO</td>
<td>Area of occupancy</td>
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<tr>
<td>DEC</td>
<td>Department of Environment and Conservation</td>
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<td>Department of the Environment</td>
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<td>Environmental Impact Assessment</td>
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<td>EOO</td>
<td>Extent of occurrence</td>
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<td>EPA</td>
<td>Environmental Protection Authority</td>
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<td>EPBC Act</td>
<td><em>Environment Protection and Biodiversity Conservation Act 1999</em> (Commonwealth)</td>
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<td>EPBC Regulations</td>
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<td>IUCN</td>
<td>International Union for Conservation of Nature</td>
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<td>Mount Gibson Mining Limited</td>
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<td>Office of Environmental Protection Authority</td>
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<td>Department of Parks and Wildlife</td>
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<td>PER</td>
<td>Public Environmental Review</td>
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<td>TSSC</td>
<td>Threatened Species Scientific Committee (Commonwealth)</td>
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<td>WA</td>
<td>Western Australia</td>
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<td>WATSSC</td>
<td>Western Australian Threatened Species Scientific Committee</td>
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<td>WC Act</td>
<td><em>Wildlife Conservation Act 1950</em> (State)</td>
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1 Introduction

Mount Gibson Mining Limited (MGM) proposes to extend its existing mining operations at the Mt Gibson Ranges to include development of the Iron Hill Deposits, located immediately south of the approved mine operations at Extension Hill. The Iron Hill Deposits Proposal (‘the Proposal’) is for a 112 ha extension to the existing approved mining operations, comprising of two mine pits (20 ha), a waste rock landform and associated support infrastructure).

The Proposal was referred to the Environmental Protection Authority (EPA) for assessment under s38(1) of the Environmental Protection Act 1986 (Western Australia; WA) in August 2014, with EPA determining the Proposal to be subject to an Environmental Impact Assessment (EIA) at the level of Public Environmental Review (PER) with a 6 week public review period. The review period for the PER document (hereafter ‘PER’; MGM 2015a) closed on 18 January 2016. On 21 January 2016, the Office of Environmental Protection Authority (OPEA) provided MGM with submissions made in relation to the Proposal.

A submission from the Department of Parks and Wildlife (Parks and Wildlife) related to the assessment of the status of the flora species *Darwinia masonii* (Mason’s Darwinia) according to the International Union for Conservation of Nature (IUCN) criteria (IUCN 2012). Due to its restricted population, *D. masonii* was listed as ‘Declared Rare Flora’ (DRF) under the WA Wildlife Conservation Act 1950 (WC Act) in 1980 and as a Threatened Species (Vulnerable) under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) in 2000. It was determined during the EIA process that the Proposal would have a direct impact on *D. masonii*, via the removal of up to 1,327 individual plants (5.9% of the known original population), within the Proposal’s development envelope (‘the development envelope’) upon full development of the Proposal (MGM 2015a). An assessment of the effect of the Proposal to *D. masonii* using the internationally accepted conservation criteria of the IUCN (IUCN 2012) was undertaken, with Globe Environments (2015) initially preparing a report assessing the potential for any change to the IUCN threatened taxa category for *D. masonii* as a result of the development of the Proposal (Appendix D).

Parks and Wildlife (2016a; Appendix A) questioned the findings of Globe Environments (2015) stating that ‘an IUCN criteria assessment taking into account this proposal and the stated intention for further exploration and mining within the Mount Gibson Range is likely to result in the threat category for *D. masonii* being changed to Critically Endangered under criteria B1(a)(b)(i,ii,iii,iv,v) and B2(a)(b)(i,ii,iii,iv,v)’.

ELA was engaged by MGM to provide a supplement to the Globe Environments (2015) report, undertaking a review of that assessment, and completing a detailed analysis of the conservation status of *D. masonii* in accordance with the IUCN criteria, taking into consideration Park and Wildlife’s comments.
2 IUCN Red List Categories and Criteria

The IUCN Global Species Programme, in conjunction with the IUCN Species Survival Commission, has been assessing the conservation status of taxa on a global scale for the past 50 years, to highlight taxa threatened with extinction and promote their conservation. The results of the assessment are published through the IUCN Red List of Threatened Species, which provides taxonomic, conservation status and distribution information on flora, fauna and fungi that have been globally evaluated using the IUCN Red List Categories and Criteria. This system is designed to determine the relative risk of global extinction and enable informed decision making. Currently, only 80,000 taxa, or less than 5% of the estimated global biodiversity of flora, fauna and fungi taxa, have been assessed (IUCN 2016).

The IUCN Red List Categories and Criteria were first published in 1994 and were developed to improve objectivity and transparency in assessing the conservation status of species (IUCN 2014). The first edition of the IUCN Red List Categories and Criteria: Version 3.1 was published in 2001, with the second (and current) edition issued in 2012.

According to the IUCN (2012) criteria, there are nine categories into which every taxon in the world can be classified: Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened, Least Concern, Data Deficient and Not Evaluated. Taxa in the categories Vulnerable, Endangered or Critically Endangered are defined as threatened species (IUCN 2014). There are five criteria used to evaluate if a taxon belongs in a threatened category; meeting any one of these criteria qualifies a taxon for listing at that level of threat (IUCN 2012, 2014):

- Declining population (past, present and/or projected);
- Geographic range size, and fragmentation, decline or fluctuations;
- Small population size and fragmentation, decline, or fluctuations;
- Very small population or very restricted distribution; and
- Quantitative analysis of extinction risk (e.g., Population Viability Analysis).

A summary of these five criteria is attached in Appendix B. The full definitions and criteria can be found in IUCN Red List Categories and Criteria (IUCN 2012) and in the Guidelines for Using the IUCN Red List Categories and Criteria (IUCN 2014).

2.1 Utilisation of the IUCN criteria for Australian threatened species

In WA, the WC Act provides for the listing of threatened flora and fauna that require special protection due to their identifiable threat of extinction, are rare, or otherwise in need of special protection. The Western Australian Threatened Species Scientific Committee (WATSSC) is appointed by the Minister for Environment, with administrative support provided by Parks and Wildlife. The WATSSC meets annually to allocate WA threatened taxa to threat categories, using the IUCN criteria (Parks and Wildlife 2016b).

Federally, the Commonwealth Threatened Species Scientific Committee (TSSC) assesses the conservation status of native species according to the EPBC Act and Environment Protection and Biodiversity Conservation Regulations 2000 (EPBC Regulations). The criteria the TSSC use to determine a species’ eligibility for listing and the threat categories are recorded in Part 7 of the EPBC Regulations. To help inform the decision making process, the TSSC has adopted indicative thresholds that have been adapted from the IUCN Criteria (IUCN 2012); however the TSSC is informed by (but not bound to) these thresholds (TSSC 2015). Assessments undertaken by the TSSC mostly align with the IUCN assessment for inclusion on the Red List, however the TSSC require the consideration of
supporting evidence to justify a decision to list a taxon in a threat category (Department of the Environment [DoE] 2016).
3 Overview of *D. masonii*

### 3.1 Description of taxon

*D. masonii* is a medium sized erect shrub growing up to 3 m tall with characteristic grey-green foliage. The leaves are small and narrow, approximately 1 cm long and are almost triangular in cross-section. The inflorescences are approximately 3 cm in diameter and have numerous spreading pinkish pendulous bracts located distally on branchlets (ELA 2015a). *D. masonii* generally flowers between April and November (MGM 2015a), with the inflorescences comprised of numerous small tubular flowers about 5 mm long with a style approximately 1.5 cm in length with hairs below the stigma (ELA 2015a). Images of *D. masonii* are provided in **Plate 1** and **2**.

![Plate 1 & 2: D. masonii. Photo credit: Eco Logical Australia 2014, 2015.](image)

### 3.2 Distribution and habitat

*D. masonii* is endemic to the Mt Gibson Ranges, located approximately 350 km north-north-east of Perth, where it occurs on the ridges and slopes at elevations above 330m AHD. It is found on skeletal or shallow clay soils and shallow pockets associated with ironstone, granite, lateritic breakaway formation and creeks (MGM 2015a). Regional surveys for *D. masonii* have not yielded any additional records of this taxon (MGM 2015a).

### 3.3 Population size

The total known original population of *D. masonii* is estimated to have consisted of 22,667 individuals prior to the development of Extension Hill mine (MGM 2015a). This is comprised of the known extant records observed by ELA (2015a) and the number of individuals removed (1,702 plants to date) upon development of the approved hematite mining operations at Extension Hill. The Proposal’s development envelope coincides with records of 1,327 individuals (5.9% of the total known original *D. masonii* population).
In 2004, a census of the *D. masonii* population recorded 16,573 individuals throughout the Mt Gibson Ranges (ATA 2004). Additional surveys (Coffey 2008, MBS 2013, Maia 2014 and ELA 2015a) increased the number of known records to 20,965 extant individuals (following the removal of 1,702 plants to date). The increase in the total population records (>6,000 new records) between the ATA (2004) and ELA (2015a) censuses is considered primarily to be due to increase in survey effort (a greater survey extent), rather than an increase to the *D. masonii population* through recruitment. It is considered unlikely that the total population could have increased by greater than 30% given there have been no significant environmental effects (e.g. fire) over the past ten years to promote such significant recruitment (ELA 2015a, MGM2015a).

*D. masonii* currently has an extent of occurrence of less than 100 km$^2$, an area of occupancy less than 10 km$^2$ and is known from a single location (the Mt Gibson Ranges; DEC 2008). The total known habitat present in the Mt Gibson Ranges prior to the commencement of mining activities was 257.2 ha. The Proposal’s development envelope coincides with 23.4 ha (9.1%) of this habitat (MGM 2015a).

Further information is detailed in Appendix B (Globe Environments 2015) and in the PER (MGM 2015a).

### 3.4 Current conservation status

Due to its restricted population, *D. masonii* was listed as ‘Declared Rare Flora’ (DRF) under of the WC Act in 1980 and as a Threatened Species (Vulnerable) under the EPBC Act in 2000. In the most recent Wildlife Conservation (Rare Flora) Notice (Parks and Wildlife 2015), *D. masonii* is listed under Schedule 3 (Flora that are considered likely to become extinct or rare, as vulnerable flora).

An assessment according to the IUCN criteria by the Department of Environment and Conservation (DEC; now Parks and Wildlife) was undertaken in 2008 (DEC 2008), and concluded *D. masonii* met the IUCN threatened taxa category of ‘Vulnerable’ under criterion D2 (restricted area of occupancy or number of locations with a plausible future threat that could drive the taxon to ‘Critically Endangered’ or ‘Extinct’ in a very short time).

*D. masonii* has not currently been independently assessed by the IUCN. It is not listed on the IUCN Red List (IUCN 2016), and falls into the IUCN category of ‘Not Evaluated’.

Existing approved mining operations at Extension Hill (approved in 2007 under Ministerial Statement 753; development commenced in 2010) received authorisation to remove up to 16.6% of the *D. masonii* population, and this did not result in an increase to the recognised conservation status of *D. masonii* in WA and/or Australia.
4 Globe Environmental (2015) Assessment

The Globe Environments (2015) assessment concluded that *D. masonii* currently still qualifies for the IUCN threatened taxa category of ‘Vulnerable’ under criterion D2, in regard to its area of occupancy being under 20 km² and its occurrence in less than five locations. The assessment stated no other criteria were met, and it was specified the cumulative effect of the approved Extension Hill mine operations at the Mt Gibson Ranges and the Proposal were not expected to result in a change to the current threatened category of ‘Vulnerable’.

In regards to criteria B1 and B2 (relates to geographic range in the form of extent of occurrence or area of occupancy; see Section 5.3), it was considered that *D. masonii* was not subject to a ‘continuing decline’ or ‘extreme fluctuations’. The risk of future mining leading to an increase in the threatened category (i.e. to ‘Endangered’ or ‘Critically Endangered’) was not considered to be applicable, with future mining (i.e. development of the Proposal) not considered to increase the threat category (Globe Environments 2015). Climate, principally extended drought, was identified as a future risk to increasing the threat category (a ‘plausible future threat’).

