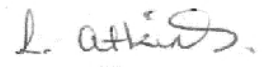
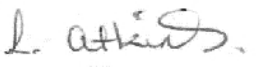
MCPHEE CREEK FLORA AND VEGETATION SURVEY

Atlas Iron

ecoscape

Revision	Author	QA Reviewer	Approved	Date
draft rev0	James Tsakalos	 LYN ATKINS PRINCIPAL ECOLOGIST	 LYN ATKINS PRINCIPAL ECOLOGIST	17/06/2020
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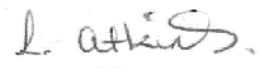
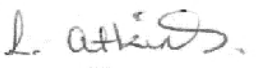
final rev1	James Tsakalos	 LYN ATKINS PRINCIPAL ECOLOGIST	 LYN ATKINS PRINCIPAL ECOLOGIST	31/07/2020

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- Damien McAlinden, Principal Policy Development
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SUMMARY

Atlas Iron Limited (Atlas Iron) is proposing to conduct mining activities at the McPhee Creek iron ore deposit located near Nullagine in the Pilbara region of Western Australia. A number of flora and vegetation surveys have previously been conducted for Atlas Iron in or close to the McPhee Creek deposit, including three field surveys that intersect at least part of the current survey area. Ecoscape was appointed to collate and consolidate previous flora and vegetation data and mapping, conduct a gap analysis to inform a field survey, and conduct a field survey over a 6,055.55 ha area, incorporating previously surveyed areas and also some additional areas largely associated with proposed haul roads, with resultant reporting and data.

The desktop assessment, which incorporated the gap analysis, identified the following significant attributes and survey requirements:

- previous mapping was conducted at a level similar to NVIS Level VI; this was subsumed into Level V mapping (which is the level of detail recommended in the EPA 2016 Flora and Vegetation Technical Guidance) and, where there were possible mismatches, targeted for ground truthing
- there were topological errors, mis-matches in vegetation type mapping from different surveys in adjacent areas and artifacts in the mapping due to merging of data; these were corrected as much as possible during the desktop phase and areas for ground truthing identified
- merged vegetation types with insufficient quadrats to meet the Flora and Vegetation Technical Guidance requirements for Detailed surveys (ie less than 3 quadrats per vegetation type), and potential quadrat locations, were identified
- five conservation-listed flora (*Acacia aphanoclada* (P1), *Eragrostis crateriformis* (P3), *Goodenia nuda* (P4), *Ptilotus mollis* (P4) and *Rostellularia adscendens* var. *latifolia* (P3)) had previously been recorded in the survey area with significant amounts of grid searches conducted during previous surveys; areas of potential habitat, including previously unsurveyed areas, were targeted for searches
- riparian areas, where Groundwater Dependent Vegetation (GDV) or potential GDV has been previously identified, were reviewed and accessible areas that had not been groundtruthed identified for survey.

The desktop assessment and gap analysis informed the requirements for field survey, which was conducted over 11 days during April 2020. Previously surveyed creeklines to the southeast of the main body of the survey area were not accessed during the 2020 field survey; results for the creeklines have been interpolated from previous assessments. Part of a proposed haul road was not accessible at the time of survey due to asbestos contamination; the results from this section of the survey area were extrapolated from adjacent areas.

The significant activities and findings of the Detailed flora and vegetation field survey were:

- 182 quadrats have been recorded from within the survey area including 42 established during 2020
- 370 vascular flora species have been recorded from within the survey area
- three conservation-listed flora species (*Acacia aphanoclada* (P1), *Ptilotus mollis* (P4) and *Rostellularia adscendens* var. *latifolia* (P3)) had new populations recorded, all of which were known from elsewhere in the McPhee Creek area
- two previously recorded conservation-listed flora were not recorded during the 2020 field survey: *Eragrostis crateriformis* (P3) was considered likely to respond to seasonal conditions, thus may not always be present, and *Goodenia nuda* (P4) that was considered to possibly represent a mis-identification
- no additional conservation-listed species were considered likely to occur based on the habitat available within the survey area and the extent of searches conducted

- seven introduced species were recorded during 2020, including one species not previously recorded from the survey area (**Calotropis procera*, Rubber Bush, which is a Declared Pest plant); over all survey periods 16 introduced species have been recorded
- 19 vegetation types consolidated from data and ground truthed using a combination of structural vegetation types, floristic analysis and subsequent review
- no vegetation types were representative of any conservation-listed ecological communities
- no vegetation types were considered significant according to the Flora and Vegetation Technical Guidance as all were considered to be well represented in the region, although Groundwater Dependent Vegetation (GDV) may be considered significant (see next points)
- likely GDV characterised by *Eucalyptus camaldulensis* was identified from the creeklines to the southeast of the main survey area
- vegetation characterised by *Eucalyptus victrix* was also recorded from creeklines; this species may, depending on groundwater availability, be a vadophyte (i.e. not dependent on groundwater) or phreatophyte (relying on groundwater) – where groundwater was accessible (i.e. less than 10 m from the surface) this vegetation type was considered a potential GDV
- vegetation condition was largely (86%) in Excellent condition, with only 1.2% in Degraded condition; assessment of vegetation condition ratings was largely influenced by grazing and weed presence.

ACRONYMS AND ABBREVIATIONS

Table 1: Acronyms and abbreviations

Acronyms and abbreviations	
agg.	Aggregate (of subtaxa); equivalent of *sens. lat.*
BAM Act	Western Australian *Biosecurity and Agriculture Management Act 2007*
BoM	Bureau of Meteorology
C1, C2, C3	Declared Pest categories under the BAM Act
CALM	Western Australian Department of Conservation and Land Management (1985-2006, now DBCA)
CR	Critically Endangered (listed under Commonwealth EPBC Act and/or Western Australian BC Act)
DAFWA	Department of Agriculture and Food, Western Australia (2006-2017, now DPIRD)
DAWE	Commonwealth Department of Agriculture, Water and Environment (2020-)
DBCA	Western Australian Department of Biodiversity, Conservation and Attractions
DEC	Western Australian Department of Environment and Conservation (2006-2013, now DBCA)
DEWHA	Commonwealth Department of the Environment, Water, Heritage and the Arts (2007-2010, now DotEE)
DMIRS	Western Australian Department of Mines, Industry Regulation and Safety
DPaW	Western Australian Department of Parks and Wildlife (2013-2017, now DBCA)
DotEE	Commonwealth Department of the Environment and Energy (2016-2020)
DPIRD	Western Australian Department of Primary Industries and Rural Development
DSEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities (2010-2013, now DotEE)
DWER	Western Australian Department of Water and Environmental Regulation
EN	Endangered (listed under Commonwealth EPBC Act and/or Western Australian BC Act)
Ecoscape	Ecoscape (Australia) Pty Ltd
EP Act	Western Australian *Environmental Protection Act 1986*
EPA	Western Australian Environmental Protection Authority
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
GDA 94	Geographic Datum of Australia 1994
GDE, GDV	Groundwater Dependent Ecosystem, Groundwater Dependent Vegetation
GIS	Geographic Information System
GPS	Global Positioning System
ha	hectare/hectares
IBRA	Interim Biogeographic Regionalisation for Australia
km	kilometre/kilometres
m	metre/metres
MGA	Map Grid of Australia
NVIS	National Vegetation Inventory System
MNES	Matters of National Environmental Significance
P; P1, P2, P3, P4, P5	Priority Flora and Fauna species rankings (P1-P4) or Priority Ecological Communities (P1-P5)
PEC	Priority Ecological Community
PF	Priority Flora
PMST	Protected Matters Search Tool (hosted by DAWE, used to search for MNES)
SFDV	Sheet Flow Dependent Vegetation
SoW	Scope of Works
sp.	Species (generally referring to an unidentified taxon or when a phrase name has been applied)
subsp.	Subspecies (infrataxon)

Acronyms and abbreviations	
TEC	Threatened Ecological Community
TF	Threatened Flora (formerly termed Declared Rare Flora, DRF, in Western Australia)
var.	Variety (infrataxon)
VU	Vulnerable (listed under Commonwealth EPBC Act and/or Western Australian BC Act)
WAH	Western Australian Herbarium
WAOL	Western Australian Organism List
WONS	Weeds of National Significance
Woodman	Woodman Environmental Consulting
*****	Introduced flora species (i.e. weed)

1 INTRODUCTION

1.1 BACKGROUND

Atlas Iron Limited (Atlas Iron) is proposing to conduct mining activities at the McPhee Creek iron ore deposit, located in the Pilbara region of Western Australia, approximately 220 km north of Newman, 30 km north of Nullagine and 5 km east of the Marble Bar-Nullagine Road.

Various biological and heritage studies are required for referral under both State (*Environmental Protection Act 1986* (EP Act)) and Commonwealth (*Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)) legislation. This report presents detailed flora and vegetation survey information for the McPhee Creek project area and associated riparian area, including compiling and updating information from Woodman Environmental Consulting's (Woodman 2019a) *McPhee Creek Iron Ore Project Detailed Flora and Vegetation Assessment* survey and earlier surveys by the same consultant.

1.2 SURVEY AREA

The survey area occupies 6,055.55 ha and is located in the Pilbara region of Western Australia approximately 220 km north of Newman, approximately 30 km north of Nullagine and east of the Marble Bar-Nullagine Road (**Figure 1**), in the Shire of East Pilbara.

The survey incorporated McPhee Creek Project Area (excluding development area), proposed haul roads and riparian (creekline) mapping. The extents within this document are inclusive of the development envelope.

The proposed haul road alignments have altered since the field survey, in addition to some parts not being accessed at the time of survey due to asbestos contamination. This has required extrapolation of vegetation types in some areas that have not been subject to field survey. Additionally, the creeklines to the southeast of the survey area were not accessed during the field survey; the vegetation types have been interpolated from previous mapping, with review of previous quadrat data used as confirmation.

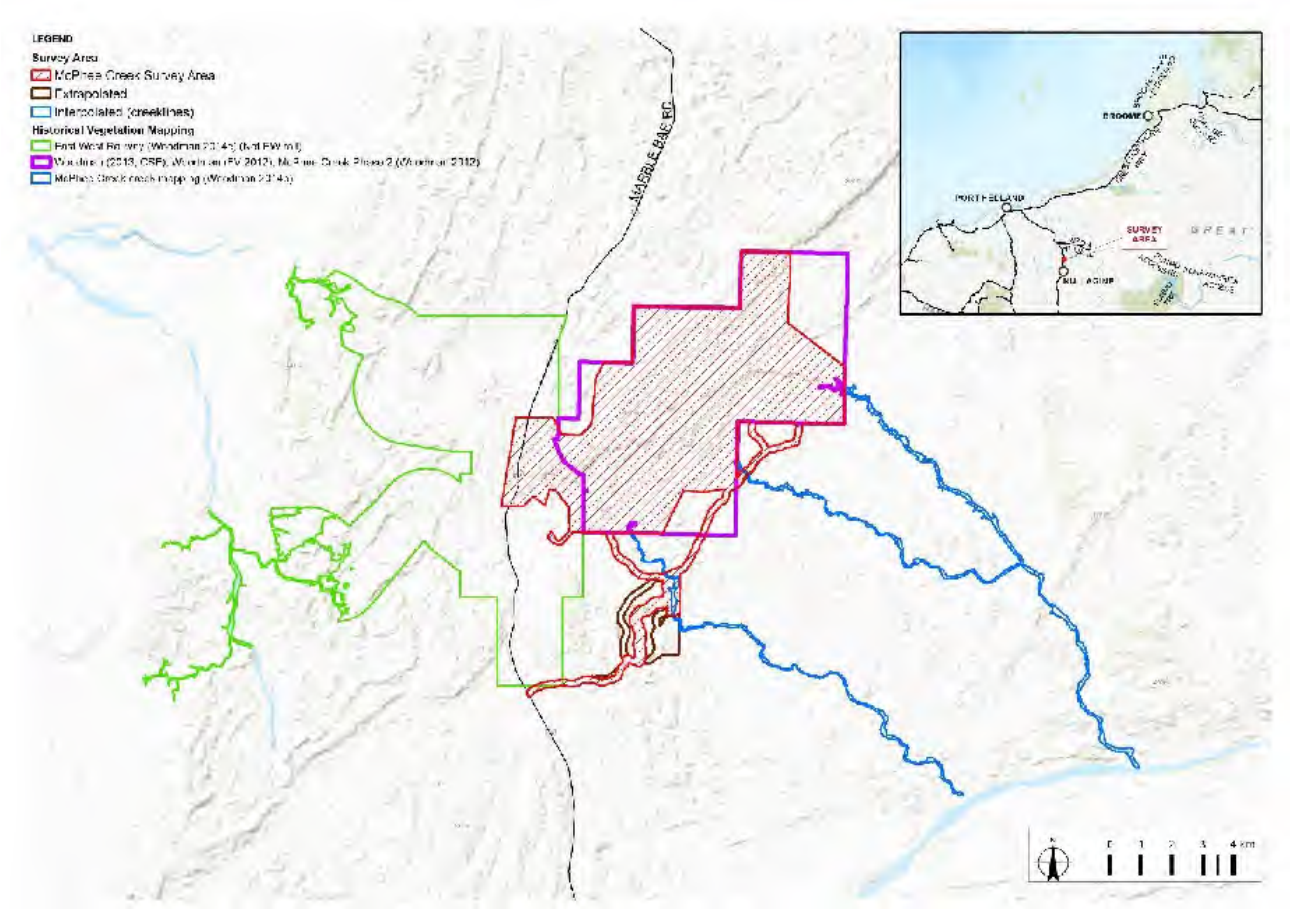


Figure 1: Survey area location

1.3 SURVEY REQUIREMENTS

The requirements of the survey were to:

- collate and consolidate previous survey flora and vegetation data and mapping
- conduct a gap analysis and develop recommendations for field surveys that are required for ground truthing, resurveying or baseline purposes, or for targeted searches for conservation-listed flora and ecological communities
- field survey
- data management and reporting.

1.4 COMPLIANCE

This environmental assessment was conducted in accordance with Commonwealth and State legislation and guidelines:

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- Western Australian *Environmental Protection Act 1986* (EP Act)
- Western Australian *Biodiversity Conservation Act 2016* (BC Act)
- Western Australian *Biodiversity Conservation Regulations 2018*
- Department of Environment Water Heritage and the Arts (DEWHA 2009) *Matters of National Environmental Significance. Significant impact guidelines 1.1 - Environment Protection and Biodiversity Conservation Act 1999.*

As well as those listed above, the assessment complied with Environmental Protection Authority (EPA) requirements for environmental survey and reporting in Western Australia, as outlined in:

- EPA (2016c) *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment*, known as the Flora and Vegetation Technical Guidance
- EPA (2016b) *Statement of Environmental Principles, Factors and Objectives*.

1.4.1 COMMONWEALTH ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

At a Commonwealth level, Threatened taxa (flora and fauna) are protected under the EPBC Act, which lists species that are considered Critically Endangered, Endangered, Vulnerable, Conservation Dependant, Extinct, or Extinct in the Wild (detailed in **Table 17** in **Appendix One**).

1.4.2 WESTERN AUSTRALIAN ENVIRONMENTAL PROTECTION ACT 1986

The Western Australian EP Act was created to provide for an Environmental Protection Authority (the EPA) that has the responsibility for:

- prevention, control and abatement of pollution and environmental harm
- conservation, preservation, protection, enhancement and management of the environment
- matters incidental to or connected with the above.

The EPA is responsible for providing the guidance and policy under which environmental assessments are conducted. It conducts environmental impact assessments (based on the information provided by the proponent), initiates measures to protect the environment and provides advice to the Minister responsible for environmental matters.

1.4.3 WESTERN AUSTRALIAN BIODIVERSITY CONSERVATION ACT 2016

The Western Australian BC Act provides for the conservation, protection and ecologically sustainable use of biodiversity and biodiversity components in Western Australia.

Threatened species (both flora and fauna) and ecological communities that meet the categories listed within the BC Act are protected under this legislation and require authorisation by the Minister to take or disturb. These are known as Threatened Flora, Threatened Fauna and Threatened Ecological Communities. The conservation categories of Critically Endangered, Endangered and Vulnerable are detailed in **Table 18** in **Appendix One**; these categories align with those of the EPBC Act.

Flora and fauna species may be listed as being of special conservation interest if they have a naturally low population, restricted natural range, are subject to or recovering from a significant population decline or reduction of range or are of special interest, and the Minister considers that taking may result in depletion of the species.

The most recent listings were published in the *Government Gazette* on 11 September 2018 (Government of Western Australia 2018c).

1.4.4 FLORA

1.4.4.1 Threatened and Priority Flora

Conservation significant flora species, also known as conservation-listed species, are those that are listed as Threatened Flora (TF) and (within Western Australia) as Priority Flora (PF). TF species are listed as Threatened by the Western Australian DBCA and protected under the provisions of the BC Act. Some State-listed TF are provided with additional protection as they are also listed under the Commonwealth EPBC Act.

Flora are listed as PF where populations are geographically restricted or threatened by local processes, or where there is insufficient information to formally assign them to TF categories. Whilst PF are not specifically listed in the BC Act, some may qualify as being of special conservation interest and thereby have a greater level of protection than unlisted species.

There are seven categories covering State-listed TF and PF species (DBCA 2019) which are outlined in **Table 18** in **Appendix One**. PF for Western Australia are regularly reviewed by the DBCA whenever new information becomes available, with species status altered or removed from the list when data indicates that they no longer meet the requirements outlined in **Table 18**.

1.4.4.2 Other Significant Flora

According to the *Flora and Vegetation Technical Guidance* (EPA 2016c) other than being listed as TF or PF, a species can be considered as significant if it is considered to be:

- locally endemic or association with a restricted habitat type (e.g. Groundwater Dependent Ecosystems, Sheet Flow Dependent Vegetation)
- a new species or has anomalous features that indicate a potential new species
- at the extremes of range, recently discovered range extensions (generally considered greater than 100 km or in a different bioregion), or isolated outliers of the main range)
- unusual species, including restricted subspecies, varieties or naturally occurring hybrids
- relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

1.4.4.3 Introduced Flora

Introduced plant species, known as weeds, are plants that are not indigenous to an area and have been introduced either directly or indirectly (unintentionally) through human activity. Species are regarded as introduced if they are listed as 'alien' on FloraBase (Western Australian Herbarium [WAH] 1998-2020) and are designated with an asterisk (*) in this document.

Weeds of National Significance

At a national level there are 32 weed species listed as Weeds of National Significance (WoNS) (Australian Government & Department of the Environment and Energy [DotEE] 2018; Weeds Australia 2012). The Commonwealth *National Weeds Strategy: A Strategic Approach to Weed Problems of National Significance* (2012) describes broad goals and objectives to manage these species.

Declared Pest Plants

The Western Australian Organism List (WAOL) details organisms listed as Declared Pests under the *Biosecurity and Agriculture Management Act 2007* (BAM Act). Under the BAM Act, Declared Pests are listed as one of the three categories, or exempt:

- C1 (exclusion), that applies to pests not established in Western Australia; control measures are to be taken to prevent their entry and establishment
- C2 (eradication), that applies to pests that are present in Western Australia but in low numbers or in limited areas where eradication is still a possibility
- C3 (management), that applies to established pests where it is not feasible or desirable to manage them in order to limit their damage
- exempt (no category).

1.4.5 ECOLOGICAL COMMUNITIES

1.4.5.1 EPBC-listed Threatened Ecological Communities

Ecological communities are naturally occurring biological assemblages associated with a particular type of habitat (Government of Western Australia 2016). At Commonwealth level, Threatened Ecological Communities (TECs) are protected under the Commonwealth EPBC Act. An ecological community may be categorised into one of the three sub-categories:

- Critically Endangered, if it is facing an extremely high risk of extinction in the wild in the immediate future
- Endangered, if it is not critically endangered and is facing a very high risk of extinction in the wild in the near future
- Vulnerable, if it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future.

1.4.5.2 Western Australian Threatened Ecological Communities

Western Australian TECs are protected under the BC Act. TECs are categorised much like those of the EPBC Act, shown in **Table 19** in **Appendix One**.

Currently described TECs are listed on the DBCA website, with the most recent list endorsed by the Minister for Environment in June 2018 (DBCA 2018).

1.4.5.3 Western Australian Priority Ecological Communities

DBCA maintains a list of Priority Ecological Communities (PECs). PECs include potential TECs that do not meet survey criteria, or that are not adequately defined. They are not protected under legislation but are taken into consideration as part of the environmental approvals process.

Currently described PECs are listed on the DBCA website, with the most recent list dated 17 January 2019 (Species and Communities Program, DBCA 2019).

1.4.6 OTHER SIGNIFICANT VEGETATION

According to the *Flora and Vegetation Technical Guidance* (EPA 2016c), other than being listed as a TEC or PEC, vegetation can be considered as significant if it is considered to have:

- restricted distribution
- a degree of historical impact from threatening processes
- a role as a refuge
- provides an important function required to maintain ecological integrity of a significant ecosystem.

Groundwater Dependent Ecosystems, also known as Groundwater Dependent Vegetation, may be considered as significant vegetation due to all of the above features, and is described below.

1.4.6.1 Groundwater Dependent Ecosystems

Groundwater Definition

Groundwater is water that is found in the saturated zone of the soil, where all soil pores are filled with water. The water table is the upper surface of the saturated zone in an unconfined aquifer. Groundwater may also occur as a perched aquifer located above unsaturated rock formations as a result of a discontinuous permeable layer or held under pressure in a confined aquifer (Goulburn-Murray Water 2010).