The influence of indirect impacts to the conservation status of *D. masonii* were not discussed within the Globe Environments (2015) assessment. Indirect impacts relating to the Proposal are summarised in Section 5.2 of this report and in the PER (MGM 2015a).
5 Discussion

5.1 Direct impacts of the Proposal

The Proposal will result in the removal of up to 1,327 *D. masonii* individuals within the development envelope (5.9% of the total known original *D. masonii* population), comprising 1,135 mature individuals, 173 juveniles, 18 seedlings and 1 senescent individual. Note for the purposes of this assessment, only mature individuals are considered (IUCN 2012). Mature individuals, as defined by the IUCN (2014), are the number of individuals known, estimated or inferred to be capable of reproduction. Non-reproductive individuals, such as seedlings/juveniles and senescent plants, are excluded from the assessment.

Currently 3,763 individuals (all life stages) are approved for clearance as part of the existing mining operations at Extension Hill under Ministerial Statement 753. However, it should be noted that as of November 2015, only 1,702 individuals (7.5% of the total population) have been removed for the approved mining operations at Extension Hill (MGM 2015a).

Cumulatively, the approved clearing for the approved operations at Extension Hill mine and for the Proposal could result in the loss of up to 5,090 individuals (22.5% of the total known original population). The remaining 77.5% of the population will contain 17,577 plants (16,068 mature individuals, 1,300 juveniles, 157 seedlings and 52 senescent individuals).

The Proposal will also result in the removal of *D. masonii* habitat, with clearing in the development envelope undertaken for the two mine pits, roads, and associated support infrastructure. A total of 257.2 ha of *D. masonii* habitat was present in the Mt Gibson Ranges prior to the commencement of mining activities (MGM 2015a). Up to 23.4 ha of this habitat (9.1%) will be removed as a result of the Proposal, 34.5 ha has currently been impacted as a result of the existing mining operations at Extension Hill (MGM 2015a), and a further 0.9 ha is anticipated to be cleared as part of exploration activities at Gibson Hill (Marguerite D’Alton, pers. comm.). The total cumulative reduction in *D. masonii* habitat as a result of the existing mining operations at Extension Hill, the Proposal and Gibson Hill exploration will be 58.8 ha (22.9%; MGM 2015a).

5.2 Indirect impacts of the Proposal

Whilst not specifically examined in Globe Environments (2015), indirect impacts to the remaining extant population of *D. masonii* were discussed at length in the PER (MGM 2015a). Ongoing monitoring and assessment indicates the identified stressors on plant health and viability (including dust, vibration, weeds, fragmentation, disease, grazing pressure and alteration to micro climates, hydrology cycles, pollinators, reproduction and seed dispersal) are unlikely to be causing a significant threat to the conservation status of this species (MGM 2015a), as there is no evidence, based on routine monitoring as summarised below, that such effects have occurred to date. A summary of the findings of these studies are attached in Appendix E (Appendix 13 of MGM 2015a).

Permanent monitoring plots were established in 2007 to monitor the condition of *D. masonii* in proximity to the approved mining operations at Extension Hill, with control sites located elsewhere on the Mt Gibson Ranges. Parameters such as plant size, survivorship, reproductive status, age, condition and the presence of recruitment have been monitored in accordance with approved monitoring and management plans. To date, there have been no significant detrimental impacts on *D. masonii* attributable to mining activities (MGM 2015a). As per the approved Environmental Management Plan (MGM 2015b), measures will continue to be implemented to manage the risk of indirect impacts on *D.
Mason’s Darwinia (*Darwinia masonii*) IUCN Criteria Assessment

*masonii* from threats including, but not limited to, fire, introduced species, dust and altered hydrological regimes.

In addition to the information contained with the PER (MGM 2015a), a recent trial was undertaken at the Mt Gibson Ranges investigating the usage of a Plant Efficiency Analyser (PEA) to measure plant health (Astron 2016). PEA is a small portable instrument that senses and analyses chlorophyll fluorescence to determine the level of photoinhibition within a leaf. The standard parameter used to measure photoinhibition is variable fluorescence ($F_v$) divided by maximum fluorescence ($F_m$), or $F_v/F_m$. Leaf photoinhibition can be affected by health stressors such as dust and lack of availability of water (Astron 2016). Results indicated that using the PEA was likely to be a valid and practical quantitative methodology suitable to be used on *D. masonii* in the field to provide an indicator of plant health (Astron 2016), and MGM is proposing to continue trials of this methodology to provide additional data to support this claim.

This study also investigated whether putative dust deposition (and distance of plants from the existing mine) was correlated with plant health. Dust levels were found to be low with little variation between sampled plants. There was no correlation the level of dust on a plant and $F_v/F_m$ values, and no significant relationship between $F_v/F_m$ values and the distance from the mine pit. Overall, there was no detectable effect on photoinhibition from dust on *D. masonii* (Astron 2016).

Ongoing monitoring and assessment of the potential indirect impacts of the approved mining operations at Extension Hill has not indicated to date that there is a significant threat to the conservation status or population viability of *D. masonii*.

5.3 IUCN threatened category

*D. masonii* was previously considered by Parks and Wildlife (DEC 2008) and Globe Environments (2015) to meet the IUCN threatened category of ‘Vulnerable’ under criterion D2.

Parks and Wildlife stated in January 2016 that ‘an IUCN criteria assessment taking into account this proposal and the stated intention for further exploration and mining within the Mount Gibson Range is likely to result in the threat category for *D. masonii* being changed to Critically Endangered under criteria B…’ (Appendix A). To meet this criteria for a threatened category of ‘Critically Endangered’, a taxon must meet the criteria (IUCN 2012) for B1 (extent of occurrence; EOO) and/or B2 (area of occupancy; AOO):

B1. EOO estimated to be less than 100 km$^2$, and estimates indicating at least two of a-c:

a. Severely fragmented or known to exist at only a single location.
b. Continuing decline, observed, inferred or projected, in any of the following: (i) extent of occurrence, (ii) area of occupancy, (iii) area, extent and/or quality of habitat, (iv) number of locations or subpopulations, or (v) number of mature individuals.
c. Extreme fluctuations in any of the following: (i) extent of occurrence, (ii) area of occupancy, (iii) number of locations or subpopulations or (iv) number of mature individuals.

B2. AOO estimated to be less than 10 km$^2$, and estimate indicating at least two of a-c:

a. Severely fragmented or known to exist at only a single location.
b. Continuing decline, observed, inferred or projected, in any of the following: (i) extent of occurrence, (ii) area of occupancy, (iii) area, extent and/or quality of habitat, (iv) number of locations or subpopulations or (v) number of mature individuals.
c. Extreme fluctuations in any of the following: (i) extent of occurrence, (ii) area of occupancy, (iii) number of locations or subpopulations, or (iv) number of mature individuals.

*D. masonii* currently has an extent of occurrence <100 km², an area of occupancy <10 km² and is known from a single location (the Mt Gibson Ranges; DEC 2008); thus only the criteria under B1(b) or (c) or B2(b) or (c) need to be met for it to belong in the 'Critically Endangered' threatened category.

There is no evidence of extreme fluctuations in the EOO, AOO, number of locations or subpopulations or the number of mature individuals, and Parks and Wildlife do not suggest *D. masonii* meets this criterion. Instead, it considers (Appendix A) *D. masonii* to meet the IUCN guidelines for ‘continuing decline’ under criteria B1(b) and B2(b),

‘...which may be through indirect impacts on the condition of the habitat, or sporadic events, such as the progressive mining of additional areas resulting in loss of plants, extent of occurrence and area of occupancy.’

This matter is further assessed below.

### 5.4 Continuing decline under criterion B

‘Continuing decline’ is defined by the IUCN (2012) as:

'...a recent, current or projected future decline (which may be smooth, irregular or sporadic) which is liable to continue unless remedial measures are taken. Fluctuations will not normally count as continuing declines, but an observed decline should not be considered as a fluctuation unless there is evidence for this.'

A future ‘continuing decline’ can be projected (it does not have to have commenced); however, according to IUCN (2014):

'...such projected declines must be justified and there must be high degree of certainty that they will take place (i.e., merely ‘plausible’ future declines are not allowed).'

The approval of the removal of up to 3,582 mature *D. masonii* individuals for the existing mining operations at Extension Hill meets the criteria for ‘a recent…decline’; noting that only 1,702 records have been removed for hematite mining to date. Furthermore, the Proposal is considered to be ‘a projected future decline’. Sections 5.1 and 5.2 and the PER (MGM 2015a) describe the maximum predicted impacts from the Proposal on *D. masonii*, primarily, the direct removal of mature individuals (v) and habitat based on recent (2014) census records. The removal of these plants for the Proposal would also cause a further reduction in AOO (i) and habitat area, extent or quality (iii), and may potentially reduce the EOO (ii). However, the Proposal would not reduce the number of locations or subpopulations (of which there is only one; (iv)).

MGM is also considering further resource exploration by drilling on parts of Gibson Hill (MGM 2015a); a Program of Works approval and Native Vegetation Clearing Permit (NVCP) are held for an area of 1.83 ha at Gibson Hill to allow for those exploration activities. As stated by MGM (2015a), if exploration at Gibson Hill were to proceed, it would involve “Access…via established and newly created tracks / drill pads would occur in a vegetated area of 1.83 hectares but not interfere with any records of Rare Flora”. Of the total 1.83 ha area, 0.93 ha is mapped as *D. masonii* habitat (Marguerite D’Alton, pers. comm.).

While MGM have committed to avoiding Rare Flora records so that it will not result in a decline of the number of mature individuals (v), the exploring drilling will cause a minor temporary decline in area, extent and/or quality of habitat of *D. masonii* (iii). Rehabilitation of disturbed habitat is proposed to be
undertaken within 6-12 months following the conclusion of drilling activities (Matthew Hamilton, pers. comm.). Additionally, it is expected that natural regeneration will occur as *D. masonii* has been previously shown to colonise areas disturbed by exploration activities in low numbers (MGM 2015a).

Notwithstanding, while the clearing of *D. masonii* mature individuals and habitat for the Proposal, and 0.93 ha of additional habitat at Gibson Hill for exploration drilling can be considered ‘projected future declines’, the IUCN definition for ‘continuing decline’ is not met. This is because the decline must be ‘liable to continue unless remedial measures are taken’. Remedial measures mitigating and offsetting the effects of the Proposal are listed within the PER (MGM 2015a) and the approved Environmental Management Plan (EMP; MGM 2015b), and are summarised in Section 5.5 below. By instigating these remedial measures, the ‘continuing decline’ of the *D. masonii* population will be prevented. Subsequently, *D. masonii* continues to qualify for the IUCN threatened category of ‘Vulnerable’ under criterion D2 only, and does not meet the criteria for the threatened categories of ‘Endangered’ or ‘Critically Endangered’.

Parks and Wildlife have also expressed a view that ‘additional resource exploration and mining at Gibson Hill...meet the IUCN guidelines for continuing decline...’. Future mining that may be proposed at Gibson Hill, or elsewhere in the Mt Gibson Ranges, would be dependent on many factors, such as economic levels and types of mineralisation, market demand for products to be mined and processed and future government assessment and approval (MGM 2015a). It is therefore evident that any future mining developments (outside of the Proposal's development envelope) do not have a ‘high degree of certainty’ that they will occur (these projects, should they be feasible, have yet to be referred under the relevant mandatory legislation), and should not be classified as reasonably foreseeable, nor subsequently considered in regard to the definition of ‘continuing decline’ in relation to the current Proposal. ‘Reasonably foreseeable’ actions are defined by the Minerals Council of Australia (2015) as:

- Financial market and forecasts are positive, new or expanded projects are considered likely; and
- Project approved and commencement announced by owner; or
- Project under assessment and full documentation available.

Potential future mining activities outside the development envelope (for example, at Gibson Hill) do not meet these criteria. The current status of potential future exploration and mining activities at Gibson Hill is shown graphically in a flowchart in Appendix C.

### 5.5 Mitigation measures

To remediate potential impacts on *D. masonii* from the Proposal, MGM (2015a) has proposed substantial management and mitigation measures. The *D. masonii* Recovery Plan (MGM and EHPL 2014), based on the Interim Recovery Plan by Parks and Wildlife (2008), will continue to be implemented, and additional measures are proposed by MGM to offset the impact of the Proposal on *D. masonii*. These measures include (MGM 2015a):

- Re-establishment and/or translocation of *D. masonii* individuals across the Mt Gibson Ranges (at least 1,700 individuals to be directly translocated). These plants will be derived from green-stock cuttings and seeds collected Iron Hill and Iron Hill South prior to vegetation clearing and comprised of representative genetic stock; and
- Ongoing financial contribution to Parks and Wildlife to coordinate the management of *D. masonii* and contribute towards the implementation of the *D. masonii* Recovery Plan (MGM and EHPL 2014) across the Mt Gibson Ranges.

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Annual plant condition monitoring of wild individual *D. masonii* on parts of Iron Hill and at other Mt Gibson Ranges fixed monitoring sites will also be undertaken; this is a continuation of the existing monitoring program for the approved mining operations at Extension Hill (MGM 2015a).

*D. masonii* has previously been successfully re-established over the course of a decade within the Mt Gibson Ranges through rehabilitation trials using green-stock cuttings (MGM 2015a). Trials have been undertaken to determine the most suitable soil substrate for cuttings propagated in nursery conditions, and the effects of irrigation and fencing (MGX and EHPL 2014). In a previous planting trial of 206 translocated plants (propagated a variety of genotypes from cuttings in nursery conditions, watered over the first two summers post-translocation and fenced to exclude herbivores), 50% of the plants reached sexual maturity (flowering) after 18 months (DEC 2008) and all had tripled in size in the first 18 months after they were planted in June 2005 (MGX and EHPL 2014). The control plants (an additional 20 individuals) were not fenced or watered, and demonstrated highly reduced growth and overall survival rates (DEC 2008). All control plants were recorded as deceased in March 2014. Nine years after translocation, a survival rate of over 81% was recorded in the fenced enclosure (MGX and EHPL 2014).

The analysis of soil-stored seed identified the presence of viable seed, and *D. masonii* has been observed to natural recolonise in low numbers on exploration tracks, drilling pads and topsoil storage areas (MGM 2015a). A small population were found to have propagated in topsoil stockpiles at Extension Hill. As these plants were considered unlikely to survive the topsoil spreading process scheduled for 2016, 15 individuals were translocated to the eastern batter of the Extension Hill waste rock landform in June 2015. An additional five plants (propagated from cuttings and grown in a nursery) were also planted in the trial area. The plants were supplementedly watered daily in the first week of the trial, with the watering frequency slowly decreasing until mid-September; since this time the plants have been watered weekly (MGM and EHPL 2015). All 20 plants translocated to the waste rock landform were recorded alive after eight months (Jessica Sackmann, pers. comm.).

MGM has identified the future key priorities for *D. masonii* recovery to be the establishment of new individuals and maintaining genetic diversity in the population. Translocation trials have provided a relatively high confidence in the ability to translocate *D. masonii* within the Mt Gibson Ranges, and further trials are proposed (MGM 2015a). The knowledge gained from these trials and habitat modelling (BGPA 2010) will assist increasing the survival rates of the translocated *D. masonii* (MGX and EHPL 2014); although seeding is considered the most appropriate approach for broad-scale regrowth and rehabilitation (MGM 2015a).

Contingent on the success of the future re-establishment and/or translocation of *D. masonii* individuals and the selected location(s) for the translocated plants, MGM could endeavour to increase, if feasible (as defined in the IUCN criteria (IUCN 2012)):

- the EOO;
- the AOO;
- the area and/or extent of habitat;
- the number of locations or subpopulations; and/or
- the number of mature individuals.

Translocated individuals are recognised by the IUCN if they meet the conditions outlined in IUCN (2014), including, but not limited to, producing viable offspring and persisting greater than five years following translocation (IUCN 2014). Clones (for example, plants propagated from cuttings) also qualify as mature individuals by the IUCN, so long as they produce viable offspring and their survival is independent of other clones (IUCN 2014). These remedial measures will act to prevent the further
The decline of *D. masonii* as a result of the direct and potential indirect impacts of the Proposal, and seek to mitigate the loss of individuals caused by clearing within the development envelope.

### 5.6 Future population viability

Parks and Wildlife (2016a) is concerned that "based on the available information, the direct, indirect and cumulative loss of *D. masonii* and its habitat associated with this proposal may also present a significant risk to the long term viability of the species".

Population viability is defined as the ability of a population to persist and to avoid extinction. The long term viability of a population will increase or decrease in response to changes in the rates of birth, death, and growth of individuals, which can be influenced by a range of genetic, demographic and environmental parameters (Knox et al. 2008). Parameters affecting population viability are often unique to the species.

The Proposal is not anticipated to affect the future viability of the *D. masonii* population. Key matters that may threaten *D. masonii* viability are summarised below in Sections 5.6.1 - 5.6.4, and addressed in detail with the PER (MGM 2015a) and/or the PER supporting reports.

#### 5.6.1 Genetic diversity

Genetic structuring between the *D. masonii* groups throughout the Mt Gibson Ranges has been identified as low (Verterra Ecological Engineering 2015), with approximately 94% of genetic variation identified within groups, rather than between groups (BGPA 2010). While BGPA (2010) found there may be some weak gene flow barriers between groups, the individuals within the development envelope proposed to be removed have not been identified as genetically different to the rest of the *D. masonii* population. Notwithstanding, to retain maximum genetic diversity, MGM propose to take cuttings across a large selection of the individuals that would be lost, undertake seed collection, and translocate a selection of mature plants prior to clearing (MGM 2015a).

#### 5.6.2 Habitat connectivity and dispersal

Significant fragmentation of *D. masonii* habitat is not anticipated to occur, as the species would continue to persist naturally in the northern parts of Iron Hill, and on the nearby Iron Hill North and Iron Hill East (MGM 2015a). *D. masonii* pollen is known to be dispersed by birds such as the White-fronted Honeyeater (*Phylidonyris albifrons*). The Proposal is not expected to significantly affect pollen transfer within the remaining *D. masonii* population distributed throughout the Mt Gibson Ranges (MGM 2015a).

#### 5.6.3 Existing population and habitat maintenance

Cumulatively, vegetation clearing for the approved mining operations at Extension Hill and for the Proposal could result in the cumulative loss of up to 5,090 *D. masonii* individuals. A total of 77.5% of the original population will remain as wildstock throughout the Mt Gibson Ranges, containing 17,577 plants (16,068 mature individuals, 1,300 juveniles, 157 seedlings and 52 senescent individuals). The Proposal will also result in the removal of *D. masonii* habitat, with up to 58.8 ha removed due to the Proposal, the approved mining operations at Extension Hill and the exploration activities at Gibson Hill. However, 77.1% of *D. masonii* habitat would remain intact throughout the Mt Gibson Ranges. It should be noted that *D. masonii* does not meet the IUCN (2012) criteria for a threatened category under criterion A (population size reduction) or criterion C (small population size and decline).

Translocation trials have provided high confidence in the ability to translocate *D. masonii* within the Mt Gibson Ranges to supplement the extant population with representative genetic stock (MGM 2015a), and MGM have committed to the re-establishment and/or translocation of at least 1,700 *D. masonii* individuals across the Mt Gibson Ranges (MGM 2015a). Following successful translocation, individuals...
will be counted as part of the *D. masonii* population in accordance with the IUCN criteria once they have persisted for more than five years and produced viable offspring (IUCN 2014).

The rehabilitation of the waste rock landform within the development envelope at the conclusion of mining would also be prospective for future *D. masonii* re-establishment, increasing habitat availability and offsetting some of the 58.8 ha of *D. masonii* habitat lost due to the mining developments. The translocation of 20 plants to the Extension Hill waste rock landform has yielded positive results to date, with all individuals recorded alive after eight months (Jessica Sackmann, pers. comm.).

### 5.6.4 Other threatening processes

MGM proposes to manage the threatening processes caused by mining, such as the introduction and spread of weed species and fire (MGM 2015a). These management measures are listed in the approved EMP (MGM 2015b). Ongoing monitoring and assessment does not provide evidence of significant impacts to the viability of the *D. masonii* population due to dust, vibration or grazing pressure (Appendix E, MGM 2015a). Grazing by introduced species such as goats and rabbits has been found to have negligible impacts on *D. masonii* (BGPA 2010), and there were no detectable impacts from dust on plant health in a recent study by Astron (2016). Affects due to blasting and vibration will be limited, and will be managed by the removal of unstable rocks and rehabilitation of damaged areas (MGM 2015a).

An analysis conducted by ELA (2015b) considered it unlikely that the development of the Proposal would impact upon the broader functioning of the ecological values adjacent to the development envelope, and across the broader Mount Gibson Ranges landform.

In light of the proposed remediation measures, it is considered that direct, indirect and cumulative impacts to *D. masonii* are unlikely to result in any significant risk to the ongoing viability of the species.
6 Summary and Conclusions

The Globe Environments (2015) assessment concluded that *D. masonii* continues to qualify for the IUCN threatened category of ‘Vulnerable’ under criterion D2 only (inclusive of potential impacts due to implementing the Proposal); however Parks and Wildlife (2016a; Appendix A) disagreed with the findings of that assessment, and stated that the ‘…proposal and the stated intention for further exploration and mining within the Mount Gibson Range is likely to result in the threat category for *D. masonii* being changed to Critically Endangered under criteria B1(a)(b)(i,ii,iii,iv,v) and B2(a)(b)(i,ii,iii,iv,v)’.

This further assessment has concluded that the criteria for ‘continuing decline’ under criterion B is not met as a result of the Proposal, as the definition is dependent on the absence of remedial measures being undertaken. Subsequently, *D. masonii* continues to qualify for the IUCN threatened category of ‘Vulnerable’ under criterion D2. Remedial measures proposed will:

- Re-establish *D. masonii* individuals via translocations and seeding, increasing the number of mature individuals and mitigating the effects of the removal of individuals within the development envelope;
- Provide potential habitat for *D. masonii* at the Proposal’s conclusion by rehabilitating areas post-mining;
- Retain genetic diversity by preserving the genomes of individuals proposed to be cleared through plant cuttings and seed collection, and by translocating a selection of plants prior to clearing;
- As per the approved EMP (MGM 2015b), management measures will continue to be implemented to control the risk of threatening processes on *D. masonii*, including but not limited to fire, introduced species, dust and altered hydrological regimes;
- Continue annual plant condition monitoring of *D. masonii* as part of the existing monitoring program for the approved mining operations at Extension Hill; and
- Provide ongoing financial contribution to Parks and Wildlife to coordinate the management of *D. masonii* and contribute towards the implementation of the *D. masonii* Recovery Plan (MGM and EHPL 2014) across the Mt Gibson Ranges.

In light of these proposed remedial measures, it is considered that direct, indirect and cumulative impacts to *D. masonii* are unlikely to result in a significant risk to the ongoing viability of the species and its ability to persist in the Mt Gibson Ranges, and would not result in a change in the IUCN threat category from ‘Vulnerable’ to ‘Endangered’ or ‘Critically Endangered’.
References


Appendix A Parks and Wildlife Submission
<table>
<thead>
<tr>
<th>Private individual 1</th>
<th>CHANGE IN THREAT CATEGORY FOR DARWINIA MASONII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parks and Wildlife</td>
<td>The cumulative impacts from mining and other pressures on the remaining populations of <em>Darwinia masonii</em> may change the threat category for the species. Taking into account the impacts of this proposal as assessed by Parks and Wildlife and the proponent’s stated intention toward further exploration and mining in the Mount Gibson Range, the IUCN threat ranking of the threatened flora species <em>D. masonii</em> would be likely to change from vulnerable to critically endangered(^1) if this proposal was approved. The assessment of the IUCN status of <em>D. masonii</em> following the proposed mining does not appear to include potential indirect impacts. Therefore, the proponent should provide further information on indirect impacts to support its conclusion that there is adequate information provided in the PER to conclude that the impact of the proposal as described will not be significant and is not likely to result in the threat category of <em>D. masonii</em> being changed to a higher category. <em>D. masonii</em> qualifies for IUCN assessment under criterion D2 as the area of occupancy is &lt;20km(^2). The species has one known location (Mount Gibson Range), with all recorded individuals located on a geological formation potentially subject to threatening processes, including direct and indirect impacts of mining where approved.</td>
</tr>
</tbody>
</table>

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\(^1\) An assessment against the IUCN criteria is an internationally accepted approach to assessing the risk of extinction of a species. For impacts on BIF specialist taxa and associated vegetation, one of the key principles from the 2007 Strategic Review related to no development activity proceeding in Yilgarn Craton BIFs that would result in the IUCN threat category changing for any taxon or ecological community.
If this proposal is approved, there will be a further decline in the area of occupancy, area of habitat and number of mature individuals of *D. masonii* as a direct result of mining activities. Further, the PER indicates that the proponent is considering additional resource exploration and mining at Gibson Hill within the area agreed for reservation during the 2007 appeals determination (p82) and the PER does not appear to indicate a view that there is any need for permanent protection of habitat and *in situ* populations of this species. These considerations meet the IUCN guidelines for continuing decline, which may be through indirect impacts on the condition of the habitat, or sporadic events, such as the progressive mining of additional areas resulting in the loss of plants, extent of occurrence and area of occupancy.