Groundwater Dependent Ecosystems Definition

Groundwater Dependent Ecosystems (GDEs) have been defined as ecosystems that are dependent on groundwater for their survival at some stage or stages of their lifecycle, however groundwater use cannot be equated with groundwater dependence (Eamus 2009b). In some contexts, GDEs are also known as Groundwater Dependent Vegetation.

Hatton and Evans (1998) identified four types of GDEs based on their geographic setting: terrestrial vegetation (vegetation communities and dependent fauna that have seasonal or episodic dependence on groundwater), river base flow systems (aquatic and riparian ecosystems that exist in or adjacent to streams that are fed by groundwater base flow), aquifer and cave ecosystems, and wetlands.

Eamus *et al.* (2006) identified three primary classes based on type of groundwater reliance:

1. Aquifer and cave ecosystems.
2. All ecosystems dependent on the surface expression of groundwater:
    a) river base flows
    b) wetlands, swamplands
    c) seagrass beds in estuaries
    d) floodplains
    e) mound springs
    f) riparian vegetation
    g) saline discharge to lakes
    h) low lying forests.
3. All ecosystems dependent on the subsurface presence of groundwater, often accessed via the capillary fringe (non-saturated zone above the water table) when roots penetrate this zone:
    a) River Red Gum (*Eucalyptus camaldulensis*) forests
    b) Banksia woodlands
    c) Riparian vegetation in the wet/dry tropics.

GDEs in the Pilbara are generally determined to be vegetation associated with riparian areas. GDEs dependent on the surface expression of groundwater (Eamus *et al.* 2006 class 2) includes vegetation associated with wetlands (permanent or semi-permanent pools) within riparian areas, and generally includes *Melaleuca argentea* in association with other species described below. GDEs associated with the subsurface presence of groundwater (Eamus *et al.* 2006 class 3) includes riparian vegetation characterised by the phreatophytic species described below.

Direct impacts on GDEs i.e. clearing, and indirect impacts, including from dewatering and reinjection, frequently feature as being a significant environmental impact in mining approvals documents e.g. (Office of the Appeals Convenor 2016a; 2016b; Rio Tinto 2016).

Phreatophytic Species

Phreatophytic species rely on groundwater sources for water intake (Maunsell Australia Pty Ltd 2006); essentially the water requirements of phreatophytes are greater than can be provided from the surface soil profile (e.g. riparian vegetation) or they are dependent on free water availability (e.g. wetland species). They frequently show low tolerance to extended water stress due to a lack of physiological and/or morphological adaptation to drought, and respond to significant water deficit by a decline in health and eventual death (*ibid.*).

Obligate phreatophytes are dependent on free access to water (i.e. they are wetland species) whereas facultative phreatophytes can switch their water source between the soil surface profile in times of rain, to groundwater in times of drought when the soil surface profile (vadosphere) is depleted (Grierson 2010).

Phreatophytic species likely to occur in the Pilbara include:

- *Eucalyptus camaldulensis* subsp. *refulgens*, which is regarded as a facultative phreatophyte that is dependent on groundwater for part of its lifecycle and/or in times of drought. This species has been reported to be tolerant of groundwater falls of up to 4 m per year (Maunsell Australia Pty Ltd 2006), has both lateral and sinker roots and is tolerant of waterlogging (Grierson 2010).
- *Eucalyptus victrix*, which may be regarded as a facultative phreatophyte. It is considered to be relatively drought tolerant and likely to be tolerant of gradual declines to the water table (to a degree) (Maunsell Australia Pty Ltd 2006). *Eucalyptus victrix* has lateral and sinker roots (i.e. a dimorphic root system) but is not tolerant of waterlogging (Grierson 2010). There is some conjecture that this species is actually a vadophyte (i.e. relies on water from within the soil surface profile, and is independent of groundwater) or, at best, weakly phreatophytic (Resource and Environmental Management Pty Ltd 2007). Depth to groundwater is likely to be an important indicator of groundwater dependence (Equinox Environmental 2017).
- wetland species such as *Melaleuca argentea*
- *Melaleuca xerophila* may be groundwater dependent in some areas (Markey 2016).

Vegetation containing *Eucalyptus camaldulensis* subsp. *refulgens* and *Melaleuca argentea* is generally considered to represent a GDE. However, there is supporting evidence that, in some circumstances, *Eucalyptus victrix* does not always depend on groundwater (Batini 2009; Eamus 2009a; EPA & Hamersley Iron Pty Ltd 2010; Resource and Environmental Management Pty Ltd 2007) and therefore vegetation characterised by this species is considered to be potentially representative of a GDE.

Atlas of Groundwater Dependent Ecosystems

The Groundwater Dependent Ecosystems Atlas (Australian Government & Bureau of Meteorology [BoM] 2018) indicates the presence of known GDEs and Inflow Dependent Ecosystems (IDEs) in Australia.

An Inflow Dependent Ecosystem is one in which the vegetation within the landscape is likely to be accessing water in addition to rainfall, from soil or surface water or groundwater, assessed using remotely sensed data. The likelihood of a landscape using additional water is rated from one to 10 (low to high), with a rating above six indicating that a landscape is likely to be inflow dependent (Australian Government & BoM 2018).

Groundwater Dependent Vegetation

Groundwater Dependent Ecosystems, by definition, refers to biota and processes (i.e. ecosystems) that are dependent on groundwater. However, in the context of a flora and vegetation survey only the botanical aspect is under investigation. Therefore, within this report areas of GDE are referred to as Groundwater Dependent Vegetation (GDV).

1.4.7 ENVIRONMENTALLY SENSITIVE AREAS

There are a number of areas around Western Australia identified as being of environmental significance within which the exemptions to the Native Vegetation Clearing Regulations do not apply. These are referred to as Environmentally Sensitive Areas (ESAs), and are declared under section 51B of the EP Act and described in the Environmental Protection (Environmentally Sensitive Areas) Notice (Government of Western Australia 2005).

1.4.8 CONSERVATION ESTATE

The National Reserve System is a network of protected areas managed for conservation under international guidelines. The objective of placing areas of bushland into the Conservation Estate is to achieve and maintain a comprehensive, adequate and representative reserve system for Western Australia. The Conservation and Parks Commission is the vesting body for conservation lands, forest and marine reserves that are managed by DBCA (Government of Western Australia 2018a).

2 DESKTOP ASSESSMENT

2.1 PHYSICAL ENVIRONMENT

2.1.1 CLIMATE

The survey area is located within the Pilbara region, which includes two broad climatic zones. Coastal areas, as well as some higher rainfall inland areas, have a semi-desert tropical climate which experience 9–11 months of dry weather, with hot humid summers and warm winters. The remaining inland areas have a dry desert climate, typically with higher temperatures and lower rainfall, and often experience up to 12 months of dry weather, with hot dry summers and mild winters (Leighton 2004). The survey area is within the dry inland area.

According to the Köppen-Geiger climate classification, the survey areas have a hot arid desert (Class BWh) (Peel *et al.* 2007). This classification is considered to represent a desert climate where annual rainfall is generally less than 200 mm or the region loses more water via evapotranspiration than it receives as rain, generally a result of hot, sunny weather without significant cloud. The mean average temperature exceeds 18°C, and summer temperatures are frequently over 40°C.

The closest Bureau of Meteorology (BoM) station with long term records is Marble Bar (station 4106, open since 2000; BoM 2020a, accessed May 2020) located approximately 60 km north northwest of the survey area. The mean annual rainfall is 392.7 mm falling mainly during the summer (December–March) period. The rainfall in the 4-month period preceding the survey in March was approximately 91% of the long-term mean for the December–March period.

December is the hottest month with a mean maximum temperature of 42° and minimum of 26.2°. July is the coldest month with a mean maximum of 27.5° and minimum of 12.2°.

Figure 2 shows the average rainfall and temperatures of the survey area, with rainfall for the year preceding the field survey.

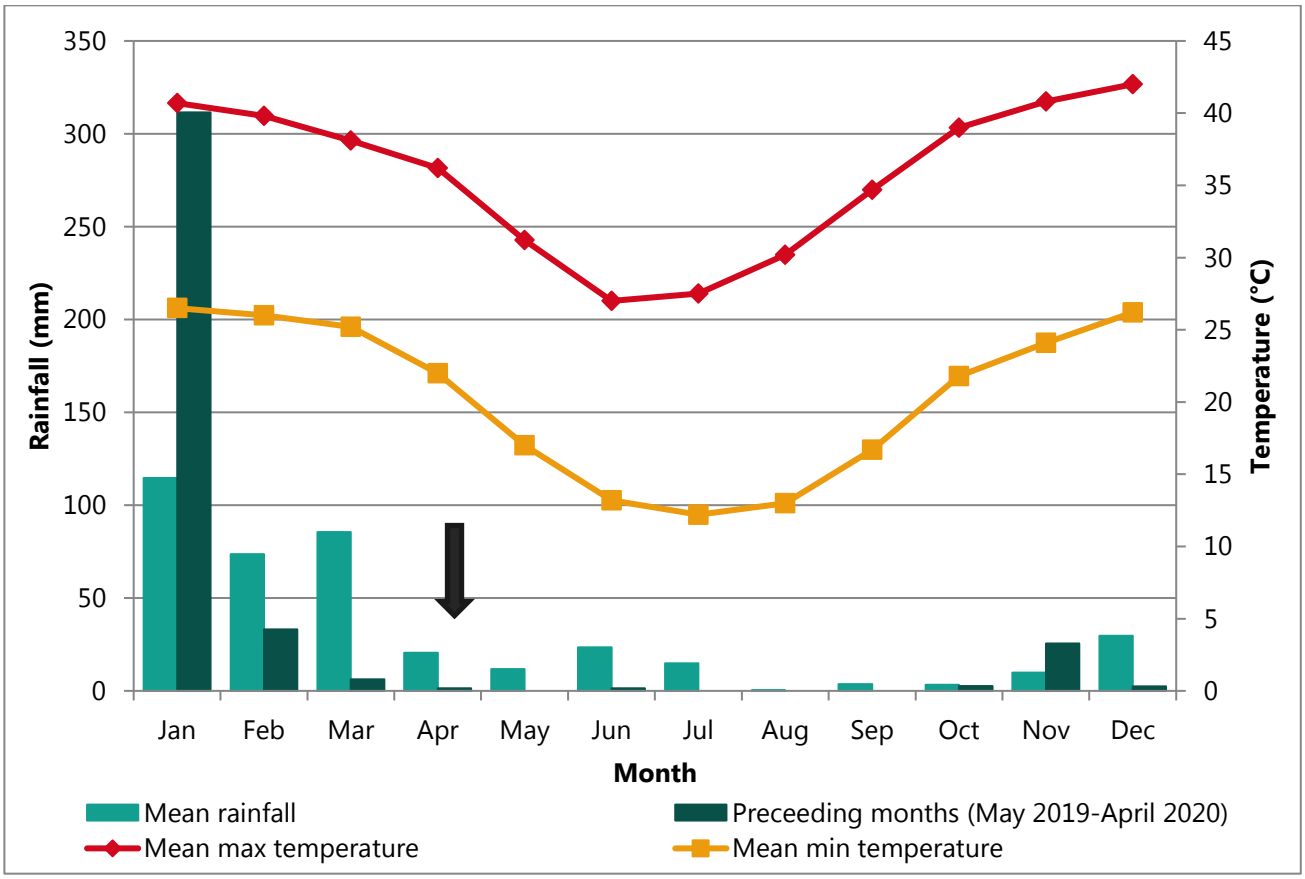


Figure 2: Rainfall and temperature data for the survey area (Marble Bar, 2000–2020, BoM 2020a); survey period indicated by arrow

2.1.2 LAND SYSTEMS

According to Department of Primary Industries and Rural Development (DPIRD 2018b) soil landscape mapping, the following land systems intersect the survey area (**Table 2** and **Map 1**).

Table 2: Land systems (DPIRD 2018b)

Mapping unit	Land System	Description	Extent (ha)	%
280Cp	Capricorn System	Rugged sandstone hills, ridges, stony footslopes and interfluves supporting low acacia shrublands or hard spinifex grasslands with scattered shrubs.	2,819.42	46.56
280Mo	Mosquito System	Stony plains and prominent ridges of schist and other metamorphic rocks supporting shrubby hard spinifex grasslands.	23.18	0.38
280Ri	River System	Narrow, seasonally active flood plains and major river channels supporting moderately close, tall shrublands or woodlands of acacias and fringing communities of eucalypts sometimes with tussock grasses or spinifex.	2.21	0.04
280Ro	Robe System	Low plateaux, mesas and buttes of limonite supporting soft spinifex and occasionally hard spinifex grasslands.	255.46	4.22
280Rk	Rocklea System	Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex and occasionally soft spinifex grasslands with scattered shrubs.	2,504.36	41.36
280Tl	Talga System	Hills and ridges of greenstone and chert and stony plains supporting hard and soft spinifex grasslands.	206.18	3.40
280Ty	Taylor System	Stony plains and isolated low hills of sedimentary rocks supporting hard and soft spinifex shrubby grasslands.	244.75	4.04

2.1.3 GEOLOGY

The survey area is located in the Pilbara region (Fortescue Botanical District) as defined by (Beard 1975; Beard 1990). The survey area is an exemplar of the region's topographic description, capturing a range of landforms including mountains (rising to 1,250 m), plains and shallow skeletal soils on ranges. The Pilbara region is formed of a basement of Archaean granite and volcanics, overlain by massive deposits of Proterozoic sediments and volcanics (Beard 1990). The regional geological setting of Nullagine falls within the West Pilbara Granite Greenstone Terrane (greenstones and granites) and the Central Pilbara Tectonic Zone (greenstones) (Bagus 2005).

At a 1:500,000 scale, the survey are is characterised by 13 geological units (**Map 2**, **Table 3**) defined within the State interpreted bedrock geology (Department of Mines Industry Regulation and Safety 2019).

Table 3: Geological units that intersect the survey area (Department of Mines Industry Regulation and Safety 2019)

GEOLCODE	Unit	Extent (ha)	%
A-DG-s	De Grey Supergroup: Siliciclastic sedimentary rocks; metamorphosed	298.54	4.93
A-FO-od	Mt Bruce Supergroup: Dolerite dyke or sill	116.86	1.93
A-GC-xca-b	De Grey Supergroup: Gorge Creek Group: Undivided; banded iron-formation and siliciclastic sedimentary rock; metamorphosed	20.50	0.34
A-GC-xci-s	De Grey Supergroup: Gorge Creek Group: Undivided; banded iron-formation and siliciclastic sedimentary rock; metamorphosed	1,549.42	25.59
A-FOh-xs-f	Mt Bruce Supergroup: Fortescue Group: Hardey Formation: sedimentary and felsic volcanic rocks; local intrusive rocks	276.41	4.56
A-od-PEP	Metadolerite in dykes and sills	204.23	3.37
A-og-PEP	Metagabbro in dykes and sills	2.09	0.03
A-NUq-mh	De Grey Supergroup: Nullagine Group: Mosquito Creek Formation: metamorphosed sandstone, siltstone, and shale; graded bedding and local cross-bedding; includes metamorphosed turbidite deposits	49.77	0.82
A-FOr-b	Mt Bruce Supergroup: Fortescue Group: Mount Roe Basalt: basaltic volcanic rocks; local volcaniclastic and siliciclastic rocks	319.93	5.28
A-WAp-xf-cc	Pilbara Supergroup: Warrawoona Group: Panorama Formation: felsic volcanic rock; local sedimentary rock; metamorphosed	5.04	0.08
A-WAp-f	Pilbara Supergroup: Warrawoona Group: Panorama Formation: felsic volcanic rock; local sedimentary rock; metamorphosed	1,045.41	17.26
A-WA-xb-f	Pilbara Supergroup: Warrawoona Group: mafic, ultramafic, and felsic volcanic and intrusive rocks, and sedimentary rocks; metamorphosed	2,167.24	35.79
A-KEw-xf-s	Pilbara Supergroup: Kelly Group: Wyman Formation: felsic volcanic and volcaniclastic rocks; local clastic sedimentary rocks, chert and basalt; metamorphosed	0.12	0.002
TOTAL		6055.55	100

2.1.4 WETLANDS AND DRAINAGE

The survey area is on the divide and has parts in both the Coongan River and Nullagine River catchments (DBCA 2007-2020). The Coongan River catchment drains towards the north to northeast. The Nullagine catchment drains, within the survey area, in a general southeast direction towards the Nullagine River, which is a tributary of De Grey River that enters the ocean approximately 70 km east northeast of Port Hedland. The survey area is within the De Grey Surface Water Management Area.

No significant riparian areas occur within the survey area, although there are three tributaries of Nullagine River within the survey area, including McPhee Creek.

No wetlands occur within the survey area.

2.1.5 GROUND WATER DEPENDENT ECOSYSTEMS

The *Groundwater Dependent Ecosystems Atlas* (Australian Government & BoM 2020) includes areas mapped as being low and moderate potential terrestrial GDE (national assessment) and contains small pools mapped as being unclassified potential aquatic GDE (regional study).

The survey area is considered as low potential for terrestrial GDEs to occur, with an IDE likelihood of mostly 7 indicating the landscape is likely to be inflow dependent.

2.1.6 ENVIRONMENTALLY SENSITIVE AREAS

No ESAs occur within or are located near the survey area. The nearest ESA is approximately 100 km to the south.

2.1.7 CONSERVATION LANDS

The survey area does not include any conservation lands. The nearest lands vested for conservation are over 100 km distant, although the survey area is approximately 11.5 km south of unallocated crown land of conservation interest to the DBCA (ex-Meentheena Station).

2.1.8 LAND USE HISTORY

The southern part of the survey area is located on Bonney Downs pastoral station and is grazed by cattle. The remaining areas are on unallocated crown land.

2.2 BIOLOGICAL ENVIRONMENT

2.2.1 BIOGEOGRAPHIC REGION

Biogeographic regions are delineated on the basis of similar climate, geology, landforms, vegetation and fauna and are defined in the Interim Biogeographical Regionalisation for Australia (IBRA) (DotEE 2016).

The survey area is located in the Pilbara IBRA region in the Chichester subregion (PIL1), described as (Kendrick & McKenzie 2002):

> *The Chichester subregion (PIL 1) comprises the northern section of the Pilbara Craton. Undulating Archaean granite and basalt plains include significant areas of basaltic ranges. Plains support a shrub steppe characterised by Acacia inaequilatera over Triodia wiseana (formerly Triodia pungens) hummock grasslands, while Eucalyptus leucophloia tree steppes occur on ranges. The climate is Semi-desert-tropical and receives 300 mm of rainfall annually. Drainage occurs to the north via numerous rivers (e.g. De Grey, Oakover, Nullagine, Shaw, Yule, Sherlock). Subregional area is 9,044,560ha.*

2.2.2 PRE-EUROPEAN VEGETATION

During the 1970s, John Beard and associates conducted a systematic survey of native vegetation, describing the vegetation systems in Western Australia at a scale of 1:250 000 in the south-west and at a scale of 1:1 000 000 in less developed areas.

Beard's vegetation maps attempted to depict the native vegetation as it was presumed to be at the time of settlement, and is known as the pre-European vegetation type and extent and has since been developed in digital form by Shepherd *et al.* (2002) and updated by DPIRD (2018a). Extents are updated annually by DBCA (Government of Western Australia 2019). This mapping indicates that the survey area corresponds with two pre-European vegetation units:

- Association 171: Hummock grasslands, low tree steppe; snappy gum over soft spinifex & *Triodia brizoides*
- Association 173: Hummock grasslands, shrub steppe; kanji over soft spinifex & *Triodia wiseana* on basalt
- Association 190: Hummock grasslands, sparse shrub steppe; *Acacia bivenosa* & *A. trachycarpa* over hard spinifex, *Triodia wiseana*, Very poor rocky country on gneiss.

The pre-European vegetation associations identified from the survey area (DPIRD 2018a) and their pre-European and current extents are listed in **Table 4** (Government of Western Australia 2019) and shown on **Map 3**.

Table 4: Pre-European vegetation association representation (Government of Western Australia 2019)

Region	Vegetation association	Original extent (ha)	Current extent (ha)	% Remaining
Western Australia	171	331,951.73	330,643.09	99.61
	173	1,753,104.09	1,748,260.83	99.72
	190	169,199.72	169,051.00	99.91
IBRA biographic region (Pilbara)	171	331,307.41	330,026.24	99.61
	173	1,752,520.89	1,747,677.63	99.72
	190	169,199.72	169,051.00	99.91
IBRA biographic sub-region (Chichester)	171	331,307.41	330,026.24	99.61
	173	1,744,029.51	1,739,189.58	99.72
	190	169,199.72	169,051.00	99.91
LGA (Shire of East Pilbara)	171	331,951.73	330,643.09	99.61
	173	1,085,704.89	1,081,937.46	99.65
	190	169,199.72	169,051.00	99.91

2.2.3 THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

The *Protected Matters Search Tool* (PMST) search (Australian Government & Department of Agriculture Water and the Environment 2020, search reference PMST_Y522MC) using a 30 km buffer around an approximation of the survey areas (excluding riparian areas), identified no EPBC-listed TECs or suitable habitat for such occur or are likely to occur within the search area buffers.