An IUCN criteria assessment taking into account this proposal and the stated intention for further exploration and mining within the Mount Gibson Range is likely to result in the threat category for *D. masonii* being changed to critically endangered under criteria B1(a)(b)(i,ii,iii,iv,v) and B2(a)(b)(i,ii,iii,iv,v). This is on the basis that the extent of occurrence is less than 100km², the area of occupancy would be less than 10km², the species occurs at one location and there is a continuing decline (as defined) in the area of occupancy, extent or condition of the habitat, and number of mature individuals, and potentially the extent of occurrence and number of subpopulations.

Based on the available information, the direct, indirect and cumulative loss of *D. masonii* and its habitat associated with this proposal may also present a significant risk to the long term viability of the species.

It appears that the cumulative impacts of the current proposal and continuation of exploration activity in the Mount Gibson Range by the proponent, present a high level of risk to *D. masonii*. It is important that the current proposal is reviewed in the context of the requirements of MS 753, as the impacts on *D. masonii* as currently proposed appear inconsistent with the requirements of MS 753 (specifically condition 5-2 and 5-3) and ultimately the objectives of the *Dansinia masonii* Recovery Plan.
### Appendix B IUCN Criteria (IUCN 2014)

#### A. Population size reduction

Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4

<table>
<thead>
<tr>
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<th>Endangered</th>
<th>Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>≥ 90%</td>
<td>≥ 70%</td>
<td>≥ 50%</td>
</tr>
<tr>
<td>A2, A3 &amp; A4</td>
<td>≥ 80%</td>
<td>≥ 50%</td>
<td>≥ 30%</td>
</tr>
</tbody>
</table>

- A1 Population reduction observed, estimated, inferred, or suspected in the past where the causes of the reduction are clearly reversible and understood may have ceased.
- A2 Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may have ceased or may not be understood or may not be reversible.
- A3 Population reduction projected, inferred or suspected to be met in the future (up to a maximum of 100 years) (ia) cannot be used for A3.
- A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased or may not be understood or may not be reversible.

#### B. Geographic range in the form of either B1 (extent of occurrence) AND/OR B2 (area of occupancy)

<table>
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<th>Vulnerable</th>
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</thead>
<tbody>
<tr>
<td>B1</td>
<td>&lt; 10 km²</td>
<td>&lt; 50 km²</td>
<td>&lt; 2,000 km²</td>
</tr>
<tr>
<td>B2</td>
<td>&lt; 10 km²</td>
<td>&lt; 500 km²</td>
<td>&lt; 2,000 km²</td>
</tr>
</tbody>
</table>

AND at least 2 of the following 3 conditions:

- (a) Severely fragmented OR Number of locations
  - ≥ 1 ≤ 5 ≤ 10
- (b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals
- (c) Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals

#### C. Small population size and decline

<table>
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<th>Endangered</th>
<th>Vulnerable</th>
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</thead>
<tbody>
<tr>
<td>Number of mature individuals</td>
<td>&lt; 250</td>
<td>&lt; 2,500</td>
<td>&lt; 10,000</td>
</tr>
</tbody>
</table>

AND at least one of C1 or C2

- C1 An observed, estimated or projected ongoing decline of at least (up to a max. of 100 years in future):
  - 25% in 3 years or 1 generation (whichever is longer)
  - 20% in 5 years or 2 generations (whichever is longer)
  - 10% in 10 years or 3 generations (whichever is longer)

- C2 An observed, estimated, projected or inferred continued decline AND at least 1 of the following 3 conditions:
  - (i) Number of mature individuals in each subpopulation
    - ≤ 50 ≤ 250 ≤ 1,000
  - (ii) % of mature individuals in one subpopulation
    - 90–100% 95–100% 100%
  - (b) Extreme fluctuations in the number of mature individuals

#### D. Very small or restricted population

<table>
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<th>Critically Endangered</th>
<th>Endangered</th>
<th>Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of mature individuals</td>
<td>&lt; 50</td>
<td>&lt; 250</td>
<td>&lt; 1,000</td>
</tr>
</tbody>
</table>

- D1. Typically: AOO < 20 km² or number of locations ≤ 5

- D2. Only applies to the VU category

#### E. Quantitative Analysis

Indicating the probability of extinction in the wild to be:

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<th>Vulnerable</th>
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<tr>
<td>≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)</td>
<td>≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)</td>
<td>≥ 10% in 100 years</td>
<td></td>
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</tbody>
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1. Use of this summary sheet requires full understanding of the IUCN Red List Categories and Criteria and Guidelines for Using the IUCN Red List Categories and Criteria. Please refer to both documents for explanations of terms and concepts used here.
Appendix C Potential Future Exploration and Mining Activities at Gibson Hill – Steps to Approval

Figure 1: Potential future exploration and mining activities at Gibson Hill; Steps to Approval. Resource exploration at Gibson Hill has been approved (green boxes). However, mining activities at Gibson Hill cannot be considered reasonably foreseeable, as there are many additional steps (red boxes) that are required to be undertaken before the development could proceed.
Appendix D Globe Environments (2015) IUCN Assessment
Iron Hill Deposit

Assessment of the Threatened Taxa Category for
Darwinia masonii using IUCN (2012) Criteria

June 2015
Document History

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<th>Distribution</th>
<th>Date</th>
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<td>MGM</td>
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<td>14.08.2014</td>
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Citation

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The assistance and contributions of staff from Mount Gibson Mining Limited is acknowledged and appreciated.

Limitations

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1 Purpose

Mount Gibson Mining Limited (MGM) is a supplier of Western Australian iron ore, with mine operations at the Mt Gibson Ranges and Tallering Peak in the Mid-West Region, and at Koolan Island in the Kimberley. MGM is a wholly-owned subsidiary of Mount Gibson Iron Limited.

MGM proposes to extend its mine operations at the Mt Gibson Ranges to include development of the Iron Hill Deposit, located immediately south of the approved mine operations. The Iron Hill Deposit contains an estimated 5-7 million tonnes of high-grade hematite ore having a gross economic value of approximately A$370million.

The approved mine operations at the Mt Gibson Ranges and the proposed Iron Hill Deposit both coincide with individuals the flora taxon Darwinia masonii. As a result of its distribution being restricted to the area of the Mt Gibson Ranges, Darwinia masonii has been declared as ‘Rare Flora’ under the Wildlife Conservation Act 1950 (WA) and as a ‘Threatened Species’ of flora under the Environment Protection and Biodiversity Conservation Act 1999 (C’th).

The recorded distribution of Darwinia masonii across the Mt Gibson Ranges, the location of approved mine operations and the location of the proposed Iron Hill Deposit are identified by Figure 1.

Development of the Iron Hill Deposit will increase the removal of Darwinia masonii individuals. To assist with the environmental assessment of the Iron Hill Deposit, and having regard to the conservation status of Darwinia masonii, it has been considered appropriate to undertake an assessment of the effect of the Iron Hill Deposit to Darwinia masonii using the internationally accepted conservation criteria of the International Union for Conservation of Nature (IUCN) (IUCN 2012). This report has been prepared to assess the potential for any change to the threatened taxa category for Darwinia masonii as a result of the development of the Iron Hill Deposit.

The IUCN (2012) criteria used in this assessment report is consistent with the approach used by both the Department of Parks and Wildlife (DPaW) in assessments under the Wildlife Conservation Act 1950 (WA) and by the Department of the Environment (DoE) in assessments under the Environment Protection and Biodiversity Conservation Act 1999 (C’th).
Figure 1  Recorded locations of *Darwinia masonii* at the Mt Gibson Ranges. The locations of *Darwinia masonii* are identified by white circles. The area of the approved mine operations is shaded in green, with the current extent of mine development visible in the underlying aerial imagery. The location of the proposed mine operations at the Iron Hill Deposit are outlined in yellow. Data Sources: ATA (2004), Coffey (2008), EcoLogical (2014).
2 Taxon Information

*Darwinia masonii* (Mason’s Darwinia) is a medium-sized erect shrub to three metres in height with characteristic grey-green foliage and numerous spreading pinkish pendulous bracts (DPaW 2008). The leaves are small, narrow and near-triangular in cross-section, crowded towards the ends of branchlets. The inflorescences are comprised of numerous small tubular flowers.

*Darwinia masonii* has been recorded only from an area of approximately 6km² within the Mt Gibson Ranges, where it occurs at elevations >330m AHD on skeletal or shallow clay soils and shallow pockets associated with ironstone, granite, lateritic breakaway formation and creeks (Brown *et al.* (1998) and DEC (2008) in Eco Logical 2014; Eco Logical 2014; MGM & EHPL 2014). *Darwinia masonii* generally flowers between April and November (Brown *et al.* 1998 in MGM & EHPL 2014).

*Darwinia masonii* is one of more than 50 Western Australian species of the genus *Darwinia*, with this genus comprising of a number of taxa considered to be naturally rare due to limiting natural factors such as substrate preferences or breeding biology constraints (MGM & EHPL 2013).

The regional distribution and images of *Darwinia masonii* are identified by Figure 2.

![Figure 2: Distribution and Images of Darwinia masonii](image)

1. Regional distribution of *Darwinia masonii* (adapted from DPaW 2014).
2. Flower and leaves of *Darwinia masonii* (Globe Environments 2014 unpublished).

Notes: 1. Consistent with the results of Maia (2014), the erroneous record of *Darwinia masonii* identified within DPaW (2014) positioned approximately 20km east of the Mt Gibson Ranges has been removed from Image 1.
In 2004, a census of the *Darwinia masonii* population by ATA Environmental (ATA) recorded 16,573 individuals, comprising 14,307 mature individuals (86%), 1,725 seedlings (10%) and 541 senescent (dead) individuals (3%) [ATA 2004]. This census formed the basis for the environmental assessment for the approved mine operations at the Mt Gibson Ranges (ATA 2006a; EPA 2006; WA Minister for Environment 2007).

Since the initial ATA (2004) census, additional surveys by Coffey Environments (Coffey) (2008), Martinick Bosch Sell Pty Ltd (MBS) (2013) and Maia Environmental Consultancy Pty Ltd (Maia) (2014) have improved knowledge on the *Darwinia masonii* population across the Mt Gibson Ranges, with these surveys increasing the population records to 17,818 individuals.

Based on the survey data of ATA (2004) and Coffey (2008) covering the area of the approved mine operations, a total of 1,702 individuals of *Darwinia masonii* have been removed by the mine operations to date (MGM & EHPL 2014).

During 2014, a census for extant *Darwinia masonii* was undertaken for MGM by Eco Logical Australia Pty Ltd (EcoLogical) to provide a contemporary record of the *Darwinia masonii* population. The census recorded 20,965 extant *Darwinia masonii* individuals, comprising 19,132 mature individuals (91%), 1,580 juveniles (8%), 188 seedlings (<1%) and 65 senescent individuals (<1%) (EcoLogical 2014).

Based on the EcoLogical (2014) *Darwinia masonii* census population data of 20,965 individuals, together with the 1,702 individuals removed to date, the total pre-disturbance *Darwinia masonii* population is considered to comprise approximately 22,667 individuals. The revised pre-disturbance *Darwinia masonii* population of 22,667 is more than 6,000 individuals greater than the 16,573 individuals originally recorded by ATA (2004).

Based on the composite survey data identified in ATA (2004), Coffey (2008), and EcoLogical (2014), the *Darwinia masonii* population of 22,667 individuals comprises 20,785 mature individuals (92%), 1,580 juveniles (7%), 210 seedlings (<1%) and 92 senescent individuals (<1%).

Table 1 summarises the population records for *Darwinia masonii*.

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Mature</th>
<th>Juvenile</th>
<th>Seedling</th>
<th>Senescent</th>
<th>Total</th>
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<tr>
<td>ATA (2004) and Coffey (2008)</td>
<td>1,653</td>
<td>0</td>
<td>22</td>
<td>27</td>
<td>1,702</td>
</tr>
<tr>
<td>EcoLogical (2014)</td>
<td>19,132</td>
<td>1,580</td>
<td>188</td>
<td>65</td>
<td>20,965</td>
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<td>Total</td>
<td>20,785</td>
<td>1,580</td>
<td>210</td>
<td>92</td>
<td>22,667</td>
</tr>
</tbody>
</table>

Table 1 Population Records for *Darwinia masonii*. Notes: 1. ATA (2004) and Coffey (2008) data for 1,702 individuals comprises only the 1,702 individuals removed by the approved mine operations to date, with the remaining data excluded to avoid duplication with the records of EcoLogical (2014). 2. ATA (2004) and Coffey (2008) did not define a 'juvenile' category.
Research on Darwinia masonii undertaken on behalf of MGM & Extension Hill Pty Ltd (EHPL) by the Botanic Gardens and Parks Authority (BGPA) (BGPA 2010) has identified the following key information regarding the reproductive biology, population genetics and restoration ecology of Darwinia masonii:

(a) Germination of fresh Darwinia masonii seed is naturally low. Results of seed bank trials indicate a complex germination/dormancy strategy combining a requirement for physical seed coat degradation, environmental (seasonal temperature) curing with cycling in- and-out of dormancy, and heat/smoke-related physiological responses. Seedling survival during the first summer has been recorded at approximately 10%. Germination can be improved artificially by a combination of physical treatments and smoke application (mimicking the effect of fire for post-fire seedling recruitment, as described below).

(b) Darwinia masonii are killed by fire, however, fire also results in high post-fire seedling recruitment from long-lived soil-stored seed, with only limited recruitment between fires within older populations.

(c) Reproduction (i.e. flowering, fruiting) commences in Darwinia masonii from six years of age, with flowering and seed production taking place over an extended period during spring and early summer. Seed production varies, with between approximately 10 to 60 seeds per plant per year in mature individuals. Observations have identified Darwinia masonii to be pollinated by a species of Honeyeater (a bird), with seed dispersal by ants.

(d) Darwinia masonii enter a period of physical dormancy during summer drought by reducing transpiration and photosynthetic function, with the capacity to restore tissues following rainfall. Roots of Darwinia masonii have the capacity to enter large cracks, pores and fissures in the regolith and may achieve considerable root depth (up to 10m). Whilst mortality is rare amongst mature Darwinia masonii (with this taxon being long-lived, to approximately 100 years), drought has been observed to contribute to mortality in both mature individuals and juveniles.

(e) Genetic structuring between groups of Darwinia masonii is low, however some groups do not mate randomly, suggesting some weak barriers to gene flow across the Mt Gibson Ranges. Analysis of molecular variance of seven groups across the Mt Gibson Ranges partitioned approximately 94% of variation within populations, and 6% between populations, indicating weak population structure. Groups sampled in areas of the Mt Gibson Ranges referred to as Extension Hill South and Mt Gibson South were statistically identified as being genetically isolated, in that the Darwinia masonii in these groups do not appear to mate randomly with the other groups on the Mt Gibson Ranges, with possible explanations for this including the sampling different generations (due to differing fire histories between the sampled groups).

(f) Successful propagation of Darwinia masonii has been demonstrated using green-stock production from cuttings. Survival of Darwinia masonii green-stock cuttings transplanted to field sites averaged approximately 10% after five years in unwatered plots, whilst cuttings in plots that were irrigated for the first two years (but not after) indicated a survival rate of approximately 90% after five years. Cuttings that were irrigated were recorded as commencing flowering in the first year.

As an update to BGPA (2010), the survival rate after approximately nine years (2005 to 2014) is approximately 80% within irrigated plots (irrigated for the first two years, but not after), with approximately 90% of measured individuals within the irrigated plots recorded as being reproductive during the 2013 year (pers. com. J Sackmann of MGM, March 2014).
3 Conservation Status

*Darwinia masonii* was declared as ‘Rare Flora’ under the *Wildlife Conservation Act 1950* (WA) in November 1980, and listed as a ‘Threatened Species’ of flora under the *Environment Protection and Biodiversity Conservation Act 1999* (C’th) in July 2000 (DPaW 2008).

As outlined by DPaW (2008), a previous assessment using the IUCN (2001) criteria identified *Darwinia masonii* as meeting the category of ‘Vulnerable’ under ‘Criteria D2’. The Criteria D2 Vulnerable category applies to taxa with an area of occupancy of <20 km² and/or occurs at ≤5 locations, and with a plausible future threat that could drive the taxon to the categories of ‘Critically Endangered’ or ‘Extinct’ in a very short period of time (IUCN 2012; IUCN 2014). The basis for the Criteria D2 determination by DPaW resulted from *Darwinia masonii* having a restricted area of occupancy (<6 km² and 1 location) and with mining considered to be a plausible future threat.

As identified by DoE (2008; 2013), the DPaW (2008) assessment has also been considered under the *Environment Protection and Biodiversity Conservation Act 1999* (C’th).

4 Assessment

4.1 Effect to *Darwinia masonii* Population

As outlined above, *Darwinia masonii* is currently recorded only from the ironstone hills of the Mt Gibson Ranges, with a total recorded population of 22,667 individuals comprising 20,785 mature individuals (92%), 1,580 juveniles (7%), 210 seedlings (<1%) and 92 senescent individuals (<1%).

Based on the current *Darwinia masonii* population records (Table 1) and the operational area outlined by the Statement 753 approval under the *Environmental Protection Act 1986* (WA) (WA Minister for Environment 2007), the approved mine operations coincide with 3,763 individuals (17%) of the total *Darwinia masonii* population of 22,667 individuals, comprising 3,582 mature individuals, 107 juveniles, 35 seedlings and 39 senescent individuals.

Assessment of the current aerial imagery for the approved mine operations indicates that 1,702 individuals (8%) of the *Darwinia masonii* population of 22,667 individuals have been removed to date (MGM & EHPL 2014), comprising 1,653 mature individuals, 22 seedlings and 27 senescent individuals. A further 2,061 individuals (9%) of *Darwinia masonii* currently remain within the area of the approved mine operations, comprising 1,929 mature individuals, 107 juveniles, 13 seedlings and 12 senescent individuals.

MGM proposes to extend its mine operations at the Mt Gibson Ranges to include development of the Iron Hill Deposit, located immediately south of the approved mine operations. Based on the *Darwinia masonii* population records (Table 1) and the proposed development boundary, development of the Iron Hill Deposit is expected to remove an additional 1,327 individuals (6%) of the *Darwinia masonii* population, comprising 1,135 mature individuals, 173 juveniles, 18 seedlings and 1 senescent individual.

Table 2 provides a summary of the *Darwinia masonii* population in relation to the approved mine operations under the Statement 753 approval, the proposed Iron Hill Deposit, and the non-impact areas. As identified by Table 2, the cumulative effect of the mining developments will be 5,090 individuals (22%) of the *Darwinia masonii* population of 22,667 individuals, with the remaining 17,577 individuals (78%) occurring within non-impact areas across the Mt Gibson Ranges.
Table 2 *Darwinia masonii Population*. The total recorded population for *Darwinia masonii* is identified, including the proportional distribution between the areas of the approved mine operations, the proposed Iron Hill Deposit, and the non-impact areas. Notes: 1. Adjusted for rounding.

<table>
<thead>
<tr>
<th></th>
<th>Darwinia masonii Population</th>
<th>Cumulative Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. Individuals</td>
<td>% Individuals</td>
</tr>
<tr>
<td>Approved Mine Operations</td>
<td>3,763</td>
<td>17%</td>
</tr>
<tr>
<td></td>
<td>(3,582 mature, 107 juvenile, 35 seedling, 39 senescent)</td>
<td></td>
</tr>
<tr>
<td>Iron Hill Deposit</td>
<td>1,327</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>(1,135 mature, 173 juvenile, 18 seedling, 1 senescent)</td>
<td></td>
</tr>
<tr>
<td>Non-impact</td>
<td>17,577</td>
<td>78%</td>
</tr>
<tr>
<td></td>
<td>(16,068 mature, 1,300 juvenile, 157 seedling, 52 senescent)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>22,667</td>
<td>100%</td>
</tr>
</tbody>
</table>

4.2 Effect to *Darwinia masonii* IUCN Population

This report has been prepared to assess the potential for any change to the threatened taxa category for *Darwinia masonii* under the IUCN (2012) criteria as a result of the cumulative effect of both the approved mine operations and the proposed Iron Hill Deposit. The IUCN criteria are considered to be the international benchmark for assessing the conservation status of flora and fauna taxa, with a summary of the IUCN assessment criteria provided in Appendix 1 (IUCN 2014).

IUCN (2012) defines a population only by mature individuals, such that non-reproductive seedlings/juveniles and senescent individuals are excluded from assessment. As such, based on the population records identified at Table 1, the *Darwinia masonii* population for the purposes of an assessment using the IUCN (2012) criteria (i.e. live and mature, and herein referred to as the ‘*Darwinia masonii* IUCN Population’) is 20,785 individuals.

Table 3 provides a summary of the *Darwinia masonii* IUCN Population in relation to the approved mine operations under the Statement 753 approval, the proposed Iron Hill Deposit, and the non-impact areas.
In applying the *Darwinia masonii* IUCN Population, the approved mine operations under the Statement 753 approval coincide with 3,582 individuals (17%) of the *Darwinia masonii* IUCN Population. Of these 3,582 individuals, 1,653 individuals (8%) have been removed to date, with a further 1,929 individuals (9%) extant.

The proposed Iron Hill Deposit coincides with 1,135 individuals (5%) of the *Darwinia masonii* IUCN Population.

The cumulative effect of the approved mine operations and the proposed Iron Hill Deposit will result in the removal of 4,717 individuals (23%) of the *Darwinia masonii* IUCN Population. The remaining 16,068 individuals (77%) of the *Darwinia masonii* IUCN Population occur within non-impact areas across the Mt Gibson Ranges.

Table 4 provides an assessment using the IUCN (2012) criteria of the potential cumulative effect to the *Darwinia masonii* IUCN Population from the approved mine operations and development of the proposed Iron Hill Deposit. Table 4 adopts the IUCN (2014) summary format (Appendix 1), which is consistent with the format previously used for assessment of *Darwinia masonii* under the *Wildlife Conservation Act 1950* (WA) as outlined within DPaW (2008). The assessment using the IUCN (2012) criteria has been undertaken consistent with the relevant guidance contained within IUCN (2012, 2014). The threatened taxa criteria considered applicable have been highlighted in yellow, with a description provided in the right-hand column to identify the basis for the assessment outcome.

### 5 Results

As identified by Table 4, the IUCN (2012) threatened taxa category of ‘Vulnerable’ remains applicable to *Darwinia masonii* based on the cumulative effect of the approved mine operations and the proposed Iron Hill Deposit meeting Criteria D2. Criteria D2 is applicable as *Darwinia masonii* has a restricted area of occupancy of ≤20km² and occurs in ≤5 locations, with climate (principally extended drought) posing a risk of increasing this threat category.

No other criteria were met.
6 Discussion

The cumulative effect of both the approved mine operations and the proposed Iron Hill Deposit is not expected to result in a change the current threatened taxa category of ‘Vulnerable’ applying to *Darwinia masonii*.

The results of this assessment are consistent with the assessment outcomes identified by DPaW (2008), in that the IUCN (2012) ‘Criteria D2’ is considered to be applicable for the ‘Vulnerable’ category, with no other criteria being met.