The DBCA database search (search reference Nullagine_Ecoscape_TecPEcSearchResults_25022020 using a 40 km buffer) identified no known TECs and two PECs within the search area:

- Priority 3 *Mosquito Land System* PEC: Stony saline clay plains of the Mosquito Land System, four occurrences. This PEC, abbreviated to 'Mosquito PEC', is described (Species and Communities Program, DBCA 2020) as:

  Triodia longiceps perennial grasslands with scattered Maireana melanocoma and Sclerolaena spp. and includes Priority flora taxa Atriplex spinulosa (P1) and Ptilotus wilsonii (P1) dissected by drainage lines. Dominated by (but not limited to) Melaleuca eleuterostachya and Acacia bivenosa occurring on saline red brown non-cracking clays with a mantle of quartz gravel and neutral subsurface soil material on level to undulating plains. Largely restricted to an area east of Nullagine.

- Priority 1 *Wona Land System* PEC: Four plant assemblages of the Wona Land System (previously Cracking clays of the Chichester and Mungaroona Range), 11 occurrences. This PEC, abbreviated to 'Wona PEC', is described (Species and Communities Program, DBCA 2020) as:

  Cracking clays of the Chichester and Mungaroona Range. This grassless plain of stony gibber community occurs on the tablelands with very little vegetative cover during the dry season, however during the wet a suite of ephemerals/annuals and short-lived perennials emerge, many of which are poorly known and range-end taxa. Annual Sorghum grasslands on self mulching clays with a moderate-dense overlay of rocks. This community appears very rare and restricted to the Pannawonica-Robe valley end of Chichester Range. Naturally species poor when dry. Mitchell grass plains (Astrebla spp.) on gilgai. Mitchell grass and Roebourne Plain grass (Eragrostis xerophila) plain on gilgai. Astrebla pectinata, A. elymoides, E. xerophila, Aristida latifolia, Eriachne and Sida fibulifera. Typical type, heavily grazed.

The creekline portions of the survey area adjacent to Nullagine River (i.e. the most southern and south-eastern parts) occupying 23.18 ha (0.38% of the survey area) intersect the Mosquito Land System (see **Table 2** and **Map 4**). Therefore, by definition, this portion of the survey area is considered representative of the *Mosquito Land System* PEC.

The Wona Land System does not intersect with the survey area.

2.2.4 THREATENED AND PRIORITY FLORA

The PMST search (as above) identified no EPBC-listed TF that are known to occur within the 30 km search buffer area.

A search of DBCA's databases was conducted (search reference 23-0220FL) using a 20 km buffer around the supplied shapefiles (TPFL List, taken from Threatened and Priority Flora Report Forms and DBCA surveys, and WA Herb, taken from vouchered specimens held in the Western Australian Herbarium).

The DBCA database searches identified no TF and 28 PF have been recorded from within the search buffer:

- P1 (11 taxa): *Acacia aphanoclada*, *Acacia cyperophylla* var. *omearana*, *Acacia fecunda*, *Acacia* sp. Marble Bar (J.G. & M.H. Simmons 3499), *Acacia* sp. Nullagine (B.R. Maslin 4955), *Atriplex spinulosa*, *Cochlospermum macnamarae*, *Fimbristylis* sp. Shay Gap (K.R. Newbey 10293), *Ptilotus wilsonii*, *Solanum* sp. Mosquito Creek (A.A. Mitchell et al. AAM 10795), *Stemodia* sp. Battle Hill (A.L. Payne 1006)
- P2 (one taxon): *Indigofera ixocarpa*
- P3 (10 taxa): *Acacia levata*, *Eragrostis crateriformis*, *Eucalyptus rowleyi*, *Heliotropium murinum*, *Heliotropium muticum*, *Nicotiana umbratica*, *Rostellularia adscendens* var. *latifolia*, *Swainsona thompsoniana*, *Themeda* sp. Hamersley Station (M.E. Trudgen 11431), *Triodia basitricha*
- P4 (four taxa): *Bulbostylis burbidgeae*, *Goodenia nuda*, *Lepidium catapycnon*, *Ptilotus mollis*.

The combined database searches results are also included in **Table 23** in **Appendix Two**.

Atlas Iron maintains a database of conservation listed flora and other flora of conservation interest associated with its operational and exploration tenements. This database consists of DBCA database search results requested for flora and vegetation assessments and the results of field surveys it has commissioned. The resultant list, and associated location data, provides a comprehensive understanding of the conservation listed flora and other flora of conservation interest (e.g. significant range extensions, unusual forms) within and close to Atlas Iron's areas of interest. The results from Atlas Iron's database did not identify any additional TF or PF within the search area or survey area boundaries. These results are consistent with previous surveys (see **Figure 1**) conducted by Woodman (2012; 2014b; 2014c; 2019a). Woodman's surveys detected *Acacia aphanoclada*, *Eragrostis crateriformis*, *Fimbristylis* sp. Shay Gap (K.R. Newbey 10293), *Goodenia nuda*, *Ptilotus mollis*, *Rostellularia adscendens* var. *latifolia* and *Themeda* sp. Hamersley Station (M.E. Trudgen 11431).

2.2.4.1 Threatened and Priority Flora Likelihood Assessment

Ecoscape conducted a likelihood assessment to identify TF and PF species that have the potential to occur within the survey area. The likelihood of a species occurring is based on the following attributes, as listed on *FloraBase* (WAH 1998-2020; 2020) or *World Wide Wattle* (WAH 2019) and tailored to local populations, and information from recent nearby surveys, incorporating an assessment of habitats likely to be present in the survey area. The attributes taken into consideration were:

- broad soil type usually associated with the species
- broad landform usually associated with the species
- usual vegetation (characteristic species) with which the species is generally associated
- species having been recorded from within approximately 20 km of the survey area (considered as 'nearby') taking age of the record and locational accuracy into account
- nearby recent records (i.e. records within the previous 25 years).

The likelihood rating is assigned using the categories listed in **Table 5**.

Table 5: Categories for the likelihood of occurrence of TF and PF

Likelihood	Categories
Recorded	Species recorded within the survey area
Possible	May occur within the survey area (but has not been recorded); broadly, 2-4 of the required attributes (but always including records from nearby) are present in the survey area
Unlikely	Could occur but is not expected; 1-3 of the required attributes are present in the survey area but: • it is not known from nearby, or • it is known from nearby but has no other required attributes, or • it is known from nearby but has at least one well-defined attribute that does not occur in the survey area (e.g. it is associated with a specific landform or soil type that does not occur in the survey area) • it is known from nearby, but the record is old (>25 years), or the locational data is potentially inaccurate, or the area has been significantly cleared at and around the location of the record and survey area and as such the habitat almost certainly no longer occurs within the survey area.
Highly unlikely	The species characteristics include only one, or none of the required attributes of soil, landform, associated vegetation and have been recorded nearby, or a critical element (often landform) is not within the survey area and as such it almost certainly does not occur.

The likelihood assessment is available in **Table 23** in **Appendix Two**.

Combined, all databases (DBCA and Atlas Iron) identified the following five PF as occurring within the survey area boundary: *Acacia aphanoclada* (P1), *Eragrostis crateriformis* (P3), *Goodenia nuda* (P4), *Ptilotus mollis* (P4) and *Rostellularia adscendens* var. *latifolia* (P3). These were prioritised for the survey, including ground truthing previous records and additional searches in areas considered likely to have a suitable habitat that had not been adequately surveyed in the past, including areas without any previous surveys.

No additional species were considered to have a high desktop likelihood of occurring within the survey area based on the expected habitat within the survey area.

Following the field survey when actual survey area characteristics (vegetation types, vegetation condition, visibility for individual species) are better understood, and the level of survey effort was considered, the likelihood of occurrence was re-evaluated. The post-survey likelihood is also incorporated into **Table 23** and discussed further in **Section 4.1.3.2**.

2.3 LITERATURE REVIEW

2.3.1 PREVIOUS SURVEYS

Several flora and vegetation surveys have been conducted for Atlas Iron in areas corresponding with the current survey area and associated infrastructure corridors (see **Figure 1**). The significant findings identified as a result of the works are summarised as follows:

- Woodman (2019b) *Memo of gap analysis of flora and vegetation works undertaken to date at McPhee Creek mining project area with reference to current standards as per the Technical Guidance (EPA)*
  - identified need for additional: database searches, flora surveys, statistical analysis for enhanced regional context and impact assessment of the current disturbance areas and layout.
- Woodman (2019c) *Memo of potential impacts to vegetation types or significant taxa and determination of additional survey requirements at McPhee Creek mining project area*:
  - identified high–moderate local impacts on vegetation types (5, 6a, 6b, 8a and 8b) within the survey area.

  - ranked low regional scale impacts to all conservation-listed flora (*Acacia aphanoclada, Eragrostis crateriformis, Ptilotus mollis* and *Rostellularia adscendens* var. *latifolia*) within the survey area.
  - barring *Acacia aphanoclada* (high) all other conservation-listed flora were ranked as low local scale impacts.
- Woodman (2019a) *McPhee Creek Iron Ore Project Detailed Flora and Vegetation Impact Assessment*[1]
- Woodman (2014a) *McPhee Creek Iron Ore Project Flora and Vegetation Impact Assessment*
  - documents the potential impacts of the proposed development (pits, waste dumps, tailings, processing, infrastructure, hydrological change) on significant flora and vegetation
  - three conservation-listed flora may be directly impacted by the development (*Acacia aphanoclada*, P1; *Eragrostis crateriformis*, P3; *Ptilotus mollis*, P4) with the local impact to each being variable but potentially High, and regional impact likely to be low for *Acacia aphanoclada* and *Ptilotus mollis*, but potentially Moderate-High for *Eragrostis crateriformis*
  - *Rostellularia adscendens* subsp. *latifolia* (P3) may be indirectly impacted by discharge water, however, likely impacts were not assessed as being significant
  - the level and significance of impacts on vegetation could not be quantified due to lack of regional data, however, it was noted that no vegetation was representative of a TEC or PEC
  - some riparian vegetation is likely to be indirectly impacted by altered hydrology, however, impacts were unlikely to be prolonged
- Woodman (2014b) *McPhee Creek Iron Ore Project Riparian Vegetation Mapping (Discharge options 1, 2 and 3)*[1]
- Woodman (2014c) *McPhee Creek Rail Project (Eastern Corridor Yandeyarra to Mt Webber and McPhee Creek) Flora and Vegetation Assessment - Post Wet Season 2013*[1]
- Woodman (2014d) *McPhee Creek Rail Spur Project Flora and Vegetation Assessment*[1]
- Woodman (2013) *McPhee Creek Iron Ore Project Conservation Significant Flora Assessment*[1]
- Woodman (2012) *McPhee Creek Project Flora and Vegetation Assessment*[1]
- Woodman (2011) *McPhee Creek Project Flora and Vegetation Desktop Review*.

[1] Reports containing primary survey (i.e., primary surveys result from field surveys while tertiary surveys resulting from desktops/literature reviews) data are presented in **Table 6**.

Table 6: Literature review of primary surveys in proximity to/overlapping the survey area

Reference	Survey name	Survey components	Flora taxa	Vegetation-types, - condition and conservation status	Conservation listed- and introduced-taxa
Woodman (2019a)	McPhee Creek Iron Ore Project Detailed Flora and Vegetation Impact Assessment	Desktop based on three historical detailed vegetation surveys: Woodman (2013) Woodman (2011) Woodman (2012)	Families: 51 Genera: 165 Taxa: 388	Vegetation types: 19 Vegetation condition: 'Excellent' to 'Very Poor' Conservation status: no PECs/TECs	Conservation taxa: 4–*Acacia aphanoclada* (P1), *Eragrostis crateriformis* (P3), *Ptilotus mollis* (P4), and *Rostellularia adscendens* var. *latifolia* (P3) Introduced taxa: 15–including one declared pest (*Argemone ochroleuca*)
Woodman (2014b)	McPhee Creek Iron Ore Project Riparian Vegetation Mapping (Discharge options 1, 2 and 3)	Single phase Level 2 flora and vegetation survey 39 quadrats	Families: 38 Genera: 105 Taxa: 165	Vegetation types: 3 Vegetation condition: 'Very Poor' to 'Very Good'. Conservation status: no PECs/TECs	Conservation taxa: 1–*Rostellularia adscendens* var. *latifolia* (P3) Introduced taxa: 12–including one declared pest (*Argemone ochroleuca*)
Woodman (2014c)	McPhee Creek Rail Project (Eastern Corridor Yandeyarra to Mt Webber and McPhee Creek) Flora and Vegetation Assessment - Post Wet Season 2013	Single Level 2 flora and vegetation survey 302 non-permanent plots	Families: 62 Genera: 193 Taxa: 508	Vegetation types: 19 following manual fusion of three outlying plots belonging to two broad groups Vegetation condition: 'Excellent' Conservation status: no PECs/TECs	Conservation taxa: 13–*Acacia cyperophylla* var. *omearana* (P1), *Acacia levata* (P3), *Acacia* sp. indet (potentially undescribed), *Acacia* sp. Nullagine (B.R. Maslin 4955) (P1), *Bulbostylis burbidgeae* (P4), *Cochlospermum macnamarae* (P1), *Eragrostis crateriformis* (P3), *Goodenia nuda* (P4), *Gymnanthera cunninghamii* (P3), *Heliotropium murinum* (P3), *Nicotiana umbratica* (P3), *Phyllanthus hebecarpus* (P3), *Ptilotus mollis* (P4) ; and *Rothia indica* subsp. *australis* (P1). Introduced taxa: 19–including one declared pest ()
Woodman (2014d)	McPhee Creek Rail Spur Project Flora and Vegetation Assessment:	Two phase Level 2 flora and vegetation survey 188 non-permanent plots	Families: 54 Genera: 159 Taxa: 364	4 broad groups and 23 No PECs/TECs Vegetation condition ranged from 'Very Good' to 'Poor'	Conservation taxa: 10–*Cochlospermum macnamarae* (P1), *Rothia indica* subsp. *australis* (P1), *Eragrostis crateriformis* (P3), *Gymnanthera cunninghamii* (P3), *Heliotropium murinum* (P3), *Nicotiana umbratica* (P3), *Rostellularia adscendens* var. *latifolia* (P3), *Bulbostylis burbidgeae* (P4), *Rhynchosia bungarensis* (P4) and *Abutilon* aff. *hannii* (potentially undescribed). Introduced taxa: 11–including one declared pest/ WoN (*Parkinsonia aculeata*)

Reference	Survey name	Survey components	Flora taxa	Vegetation-types, - condition and conservation status	Conservation listed- and introduced-taxa
Woodman (2013)	McPhee Creek Iron Ore Project Conservation Significant Flora Assessment	Targeted flora survey	Not applicable	Not applicable	Conservation taxa: 4–*Eragrostis crateriformis* (P3), *Ptilotus mollis* (P4) and *Rostellularia adscendens* var. *latifolia* (P3)
Woodman (2012)	McPhee Creek Project Flora and Vegetation Assessment:	Two phase Level 2 flora and vegetation survey 125 quadrats	47 families 141 genera 309 taxa Families: 47 Genera: 141 Taxa: 309	Vegetation types: 12 belonging to two broad groups Vegetation condition: 'Excellent' Conservation status: no PECs/TECs; vegetation type 3b delineated as facultative phreatophytic vegetation	Conservation taxa: 3–*Acacia aphanoclada* (P1), *Eragrostis crateriformis* (P3) and *Ptilotus mollis* (P4) Introduced taxa: 8–including highly invasive **Cenchrus ciliaris*, **C. setiger* and **Aerva javanica*.

2.3.2 OTHER NEARBY SURVEYS

Other areas located within the same IBRA subregion have been subject to flora and vegetation surveys. Some of the more significant findings are summarised below.

Hazelwood Resources Cookes Creek Tungsten Project area, located approximately 20 km east of the survey area:

- Ecoscape (2011) *Cookes Creek - Level 2 Flora and Vegetation Survey*, detailed the findings of a Level 2 (now Detailed) survey of the combined earlier survey area (adding a second phase) and a number of previously inaccessible parts of the tenement and additional areas of interest. The significant findings were three Priority-listed flora species, one range extension and one range edge flora species, and vegetation on the relevant land system potentially representative of the Mosquito PEC.
- Ecoscape (2009) *Cookes Creek Vegetation and Flora Assessment*, identified 161 flora species (three Priority-listed) and five vegetation types, none of significance.
- Ecologia Environment (2007) *Cookes Creek Tungsten Project: Level 1 Vegetation and Flora Survey*, identified 82 vascular flora species, none conservation-listed, and five vegetation types, none considered significant.

Millennium Minerals project areas, located approximately 25 km south of the survey area:

- Mattiske Consulting (2010a) *Assessment of flora and vegetation on the Airstrip Expansion Area*, during which 15 vascular flora and two plant communities were recorded, none of significance.
- Mattiske Consulting (2010b) *Assessment of flora and vegetation on the All Nations Lease Area*, identified 61 vascular flora species and five plant communities, none of significance.
- Mattiske Consulting (2010c) *Assessment of flora and vegetation on the Barton Lease Area*, identified 61 vascular flora species and five plant communities, none of significance, although it was noted that two Priority-listed species had been previously recorded within the survey area or wider lease area.
- Mattiske Consulting (2010d) *Assessment of flora and vegetation on the Golden Gate and associated Lease Areas*, identified 105 vascular flora species and three plant communities, none of significance.
- Mattiske Consulting (2010e) *Assessment of flora and vegetation on the Little Wonder Lease Area*, identified 20 vascular flora species and three plant communities, none of significance.
- Mattiske Consulting (2010f) *Assessment of flora and vegetation on the Otways Lease Area*, identified 20 vascular flora species and four plant communities, none of significance.
- Mattiske Consulting (2010g) *Assessment of flora and vegetation on the Shearers Lease Area*, identified 89 vascular flora species including one Priority-listed species (*Acacia aphanoclada*) and four plant communities, none of significance.
- Mattiske Consulting (2010h) *Flora and Vegetation of the Nullagine Project Areas*; this report updates on previous surveys and summarises results. The combined surveys have identified 259 taxa including one TF (now P4, *Lepidium catapycnon*) and two other Priority-listed species (and another potential PF), and no significant vegetation.

Atlas Iron's Corunna Downs Iron Ore Project area, located approximately 40 km northwest of the survey area:

- Woodman (2017) *Corunna Downs Intersection Works Flora and Vegetation Assessment*, details the survey results of three separate areas. No conservation-listed flora or vegetation was recorded.
- Woodman (2016) *Corunna Downs Project Level 2 Flora and Vegetation Assessment*, identified 413 vascular flora taxa including 11 Priority-listed taxa three potentially undescribed taxa and two disjunct taxa, and 15 vegetation types, none of which were conservation-listed although two were considered as potentially groundwater dependent due to the presence of *Eucalyptus camaldulensis* and *Melaleuca argentea*.

BC Iron Nullagine Project, located approximately 45 km south of the survey area:

- Astron Environmental Services (Astron 2009) *Nullagine Project flora and vegetation survey May-September 2008*, identified: 462 vascular flora species including eight Priority Flora and 59 vegetation types including one from the Wona PEC and a number located on Robe Pisolite that were considered significant.

Roy Hill Mine and vicinity, located approximately 60 km south:

- Botanic Gardens and Parks Authority (2017) *Population survey for Triodia veniciae in the East Pilbara, June 2017*, detailing the results of a survey for this (now P3-liisted) species that identified it as occurring across a 140 km range in shale substrate.

Atlas Iron Abydos area, located approximately 100 km northwest:

- Coffey Environments (2014b) *Significant Species Management Plan Abydos DSO Project*, detailing management objectives and requirements for significant species six conservation-listed flora species (one now TF), weeds and vegetation, although no recorded vegetation types were representatives of conservation-listed ecological communities.
- Woodman (2013) *Abydos Direct Shipping Ore Project Stage 2 Flora and Vegetation Impact Assessment*, identified a gorge with groundwater dependent tree species (*Melaleuca argentea* and *Eucalyptus camaldulensis*) as being significant but did not identify a specific vegetation unit within it.

Fortescue Metals Group North Star project area, located approximately 120 km west northwest of the survey area:

- Ecoscape (2018) *Glacier Valley Extension Flora and Vegetation Survey, North Star Project*, described a two phase detailed flora and vegetation survey that recorded 218 vascular flora species including three conservation-listed species (one TF) and one Declared Pest plant not previously recorded from the area, and 11 vegetation types, three of which were considered significant including one potential GDE and two with only small extents (<1% of the survey area).
- Ecologia Environment (2015a) *North Star Aerodrome Flora Level 2 and Fauna Level 1 Assessment*, details the survey results of a 6,230 ha area during which no significant flora or vegetation were recorded.
- Ecologia Environment (2015b) *North Star Slurry and Infrastructure Corridors Conservation Significant Flora and Vegetation Assessment*, identified 12 pl-flora species and three vegetation types (characterised by *Eucalyptus camaldulensis* and *Melaleuca argentea*) that were considered significant as they represented GDEs.
- Coffey Environments (2014a) *North Star Alternate Access Road Flora and Vegetation Assessment*, identified 116 flora species including two Priority-listed species and 10 vegetation types, none of which were considered to be significant.
- Ecologia Environment (2012a) *North Star Access Corridor Flora, Vegetation, Vertebrate Fauna and Fauna Habitat Assessment*, identified 163 vascular flora species, one Priority-listed and one a significant range extension, and nine vegetation types, one considered as significant as habitat for the species with a significant range extension and one GDE.
- Ecologia Environment (2012b) *North Star Vegetation and Flora Assessment*, identified 472 vascular flora species including eight Priority-listed species (one of which is now TF-listed) and a number of vegetation types considered as significant including:
  - four vegetation units that correlated with the now TF-listed species (*Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp4)) that meet the requirements to be significant as a key habitat for threatened species
  - two vegetation types that were poorly represented and restricted to particular habitats

- Ecologia Environment (2012c) *Pityrodia* sp. *Marble Bar Targeted Flora Survey* details the findings of a targeted survey for this species.

2.4 VEGETATION TYPE CONSOLIDATION

Woodman had previously conducted a significant amount of flora and vegetation survey within, adjacent and near to the McPhee Creek survey area, as detailed in **Section 2.3.1** above. However, Woodman mapped the vegetation at a level similar to National Vegetation Information System (NVIS) Level VI (NVIS Technical Working Group 2017) whereas the current recommendation for vegetation survey in Western Australia is generally considered to be NVIS Level V (EPA 2016c), which is a lower level of detail. NVIS Level V vegetation descriptions incorporate up to three dominant and characteristic species from up to three strata, with the order that species are listed being the order of dominance within the stratum. Woodman descriptions listed multiple species from each strata present, apparently in alphabetical order and for some with density information for each species rather than stratum, and provided a complicated description incorporating species with very low cover values or significance within the vegetation. An example of a Woodman vegetation type description simplified and converted to NVIS Level V is provided in **Table 7**.

Table 7: Example comparison of Woodman vegetation type description and conversion to NVIS Level V description

Woodman Vegetation Type Description (from Woodman 2019a)	Preliminary Consolidated Ecoscape Description
Low Isolated Trees to Low Woodland of *Eucalyptus leucophloia* subsp. *leucophloia* over Tall Isolated Clumps of Shrubs to Tall Sparse Shrubland of *Acacia monticola* over Low to Mid Isolated Clumps of Shrubs to Mid Open Shrubland of *Acacia bivenosa* (occasionally with *A. synchronicia*, *Corchorus parviflorus*, *Ptilotus obovatus*, *Senna glutinosa* subsp. *glutinosa*, *Senna symonii* and/or *Tribulus suberosus*) over Low Hummock Grassland of *Triodia brizoides* (occasionally *T. wiseana*) and Low Isolated Clumps of Tussock Grasses to Mid Open Tussock Grassland of *Cymbopogon ambiguus* and *Eriachne mucronata* on brown to red-brown clay loam, with granite outcropping on very steep upper slopes on hills adjacent to the main range	*Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Acacia bivenosa*, *A. monticola* and *A. synchronicia* mid open shrubland over *Triodia brizoides* and *T. wiseana* low hummock grassland

The greater level of detail recorded by Woodman contributed to the issues identified during the gap analysis, particularly disparity in the vegetation mapping, and provided an overly complicated description of the vegetation present.

Ecoscape consolidated and simplified the vegetation type descriptions by identifying the dominant species and strata within the Woodman description and converting these to plain English versions of the NVIS code descriptions. Where simplified vegetation types were appreciably similar, the aerial image signature and Ecoscape experience was used to confirm if they were likely to be similar and could be merged, or if they required ground truthing during the field survey (see **Section 2.5.1.3** below).

The consolidated, simplified vegetation types were used during the gap analysis detailed below.

2.5 GAP ANALYSIS

A gap analysis was conducted before conducting any field surveys. The analysis focused mostly on data collation and consolidation between three overlapping studies (Woodman 2012; Woodman 2014b; Woodman 2014c).

The results of the gap analysis identified several locations within the survey area that required:

- ground-truthing, including the rectification of misalignments due to being adjoining areas of different surveys or where the NVIS Level VI vegetation types could not be subsumed into Level V types
- resurveying, including where there were insufficient quadrats within the survey area to align with the requirements of a detailed survey according to the EPA (2016c) Flora and Vegetation Technical Guidance (noting that sufficient quadrats had been recorded during previous surveys, however, many representatives were outside the current survey area)
- locating quadrats in areas of apparent spatial gaps
- survey for baseline purposes, i.e. previously unsurveyed areas
- targeted searches for conservation-listed flora and ecological communities
- ground truthing of some riparian areas to confirm groundwater dependence status.

The results of the gap analysis, and resultant recommendations for field survey, were discussed with Atlas Iron before commencing the field survey.

The following activities were undertaken as part of the gap analysis.

2.5.1 DATA COLLATION AND CONSOLIDATION

Ecoscape conducted a preliminary visual inspection of the vegetation mapping studies (Woodman 2012, McPhee Creek; Woodman 2014b, riparian vegetation mapping; Woodman 2014c, rail project) intersecting through the Esri ArcGIS platform. The inspection demonstrated:

1. Topological errors within Woodman's (2012) mapping e.g. mapping of creek line vegetation types should follow creek lines, however, several of the vegetation types were found askew to creek lines.
2. Spatial overlap between all survey areas.
3. Several vegetation types from one series of vegetation mapping did not match the vegetation types of the adjacent map.
4. Vegetation types were not extended between adjacent mapping studies.

2.5.1.1 Topological Errors

A preliminary inspection identified topological errors (e.g. mapping of creek line vegetation types, as above) within the Phase 2 Vegetation Mapping (Woodman 2014c) layer. The topological errors were fixed by manually moving the mapping 30 m west and 10 m south followed by systematic checks that of all vegetation types corresponded to visual signatures in the aerial imagery and that their descriptions matched nearby quadrat data.

This movement resulted in small gaps on the eastern and northern boundaries of the survey area; these gaps were filled by expanding the current vegetation to the perimeter of the survey area using high-quality aerial imagery (provided by Atlas Iron, 10 m resolution) after confirming that there were no major vegetation type changes within the extrapolated area.

2.5.1.2 Spatial Overlap Between the Historical Survey Areas

Spatial overlap between the vegetation mapping was minor. The most significant areas of overlap occurred between Woodman's (2012) and (2014c) vegetation mapping. We used ArcGIS to remove the vegetation types from the E-W mapping (2012) that were overlapping the Phase 2 (2014c) vegetation. Likewise, the small areas of the Woodman (2014b) overlapping the Woodman (2014c) vegetation was trimmed.

The merging of the non-overlapping vegetation layers formed an interim vegetation mapping layer that was groundtruthed during the field survey.

2.5.1.3 The Mismatch Between Adjacent Vegetation Types

Merging vegetation maps produces 'artefacts'. For example, discrete vegetation patches form along the adjacent edges where two vegetation maps intersect.

To overcome this, Ecoscape sought to confirm if the vegetation types had continuity by visualising the underlying signature presented in the spectral imagery provided by Atlas Iron (10 m resolution), and checked if the neighbouring polygons shared the same NVIS description. Ecoscape used the NVIS Level VI vegetation type descriptions converted into Level V types to both improve commensurability between the mapping units and align with the requirements of a detailed survey according to the EPA (2016c) Flora and Vegetation Technical Guidance.

2.5.1.4 Riparian Area/Groundwater Dependence Confirmation

Previous mapping of the McPhee Creek area by Woodman (see **Section 2.3.1** above for list of references) had identified a number of areas described as being representative of GDVs). Woodman used hydrological information to inform its assessment as well as identifying vegetation with phreatophytic species. However, Woodman's field surveys also incorporated a larger extent than Ecoscape groundtruthed in 2020.

Woodman (2019a) identified 19 vegetation types characterised by phreatophytic species, however, taking into consideration hydrological information and physiological characteristics of the phreatophytic species, only one was considered likely to represent a GDV, although only in localised areas, and three potentially representative, also only in localised areas (**Table 8**).

Woodman based its considerations of groundwater dependence on the following physiological traits:

- *Eucalyptus camaldulensis* was considered an obligate or facultative phreatophyte depending on the hydrological characteristics of the site
- *Eucalyptus victrix* was considered a presumed facultative phreatophyte although in most cases is likely to be a vadophyte
- *Acacia ampliceps* was considered a presumed facultative phreatophyte
- *Atalaya hemiglauca* was considered a presumed facultative phreatophyte
- *Melaleuca glomerata* was considered a presumed facultative phreatophyte
- *Sesbania cannabina* was considered a presumed facultative phreatophyte but potentially an obligate phreatophyte.

Table 8: Woodman (2019a) Groundwater Dependent Ecosystems

Woodman Vegetation Type (removing grassy ground strata)	GDV	Woodman Comment (quote)
15: Mid Isolated Clumps of Trees to Mid Open Forest of *Eucalyptus camaldulensis* and *Eucalyptus victrix* over Mid to Tall Isolated Clumps of Shrubs to Mid to Tall Open Shrubland *of Acacia pyrifolia* subsp. *pyrifolia*, *A. trachycarpa* and *Atalaya hemiglauca* over Low Isolated Clumps of Shrubs of *Pluchea tetranthera*, *Sesbania cannabina* and *Stemodia grossa* on brown sand, sandy loam and sandy clay in drainage lines associated with granite outcropping.	'likely'	There is a potential for GDV to occur through a combination of phreatophytic taxa and depth to groundwater being generally <10m from surface; however, this may be localised patches only, as sampled by areas where denser layers of taxa such as *Melaleuca glomerata*, or combinations of *E. camaldulensis*, *M. glomerata* and *S. cannabina* occur. This VT was associated an underlying granite substrate.
14: Description: Mid Open Woodland to Mid Open Forest of *Eucalyptus camaldulensis* and *Eucalyptus victrix* over Tall Sparse Shrubland to Tall Open Shrubland of *Acacia ampliceps*, *A. coriacea* subsp. *pendens*, *A. pyrifolia* subsp. *pyrifolia*, *A. trachycarpa*, *Atalaya hemiglauca*, *Melaleuca glomerata* and *Petalostylis labicheoides* over Low Isolated Clumps of Shrubs of *Cullen leucanthum* and *Sesbania cannabina* on red or redbrown sand, sandy loam or sandy clay in drainage lines associated with ephemeral pools.	'Potential (localised patches)'	*E. camaldulensis* is a dominant taxon (some areas had dense cover), and *S. cannabina* and *M. glomerata* were also recorded; however, as the depth to groundwater is generally mapped at >10m throughout this VT, these patches could be localised only. Ephemeral pools were noted, and this VT was associated with sandy to clay substrates, which may indicate a reliance on surface water only. Potential GDV areas may be located where groundwater is within 10m of the ground surface.
13: Low Isolated Clumps of Trees to Mid Open Woodland of *Eucalyptus victrix* (occasionally with *Corymbia hamersleyana* and *Eucalyptus camaldulensis*) over Tall Sparse Shrubland to Tall Shrubland of *Acacia pyrifolia* subsp. *pyrifolia*, *A. trachycarpa* and *Atalaya hemiglauca* over Mid Isolated Clumps of Shrubs to Mid Open Shrubland of *Acacia bivenosa* over Low Isolated Clumps of Shrubs of **Aerva javanica*, *Gossypium australe* and *Sida rohlenae* subsp. *rohlenae* on redbrown or red sand or sandy loam in drainage lines and stony outwash areas associated with drainage lines.	'Potential (localised patches)'	The main upper stratum tree layer was dominated by non-phreatophytic taxa; although *E. camaldulensis* occurred it did not dominate. However, the majority of the mapped area of this VT has access to groundwater, with no impeding layer as it occurs on sandy to sand loams on drainage lines. Potential GDV areas may be located where groundwater is within 10m of the ground surface.
7: Low Isolated Clumps of Trees to Mid Open Woodland of *Corymbia hamersleyana*, *Eucalyptus leucophloia* subsp. *leucophloia* and/or *E. victrix* (occasionally *C. candida* subsp. ?*dipsodes*) over Tall Sparse to Tall Shrubland of *Acacia pyrifolia* subsp. *pyrifolia* and *A. tumida* var. *pilbarensis* (occasionally *A. acradenia*, *A. inaequilatera*, *A. eriopoda*, *A. trachycarpa*, *Ehretia saligna* var. *saligna* and *Grevillea wickhamii* subsp. *hispidula*) over Mid Isolated Clumps of Shrubs to Mid Shrubland of *Acacia acradenia*, *A. bivenosa* and/or *A. trachycarpa* (occasionally **Aerva javanica*, *Gossypium australe*, *Carissa lanceolata*, *Petalostylis labicheoides*, *Santalum lanceolatum* or *Scaevola spinescens*) over Low Isolated Clumps of Shrubs to Low Open Shrubland of *Corchorus parviflorus* and/or *Indigofera monophylla* on brown to red-brown sandy loam, sandy clay, clay loam or sand in drainage lines (of any size) and associated floodplains adjacent to the main range.	'Potential (localised patches)'	Although *Sesbania cannabina* was recorded in this VT, it was not widespread nor a dominant taxon in this VT. As a whole, the vegetation is more likely to be dependent upon surface water drainage. However, localised areas of potential GDV may be present where the groundwater naturally occurs within 10m of the surface (Figure 15).

Atlas Iron required ground truthing of riparian vegetation within the McPhee Creek survey area to confirm Woodman's interpretation of groundwater dependence. However, due to lack of access this was not possible during the allocated field survey time.

3 FLORA AND VEGETATION SURVEY METHODS

3.1 GUIDING PRINCIPLES

The flora and vegetation survey was conducted as a Detailed survey according to the Flora and Vegetation Technical Guidance (EPA 2016c). The EPA considers that a Detailed survey requires:

- a comprehensive survey design, including giving consideration to the survey timing that should be conducted during the primary season of the survey for the bioregion and disturbance events, and the potential requirement for supplementary surveys
- a minimum of three quadrats (in proportion to the extent of the vegetation unit), located throughout each preliminary vegetation types sampled throughout its geographic range, with additional quadrats and rescoring during supplementary surveys to clarify vegetation unit boundaries
- regional surveys if there is insufficient information available (identified during the desktop assessment) to provide local and regional context
- the survey may include a number of sampling techniques including quadrats, relevés, transects and traverses, as well as opportunistic observations
- the flora inventory should be comprised of data collected from quadrats and relevés, supplemented by opportunistic observations, systematic surveys and targeted inspections of various habitat areas
- it may be appropriate to increase survey effort in areas of unusual habitat
- sampling sites that are placed at representative locations throughout the survey area considering landform, geology, elevation, slope, aspect, surface or groundwater expression and soil type, as well as vegetation structure, composition and condition.

3.2 METHODS

The methods utilised during the field survey followed those outlined in the Flora and Vegetation Technical Guidance (EPA 2016c), conducted as a single-phase survey. The survey was within the period considered optimal for a primary season of survey within the bioregion, being conducted during April 2020.

Conservation criteria used in this assessment are included in **Table 17** and **Table 18** in **Appendix One**.

Survey method details are outlined below.

3.2.1 FLORISTIC QUADRATS

Floristic quadrat ('quadrat') locations were selected using aerial photography, environmental values, and field observations to best represent the vegetation values existing at the site. The unmarked quadrats were 50 m x 50 m in dimension, as required according to the Flora and Vegetation Technical Guidance 2016. Where the vegetation consisted of a narrow linear corridor, quadrats were linear but of the same overall size i.e. 2,500 m^2.

The following information was collected from within each quadrat:

- observer
- date
- quadrat/site number
- GPS location (GDA94) of the northwest corner
- digital photograph (spatially referenced with a reference number), taken from the northwest corner, looking diagonally across the quadrat

- soil type and colour
- topography
- list of flora species recorded with the average height and total cover within the quadrat for each species
- vegetation description (as per below)
- vegetation condition.

At least three quadrats per vegetation type were recorded for the Detailed survey where there was sufficient extent.

All quadrat locations are displayed on the **Map 6** series.

3.2.2 TARGETED SEARCHES

PF identified during the desktop analysis and previous surveys as known or having the potential to occur were targeted for searches in areas of potential habitat (noting that no TF have been recorded from within 50 km of the survey area and are, therefore, highly unlikely to occur).

The locations of all targeted taxa collected were recorded using a handheld GPS with the following data recorded:

- observer, date and time
- reproductive status and other features such as the health of plants, percentage flowering and fruiting
- local abundance/population size and/or population boundary, including outside the development envelopes where possible
- landform
- brief vegetation community description
- representative photos of each species and habitat
- collection of representative specimens.

Approximately four field person days were dedicated to targeted searches.

3.2.3 INTRODUCED SPECIES

Introduced species (weeds) were recorded during the collection of the overall flora inventory.

The field survey included searches for WONS and Declared Pest plants. Their locations and numbers/extents were recorded where noted during the field survey, and each WONS or Declared Pest plant species photographed.

3.2.4 VEGETATION DESCRIPTION AND CLASSIFICATION

Vegetation was described from each of the quadrats using the height and estimated cover of dominant and characteristic species of each stratum based on the National Vegetation Information System, recorded at Level V (NVIS Technical Working Group 2017) (**Table 20** and **Table 21** in **Appendix One**). Up to three species per stratum from each stratum (upper, mid and ground) were used to formulate vegetation descriptions for each quadrat and each vegetation type.

Vegetation type descriptions were created by combining quadrat descriptions and modifying, where necessary, based in the broader vegetation. Vegetation codes were formulated using the first letter of genus and species names of the dominant species of each stratum, e.g. **ChAiTe** refers to ***C****orymbia* ***h****amersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* low woodland over ***A****cacia* ***i****naequilatera*, *A. bivenosa* and *Indigofera monophylla* low isolated shrubland over ***T****riodia* ***e****pactia* low hummock grassland. Where more than one species has the same code they are distinguished by using the second letter of the species name e.g. **Cca** refers

to ***C**orymbia **ca**ndida* subsp. *dipsodes* whereas **Cci** refers to ****C**enchrus **ci**liaris*. Where the dominant species make up more than one version of the same code they are distinguished by a number at the end of the code (e.g. **AiTw1**).

3.2.5 VEGETATION CONDITION ASSESSMENT

Vegetation condition was assessed broadly and continuously throughout the survey area and at each quadrat using the Vegetation Condition Scale for the Eremaean and Northern Botanical Provinces (EPA 2016c) (**Table 22** in **Appendix One**). As quadrats are positioned in the best condition parts of a vegetation type, the condition rating of the quadrat may not match that of the broader vegetation type due to the scale of mapping.

In areas that were not accessible or accessed during the field survey, including where proposed development areas have altered since the field survey, vegetation condition is extrapolated based adjacent areas and surveyor understanding of likely disturbance factors, particularly grazing in favoured areas.

3.3 MAPPING

Some parts of the survey area were not accessible or accessed during the field survey, leading to a variety of techniques being used to define and describe the vegetation within the overall survey area, as below.

3.3.1 GROUND-TRUTHED FIELD SURVEY

The main body of the survey area and accessible areas of proposed roads were subject to field survey in 2020; these are referred to as 'survey area' (without qualification) in the mapping data.

3.3.2 EXTRAPOLATED SURVEY AREA

Part of the nominated survey area corresponding with a proposed haul road was not accessible during the field survey due to asbestos contamination. A further section was included in the survey area after the field survey had been completed (GIS data provided on 22 June 2020, after submission of the draft report).

The vegetation types and condition in these parts were extrapolated from adjacent areas using aerial imagery interpretation and the surveyor's understanding of the landscape based on the conditions in nearby areas. Survey limitations are detailed in **Section 0**. The aerial imagery interpretation utilised identifiable factors including landscape position, slope, presence or absence of trees and large shrubs, colour and density of grass layer and substrate colour and intensity to compare with adjacent areas and thus adjacent vegetation types. Changes in these factors were used to indicate changes in vegetation types. Land systems, which take into consideration vegetation, topography and geology GIS layers were also used as a guide to determine if nearby vegetation was likely to be similar.

Some creeklines within the area that were inaccessible during the field survey had previously been surveyed by Woodman (2014b); the vegetation type and condition assessment and mapping in these areas were interpolated from previous results, and are indicated on maps and data as the following (interpolated mapping) rather than extrapolated mapping.

Note that extrapolated vegetation mapping does not indicate presence or absence of conservation-listed species.

3.3.3 INTERPOLATED SURVEY AREA

The creeklines to the southeast of the main body of the survey area were not accessed during the 2020 field survey. Previous vegetation mapping by Woodman (2014b), which is Ecoscape's opinion is accurate although more detailed than required according the Flora and Vegetation Technical Guidance (EPA 2016c) i.e. mapped

as Level VI rather than Level V according to the NVIS system (NVIS TWG 2017), along with the floristic quadrat data, was used to determine vegetation types in the area.

The vegetation types along the creeklines are considered to represent interpolated vegetation types.

3.3.3.1 Groundwater Dependence

The classification of vegetation as being representative of a GDV or potential GDV took into consideration the following:

- interpolated vegetation type (see above)
- depth to groundwater, as per **Section 2.5.1.4**, with 10 m below the ground surface being considered as the maximum depth at which tree roots are likely to be able to extend to access groundwater. GIS data was not available, and depth to groundwater was taken from maps in Woodman (2014b; 2019a) reports, georeferenced where possible and extrapolated (and therefore estimated) where there was insufficient coverage. Areas with insufficient coverage were close to Nullagine River thus likely have groundwater close to the surface.
- presence or absence of phreatophytic (or potentially phreatophytic) species, principally *Eucalyptus camaldulensis* that was considered, where depth to groundwater is less than 10 m, to be an obligate phreatophyte (and a facultative phreatophyte where depth to groundwater is greater), and *Eucalyptus victrix*, which may be potentially phreatophytic (i.e. facultatively phreatophytic) where it can access groundwater (i.e. less than 10 m to groundwater) or a vadophyte where it is unlikely to be able to access groundwater.

GDV was considered, in agreeance with Woodman's earlier assessment, to be indicated by the presence of a vegetation type characterised by *Eucalyptus camaldulensis* although other phreatophytic or potentially phreatophytic species may also be present, where depth to groundwater was less than 10 m.