Whilst ‘Criteria D2’ was identified by both DPaW (2008) and this assessment as being applicable, the risk of future mining leading to an increase in the threat category (i.e. to ‘Critically Endangered’ or ‘Extinct’) as outlined by DPaW (2008) is not considered to be applicable; noting future mining (i.e. development of the Iron Hill Deposit) does not increase the threat category. As identified by Table 4, climate (principally extended drought) is considered to be a risk factor relevant to a potential future increase in the threat category; noting that as the population occurs at only a single location, a single detrimental climatic event could have the potential to affect the population as a whole.
Table 4 Assessment of Threatened Taxa Categories for *Darwinia masonii* using IUCN (2012) Criteria. The assessment for *Darwinia masonii* includes consideration of the effect of the approved mine operations and the development of the proposed Iron Hill Deposit. The assessment has been undertaken consistent with the relevant guidance contained within IUCN (2012) and IUCN (2014), including in the application of defined terms relevant to interpretation of each criterion. The yellow highlighted criteria are considered to be applicable to the *Darwinia masonii* IUCN Population.

<table>
<thead>
<tr>
<th>IUCN (2012) CRITERIA</th>
<th>ASSESSMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Population size reduction.</strong> Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Critically Endangered</td>
</tr>
<tr>
<td>A1</td>
<td>≥ 90%</td>
</tr>
<tr>
<td>A2, A3 &amp; A4</td>
<td>≥ 80%</td>
</tr>
<tr>
<td><strong>A1.</strong> Population reduction observed, estimated, inferred, or suspected in the past where the causes of the reduction are clearly reversible AND understood AND have ceased, based on any of the following: (a) direct observation (b) an index of abundance appropriate to the taxon (c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality (d) actual or potential levels of exploitation (e) effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites</td>
<td>NOT APPLICABLE</td>
</tr>
<tr>
<td>This criterion relates to past population reduction that is reversible, understood and has ceased.</td>
<td></td>
</tr>
<tr>
<td>There is no recorded past population reduction known to be applicable to <em>Darwinia masonii</em> that is reversible, understood and has ceased.</td>
<td></td>
</tr>
<tr>
<td><strong>A2.</strong> Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased OR may not be understood OR may not be reversible, based on any of the following: (a) direct observation (b) an index of abundance appropriate to the taxon (c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality (d) actual or potential levels of exploitation (e) effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites</td>
<td>NOT APPLICABLE</td>
</tr>
<tr>
<td>This criterion relates to past population reduction that may not have ceased, may not be understood or may not be reversible.</td>
<td></td>
</tr>
<tr>
<td>The past population reduction of <em>Darwinia masonii</em> of 8% (being 1,653 of 20,785 individuals) from development of the approved mine operations which have not ceased (i.e. removal to date, with some areas of the approved mine operations yet to be developed), is less than the ≥30% criteria under A2. The past population reduction of <em>Darwinia masonii</em> (existing removal plus the remaining approved individuals) of 17% (3,582 of 20,785 individuals) from development of the approved mine operations (to completion) is also less than the ≥30% criteria under A2.</td>
<td></td>
</tr>
</tbody>
</table>
A3. Population reduction projected, inferred or suspected to be met in the future (up to a maximum of 100 years), based on any of the following:
   (b) an index of abundance appropriate to the taxon
   (c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality
   (d) actual or potential levels of exploitation
   (e) effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

A4. An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in the future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible, based on any of the following:
   (a) direct observation
   (b) an index of abundance appropriate to the taxon
   (c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality
   (d) actual or potential levels of exploitation
   (e) effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

B. Geographic range in the form of either B1 (extent of occurrence) AND/OR B2 (area of occupancy)

<table>
<thead>
<tr>
<th>Critically Endangered</th>
<th>Endangered</th>
<th>Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1. Extent of occurrence (EOO)</td>
<td>&lt; 100 km²</td>
<td>&lt; 5,000 km²</td>
</tr>
</tbody>
</table>

NOT APPLICABLE
This criterion relates to the Extent of Occurrence (EOO) and where the locations are severely fragmented or small, there is a continuing decline or there are extreme fluctuations.

Whilst the EOO for Darwinia masonii meets the occurrence area and number of locations applicable to the Critically Endangered category (i.e., EOO <100km² under B1, and 1 location under B2(a)), Darwinia masonii is not subject to a continuing decline (i.e. B2(b)) or extreme fluctuations (i.e. B2(c)) as defined by IUCN (2014).
B2. Area of occupancy (AOO)  

<table>
<thead>
<tr>
<th>Category</th>
<th>AOO</th>
<th>Number of locations</th>
<th>Number of mature individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td>B2.</td>
<td>&lt; 10 km²</td>
<td>= 1</td>
<td>≥ 250</td>
</tr>
<tr>
<td></td>
<td>&lt; 500 km²</td>
<td>≤ 5</td>
<td>≥ 2,500</td>
</tr>
<tr>
<td></td>
<td>&lt; 2,000 km²</td>
<td>≤ 10</td>
<td>≥ 10,000</td>
</tr>
</tbody>
</table>

AND at least 2 of the following 3 conditions:

(a) Severely fragmented OR

(b) Continuing decline in observed, estimated, inferred or projected in any of (i) extent of occurrence (ii) area of occupancy, (iii) area, extent and/or quality of habitat, (iv) number of locations or subpopulations; (v) number of mature individuals.

(c) Extreme fluctuations in any of (i) extent of occurrence, (ii) area of occupancy, (iii) number of locations or subpopulations; (iv) number of mature individuals.

**NOT APPLICABLE**

This criterion relates to the Area of Occupancy (AOO) and where the locations are severely fragmented or small, there is a continuing decline or there are extreme fluctuations.

Whilst the AOO for *Darwinia masonii* meets the occurrence area and number of locations applicable to the Critically Endangered category (i.e. AOO <10km² under B2, and 1 location under B2(a)), *Darwinia masonii* is not subject to a continuing decline (i.e. B2(b)) or extreme fluctuations (i.e. B2(c)) as defined by IUCN (2014).

C. Small population size and decline

<table>
<thead>
<tr>
<th>Category</th>
<th>Critically Endangered</th>
<th>Endangered</th>
<th>Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of mature individuals</td>
<td>&lt; 250</td>
<td>&lt; 2,500</td>
<td>&lt; 10,000</td>
</tr>
</tbody>
</table>

AND at least one of C1 or C2

C1. An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in the future)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Critically Endangered</th>
<th>Endangered</th>
<th>Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>25% in 3 years or 1 generation (whichever is longer)</td>
<td>20% in 5 years or 2 generations (whichever is longer)</td>
<td>10% in 10 years or 3 generations (whichever is longer)</td>
<td></td>
</tr>
</tbody>
</table>

**NOT APPLICABLE**

This criterion relates to the number of mature individuals and a past or future continuing decline in the population.

The *Darwinia masonii* population of 20,785 mature individuals is greater than the ‘Vulnerable’ criteria of <10,000 individuals under C.

C2. An observed, estimated, projected or inferred continuing decline AND at least 1 of the following 3 conditions:

(a)(i) Number of mature individuals in each subpopulation:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Critically Endangered</th>
<th>Endangered</th>
<th>Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 50</td>
<td>≤ 250</td>
<td>≤ 1,000</td>
<td></td>
</tr>
</tbody>
</table>

(b) Extreme fluctuations in the number of mature individuals

90-100% 95-100% 100%

**NOT APPLICABLE**

This criterion relates to the number of mature individuals and a past or future continuing decline in the population.

The *Darwinia masonii* population of 20,785 mature individuals is greater than the ‘Vulnerable’ criteria of ≤1,000 individuals under C.
### D. Very small or restricted population

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Critically Endangered</th>
<th>Endangered</th>
<th>Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Number of mature individuals</td>
<td>&lt; 50</td>
<td>&lt; 250</td>
</tr>
<tr>
<td>D1</td>
<td>&lt; 1,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOT APPLICABLE**

This criterion relates to the number of mature individuals and a past or future decline in the population.

The *Darwinia masonii* population of 20,785 mature individuals is greater than the ‘Vulnerable’ criteria of <1,000 individuals under D.

**D2**

*Only applies to the VU category*

Restricted area of occupancy or number of locations with a plausible future threat that could drive the taxon to CR or EX in a very short time.

**D2. Typically:**

- AOO < 20 km² or number of locations ≤ 5

**CRITERIA D2 IS APPLICABLE FOR THE ‘VULNERABLE’ CATEGORY**

This criterion relates to where a restricted area of occupancy (AOO) or the number of locations may result in the taxon being driven to the threat categories of ‘Critically Endangered’ or ‘Extinct’ in a very short period of time due to a plausible future threat.

The D2 criteria are applicable for both the AOO of < 20 km² and the number of locations being ≤ 5. The AOO of *Darwinia masonii* is <6km² and the number of locations is 1.

Climate (principally extended drought) is considered to be a plausible future threat that may have a likelihood of driving *Darwinia masonii* to the threat categories of ‘Critically Endangered’ or ‘Extinct’ in a very short period of time, noting as the entire population occurs at only a single location, a single detrimental climatic event could affect the population as a whole.

Whilst development of the approved mine operations and the proposed Iron Hill Deposit will remove individuals of *Darwinia masonii* 23% (4,717 of 20,785 individuals), this removal is fixed (i.e. not a continuing decline), such that these mining developments are not expected to have a likelihood of increasing the threat category to ‘Critically Endangered’ or ‘Extinct’ in a very short period of time.
E. Quantitative Analysis

<table>
<thead>
<tr>
<th></th>
<th>Critically Endangered</th>
<th>Endangered</th>
<th>Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicating the probability of extinction in the wild to be:</td>
<td>≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)</td>
<td>≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)</td>
<td>≥ 10% in 100 years</td>
</tr>
</tbody>
</table>

**NOT APPLICABLE**

Sufficient data does not exist to undertake a quantitative analysis of the risk of extinction in the wild for *Darwinia masonii*.
7 References

All references cited within this report are identified below. Where an organisational name has changed since the original date of publication, the new organisational name has been used and the former organisational name noted.

Subject to the provisions of the Copyright Act 1968 (C’th), a copy of each reference to which MGM has authority to reproduce is provided on the compact disc attached to this report.


### Appendix 1

**IUCN criteria (IUCN 2014)**

<table>
<thead>
<tr>
<th>A. Population size reduction</th>
<th>Critically Endangered</th>
<th>Endangered</th>
<th>Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 Population reduction observed, estimated, inferred, or suspected in the past where the causes of the reduction are clearly reversible AND understood AND have ceased.</td>
<td>≥ 90%</td>
<td>≥ 70%</td>
<td>≥ 50%</td>
</tr>
<tr>
<td>A2 Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.</td>
<td>≥ 80%</td>
<td>≥ 50%</td>
<td>≥ 30%</td>
</tr>
</tbody>
</table>

Based on any of the following:
- (a) direct observation (except A3)
- (b) an index of abundance appropriate to the taxon
- (c) a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality actual or potential levels of exploitation
- (d) effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

<table>
<thead>
<tr>
<th>B. Geographic range in the form of either B1 (extent of occurrence) AND/OR B2 (area of occupancy)</th>
<th>Critically Endangered</th>
<th>Endangered</th>
<th>Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1. Extent of occurrence (EOO)</td>
<td>&lt; 100 km²</td>
<td>&lt; 5,000 km²</td>
<td>&lt; 20,000 km²</td>
</tr>
<tr>
<td>B2. Area of occupancy (AOO)</td>
<td>&lt; 10 km²</td>
<td>&lt; 500 km²</td>
<td>&lt; 2,000 km²</td>
</tr>
</tbody>
</table>

AND at least 2 of the following 3 conditions:
- (a) Severely fragmented OR Number of locations | 1 | ≤ 5 | ≤ 10 |
- (b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals
- (c) Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals

<table>
<thead>
<tr>
<th>C. Small population size and decline</th>
<th>Critically Endangered</th>
<th>Endangered</th>
<th>Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of mature individuals</td>
<td>&lt; 250</td>
<td>&lt; 2,500</td>
<td>&lt; 10,000</td>
</tr>
</tbody>
</table>

AND at least one of C1 or C2
- C1. An observed, estimated or projected continuing decline of at least up to a max. of 100 years in future: 75% in 3 years or 1 generation (whichever is longer)
- C2. An observed, estimated, projected or inferred continuing decline AND at least 1 of the following 3 conditions:
  - (a) Number of mature individuals in each subpopulation
    - ≤ 50
    - 90–100%
  - (b) Extreme fluctuations in the number of mature individuals
    - ≤ 250
    - 95–100%

<table>
<thead>
<tr>
<th>D. Very small or restricted population</th>
<th>Critically Endangered</th>
<th>Endangered</th>
<th>Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of mature individuals</td>
<td>&lt; 50</td>
<td>&lt; 250</td>
<td>&lt; 1,000</td>
</tr>
</tbody>
</table>

D2. Only applies to the VU category
- Restricted area of occupancy or number of locations with a plausible future threat that could drive the taxon to CR or EX in a very short time.