Potential GDV was considered to occur where the potential/facultative phreatophytic *Eucalyptus victrix* was present as a characteristic species, where the depth to groundwater was less than 10 m below the surface, or presence of *Eucalyptus camaldulensis* where groundwater was more than 10 m below the surface. Presence of *Eucalyptus victrix* in areas where groundwater is typically more than 10 m below the surface is unlikely to represent GDV.

3.4 STATISTICAL ANALYSIS

3.4.1 FLORISTIC ANALYSIS

Interpretation of floristic groups into recognisable and mappable on-ground units is a tool used to identify broad vegetation types. Generally, quadrats that are closely floristically related on the dendrogram form identifiable vegetation units; however, interpretation is frequently required for imperfect results. Vegetation types are therefore determined as a combination of floristic analysis and on-ground interpretation using dominant and characteristic species.

JUICE software (Tichý 2002) was used to assist in the translation of non-hierarchical data (quadrats) into a system of hierarchical floristic groups based on species co-occurrence. To that end, we applied the OptimClass (Tichý *et al.* 2010) routine (through JUICE) to achieve the following: (1) to identify the most robust choice of data transformation, resemblance measure and clustering algorithm, and (2) to assist in the selection of the optimal number of clusters. The OptimClass routine is intuitive; it promotes the choice of data transformation, resemblance measure and clustering algorithm which produces a 'robust classification'. Essentially a

classification is considered robust when the floristic groups are defined by a high number of 'diagnostic species' (i.e. species which occur at a high frequency within a floristic group and a low rate across other groups).

The application of JUICE and OptimClass is prevalent across Europe (Indreica 2012; Lengyel *et al.* 2016; Purger *et al.* 2014), Africa (Lötter *et al.* 2013) and is gaining momentum as an expert tool designed to assist ecologists in vegetation classification within Western Australia (Mucina *et al.* 2019; Mucina & Daniel 2013; Tsakalos *et al.* 2019).

Vegetation Type descriptions were developed using three main features: 'diagnostic', 'constant' and 'dominance'. The IndVal procedure as offered by Dufrêne and Legendre (1999) and presented in the R package *labdsv* (Roberts 2016) was used to identify diagnostic species ($P \leq 0.05$). Species occurring in greater than 50% of the quadrats in a vegetation type were defined as constant. Species with greater than 3% project cover abundance (%) were defined as dominant.

3.4.2 MULTIVARIATE PATTERNS AND DRIVERS

To identify broad environmental drivers explaining the vegetation type patterns we applied a distance-based redundancy analysis (db-RDA; Legendre & Anderson M.J. 1999). A db-RDA is an ordination method used to visually present and interpret the environmental drivers of the newly defined vegetation types. This method was applied to enhance the descriptions of the environment in which the vegetation types occur. The datasets used in the dB-RDA analysis include the species × site data generated and a newly defined environmental dataset.

The environmental data was collected using CSIRO's TERN soil layers (Viscarra Rossel *et al.* 2015) and topographic variables (aspect, elevation and slope). The topographic variables were derived from NASA Earth Explorer's non-void filled radar topographic mission series at a 90 m resolution (Farr *et al.* 2007). The Soil and Landscape Grid of Australia provides relevant, consistent, comprehensive, nation-wide data in an easily accessible format at a 90 m resolution. The specific soil variables that were used in the environmental data were:

- Bulk Density (BD; Bulk Density of the whole soil (including coarse fragments) in mass per unit volume by a method equivalent to the core method)
- Organic Carbon (C; Mass fraction of carbon by weight in the <2 mm soil material as determined by dry combustion at 900 Celcius)
- Clay (Clay; < 2 um mass fraction of the <2 mm soil material determined using the pipette method)
- Silt (Silt; 2-20 um mass fraction of the <2 mm soil material determined using the pipette method)
- pH (pH; pH of 1:5 soil/0.01M calcium chloride extract)
- Available Water Capacity (AWC; Available water capacity computed for each of the specified depth increments)
- Total Nitrogen (TN; Mass fraction of total nitrogen in the soil by weight)
- Total Phosphorus (TP; Mass fraction of total phosphorus in the soil by weight)
- Effective Cation Exchange Capacity (ECEC; Cations extracted using barium chloride (BaCl2) plus exchangeable H + Al)
- Depth of Regolith (DOR; Depth to hard rock. Depth is inclusive of all regolith)
- Depth of Soil (DOS; Depth of soil profile (A & B horizons)).

All calculations were conducted using the Vegan package (Oksanen *et al.* 2019) in the R statistical Program (R Core Team 2019).

3.4.3 ADEQUACY OF SAMPLING

In order to demonstrate adequacy of sampling, a species accumulation curve was generated by the software *Species Diversity and Richness IV* (Pisces Conservation Ltd 2010) using five random selections of sample order, and using quadrat data only.

Species accumulation curves were also generated using the *specaccum* function offered by the vegan R package (Oksanen *et al*. 2007). A separate curve was generated for floristic data collected by Woodman during 2014 and 2019 (Woodman Environmental Consulting Pty Ltd 2014c; Woodman Environmental Consulting Pty Ltd 2019a) and the newly established quadrats. Confidence intervals for each curve were generated by adding random quadrats using 1000 permutations.

4 RESULTS

4.1 FLORA AND VEGETATION SURVEY

4.1.1 FIELD SURVEY TIMING

The 2020 Ecoscape field survey was conducted by Dr James Tsakalos (Senior Botanist, flora licence FB62000163 and Threatened Species Licence TFL 58-1920) and assisted by Ms Bronte Winterbottom (Botanist). The field survey was conducted during the 9–19 April, which is within the optimal period for a primary survey within the Pilbara bioregion according to the Flora and Vegetation Technical Guidance (EPA 2016c). The rainfall before the field survey was above average, with 91% of the mean rainfall in the 5 months before the survey (**Figure 3**). Most of this rainfall followed Tropical Cyclone Blake during January 2020, approximately 3 months before the survey.

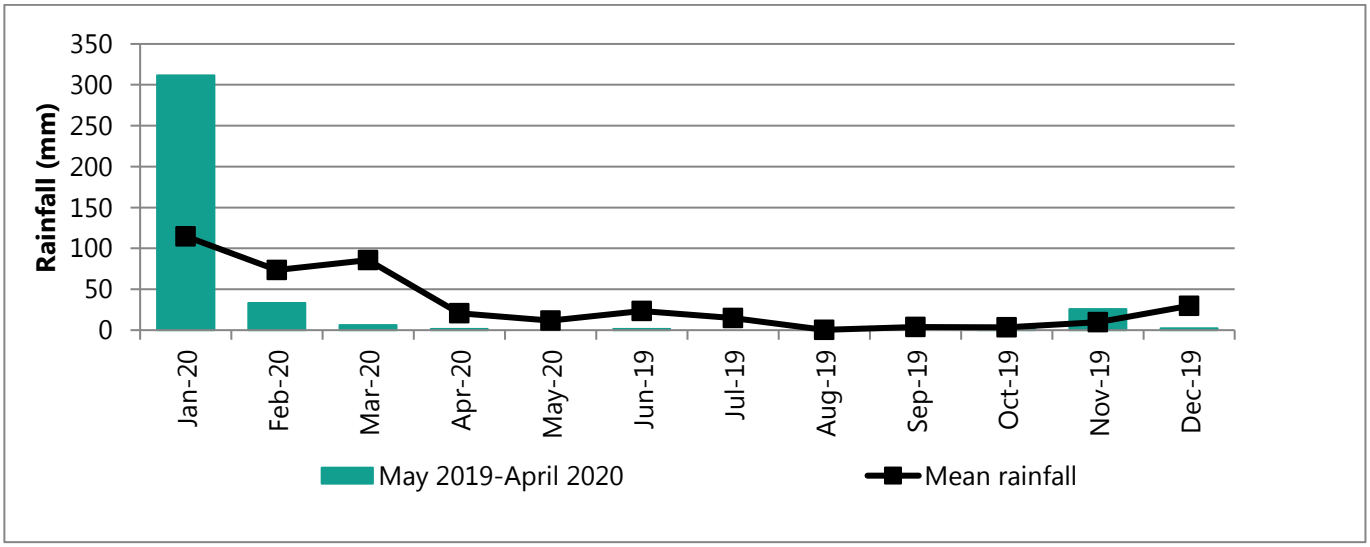


Figure 3: Mean rainfall and rainfall before the field survey(Marble Bar, BoM 2020a)

Where noted, the results that follow take into consideration previous mapping and floristic quadrat data from earlier Woodman surveys.

4.1.2 FLORA

The combined site x species table for all quadrats within the survey area and Ecoscape 2020 opportunistic observations is **Table 24** in **Appendix Three**. Ecoscape 2020 quadrat data is presented in **Appendix Four**.

4.1.2.1 2020 Ecoscape Survey

Forty-two quadrats were established during the 2020 Ecoscape field survey, resulting in 224 vascular flora being recorded from 34 families and 97 genera from the quadrats and opportunistic observations.

The most represented families were Fabaceae with 51 taxa, Poaceae (42 taxa) and Malvaceae (24 taxa). The most represented genera were *Acacia* with 26 taxa, *Ptilotus* (nine taxa) and *Senna* (nine taxa). The most frequently recorded taxa were *Triodia epactia* (from 33 quadrats), *Indigofera monophylla* (32) and *Corchorus parviflorus* (31). A small portion (6.7%) of the flora could not be identified with certainty due to the lack of reproductive material largely due to the slightly below average seasonal conditions and intensive grazing.

The number of species per quadrat ranged from 11 (quadrat MC20Q20) to 50 (quadrat MC20Q12). The average species diversity per quadrat was 28; there was no significant difference (P = 0.806) between the average species diversity per quadrat between existing surveys.

4.1.2.2 Combined

Incorporating the Ecoscape 2020 quadrats and opportunistic observations, plus all quadrats established by Woodman within the survey area (including creeklines) over a number of survey periods, the following have been recorded from within the entire survey area:

- 182 floristic quadrats
- 370 vascular flora taxa including five conservation-listed species (see **Section 4.1.3** below) and 16 introduced species (see **Section 4.1.5** below).

4.1.3 CONSERVATION-LISTED FLORA

No Commonwealth EPBC Act or Western Australian BC Act-listed Threatened Flora were recorded during the field survey, nor were anticipated to occur as none have been previously recorded from within 50 km of the survey areas.

Three PF were recorded during 2020, summarised in **Table 9** and described in more detail in **Table 10**. Locations are presented in the **Map 5** series.

Table 9: Summary of Priority Flora recorded within survey area during 2020

Status	Taxon	# Locations	# Individuals
P1	*Acacia aphanoclada*	80	2,000
P3	*Rostellularia adscendens* var. *latifolia*	1	2
P4	*Ptilotus mollis*	1	4

4.1.3.1 Previously Recorded Conservation-Listed Flora

Two Priority-listed flora taxa (*Eragrostis crateriformis* and *Goodenia nuda*) have been previously recorded from the survey areas; these were not recorded during the survey.

Eragrostis crateriformis (P3)

There are 63 locations of *Eragrostis crateriformis* located within the McPhee Creek survey area along the entry road; these records are from previous surveys (Woodman 2014c; 2014d). During the 2020 survey the location and surrounding area were searched and several (n = 4) collections of annual *Eragrostis* spp. matching the description were collected throughout the survey area, however, no *Eragrostis crateriformis* plants were located. Several of these locations along roads in depressions on clayey loam and clay were rechecked; it is considered likely that *Eragrostis crateriformis* has a scattered/sporadic distribution within the survey area and responds strongly to seasonal rainfall events. We consider that the identification of this species by Woodman is likely to be correct.

Goodenia nuda (P4)

There is one record of *Goodenia nuda* located ca. 2 km southwest of the McPhee camp; this record is from a previous survey (Woodman 2014c). This previous record was not vouchered, and inspection of Woodman's identification notes suggested that the collection was not a perfect match for this taxon. Further, although retained in Atlas Iron's GIS data, Woodman (2019a, p111) suggests this was a mis-identification. During the 2020 survey the adjoining drainage line vegetation close to where the record was located was checked and

several independent collections were made for the taxon; no *Goodenia nuda* plants were confirmed. Therefore, it is likely that this species has been incorrectly identified in the past.

Table 10: Priority Flora species recorded from the survey

Acacia aphanoclada				
	Description (WAH 1998-2020; 2020)	**Habitat (WAH 1998-2020; 2020)**	**Survey Results**	**Photograph**
P1	Slender, wispy, glabrous, single-stemmed shrubs to 5 m tall. Flowers yellow from August–October.	This taxon has been recorded from rocky spinifex (*Triodia* spp.) hills with scattered eucalypts and acacias. Occurs on Mosquito Creek sediments and on conglomerates. Distribution: 44 records from the Chichester area in the Pilbara region.	**Records**: 80 locations featuring over 2,000 individual plants. **Populations**: 1 large population along the haul road to the south-west of the survey area. **Habitat**: Occurs at high frequencies in the **ChAiTe** vegetation type	
Rostellularia adscendens* var. *latifolia				
	Description (WAH 1998-2020; 2020)	**Habitat (WAH 1998-2020; 2020)**	**Survey results**	**Photograph**
P3	Herb or shrub growing to 0.1–0.3 m high with blue-purple-violet flowers in April and May.	This taxon has been recorded from ironstone soils, near creeks and on rocky hills. Distribution: 42 records from the Ashburton and East Pilbara areas in the Pilbara region. 313 records from New South Wales, the Northern Territory, Queensland and South Australia.	**Records**: 1 location totaling 2 individuals. **Populations**: 1 small population along the haul road to the north-east of the survey area. **Habitat**: Occurs in the **EvApyCci** vegetation type	

Ptilotus mollis				
	Description (WAH 1998-2020; 2020)	**Habitat (WAH 1998-2020; 2020)**	**Survey results**	**Photograph**
P4	Hairy, compact erect perennial shrub growing to 0.5 m high with pink/white flowers.	Has been recorded from rock piles, scree, gorges, riverbeds and alluvial soils. Distribution: 37 records from the Chichester, Hamersley, Roebourne and Rudal areas in the Little Sandy Desert and Pilbara regions.	**Records**: 1 location totaling 4 individuals. **Populations**: 1 population to the north-east of the survey area. **Habitat**: Occurs at high frequencies in the **ChAiTe** vegetation type	

4.1.3.2 Post-survey Likelihood Assessment

Following field survey, when additional information was available regarding actual habitat availability and searches have been conducted, the likelihood of conservation-listed flora occurring in the survey area was revised. This revised likelihood, that took into account vegetation condition, grazing and other disturbances, actual habitat availability and search effort, is included in **Table 23** in **Appendix Two**.

The likelihood of detection was decreased for four species; all other species remained unchanged. No species that have not previously been recorded were considered likely to occur (i.e. have a High likelihood of occurring) in the survey area.

4.1.4 OTHER SIGNIFICANT FLORA

None of the flora taxa recorded from the survey area are considered to represent range extensions of any significance.

4.1.5 INTRODUCED FLORA

Seven introduced flora species (weeds), representing 3.13% of the total flora species, were recorded during the 2020 field survey (**Table 11**). **Cenchrus ciliaris* (Buffel grass) was the most recorded introduced species occurring in 12 of 42 quadrats (30 quadrats from the total of 149 quadrats recorded within the survey area). Buffel Grass (including suspected occurrences) contributed to vegetation condition assessment along drainage lines.

One of the introduced flora species (**Calotropis procera*, Rubber Bush; **Image 1** and **Image 2**) is a Declared Pest plant and was found amongst an outcropping in the central survey area; it had not been previously recorded. Locations of introduced species are shown on **Map 7**. Six of the these introduced taxa are ranked as having High ecological impact and rapid invasiveness for the Pilbara Region (Department of Parks and Wildlife [DPaW] 2013); *Calotropis procera* is not listed by DPaW (see below).

Table 11: Ecological impact and invasiveness ratings of introduced flora species recorded from the survey ranked according to DPaW's Pilbara Region Species Prioritisation Process (DPaW 2013)

Species name	Common Name	Number of Records and Individuals in the Survey Area	Ecological Impact (DPaW 2013)	Invasiveness (DPaW 2013)
**Calotropis procera*[A]	Rubber Bush	1 (2)	-	-
Aerva javanica* (Image 3**)	Kapok Bush		High	Rapid
**Cenchrus ciliaris*	Buffel Grass		High	Rapid
**Cenchrus setiger*	Birdwood Grass		High	Rapid
**Cynodon dactylon*	Couch		High	Rapid
**Echinochloa colona*	Awnless Barnyard Grass		High	Rapid
**Malvastrum americanum*	Spiked Malvastrum		High	Rapid

[A]Ranked as a 'Priority Alert' – this species found within the Pilbara Region but not on DPaW managed lands or waters it has not been ranked according to its ecological impact or invasiveness.

Image 1: *_Calotropis procera_

Image 2: *_Calotropis procera_

Image 3: *_Aerva javanica_

Woodman, over all of its surveys encompassing the current survey area, recorded an additional nine introduced species: **Argemone ochroleuca* (Mexican Poppy), **Chloris barbata* (Purpletop Chloris, Feathertop Rhodes Grass), **Citrullus amarus* (Pie Melon), **Euphorbia hirta* (Asthma Plant), **Flaveria trinervia* (Speedy Weed), **Portulaca pilosa* (Djanggara), **Setaria verticillata* (Whorled Pigeon Grass), **Sonchus oleraceus* (Common Sowthistle) and **Vachellia farnesiana* (Mimosa Bush). None are Declared Pest or WoNS species.

4.2 VEGETATION

Vegetation was defined using all existing (140) and new quadrats (42) located within the McPhee Creek survey area, totalling 182 quadrats.

Nineteen vegetation types belonging to two floristic super-groups were recorded from within the survey area (**Table 12)**, based on structural vegetation type as identified in the field, floristic analysis and subsequent desktop review. The extents of the vegetation types and representative quadrat locations are shown on the **Map 6** series. Interpolated (i.e. based on previous Woodman mapping) and extrapolated (i.e. based on adjacent and nearby mapping but not ground-truthed) vegetation types are indicated on these maps. Extents of each vegetation type are shown in **Table 13**.

The split between the three floristic super-groups has both a floristic and environmental foundation. The first supergroup contains vegetation types with emergent/dominant *Eucalyptus leucophloia* subsp. *leucophloia* (i.e. woodlands and isolated trees) coupled with *Acacia monticola, Acacia ptychophylla, Triodia brizoides* and *Triodia epactia* as diagnostic species (i.e., $P < 0.05$). The second floristic supergroup contains a different suite of upper stratum trees and higher densities of tussock grasses with the following species considered diagnostic: *Eucalyptus victrix, E. camaldulensis*, *Atalaya hemiglauca* and Cenchrus ciliaris. The third floristic supergroup contains high densities of mixed shrublands with the following species considered diagnostic: *Acacia inaequilatera* and *Triodia wiseana*.

Distance-based redundancy analysis performed on the synoptic table and environmental data shows a clear split between the three super-groups (**Figure 4**). The first (grey) and third (green) supergroups occupy areas in the landscape featuring high elevation and slope (i.e. hillslopes and crests), clay, silt, and soil organic carbon compared to the second (red) and third (green) supergroups. The third supergroup occupies lower sloping areas (i.e. foothills) in the landscape featuring deeper soil (DES), regolith (DER) and higher available water capacity (AWC) compared to the first supergroup. The second supergroup is located in low elevation and low slope (i.e. flat) areas in the landscape and contains high AWC.

The vegetation types recorded from the survey area can be broadly grouped based on the following landform types:

- predominantly hillcrests/hillslopes: **AiTw2**, **AiTw1, CcaAiTe**, **ChAiTe**, **ChAiTa**, **ChAiTw**, **ElAbTe**, **ElAptTe**, **ElAmTb**, **ElAmTe**, **ElGwTe**
- stony plains: **AoTl**, **AsTe**, **AsTl**, **AtTe**
- predominantly drainage lines: **ChAmTe**, **ChApyTt**, **EcApyCci**, **EvApyCci**.

A summary of consolidated vegetation types (i.e. those previously described during the earlier Woodman surveys) and the vegetation type units described herein is provided in **Table 25** in **Appendix Three**.

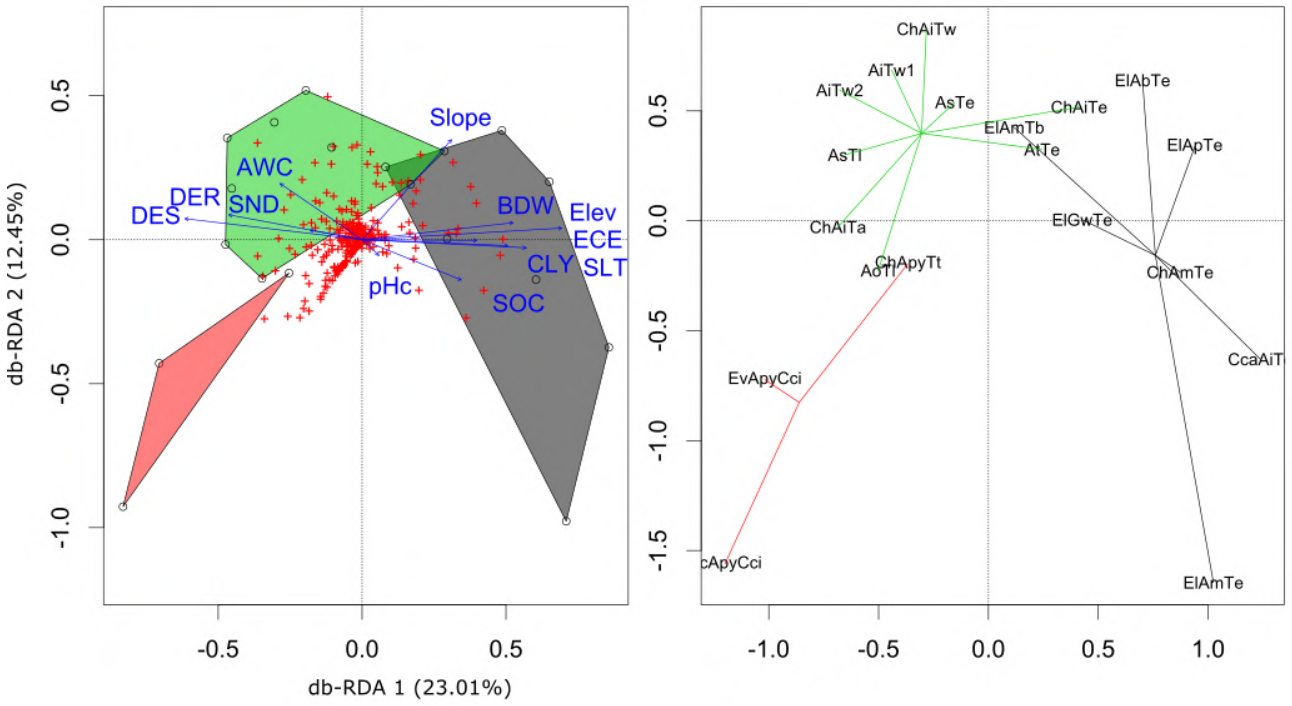


Figure 4: Distance-based redundancy analysis of the McPhee Creek vegetation

Table 12 Vegetation types

Land-form	Mapping Unit and Floristic Quadrats	Vegetation Type	Representative Photograph	Other Characteristic Species
Stony Plain/Hillcrest/Hillslope	**AiTw1** MC048 MC050 MC053 MC059 **MC066** MC072 MC108 MC110 MC121 MC122 MC129 MC153	*Acacia inaequilatera* and *A. bivenosa* mid isolated shrubs over *Triodia wiseana* hummock grassland	 Photo from Woodman (2019a)	**Diagnostic:** *Swainsona decurrens, Triodia wiseana* **Constant:** *Acacia inaequilatera, Triodia wiseana, Senna symonii, Senna glutinosa* subsp. *glutinosa, Swainsona decurrens* **Dominant:** *Triodia wiseana, Triodia longiceps, Acacia bivenosa, Corymbia hamersleyana, Acacia inaequilatera, Acacia orthocarpa*
Hillcrest/Hillslope	**AiTw2** MC012 MC051 MC130 MC131 MC20OP01 **MC20Q13** MC20Q16 MC20Q17 RC415	*Acacia inaequilatera* and *A. bivenosa* mid isolated shrubs over *Triodia wiseana* and *T. longiceps* mid hummock grassland		**Diagnostic:** *Boerhavia coccinea, Bulbostylis barbata, Sida echinocarpa, Tragus australianus* **Constant:** *Acacia inaequilatera, Aristida contorta, Bulbostylis barbata, Sida echinocarpa, Cleome viscosa, Fimbristylis dichotoma, Triodia wiseana, Boerhavia coccinea, Corchorus lasiocarpus* subsp. *lasiocarpus, Hibiscus sturtii* agg., *Senna glutinosa* subsp. *glutinosa x luerssenii, Triumfetta clementii, Gomphrena cunninghamii, Indigofera monophylla, Senna artemisioides* subsp. *oligophylla, Senna glutinosa* subsp. *pruinosa, Triodia brizoides, Triodia longiceps* **Dominant:** *Triodia epactia, Triodia brizoides, Triodia wiseana, Acacia synchronicia, Acacia bivenosa, Heliotropium crispatum, Triodia longiceps, Acacia orthocarpa, Gossypium australe, Acacia inaequilatera*

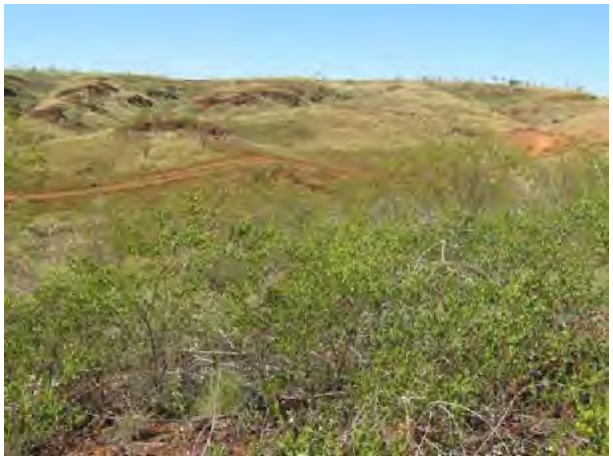
Land-form	Mapping Unit and Floristic Quadrats	Vegetation Type	Representative Photograph	Other Characteristic Species
Stony Plain	**AoTl** MC20Q22 **MC20Q23** MC20Q25	*Acacia orthocarpa, A. monticola* and *A. bivenosa* low sparse shrubland over *Triodia longiceps* and *T. epactia* low hummock grassland		**Diagnostic:** *Acacia orthocarpa, Alysicarpus muelleri, *Cenchrus setiger, Euphorbia* sp., *Triodia longiceps* **Constant:** *Acacia bivenosa, Acacia monticola, Acacia orthocarpa, Alysicarpus muelleri, Fimbristylis dichotoma, Rhynchosia minima, Triodia longiceps, Acacia inaequilatera, *Cenchrus ciliaris, *Cenchrus setiger, Corchorus parviflorus, Euphorbia* sp. , *Goodenia microptera, Indigofera linifolia, Pluchea ferdinandi-muelleri, Senna artemisioides* subsp. *helmsii, Senna glutinosa* subsp. *glutinosa, Senna symonii, Sporobolus australasicus, Stemodia grossa, Triodia epactia* **Dominant:** *Triodia longiceps, Triodia epactia, Acacia monticola, Acacia bivenosa*
Stony Plain	**AsTe** **MC20OP03** MC20Q05 MC20Q19	*Acacia synchronicia, A. bivenosa, A. inaequilatera* tall open shrubland over *Triodia epactia* low open hummock grassland		**Diagnostic:** *Goodenia muelleriana, Senna glutinosa* subsp. *glutinosa x luerssenii* **Constant:** *Acacia inaequilatera, Aristida contorta, Cleome viscosa, Corchorus parviflorus, Eriachne pulchella* subsp. *dominii, Goodenia muelleriana, Gossypium australe, Senna glutinosa* subsp. *glutinosa x luerssenii, Sida echinocarpa, Triodia epactia, Acacia acradenia, Acacia bivenosa, Acacia synchronicia, Hibiscus sturtii* agg., *Indigofera monophylla, Ptilotus calostachyus, Senna glutinosa* subsp. *pruinosa, Senna symonii, Sida fibulifera, Sida* sp. Pilbara (A.A. Mitchell PRP 1543), *Sporobolus australasicus, Themeda triandra, Trigastrotheca molluginea, Triodia wiseana* **Dominant:** *Triodia epactia, Acacia synchronicia, Acacia bivenosa, Acacia inaequilatera*

Land-form	Mapping Unit and Floristic Quadrats	Vegetation Type	Representative Photograph	Other Characteristic Species
Stony Plain	**AsTl** MC057 MC146 MC147 MC148 MC150 **MC152**	*Acacia synchronicia* mid isolated shrubs over *Triodia longiceps* and *Triodia wiseana* mid sparse hummock grassland	 Photo from Woodman (2019a)	**Diagnostic:** *Abutilon malvifolium, Abutilon oxycarpum* subsp. Prostrate (A.A. Mitchell PRP 1266), *Aristida contorta, Aristida latifolia, Brachyachne convergens, Carissa lanceolata, Corchorus tridens, Dichanthium sericeum* subsp. *humilius, Eragrostis setifolia, Eriachne pulchella* subsp. *dominii, Euphorbia trigonosperma, Heliotropium cunninghamii, Neptunia dimorphantha, Operculina aequisepala, Ptilotus aervoides, Ptilotus exaltatus, Sclerolaena costata, Senna artemisioides* subsp. *oligophylla, Sporobolus australasicus, Streptoglossa bubakii, Streptoglossa liatroides, Trianthema triquetrum* **Constant:** *Acacia synchronicia, Aristida contorta, Brachyachne convergens, Triodia longiceps, Senna artemisioides* subsp. *oligophylla, Triodia wiseana, Acacia bivenosa, Corchorus lasiocarpus* subsp. *lasiocarpus, Heliotropium cunninghamii, Hibiscus sturtii* agg.*, Neptunia dimorphantha, Pluchea tetranthera, Polycarpaea holtzei, Polygala isingii, Ptilotus aervoides, Sclerolaena costata, Senna symonii, Sida fibulifera* **Dominant:** *Triodia wiseana, Triodia longiceps, Eragrostis setifolia, Acacia synchronicia, Chrysopogon fallax, Dichanthium sericeum* subsp. *humilius, Acacia inaequilatera, Sporobolus australasicus, Themeda triandra*

Land-form	Mapping Unit and Floristic Quadrats	Vegetation Type	Representative Photograph	Other Characteristic Species
Stony Plain	**AtTe** MC20OP10 MC20OP11 **MC20Q21**	*Acacia trachycarpa* low sparse mallee shrubland over *Triodia epactia* and *T. brizoides* open hummock grassland		**Diagnostic:** *Acacia* sp., *Bonamia erecta, Bonamia pilbarensis, Heliotropium chrysocarpum* **Constant:** *Acacia* sp., *Aristida contorta, Bonamia erecta, Bulbostylis barbata, Eriachne pulchella* subsp. *dominii, Fimbristylis dichotoma, Heliotropium chrysocarpum, Indigofera monophylla, Triodia epactia, Acacia bivenosa, Acacia ptychophylla, Acacia trachycarpa, Bonamia pilbarensis, Corchorus parviflorus, Fimbristylis simulans, Goodenia microptera, Goodenia stobbsiana, Grevillea wickhamii* agg., *Hakea chordophylla, Hibiscus sturtii* agg., *Hybanthus aurantiacus, Pluchea dentex, Polycarpaea longiflora, Ptilotus calostachyus, Scaevola amblyanthera* var. *centralis, Senna notabilis, Sida* sp. Pilbara (A.A. Mitchell PRP 1543), *Sporobolus australasicus, Trigastrotheca molluginea, Triodia brizoides, Triodia wiseana* **Dominant:** *Triodia brizoides, Triodia epactia, Acacia trachycarpa, Acacia* sp.
Stony Plain/Hillcrest/Hillslope	**CcaAiTe** MC031 **MC034** MC039 MC043	*Corymbia candida* subsp. *dipsodes, C. hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees over *Acacia inaequilatera, Grevillea wickhamii* subsp. *hispidula* and *Hakea chordophylla* tall isolated shrubs over *Triodia epactia* low hummock grassland	 Photo from Woodman (2019a)	**Diagnostic:** *Amphipogon sericeus, Fimbristylis simulans, Hakea chordophylla, Ptilotus calostachyus* **Constant:** *Amphipogon sericeus, Eriachne lanata, Fimbristylis simulans, Goodenia stobbsiana, Hakea chordophylla, Ptilotus calostachyus, Triodia epactia, Acacia ptychophylla, Bonamia* sp. Dampier (A.A. Mitchell PRP 217), *Dampiera candicans, Grevillea wickhamii* agg., *Senna glutinosa* subsp. *glutinosa x luerssenii, Senna symonii* **Dominant:** *Triodia epactia, Amphipogon sericeus*

Land-form	Mapping Unit and Floristic Quadrats	Vegetation Type	Representative Photograph	Other Characteristic Species
Stony Plain	**ChAiTa** **MC060** MC067 MC073	*Corymbia hamersleyana* low isolated trees over *Acacia inaequilatera* tall isolated shrubs over *Triodia angusta* and *T. wiseana* low hummock grassland	 Photo from Woodman (2019a)	**Diagnostic:** *Stackhousia intermedia, Swainsona stenodonta, Triodia angusta* **Constant:** *Hakea lorea* subsp. *lorea, Swainsona stenodonta, Triodia angusta, Triodia wiseana, Acacia bivenosa, Acacia inaequilatera, Corymbia hamersleyana, Senna symonii, Stackhousia intermedia, Swainsona decurrens* **Dominant:** *Triodia angusta, Triodia wiseana, Corymbia hamersleyana*
Stony Plain/Hillcrest/Hillslope	**ChAiTe** MC014 MC019 MC025 MC045 MC070 MC082 MC084 MC085 MC092 MC096 MC106 MC116 MC120 MC127 MC135 MC20OP04 MC20OP05	*Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* low woodland over *Acacia inaequilatera, A. bivenosa* and *Indigofera monophylla* low isolated shrubland over *Triodia epactia* low hummock grassland		**Diagnostic:** NA **Constant:** *Triodia epactia, Acacia inaequilatera, Corchorus parviflorus, Acacia bivenosa, Indigofera monophylla, Senna glutinosa* subsp. *glutinosa, Trigastrotheca molluginea, Goodenia stobbsiana, Ptilotus calostachyus, Bonamia* sp. Dampier (A.A. Mitchell PRP 217), *Corymbia hamersleyana, Grevillea wickhamii* agg. **Dominant:** *Triodia epactia, Triodia brizoides, Triodia wiseana, Acacia tumida* var. *pilbarensis, Themeda triandra, Triodia longiceps, Indigofera monophylla, Acacia bivenosa, Acacia monticola, Acacia inaequilatera, Acacia synchronicia, Eucalyptus leucophloia* subsp. *leucophloia, Eriachne mucronata, Acacia ptychophylla, Corymbia hamersleyana, Grevillea wickhamii* agg.

Land-form	Mapping Unit and Floristic Quadrats	Vegetation Type	Representative Photograph	Other Characteristic Species
	MC20OP08 MC20Q02 MC20Q03 **MC20Q04** MC20Q08 MC20Q09 MC20Q14 MC20Q15 MC20Q18 MC20Q20 MC20Q26			
Hillcrest/Hillslope/Stony Plain	**ChAiTw** MC081 MC094 **MC097** MC109 MC20Q01	*Corymbia hamersleyana* low isolated clumps of trees over *Acacia inaequilatera, A. bivenosa* mid open shrubland over *Triodia wiseana* low hummock grassland	 Photo from Woodman (2019a)	**Diagnostic:** *Acacia inaequilatera, Bonamia* sp. Dampier (A.A. Mitchell PRP 217) **Constant:** *Acacia bivenosa, Acacia inaequilatera, Bonamia* sp. Dampier (A.A. Mitchell PRP 217), *Corchorus parviflorus, Corymbia hamersleyana, Hakea lorea* subsp. *lorea, Triodia wiseana, Indigofera monophylla, Aristida contorta, Eriachne mucronata, Goodenia microptera, Hibiscus sturtii* agg., *Senna glutinosa* subsp. *glutinosa, Sida echinocarpa, Trigastrotheca molluginea* **Dominant:** *Triodia wiseana, Acacia bivenosa, Acacia inaequilatera, Corchorus parviflorus*

Land-form	Mapping Unit and Floristic Quadrats	Vegetation Type	Representative Photograph	Other Characteristic Species
Minor Drainage Line/Hillcrest/Hillslope	**ChAmTe** MC003 MC004 MC013 MC017 MC021 MC032 MC035 MC038 MC040 MC104 **MC119**	*Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees over *Acacia monticola, A. tumida* var. *pilbarensis,* and *Grevillea wickhamii*. tall open shrubland over *Triodia epactia and Eriachne lanata low open hummock/ tussock grassland*	 Photo from Woodman (2012)	**Diagnostic:** *Dampiera candicans, Gompholobium oreophilum, Sida* sp. Articulation below (A.A. Mitchell PRP 1605), *Tephrosia virens* **Constant:** *Bonamia* sp. Dampier (A.A. Mitchell PRP 217), *Grevillea wickhamii* agg., *Ptilotus calostachyus, Sida* sp. Articulation below (A.A. Mitchell PRP 1605), *Triodia epactia, Dampiera candicans, Goodenia stobbsiana, Acacia tumida* var. *pilbarensis, Corymbia hamersleyana, Fimbristylis simulans, Gompholobium oreophilum, Indigofera monophylla, Acacia monticola, Acacia ptychophylla, Eriachne lanata, Eriachne mucronata, Hibiscus sturtii* agg., *Hybanthus aurantiacus, Senna glutinosa* subsp. *glutinosa, Acacia pyrifolia* agg., *Eucalyptus leucophloia* subsp. *leucophloia, Corchorus parviflorus, Cymbopogon ambiguus, Senna symonii, Triumfetta maconochieana* **Dominant:** *Acacia tumida* var. *pilbarensis, Acacia monticola, Triodia epactia, Eriachne lanata, Eucalyptus leucophloia* subsp. *leucophloia, Dampiera candicans, Eriachne mucronata, Eriachne benthamii, Grevillea wickhamii* agg., *Gompholobium oreophilum, Acacia ptychophylla*
Minor Drainage Line	**ChApyTt** MC042 MC098 MC107 MC111 MC145 MC151 **MC20OP02**	*Corymbia hamersleyana* low open woodland over *Acacia pyrifolia* and *Acacia tumida* var. *pilbarensis* tall shrubland over *Themeda triandra, Triodia longiceps* and *Chrysopogon fallax* tall tussock grassland/hummock grassland		**Diagnostic**: *Acacia acradenia, Acacia tumida* var. *pilbarensis, Bothriochloa ewartiana, Chrysopogon fallax, Ehretia saligna* var. *saligna, Eragrostis cumingii, Evolvulus alsinoides* var. *decumbens, Gossypium robinsonii, Hibiscus sturtii* agg., *Jasminum didymum* subsp. *lineare, Melhania oblongifolia, Polymeria ambigua, Santalum lanceolatum, Scaevola spinescens, Themeda triandra* **Constant**: *Acacia acradenia, Acacia bivenosa, Acacia pyrifolia* agg., *Corchorus parviflorus, Acacia tumida* var. *pilbarensis, Enneapogon lindleyanus, Evolvulus alsinoides* var. *decumbens, Grevillea wickhamii* agg., *Hibiscus sturtii* agg., *Hybanthus aurantiacus, Indigofera monophylla, Polymeria ambigua, Senna glutinosa* subsp. *glutinosa, Themeda triandra, Trigastrotheca molluginea, Triodia epactia, Chrysopogon fallax, Cleome viscosa, Corymbia hamersleyana, Cymbopogon ambiguus, Eragrostis cumingii, Euphorbia trigonosperma, Gossypium australe,*

Land-form	Mapping Unit and Floristic Quadrats	Vegetation Type	Representative Photograph	Other Characteristic Species
				Melhania oblongifolia, Paraneurachne muelleri, Phyllanthus maderaspatensis, Rhynchosia minima, Carissa lanceolata, Crotalaria medicaginea var. *neglecta, Dampiera candicans, Ehretia saligna* var. *saligna, Eriachne mucronata, Euphorbia australis, Evolvulus alsinoides var. villosicalyx, Gossypium robinsonii, Jasminum didymum* subsp. *lineare, Sida rohlenae* subsp. *rohlenae, Sida* sp. Pilbara (A.A. Mitchell PRP 1543), *Trichodesma zeylanicum* var. *zeylanicum, Triodia longiceps* **Dominant:** *Triodia longiceps, Themeda triandra, Acacia acradenia, Acacia tumida var. pilbarensis, Chrysopogon fallax, Acacia bivenosa, Indigofera monophylla, Triodia epactia, Corymbia ferriticola, Grevillea wickhamii* agg., *Acacia pyrifolia* agg., *Corchorus parviflorus, Corymbia hamersleyana, Hibiscus sturtii* agg., *Santalum lanceolatum, Cymbopogon ambiguus, Eucalyptus leucophloia* subsp. *leucophloia, Eucalyptus victrix*
Drainage Line	**EcApyCci** MCC-03 MCC-04 MCC-05 MCC-06 MCC-09 MCC-11 **MCC-12** MCC-13 MCC-14 MCC-15 MCC-16 MCC-17 MCC-18 MCC-19 MCC-20 MCC-21 MCC-22 MCC-23	*Eucalyptus camaldulensis* and *Eucalyptus victrix* mid woodland over *Acacia pyrifolia, Atalaya hemiglauca* and *Acacia trachycarpa* tall open shrubland over **Cenchrus ciliaris* and *Cyperus vaginata* low tussock grassland/sedgeland	 Photo from Woodman (2019a)	**Diagnostic:** *Acacia ampliceps, Amaranthus cuspidifolius, Ammannia multiflora, Atalaya hemiglauca, Boerhavia schomburgkiana, *Cenchrus ciliaris, Cyperus vaginatus, Echinochloa colona*, Eucalyptus camaldulensis, Eucalyptus victrix, Euphorbia alsiniflora, Euphorbia australis, Marsilea hirsuta, Sesbania cannabina, Stemodia grossa, Vigna lanceolata* var. *lanceolata, *Argemone ochroleuca, Centipeda minima* subsp. *macrocephala, Cullen leucanthum, Ipomoea muelleri, Leptochloa fusca* subsp. *fusca, *Sonchus oleraceus* **Constant**: *Atalaya hemiglauca, *Cenchrus ciliaris, Cyperus vaginatus, Eucalyptus camaldulensis, Acacia pyrifolia* agg., *Eucalyptus victrix, Triodia longiceps, Phyllanthus maderaspatensis, Acacia trachycarpa, *Echinochloa colona, Euphorbia australis, Sesbania cannabina, Stemodia grossa, Amaranthus undulatus, Vigna lanceolata var. lanceolata, Melaleuca glomerata, Pluchea tetranthera, Centipeda minima subsp. macrocephala, Cleome viscosa, Euphorbia alsiniflora, Evolvulus alsinoides* var. *villosicalyx, Rhynchosia minima* **Dominant**: **Cenchrus ciliaris, Eucalyptus camaldulensis, Eucalyptus victrix, Cyperus vaginatus, Eriachne benthamii, Acacia*