E. Quantitative Analysis

<table>
<thead>
<tr>
<th>Indicating the probability of extinction in the wild to be:</th>
<th>Critically Endangered</th>
<th>Endangered</th>
<th>Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)</td>
<td>≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)</td>
<td>≥ 10% in 100 years</td>
<td></td>
</tr>
</tbody>
</table>
for professional environmental services in:

- Project Management  -  Impact Assessment  -  Government Approvals
- Planning & Design  -  Management Plans  -  Training & Legislation
- Compliance Auditing  -  Compliance Systems  -  Incident Investigation
Appendix E Potential indirect effects on rare plants from mine development and mining operations (MGM 2015a)
Background
The scope of the impact assessment requires examination of both direct and indirect impacts and risk of exploration and mining activities to the long term survival and population viability of the rare flora species found at the Mount Gibson Ranges.

Indirect impacts are specified by the ESD as dust, changed microclimate, changed hydrology, changed ecosystem processes, including impacts to pollinators and reproductive success, reduced genetic diversity, fragmentation, introduced weeds/disease, increased grazing pressure and changes in seed dispersal.

Contemporary site-based evidence of actual effects and potential indirect impacts can be derived from the Extension Hill mine at the Mount Gibson Ranges thus:

- site based management and monitoring being implemented through the EMP and other factor-based plans;
- an assessment of current land and vegetation conditions at Extension Hill mine some five years after its development.

Stressors potentially causing indirect impacts on rare plants
Table 7 of the Iron Hill Environmental Management Plan lists the key aspects of mining activity including indirect potential stressors such as dust, vibration, weeds and hydrology/micro-climate. These stressors are summarised as follows. All potential stressors nominated by the ESD are considered in Table A13.1. Uncontrolled fire, weed infestation and altered micro-climate/hydrology would be the aspects that cause an indirect impact of greatest consequence to natural habitats.

Change to hydrology and microclimate in areas adjacent to mine development
Mining activities may potentially affect surface hydrology, which is characterised by intermittent ephemeral flow paths and localised drainage. At the boundary of mine infrastructure, the quantity or quality of water available may change in the way it flows into the floristic communities at a micro- or meso-scale; noting the sporadic patterns and low rainfall amounts that occur at the site. In the setting on Mt Gibson ranges, evaporation, infiltration and percolation of water would actually reduce the volume available for sheet or channelized flows at the surface.

Darwinia masonii generally occurs on the crests, upper slopes and ridges of the hills and is, therefore, unlikely to be impacted by any changes in drainage resulting from the mine activity; typically, plants would sequester moisture from incident rain and infiltration below the surface into cracks and small crevices below ground. Lepidosperma gibsonii is generally restricted to the slopes and gullies of the hills and to areas of breakaways and associated flow lines and is also therefore, unlikely to be impacted by any changes in sheet flow on the lower plains and flats resulting from the project. Acacia cerastes locations generally coincide with either Darwinia masonii or Lepidosperma gibsonii so are also unlikely to be impacted by changes in sheet flow resulting from the project.

Groundwater levels in the project area are naturally deep (tens of metres below natural surface) and do not support phreatophytic vegetation as the regional water table is typically at 310mAHD (MGM 2015).

Changes to surface hydrology may potentially modify vegetation types with time which, in turn, may change the quality of fauna habitats, and the availability of water. However, there is no evidence at site to date, based on Extension Hill modified terrain and built infrastructure, that ‘shadowing’ or run-on has caused changes in vegetation condition. Photographs in sheet A13.1 shows proximity of mature and seedling D.masonii near modified lands (potentially with altered micro-climate and changed hydrology).

Fire ignition
Fire may present a significant threat to the long term survival of Darwinia masonii, which is a re-seeder species. By contrast, Lepidosperma gibsonii are re-sprouting species and, therefore capable of
surviving fire to a greater extent than seeder species. Fire can cause large fluctuations in population size, age of plants and geographical distribution of re-seeder species.

There is no specific information on the impact of fire on Mt Gibson Ranges floristic communities. However frequent or intense fires and the seasonal timing of these are likely to change the composition of the vegetation communities over the long term. Fire can reduce the habitat available for flora and fauna, and may cause competition for limited resources.

Mining activity and the availability of rapid management response to fire ignition may result in a reduction in the area burnt and the fire intensity for any given fire event either natural or mine related. Fire alert and response systems have prevented fires from mining operations over the Ranges since the commencement of the mine at Extension Hill in 2010.

**Weed infestation**

Environmental weeds have potential to establish, reproduce and disperse and can have an impact on natural systems and conservation values if the weeds become dominant over the ground in an area. Weeds can displace native plants by competing for resources (water, nutrients, light, etc.), and may alter fire dynamics. The introduction and/or spread of weeds as a result of human activities may result in the decline of significant flora and/or floristic communities. In addition, weeds can also have a significant adverse impact on fauna habitats.

An environmental weed species that is highly invasive will have a high rating for its potential to impact on the environment. Highly invasive weeds often spread rapidly. Species with a fast rate of spread will have a more extensive final distribution. Early action to remove these plants is highly effective in preventing serious weed problems.

No significant weed invasion has been observed to date in the vicinity of significant flora or significant floristic communities at the Extension Hill project area, but known to exist in the region before the commencement of mining [Bennett Environmental Consulting 2000; Paul Armstrong and Associates 2004]. Records of environmental weeds are known and these are reported in the PER. Maltese Cockspur Centaurea melitensis was first recorded at Iron Hill in 2011 and continues to occur there from time to time.

Weeds can be locally prevalent along sections of service corridors, particularly in the nearby agricultural district; stringent weed hygiene protocols are implemented at the property-level to manage the risk of spread during construction, exploration, operations and upon rehabilitation. Where weeds are known to occur, they are identified by inspections and then treated to contain their growth.

**Dust generation and settlement on plants**

At the Mount Gibson ranges, there are no apparent impacts arising from settlement of dust generated from mining activities on the foliage of Darwinia masonii and Lepidosperma gibsonii or other vegetation in significant floristic communities. The approved EMP for mining operations at Extension Hill at Mt Gibson Ranges has involved implementation of a dust emission and vegetation health (plant size, reproductive status, age, condition and seedling recruitment and mortality) monitoring program for Darwinia masonii. Astron (2014) performed a statistical analysis of results to date which have shown no detrimental impacts on the vegetation attributable to mining activities (including effects through dust deposition). This may be due to the successful implementation of adequate control measures to mitigate dust emission loads associated with mining operations. However, the potential for settled dust on surfaces affecting any plant’s photosynthesis rate and water regulation is still a risk requiring evaluation and the continued implementation of control measures.

Dust is more likely to be a stressor in very close proximity to sources such as crusher units and unsealed haul roads (e.g. less than 100m) while, away from these mining operations, dispersion reduces this hazard for a given wind speed and direction (Astron 2014). Of these potential dust sources, only the mine pit and haul ramps are in proximity to rare flora species or the key vegetation component of the PEC.

It appears that the potential effect of dust on Darwinia masonii or Lepidosperma gibsonii is a function of a combination of at least the following variables:

- point source extent and dust suppression success;
• rainfall or removal of dust and cumulative settled dust (g/m²) on the plant surfaces;
• time of the year including:
  o incident solar radiation;
  o wind speed and direction;
  o season when pre-stripping of the ground occurs.
• phase of mining operations
• duration over which the dust has settled, inversely proportional to the distance from the source; and
• plant morphology and physiology.

The potentiality of dust effects can be put into context by examining current ground conditions after five years of site development and operation at Extension Hill mine. It is evident that dust from regular or constant activity (such as the crushing of ore and stockpiling) settles on outer plant vegetation (see Sheet A13.2) during prolonged dry periods, but at Extension Hill this is:

• well beyond mapped occurrences of rare flora further away on the ironstone ridges;
• beyond the boundary of the key component of the PEC; and
• not recorded to have any detrimental effect to plant survivorship.

For the Iron Hill proposal, the established ROM and crushing and loading circuit for Extension Hill would be used, so dusting of plants to the extent it occurs would occur on sandplains vegetation. The settled dust on the plant is dependent on the rate of settlement (g/m²/unit time) and the length of time over which the settling occurs and will be subject to dust removal processes such as washing after rainfall. Photographs in Sheet A13.2 shows typical dust generation sources and that settled on plant leaves generally near Crusher ROM and haul roads during the operational phase. Whilst dust is temporarily present on its leaves, death of plants has not occurred after almost five years of mining activity.

**Figure A13.1**: Latest annual dust settlement monitoring data at Mount Gibson Ranges mine

Measurements and observations by Astron in October 2015 made records of chlorophyll fluorescence (CF) on leaves of *D.masonii* individuals and the following observations about plant health. A CF meter was used in a field trial on *D.masonii* at Mt Gibson Ranges with view it may be empirically used in the future to supplement the way plant health monitoring is done and reported upon:

• A healthy plant generally registers a score of 0.7 (health metric Fv/Fm) and the majority of individual plants assessed were healthy based on visual health scores and the CF records (health metric Fv/Fm) with D24 being the only site to register a mean score below 0.7 of 0.6 (however the standard error shows that this may in fact be above 0.7)
• It appears that physical setting rather than proximity of mining activities accounted for much of the variation in plant health observed across sites. The variation between sites was small compared to that through the course of the day.
Overall, dust deposition on Darwinia was absent or very minor; only one plant was observed very close to the existing pit that had low levels of dust deposited on some of its (windward side) leaves, but the underlying leaf colour was easily visible.

These observations and others, as presented in Figure A13.2 below, show the low level and limited effects and lack of detectable effect on the photosynthetic activity on D.masonii plants at the mine. This is validated by the fact that CF levels in D.masonii plants immediately adjacent the existing operational footprint (the EH pit) were as healthy (or higher) than plants distant away (>5km) elsewhere on the Ranges. Note also the CF ‘health’ check of the nine year old D.masonii at Translocation Plot were similar to wild stock measurements.

**Figure A13.2: Mean chlorophyll fluorescence (CF) levels in D.masonii plants in October 2015**

Also, Matsuki et al. (in press; Austral Ecology, 2015) will report that trends in plant health are likely to be driven more by the variability of cumulative rainfall in the preceding 5 months than dust load. The authors conclude, based on two WA case studies from semi-arid Australia, there was no evidence to support the perception that, under the climatic and elevated dust deposition rates up to 20 or 77 g/m²/month at Windarling Range and Barrow Island, respectively, dust accumulation on plants causes short-to medium-term negative impacts. Refer to Figure A13.1 showing the rates of no more than 3.5 g/m²/month at MGM’s Extension Hill mine.

**Blasting and vibration**

Flyrock that clears the pit crest or batter slope rock that dislodge have potential energy and may land on native vegetation outside of the development envelope. Rocks may strike plants and cause for them to be uprooted, branches to be broken or defoliated. While individual trees may be partially defoliated by strikes from flyrock close to the pit boundary that effect would be temporary and foliage would regrow. It is possible that a very limited number of rock strikes ie. several may cause mortalities during the life of pit mining meaning that only a portion of these (such as one or two) would by chance be on rare flora outside the pit. There is some evidence that this occurs very near the mine pit at Extension Hill inside the approved development envelope.

At Iron Hill, given the slope from the excavated pit crest on the northern and eastern aspects, it is possible that loose or unstable rocks could be broadcast beyond the development envelope.
boundary. Mitigations such as removal of unstable rocks at completion of pre-stripping, ongoing routine inspection of integrity and stability and blast control would be applied to eliminate the risk of rock broadcast beyond the pit shell. A further mitigation should it be required is that any land with damaged plants could be rehabilitated according to established protocols.

**Ecosystem functions potentially causing indirect impacts on rare plants**

Matters related to potential changes in microclimate and hydrology, ecosystem processes, including impacts to pollinators and reproductive success, reduced genetic diversity, fragmentation, weeds and seed dispersal are considered in Eco Logical (2015b).