Land-form	Mapping Unit and Floristic Quadrats	Vegetation Type	Representative Photograph	Other Characteristic Species
	MCC-24 MCC-29 MCC-30 MCC-31 MCC-32 MCC-33 MCC-34 MCC-38			*trachycarpa, Melaleuca glomerata, Melaleuca bracteata, Acacia coriacea* subsp. *pendens, Acacia pyrifolia* agg., **Cynodon dactylon, *Echinochloa colona, Atalaya hemiglauca, Acacia ampliceps*
Hillcrest/Hillslope	**ElAbTe** MC018 MC023 MC030 MC036 MC041 MC044 MC099 MC100 MC105 MC149 **MC20OP06** MC20OP12 MC20Q07	*Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees over *Acacia bivenosa, A. ptychophylla* and *A. monticola* mid shrubland over *Triodia brizoides, T. epactia* and *Cymbopogon ambiguus* mid hummock/tussock grassland		**Diagnostic:** NA **Constant:** *Corchorus parviflorus, Eucalyptus leucophloia* subsp. *leucophloia, Indigofera monophylla, Senna glutinosa* subsp. *glutinosa, Senna symonii, Triodia epactia, Acacia inaequilatera, Cymbopogon ambiguus, Ptilotus calostachyus, Triodia brizoides, Acacia bivenosa, Bonamia* sp. Dampier (A.A. Mitchell PRP 217), *Eriachne mucronata, Goodenia triodiophila, Polycarpaea holtzei, Tephrosia* sp. NW Eremaean (S. van Leeuwen et al. PBS 0356), *Bulbostylis barbata, Goodenia stobbsiana, Dampiera candicans, Sida* sp. Pilbara (A.A. Mitchell PRP 1543), *Trigastrotheca molluginea* **Dominant:** *Triodia brizoides, Triodia epactia, Triodia wiseana, Acacia bivenosa, Eucalyptus leucophloia* subsp. *leucophloia, Acacia ptychophylla, Acacia pyrifolia* agg., *Senna symonii*

Land-form	Mapping Unit and Floristic Quadrats	Vegetation Type	Representative Photograph	Other Characteristic Species
Hillcrest/Hillslope	**ElAmTb** MC142 MC143 MC20OP07 MC20OP13 **MC20Q06**	*Eucalyptus leucophloia* subsp. *leucophloia* low woodland over *Acacia monticola* mid isolated clumps of shrubs over *Triodia brizoides* and *T. epactia* low hummock grassland		**Diagnostic:** *Cheilanthes brownii, Clerodendrum floribundum, Hibiscus coatesii, Ptilotus obovatus, Triodia brizoides* **Constant:** *Eriachne mucronata, Eucalyptus leucophloia* subsp. *leucophloia, Fimbristylis dichotoma, Hibiscus coatesii, Senna symonii, Triodia brizoides, Acacia monticola, Corchorus parviflorus, Cymbopogon ambiguus, Goodenia triodiophila, Hakea lorea* subsp. *lorea, Pluchea tetranthera, Senna glutinosa* subsp. *glutinosa, Tephrosia* sp. NW Eremaean (S. van Leeuwen et al. PBS 0356), *Bulbostylis barbata, Cheilanthes brownii, Enneapogon lindleyanus, Evolvulus alsinoides* var. *villosicalyx, Indigofera monophylla, Polycarpaea holtzei, Ptilotus calostachyus, Ptilotus obovatus, Senna glutinosa* subsp. *pruinosa, Tribulus suberosus* **Dominant:** *Triodia brizoides, Eriachne mucronata, Acacia bivenosa, Acacia monticola, Eucalyptus leucophloia* subsp. *leucophloia, Cymbopogon ambiguus, Triodia wiseana, Triodia epactia*
Hillcrest/Hillslope	**ElAmTe** **MC046** MC069 MC20Q24	*Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees over *Acacia monticola, A. bivenosa* and *Grevillea wickhamii*. shrubland over *Triodia epactia, Eriachne lanata* mid hummock/tussock grassland	 Photo from Woodman (2019a)	**Diagnostic:** *Acacia monticola, Eriachne lanata* **Constant:** *Acacia monticola, Eriachne lanata, Goodenia stobbsiana, Grevillea wickhamii* agg., *Triodia epactia, Sida* sp. Pilbara (A.A. Mitchell PRP 1543) **Dominant:** *Acacia monticola, Eriachne lanata, Triodia epactia, Grevillea wickhamii* agg.

Land-form	Mapping Unit and Floristic Quadrats	Vegetation Type	Representative Photograph	Other Characteristic Species
Hillcrest/Hillslope	**ElAptTe** MC002 MC011 MC015 MC016 MC022 **MC024** MC029 MC037 MC086 MC088 MC124 MC128	*Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia hamersleyana* low woodland over *Acacia ptychophylla, A. inaequilatera* and *Indigofera* monophylla low isolated shrubland over *Triodia epactia, T. brizoides* low hummock grassland	 Photo from Woodman (2019a)	**Diagnostic:** *Acacia ptychophylla, Dodonaea coriacea, Eriachne ciliata, Goodenia triodiophila* **Constant:** *Eriachne ciliata, Eucalyptus leucophloia* subsp. *leucophloia, Triodia epactia, Acacia ptychophylla, Corymbia hamersleyana, Dampiera candicans, Goodenia stobbsiana, Goodenia triodiophila, Indigofera monophylla, Dodonaea coriacea, Fimbristylis dichotoma, Polygala isingii, Senna glutinosa* subsp. *glutinosa, Grevillea wickhamii* agg., *Triodia brizoides, Bonamia* sp. Dampier (A.A. Mitchell PRP 217), *Fimbristylis simulans, Polycarpaea holtzei* **Dominant:** *Triodia epactia, Triodia brizoides, Acacia ptychophylla, Acacia retivenea* subsp. *clandestina, Eucalyptus leucophloia* subsp. *leucophloia, Dampiera candicans, Grevillea wickhamii* agg., *Acacia inaequilatera, Corymbia hamersleyana, Acacia bivenosa, Acacia orthocarpa*
Hillcrest/Hillslope	**ElGwTe** MC047 **MC063** MC064 MC068	*Eucalyptus leucophloia* subsp. *leucophloia* low isolated clumps over *Senna glutinosa* subsp. *glutinosa* and *Grevillea wickhamii*. tall open shrubland over *Triodia epactia* and *Eriachne mucronata* mid hummock grassland/ mid isolated clumps of tussock grasses	 Photo from Woodman (2019a)	**Diagnostic:** *Amaranthus undulatus, Clerodendrum tomentosum* var. *lanceolatum, Eriachne mucronata, Eucalyptus leucophloia* subsp. *leucophloia, Hibiscus goldsworthii, Ptilotus incanus, Senna glutinosa* subsp. *glutinosa, Sida ?*macropoda (complex), *Sida* sp. Pilbara (A.A. Mitchell PRP 1543), *Triodia epactia* **Constant:** *Amaranthus undulatus, Aristida contorta, Bonamia* sp. Dampier (A.A. Mitchell PRP 217), *Cymbopogon ambiguus, Eriachne mucronata, Eucalyptus leucophloia* subsp. *leucophloia, Grevillea wickhamii* agg., *Pluchea tetranthera, Ptilotus calostachyus, Senna glutinosa* subsp. *glutinosa, Sida ?macropoda* (complex), *Sida rohlenae* subsp. *rohlenae, Sida* sp. Pilbara (A.A. Mitchell PRP 1543), *Triodia epactia, Acacia bivenosa, Corchorus lasiocarpus* subsp. *lasiocarpus, Goodenia stobbsiana, Hibiscus coatesii, Hibiscus goldsworthii, Pluchea ferdinandi-muelleri, Ptilotus incanus* **Dominant:** *Triodia epactia, Eriachne mucronata, Eucalyptus leucophloia* subsp. *leucophloia, Senna glutinosa* subsp. *glutinosa, Grevillea wickhamii* agg., *Goodenia stobbsiana*

Land-form	Mapping Unit and Floristic Quadrats	Vegetation Type	Representative Photograph	Other Characteristic Species
Drainage Line	**EvApyCci** MC074 MC091 MC093 MC125 MC144 MC20OP09 MC20OP14 MC20Q10 MC20Q11 MC20Q12 **MC20Q27** MCC-01 MCC-02 MCC-07 MCC-08 MCC-10 MCC-25 MCC-26 MCC-27 MCC-28 MCC-35 MCC-36 MCC-37 MCC-39 RC407	*Eucalyptus victrix* and *Corymbia hamersleyana* mid open woodland over *Acacia pyrifolia, Acacia trachycarpa* and *Acacia tumida* var. *pilbarensis* tall shrubland over **Cenchrus ciliaris, Triodia longiceps* and *Cyperus vaginata* low tussock grassland/hummock grassland/sedgeland		**Diagnostic:** *Acacia pyrifolia* agg., *Phyllanthus maderaspatensis, Solanum diversiflorum, Tephrosia rosea* var. *clementii* **Constant:** **Cenchrus ciliaris, Acacia pyrifolia* agg., *Phyllanthus maderaspatensis, Rhynchosia minima, Eucalyptus victrix, Triodia longiceps, Acacia trachycarpa, Gossypium australe, Euphorbia australis, Evolvulus alsinoides* var. *villosicalyx, Polymeria ambigua, Atalaya hemiglauca, Chrysopogon fallax, Hybanthus aurantiacus, Amaranthus undulatus, Cymbopogon ambiguus, Acacia bivenosa, Corchorus lasiocarpus* subsp. *lasiocarpus, Indigofera monophylla, Tephrosia rosea* var. *clementii, Cleome viscosa, Themeda triandra, Corymbia hamersleyana, Eriachne benthamii* **Dominant:** **Cenchrus ciliaris, Melaleuca glomerata, Acacia pyrifolia* agg., *Acacia acradenia, Triodia longiceps, Triodia epactia, Acacia tumida* var. *pilbarensis, Eucalyptus victrix, Melaleuca bracteata, Acacia bivenosa, Cyperus vaginatus, Eucalyptus camaldulensis, Eriachne benthamii, Acacia coriacea* subsp. *pendens, Acacia trachycarpa, Themeda triandra, Triodia wiseana, Petalostylis labicheoides, *Aerva javanica, *Cenchrus setiger, Corchorus parviflorus, Corymbia hamersleyana, Pluchea ferdinandi-muelleri, Typha domingensis*

Table 13: Vegetation type extents

Vegetation type	Total extent (ha)	Proportion (%)	Ground-truthed extent (ha)	Extrapolated extent (ha)	Interpolated extent (ha)
AiTw1	893.78	14.76	882.10	11.67	
AiTw2	193.00	3.19	193.00		
AoTl	47.81	0.79	47.59	0.21	
AsTe	31.08	0.51	25.09	5.99	
AsTl	112.00	1.85	112.00		
AtTe	23.57	0.39	23.57		
CcaAiTe	103.37	1.71	103.37		
ChAiTa	155.26	2.56	155.26		
ChAiTe	1,865.06	30.80	1,712.26	152.79	
ChAiTw	57.19	0.94	57.19		
ChAmTe	541.48	8.94	540.23	1.25	
ChApyTt	117.75	1.94	117.75		
EcApyCci	192.64	3.18			192.64
ElAbTe	1,023.49	16.90	1,021.86	1.63	
ElAmTb	42.78	0.71	42.78		
ElAmTe	26.43	0.44	26.43		
ElAptTe	149.00	2.46	149.00		
ElGwTe	86.49	1.43	86.49		
EvApyCci	386.63	6.38	212.70	19.21	154.72
Not Vegetated	7.18	0.12	7.18		
Total	**6,055.99**	**100.00**	**5,515.85**	**192.75**	**347.36**

* The difference between this and the actual total extent (total = 6,055.55 ha) is due to rounding and artefacts of GIS mapping (0.44 ha; 0.007% of total)

4.2.1 GDV (CREEKLINE) VEGETATION

As per the methods detailed in **Section 3.3.3.1**, vegetation characterised by *Eucalyptus camaldulensis* and *Eucalyptus victrix* were used to identify vegetation that may be dependent on groundwater. Two vegetation types were characterised by these species; **EcApyCci** and **EvApyCci**. Taking into consideration depth to groundwater, these vegetation types were further divided into areas where dependence on groundwater was considered likely (less than 10 m) or unlikely (more than 10 m to groundwater). All areas where *Eucalyptus camaldulensis* was recorded as a characteristic species were located in areas where the depth to groundwater was less than 10 m, therefore all of vegetation type **EcApyCci** is likely to be at dependent on groundwater.

The extents of groundwater dependence within the survey area are as shown in **Table 14**.

Table 14: GDV vegetation extents

Vegetation type	Total extent (ha)	Likely to be GDV	Potential GDV	Unlikely to be GDV
EcApyCci	192.64	192.64	-	-
EvApyCci	386.63	-	345.16	41.47
Total	**579.27**	**192.64**	**345.16**	**41.47**

4.2.1.1 Floristic Analysis

OptimClass analysis was run on all (182) quadrats contained within the survey area. OptimClass identified Wards Clustering combined with Chord distance generated on a presence absence transformation produces the most robust and ecologically informative vegetation types (n = 20). Visual assessment of the resulting dendrogram (**Appendix Six**) suggested the presence of three floristic super-groups. One of these super-groups consisted of quadrats located along drainage and required a separate OptimClass analysis. A separate analysis was also conducted on the remaining two supergroups (combined). Analysis of the drainage quadrats suggested that flexible beta (-0.25) Clustering combined with Chord distance generated on a square root transformation produced well defined vegetation types (n = 3). Separate analysis of the supergroups resulted in a more robust and ecologically informative classification scheme for the McPhee creek area.

The floristic analysis dendrograms (**Appendix Six**) for McPhee Creek indicates that there are a total of 19 vegetation types belonging to two super-groups. The vegetation types described and mapped are well supported by clustering in the floristic dendrogram.

4.2.1.2 Vegetation Type Crosswalk

Table 25 in **Appendix Three** shows the Woodman quadrats and their vegetation types, and their Ecoscape equivalent vegetation type.

4.2.1.3 Vegetation Condition

The vegetation of the survey area ranged from Excellent to Poor condition, with the majority in Excellent condition (**Table 15**, **Map 7**). The main factor/s influencing vegetation condition were grazing, historical drill lines/ exploration tracks and the presence of weeds.

The vegetation condition in extrapolated areas was interpreted based on nearby vegetation condition, noting that, unless the area was obviously disturbed or likely to be subject to heavy grazing (generally riparian areas), the condition was likely to be Excellent. The vegetation in interpolated areas (i.e. creeklines) were as interpreted by Woodman (2014b) as is unlikely to have been subject to changes in land use or grazing intensity and thus unlikely to have improved since surveyed.

Table 15: Vegetation condition extents

Vegetation condition	Extent (ha)	Proportion (%)	Ground-truthed extent (ha)	Extrapolated extent (ha)	Interpolated extent (ha)
Excellent	5,207.25	85.99	5,033.59	173.65	-
Very Good	19.53	0.32	-	-	19.53
Good	708.57	11.70	475.09	19.12	214.36
Poor	40.82	0.67	-	-	40.82
Degraded	72.64	1.20	-	-	72.64
Cleared (not vegetated)	7.18	0.12	7.18	-	-
Total	**6,055.99***	**100**	**5515.86**	**192.77**	**347.35**

* The difference between this and the actual total extent (6,055.55 ha) is due to rounding and artefacts of GIS mapping.

4.2.1.4 Adequacy of Survey

Adequacy of survey can be demonstrated using a species accumulation curve; if the curve has reached (or almost reached) an asymptote it is considered that most species are likely to have been recorded from the survey area.

The species accumulation curve generated using the Pisces Conservation (2010) package (**Figure 5**) indicates that an asymptote has almost been reached, suggesting that the combined floristic surveys over the entire survey area would be unlikely to record many additional species with additional effort and survey effort has been adequate to describe the flora of the survey area. Additionally, the Michaelis-Menten estimate of species richness is 364; including Ecoscape's opportunistic observations the number of recorded species (370) is greater than this estimate, indicating adequacy of survey.

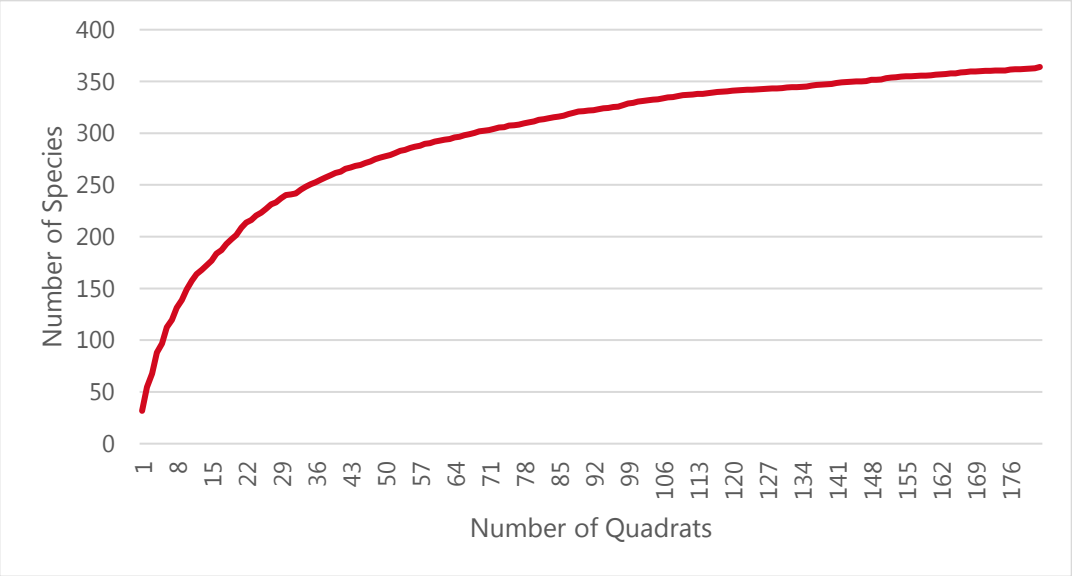


Figure 5: Species accumulation curve using quadrat data (Pisces Conservation Ltd 2010)

The species accumulation curve generated using the vegan R package (Oksanen *et al.* 2007) suggests that additional survey would have recorded only minimal additional species (**Figure 6**). The Woodman (2014c) survey featured a significantly higher (as indicated by the non-overlapping confidence intervals) species richness compared to the Woodman (2019a) and the current survey results; this result is not surprising since the data used extends over a large spatial area (i.e. from the Pilbara coast to McPhee creek) compared to the other surveys.

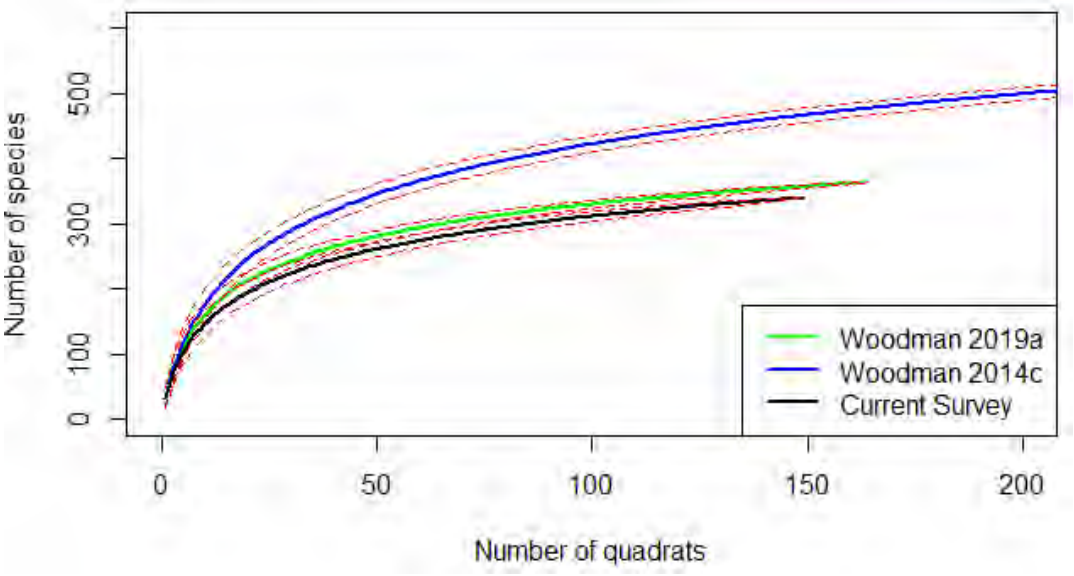


Figure 6: Species accumulation curve using quadrat data. Red dotted lines represent a 95% confidence interval.