The PEC covers a total land area of 2,732 ha, of which 546 ha (20%) coincides with the area of the approved Mount Gibson Ranges mining operations. The Proposal would increase the land area that coincides with the PEC by 107 ha to 653 ha (24% of its extent). The PEC, post-development, would be represented by 2,079 ha, which is 76% of its mapped extent. It would retain connectivity, and is not highly fragmented as it is draped over variable terrain of flats, slopes and ridgetops and retains extensive tracts of native vegetation in excellent condition.

While the Proposal would result in a reduction of *Darwinia masonii* abundance by 6.3%, the species would still be known from a relatively high population size that occurs across the majority of the Mount Gibson Ranges. The species would most likely persist in the surrounding area of the Proposal, including on the northern parts of Iron Hill and adjacent land on Iron Hill North, Iron Hill East and across the species’ range. *Darwinia masonii* is bird pollinated including by a honeyeater. The pollen dispersal for *Darwinia masonii* is considered extensive across the full species distribution and the Proposal is unlikely to significantly alter potential pollen transfer between individuals on hilltops and slopes across the Ranges. *Lepidosperma gibsonii* is wind pollinated and has a high outcrossing rate of 91.7% with a high genetic diversity indicating high genetic transfer between populations. While the Proposal would reduce the known number of individuals by up to 9,029 (approximately 15% of the total population records) the species is likely to persist in the landscape and maintain ecological viability. This is due to a population abundance, largely intact habitat, high genetic flow, and the reasonable possibility of further populations being found across the species’ range and potentially within the region as the species can occur in a variety of habitats, including on the plains.

In terms of the integrity of the Mount Gibson Ranges landform, hydrology is unlikely to be affected as there are no major drainage lines running through, or in the immediate vicinity of the development envelope and dewatering of the aquifer is not required. The Mount Gibson Ranges are not unique in terms of slope or topographical features in the region. The representation of similar slopes across the individual ridges within the Mount Gibson Ranges would remain post-development. The Proposal is also considered unlikely to result in unstable landforms and/or soils, or lead to erosion in terms of rehabilitated areas. The surface soils are typically shallow and dominated by a high coarse fragment content. The soils and subsoils of the Proposal area have been determined as generally having a low inherent erodibility in terms of suitability for rehabilitation and there is a low risk of acidic, metalliferous drainage from waste rock. With time, ongoing rehabilitation of the Waste Rock Landform would allow for the regrowth of native vegetation for habitat for re-establishment through active rehabilitation by MGM and natural rates of recolonization in time of *Darwinia masonii* and *Lepidosperma gibsonii*. 
<table>
<thead>
<tr>
<th>Aspect potentially having an effect outside of development envelope (DE)</th>
<th>Sources of risk</th>
<th>Occurrence; Duration</th>
<th>Potential impacts</th>
<th>Controls</th>
<th>Residual Risk Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust</td>
<td>Pit blasts; ground clearing; crusher circuit operations; truck movements on unsealed roads</td>
<td>Infrequent; Temporary</td>
<td>Emitted or fugitive dust may settle on plant leaf surfaces and limit primary production or clog stomata.</td>
<td>Haul road speed control; civil methods; watering; plant health monitoring for feedback controls</td>
<td>Very low – occurrence at operating mine site evident only on very local scales and no evident effect on plant health</td>
</tr>
<tr>
<td>Changed hydrology; changed microclimate; erosion</td>
<td>Slope truncations and re-directions; altered drainage by interception or redirection in flows</td>
<td>Constant; Permanent</td>
<td>Shadowing: run-on / run-off volume changes which alter the way in the future that plants may germinate or grow.</td>
<td>Construct-on-grade sympathetic with terrain; drainage structures and erosion control where needed (eg. Camp Access Road)</td>
<td>Low - effects at operating mine site not evident</td>
</tr>
<tr>
<td>Pollinators and reproductive success</td>
<td>Mine activity may dissuade animal (eg. bird and insect) pollinators</td>
<td>Infrequent; Temporary</td>
<td>Mine activity (presence; vibration; lighting) reduces rate at which pollinators visit flowers.</td>
<td>Limited timeframes (two years) within reproductive periods of many years for dominant vegetation. Seeds held in existing seedbank outside of DE.</td>
<td>Nil to very low</td>
</tr>
<tr>
<td>Genetic diversity</td>
<td>Ground clearing</td>
<td>One-off; Permanent</td>
<td>Reducing the abundance of populations may eliminate rare genes.</td>
<td>Apply species recovery plan actions at Iron Hill too; restore in situ population with re-established stock</td>
<td>Nil to very low</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>Ground clearing</td>
<td>One-off; temporary</td>
<td>Removing ridgetop or creating elevated WRLs ‘blocks’ connectivity in space and/or time</td>
<td>Rehab and revegetation of domains at closure; retention of linkage corridors of natural terrain.</td>
<td>Very low</td>
</tr>
<tr>
<td>Introduced weeds</td>
<td>Mine activity vehicles may introduce or spread seeds</td>
<td>Infrequent; permanent</td>
<td>Weeds infest significant areas of native vegetation.</td>
<td>Weed monitoring and treatments; quarantine protocols and vehicle inspections</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>Grazing pressure</td>
<td>Mine activity attracts non-native grazers</td>
<td>Infrequent; temporary</td>
<td>Grazers reduce the foliage and health of vegetation including rare plants.</td>
<td>Monitoring (no significant impacts on foliage of rare plants); eradication programs for ferals</td>
<td>Nil to very low</td>
</tr>
<tr>
<td>Seed dispersal</td>
<td>Mine infrastructure</td>
<td>Constant; temporary</td>
<td>Infrastructure may create barriers to dispersal by insects, wind and water</td>
<td>Decommissioning and rehabilitation of land at closure.</td>
<td>Nil to very low</td>
</tr>
<tr>
<td>Fire</td>
<td>Man made ignition sources – hot work tools; cigarettes</td>
<td>Infrequent; temporary - permanent</td>
<td>Uncontrolled extensive blaze that permanently destroys native vegetation and rare flora</td>
<td>Fire management systems and procedures</td>
<td>Moderate</td>
</tr>
<tr>
<td>Vibration</td>
<td>Blasting and road haulage</td>
<td>Infrequent; temporary</td>
<td>Rocks may dislodge and trample native vegetation</td>
<td>Civil works management (rock placement); blast operational procedures.</td>
<td>Nil to very low</td>
</tr>
</tbody>
</table>
Sheet A13.1: Buffer distances adjacent to built infrastructure - potential to change hydrology and alter microclimates

Shown above (A) is a setting typical of existing mining infrastructure at Extension Hill mine at Mt Gibson Ranges; it is a road built by ‘cut and fill’ method, adjacent the Extension Hill mine pit. Land clearing caused the direct impact of vegetation including rare flora on the hill side, approved for development. After clearing and the placement of fill for civil works, indirect effects on adjacent vegetation may be potentially caused in time by changed ground conditions related to factors such as slope, hydrology and soil wetting/drying cycles (known as micro-climate effects). The physical setting and functional processes may potentially affect vegetation quality and vegetation types and habitat condition in the longer term.

As shown below (B-E), native plants continue to occur (germinate, grow and reproduce) immediately below the toe of built infrastructure. Natural recolonisation of native vegetation can also be seen on the batter slopes (B, E, F), so restoration of ground conditions is shown to occur with time. Darwinia masonii seedlings and juveniles occur in very close alignment with the batter toe (C, E) meaning that these plants, like other native vegetation, have germinated and/or grown in recent years, since the placement of the built batter. Current and recent observations made after five years of mine disturbance on Mt Gibson Ranges at Extension Hill indicate that:

- *D. masonii* and other native plant species either continue to survive and grow in very close spatial alignment (less than 1 metre distance) to modified land or built infrastructure; and,
- Natural rates of germination occur from seed bank in re-spread or in situ soils is evident for both rare flora and other native flora.

There is no indication of adverse effects from changed topography or modified substrate resulting in small scale drainage, drying or altered micro-climate effects. Indications are that a buffer of one metre (or less) beyond the toe of any built infrastructure or modified land is adequate to estimate any zone of indirect impact. Note that the areas where this information was collected is within the approved development envelope of MS753.
Mature healthy *D. masonii* at toe of batter slope

Juvenile *D. masonii*
Vehicle access track on pit crest

Regrowth of native vegetation from seedbank and rootstock
Sheet A13.2: Dust generation and indirect effects from its settlement on plant foliage

Dust is intermittently generated in and around the mine because of:

- blasting of rock on the pit floor;
- loading and crushing of mined materials;
- haulage of materials to the crusher or the waste dumps and product taken to the mine gate (see next page).

Certain native vegetation can be dusted directly adjacent to active mining operations such as near regularly-used internal haul roads. Observations show that the settled dust typically washes off after rainfall. There is no evidence of increased rates of senescence of foliage on dusted plants. At Extension Hill, the location of the vegetation that is dusted and may be affected is all within the approved development envelope (MS753). Evidence of the condition is shown below.

For additional reports on the matter, note observations from 2015 Extension Hill mine Annual Inspection report by Department of Mines & Petroleum (Environment Division) in "Mt Gibson Iron - J00596; A&I Ref No: AI-979-584":

**ROM Pad and Crusher Area**

*Limited dust emissions were observed to be coming from the ROM Pad and Crusher areas.*

**Dust management**

*From the areas observed, dust emissions from operational areas appeared limited. However, at the time, the project area was subject to recent rains.*

Blasting on the pit floor occurs from time to time (ie. rates vary - approximately two per week or once every other day), so the load of particulates is small compared to the ongoing stirring of dust which is localised around edges of unsealed haul roads, particularly those near the crushing circuit.

An overview of mine site operations at Extension Hill (G) shows extensive tracts of native vegetation immediately adjacent the mine infrastructure (pit; roads; crusher) footprints. Note large area of vegetation east of the Great Northern Highway is within the approved development envelope, but currently retains key vegetation community qualities such as structural values (ie. canopy cover, connectivity, biodiversity) and functional values (productivity, fauna habitat; carbon and energy dynamics; seed generation).

Observations show (H) dusting of native vegetation typical of that directly adjacent the crushing circuit, well-within the Extension Hill development envelope. Note these plants provide a buffer for adjacent native vegetation and, after almost five years of access tracks and internal road use, do not show signs of senescence or die off causing a modification or loss of the vegetation community type. The crushing circuit is located in a common type of Open Woodland vegetation community dominated by an overstorey of Eucalyptus spp, Callitris spp, Acacia spp and Allocasuarina spp, and not containing significant (DRF or P) flora species.

For Iron Hill Deposits development, the crushing circuit would continue to operate in the situation as it currently does, so no additional indirect effect from dust would occur from that operation. The effect of dust settlement from pit blasting, truck loading and traffic haulage on vegetation is predicted to be limited to ten metres from the edge of the infrastructure boundary but not to cause plant mortality in that zone. As no infrastructure comes closer than ten metres from the edge of any part of the Iron Hill development envelope, no permanent loss of flora or vegetation is predicted to occur due to dust settlement beyond the development boundary.
Dust sources at MGM's Extension Hill mine

Dust from pit blast

Extension Hill

Pit floor

Photo at distance of approx. 1200m

Pit development at Extension Hill in 2010
Sheet A13.3: Indirect effects from blasting, vibration and rockfall

Generation of dust from blasting was described in a separate section. Blasting also indirectly results in vibrational forces that over time may dislodge medium and large size material from batter slopes or beyond the pit that then might cause strikes downslope on standing vegetation (I). This may cause temporary impact over small areas estimated in the order of tens to hundreds of square metres in total; so very much less than 0.1 ha over a decadal period. Such an area on Mt Gibson Ranges typically contains at least several rare plant records. Vibration forces would only be generated at Iron Hill over no more than two to three years so it is unlikely any rare plant would be struck by vagrant rocks. Mitigations are to remove or make rocks secure above slopefields at Iron Hill and monitor blast and field conditions to eliminate the consequences of this source of risk.

The case at left was of rock displacement downslope, probably not embedded during upslope track construction, likely dislodged by vibrations from nearby pit blasts or machinery workings. Trampled vegetation is evident (I). Such events, including flyrock, would be rare and only temporarily remove individual plants before they re-grow from stem shoots or seed banks in soils.