4.3 BOTANICAL LIMITATIONS

Survey design: Single phase, quadrat-based flora and vegetation survey with extensive traverses searching for conservation-listed flora. Results from previous surveys were considered as part of survey design and the desktop assessment.

Survey type: Detailed flora and vegetation survey with targeted searches for conservation-listed flora searches conducted over one phase. All areas were adequately surveyed using floristic quadrats to sample vegetation types, and targeted searches for conservation-listed flora.

Type of vegetation classification system: Vegetation classified at NVIS Level V (NVIS Technical Working Group 2017) using largely structural vegetation types defined using dominant and characteristic species and vegetation structure as recorded during the field surveys. Floristic analysis was used to identify major floristic groups and outlier groups of floristic interest.

Survey timing, which was optimal for the bioregion, corresponded with excellent seasonal conditions as a consequence of above average rainfall (**Figure 7**). A full summary of botanical limitations is presented in **Table 16**.

Table 16: Botanical limitations

Possible limitations	Constraints (yes/no): Significant, moderate or negligible	Comment
Availability of contextual information at a regional and local scale	No	The entire area has previously surveyed and mapped with several previous flora and vegetation survey areas intersecting survey area. There have been many other surveys in the nearby surrounding areas. Thus, there is good availability of information to provide local and regional context.
Competency/experience of the team conducting the survey, including experience in the bioregion surveyed	No	The lead botanist conducting the field survey has over 6 years' experience conducting flora and vegetation surveys in Western Australia, including the Pilbara region.

Possible limitations	Constraints (yes/no): Significant, moderate or negligible	Comment
Proportion of the flora recorded and/or collected, and any identification issues	No	A total of 224 flora taxa were recorded during the 2020 Ecoscape field survey of which a small portion (6.7%) were not identifiable to species and one not identifiable to genus due to lack of reproductive material, most likely due to seasonal conditions rather than survey timing. None are similar to any currently listed TF or PF.
Was the appropriate area fully surveyed (effort and extent)	No (most areas) Moderate (flora: extrapolated areas only) Negligible (interpolated areas)	The majority of the survey area was surveyed adequately to describe the flora, vegetation types and vegetation. The main portion of the survey area had been subject to a number of previous surveys by Woodman, with this survey consolidating and ground-thruthing the previous works and ensuring that the survey effort met current EPA requirements for botanical survey in Western Australia. Sections corresponding with proposed haul roads near the southwest of the survey area were not accessed during the field survey due to asbestos contamination and re-alignment post survey. Vegetation mapping in this section was extrapolated by interpretation of high-resolution aerial imagery. The vegetation in these areas is not complex and interpretation uncomplicated; additionally, there are no conservation-listed vegetation types in the area thus this is considered as only a negligible constraint in regard to vegetation type and condition mapping. However, these parts correspond with, or are close to, locations where conservation-listed flora were recorded. It is not possible to interpret the presence or absence of conservation-listed species in areas that have not been ground-truthed, thus (for flora), there is considered a moderate limitation in extrapolated areas. The creeklines to the southeast of the survey area were not accessed during the 2020 survey, however, they have previously been surveyed and mapped in detail by Woodman. Ecoscape's interpretation is that Woodman's vegetation mapping is an accurate representative of the conditions present, and due to the low likelihood of significant changes since survey, there is a negligible constraint in regard to the botanical survey in this portion of the survey area.
Access restrictions within the survey area	No (most areas) Negligible (interpolated creekline areas; vegetation in extrapolated areas) Moderate (flora in extrapolated area)	Most (ie the main body) of the survey area was fully accessible thus there were no constraints in regard to access in these parts. Sections to the southeast along a proposed haul road were not accessible due to ongoing asbestos reporting (results were not provided at the time of the survey). Additionally, Atlas Iron added a new potential road alignment after the survey had been completed; results for this area have also

Possible limitations	Constraints (yes/no): Significant, moderate or negligible	Comment
		been extrapolated. However, the vegetation in this part of the survey area is relatively uncomplicated and there is no vegetation considered as significant, thus negligible constraints in this area. However, conservation-listed flora have potential to occur, thus providing a moderate constraint for flora in regard to access. The creeklines to the southeast of the main survey area were not accessed. However, the previous Woodman mapping was considered an accurate representation of the conditions present thus there is only a negligible constraint in regard to access for the interpolated areas.
Survey timing, rainfall, season of survey	No	The field survey was conducted in April, which is within the optimal season for survey in the Eremaean region of Western Australia. The rainfall in the 4-month period preceding the survey in March was approximately 91% of the long-term mean for the December–March period resulting in average seasonal conditions
Disturbance that may have affected the results of the survey e.g. fire, flood, clearing	No	There were no recent disturbances that would have affected the results of the survey.

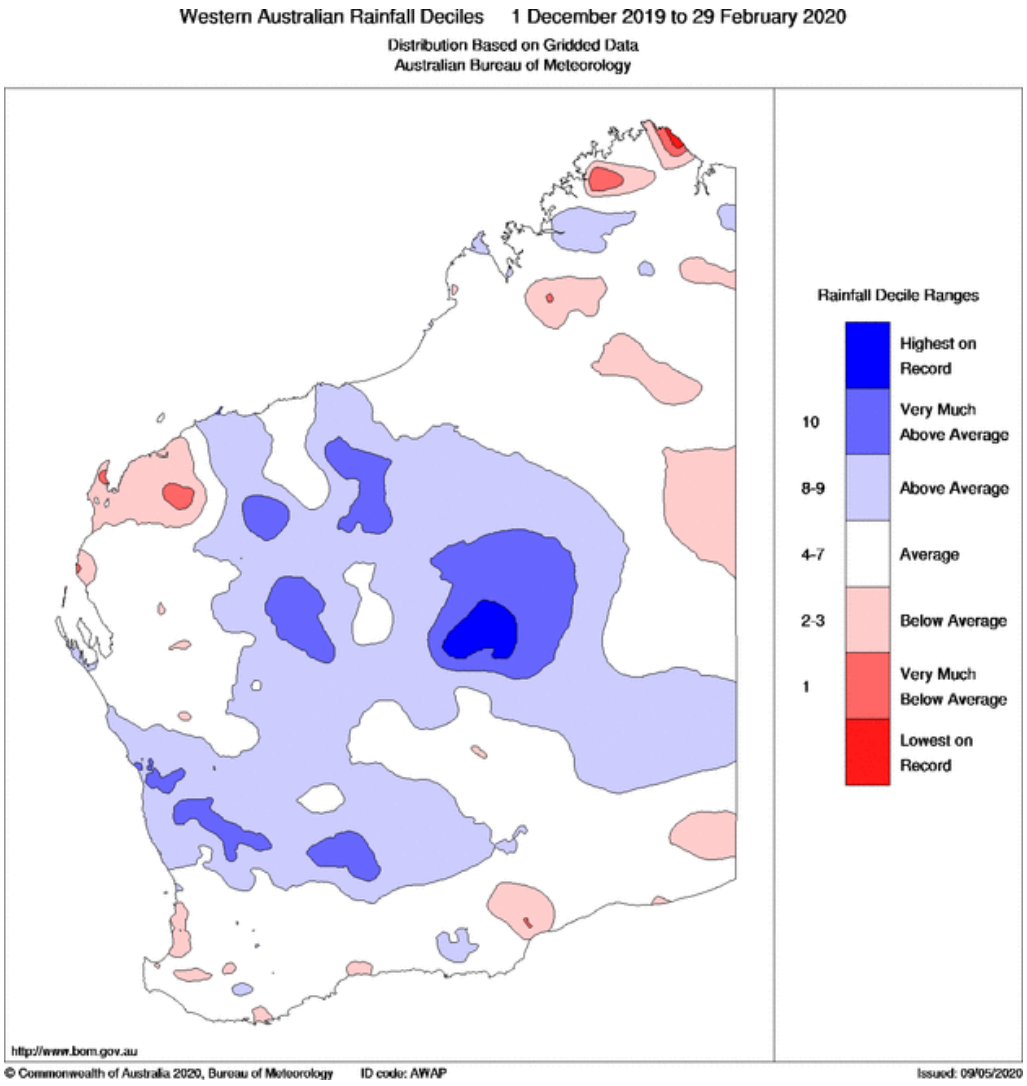


Figure 7: Rainfall percentages for the three months prior to the field survey (BoM 2020b)

5 DISCUSSION

5.1 FLORA SIGNIFICANCE

There were 370 vascular flora taxa recorded from the survey area from 182 floristic quadrats (inclusive of previously established quadrats) and opportunistic searches. Of these, 224 taxa were recorded from Ecoscape's 2020 flora and vegetation survey from 42 newly established floristic quadrats (i.e. this survey). Seven introduced species were detected during the 2020 survey; combined with previously established quadrats there were 16 (4.32%) introduced species indicating that weeds make up only a small portion of the flora inventory.

The species accumulation curve (**Section 4.2.1.4**) indicates that the majority of species are likely to have been recorded from the survey area. The average number of species recorded per quadrat from all data was 33.81 and ranged from 6 to 80 species per quadrat. This species richness is considered commensurate with other flora and vegetation surveys in the bioregion.

The vegetation types with the highest species diversity were vegetation types **AiTw1** (47.11 species), **AsTl** (50.17 species), **ChApyTt** (52.14 species) and **EvApyCci** (47.69 species). The latter two are riparian, being vegetation of minor and medium sized drainage lines (creeklines), however, the species richness of the larger creeklines was less (average 38.00 for vegetation type **EcApyCci**), with weed invasion (Buffel Grass; Birdwood Grass) and more intense grazing as result of the presence of grass and water in associated pools or wallows potentially contributing.

5.1.1 CONSERVATION-LISTED FLORA

5.1.1.1 Threatened Flora

No TF species listed for protection under the Commonwealth EPBC Act or Western Australian BC Act were recorded during this survey, nor have any been recorded during any of the previous surveys conducted by Woodman. The database searches indicate that no TF species are known to occur within 50 km of the survey area, therefore, no currently listed TF species are likely to occur.

5.1.1.2 Priority Flora Recorded During 2020

Three PF were recorded from the survey area during 2020: one P1 (*Acacia aphanoclada*), one P3 (*Rostellularia adscendens* var. *latifolia*), and one P4 (*Ptilotus mollis*).

Acacia aphanoclada

P1 species are considered poorly known and are known from few locations which are potentially at risk (DBCA 2019). *Acacia aphanoclada* was the only P1 species located within the survey area. It is known from 44 records in Western Australia all from within the Chichester IBRA subregion (DBCA 2007-2020). This taxon is likely to be locally common within the **ChAiTe** vegetation type located on pebble conglomerate, sandstone, siltstone, and minor layered chert and thin-bedded felsic tuff with interlayered ultramafic rocks (metamorphosed) located 6 km southwest of the McPhee camp along the haul road. The total extent of *Acacia aphanoclada* is indicated on *NatureMap* (DBCA 2007-2020) as occupying approximately 65 km east-west and 40 km north-south, although most of the 46 records for this species are to the south of the McPhee Creek population. There are two loci within the McPhee Creek survey area representing two populations.

The southern population along the potential haul road, indicated on **Map 5H**, had over 2,000 individual *Acacia aphanoclada* recorded, with the population also extending outside of the area surveyed (noting that, due to

access restrictions due to asbestos and further areas added after completion of the field survey, some parts could not be surveyed; these are in the extrapolated survey area). It would be unlikely that clearing for a haul road, regardless of where it gets located within the general vicinity of the area subject to this survey, would have a significant regional impact on the population of this species and only a low local impact with likely less than 10% of the local population affected, and likely even less if the road is located on the westernmost option.

Woodman (2019c) only recorded a single individual in the northern population in the main body of the survey area, which is located within the proposed disturbance footprint. Impacts on this population would be high, with complete removal, however, on a regional scale the impact from removing a single individual would be insignificant (low). Occasional individuals were also recorded along the creeklines; no clearing is proposed along the creeklines, however, it is not possible determine the effect of indirect impacts on these individuals, although significant impacts on the species as a whole would be likely to be insignificant (low).

Rostellularia adscendens* var. *latifolia

P3 species are considered poorly known and in need of further survey but are not currently under threat (DBCA 2019). As such, and based on the known distribution, the P3 species in the survey area (*Rostellularia adscendens* var. *latifolia*) is unlikely to be considered currently under threat and the potential impact is considered negligible. Woodman (2014a; 2019c), when considering the likely impacts on this species due to hydrological change, also considered the potential impact negligible.

Ptilotus mollis

P4 species are rare but present on conservation lands, near threatened but have been adequately surveyed and are not considered to be currently threatened, or are otherwise in need of monitoring (DBCA 2019). As such, P4 species are not currently under threat and any potential impact is considered negligible.

Woodman (2019c) has recorded over 6,000 individuals from the area (Ecoscape recorded only four individuals); as this species has an east-west distribution of over 650 km, any regional impacts of removing local populations are likely to be insignificant (low).

5.1.1.3 Other Conservation-listed Flora

There are two PF taxa (*Eragrostis crateriformis* and *Goodenia nuda*) that have been previously recorded from the survey area that was not recorded during the 2020 survey. Of these, the previous recording of *Eragrostis crateriformis* (P3) is considered likely to be accurate as it is represented by vouchered herbarium specimens and, although not recorded during 2020 it may be present in low numbers despite not being detected during searches in previously recorded locations. However, the *Goodenia nuda* record is unconfirmed (i.e. there is no vouchered specimen, and Woodman (2019a) indicates it as a possible mis-identification) and unlikely as the habitat it was recorded from is not its usual habitat (see **Section 4.1.3.1**). *Goodenia nuda* has an extensive range within the Pilbara and other bioregions, occurring primarily on moist depressions, claypans, edge of drainage lines and floodplains, and does not occur in habitats that might be considered as locally restricted.

Barring *Eragrostis crateriformis* and *Goodenia nuda*, no additional conservation-listed flora species that were identified by the database searches from nearby were considered a High likelihood of occurring within the survey area based on their known distribution, habitat as described on *FloraBase* and in specimen records (WAH 1998-2020; 2020), having potentially suitable habitat available within the survey area or been detected by the any previous detailed surveys conducted on the survey area (i.e. previous survey effort; see **Section 4.1.3.2**).

5.1.2 INTRODUCED FLORA

Seven introduced flora were recorded during the 2020 field survey. One of the introduced flora species, **Calotropis procera*, is a Declared Pest plant and was found amongst a rocky outcrop in the central survey area. *Calotropis procera* is in the Exempt category and has no management requirements in regard to its presence. The remaining six introduced taxa recorded in 2020 (**Aerva javanica*, **Cenchrus ciliaris*, **Cenchrus setiger*, **Cynodon dactylon*, **Echinochloa colona*, **Malvastrum americanum*) are ranked as having High ecological impact and rapid invasiveness for the Pilbara Region (DPaW 2013).

Additional to those recorded during the 2020 survey, Woodman (2019a) has also recorded **Argemone ochroleuca*, **Chloris barbata*, **Citrullus amarus*, **Euphorbia hirta*, **Flaveria trinervia*, **Portulaca pilosa*, **Setaria verticillata*, **Sonchus oleraceus* and **Vachellia farnesiana*. None are unusual occurrences in the Pilbara although **Euphorbia hirta* is more common in the Kimberley, and none are Declared Pest plants or WoNS species.

No introduced flora have any management requirements under the BAM Act.

5.2 VEGETATION SIGNIFICANCE

Nineteen consolidated vegetation types were recorded as occurring in the survey area, corresponding with three major landforms:

- predominantly hillcrests/hillslopes: **AiTw2**, **AiTw1, CcaAiTe**, **ChAiTe**, **ChAiTa**, **ChAiTw**, **ElAbTe**, **ElAptTe**, **ElAmTb**, **ElAmTe**, **ElGwTe**
- stony plains: **AoTl**, **AsTe**, **AsTl**, **AtTe**
- predominantly drainage lines: **ChAmTe**, **ChApyTt**, **EcApyCci**, **EvApyCci**.

5.2.1 SIGNIFICANT ECOLOGICAL COMMUNITIES

No vegetation was considered to represent any current Western Australian-listed or Commonwealth EPBC Act-listed TEC within the survey area. None are known from the vicinity.

The DBCA database search identified areas mapped as the *Stony saline clay plains of the Mosquito Land System* PEC approximately 4 km west of the main body of the survey area, intersecting with the creeklines portion of the survey area near Nullagine River (23.18 ha, representing 0.38% of the survey area). The Land System defining the PEC occupies 8,134.63 ha in total, therefore the intersecting portion within the survey area represents 0.003% of the total extent, based on Land System mapping (DPIRD 2018b). However, the vegetation within the survey area is not similar to the characteristic vegetation of the PEC, which is a *Triodia longiceps* perennial grassland with scattered *Maireana melanocoma*, *Sclerolaena* spp., *Melaleuca eleuterostachya* and *Acacia bivenosa* (Species and Communities Program, DBCA 2020). Therefore, despite intersecting with the definitive Land System, it is unlikely that the PEC occurs within the survey area.

5.2.2 OTHER SIGNIFICANT VEGETATION

Based on the criteria provided in the Flora and Vegetation Technical Guidance (EPA 2016c), a number of vegetation types may be considered as significant (restricted distribution, history of impact, role as a refuge, function in maintaining ecological integrity). These are discussed below.

5.2.2.1 Restricted Distribution

The following vegetation types have extents of less than 1% of the McPhee Creek survey area and may be considered as spatially restricted vegetation types:

- **AoTl** (47.81 ha, 0.79%)
- **AsTe** (31.08 ha, 0.51%)
- **AtTe** (23.57 ha, 0.39%)
- **ChAiTe** (57.19 ha, 0.94%)
- **ElAmTb** (42.78 ha, 0.71%)
- **ElAmTe** (26.43 ha, 0.44%).

While vegetation type interpretation and mapping, and therefore extents within a survey area, are open to interpretation, small extents, particularly if they are associated with an uncommon landform or meet a particular defining attribute as listed in the Flora and Vegetation Technical Guidance (EPA 2016c) may be significant.

None of those listed above meet any of the other requirements listed in the Flora and Vegetation Technical Guidance to be considered as significant, except as a result of their small extents.

Ecoscape does not consider any of the vegetation types within the survey area to have any particular significance

5.2.3 GROUNDWATER DEPENDENT VEGETATION

Woodman (2019a), when taking into consideration hydrological information as well as indicator plant physiology, only considered one of its vegetation types, characterised by *Eucalyptus camaldulensis*, to likely represent a GDV, and then only in localised areas as the characteristic species may be a facultative phreatophyte in some areas and circumstances. Ecoscape's research indicates that *Eucalyptus camaldulensis sens. lat.* is (in most circumstances) considered to be an obligate phreatophyte, and therefore vegetation with this species included is likely to be representative of a GDV (Eamus *et al.* 2006; Grierson 2010).

Traverses within the main body of the survey area did not detect *Eucalyptus camaldulensis sens. lat.* within any of the drainage lines, including along the haul road, therefore we have concluded that no GDV corresponds with the majority of the survey area.

The creeklines to the southeast of the main body of the survey area were not ground-truthed. Ground-truthing Woodman's vegetation mapping in other parts was considered to be an accurate representation of the vegetation present, although mapped in more detail than required. Due to the accuracy of Woodman's vegetation mapping, against which Ecoscape has cross-referenced quadrat data to confirm and incorporated depth to groundwater, we do not consider that there are any significant constraints in regard to not having ground-truthed the mapping (see **Table 16** in **Section 4.3**). The vegetation types along the creeklines are considered to be interpolated.

A total of 579 ha has been considered to possibly represent GDV.

Woodman's vegetation type 15 (see **Table 8** in **Section 2.5.1.4**), which Woodman (2019a) considered to be a 'likely GDV' has, as a result of cross-referencing species within quadrats, been divided into the two riparian vegetation types within the survey area, most in **EcApyCc**i and a smaller extent in **EvApyCci**. All of vegetation type **EcApyCci** is located in parts where the depth to groundwater is less than 10 m, therefore this vegetation type, which occupies 192.64 ha, is considered likely to represent a GDV type.

Woodman's vegetation types 13 and 14 have, except where *Eucalyptus camaldulensis* occurred within the quadrats (now in vegetation type **EcApyCci**) have been incorporated into vegetation type **EvApyCci**. Woodman's vegetation type 7, where *Eucalyptus victrix* was a component, has also been incorporated into this vegetation type. **EvApyCci** occupies 386.63 ha. Where the depth to groundwater is less than 10 m and it is possible that *Eucalyptus victrix* can access the groundwater, this vegetation type is considered as a potential GDV (345.16 ha). Where the depth to groundwater is more than 10 m and *Eucalyptus victrix* is unlikely to be able to access groundwater, this vegetation type is considered unlikely to be GDV.

The **Map 6** series and GIS data should be viewed for locations of likely, potential GDVs and riparian (creekline) vegetation unlikely to be GDV.

Vegetation types **EcApyCci** and **EvApyCci** also include *Atalaya hemiglauca*, *Melaleuca glomerata* and *Sesbania cannabina* that potentially rely on the continual access to groundwater and are commonly considered as ecological indicators for groundwater dependence (Batini 2009; Eamus 2009a; EPA & Hamersley Iron Pty Ltd 2010; Equinox Environmental 2017; Resource and Environmental Management Pty Ltd 2007). However, taking into consideration their low density and only occasional occurrence, as well as depth to groundwater in the survey area, herein they are more likely to be facultative phreatophytes and therefore an indicator of potential GDV.

5.2.4 EXTRAPOLATED VEGETATION TYPE ASSESSMENT AND MAPPING

Prior to fieldwork commencing Atlas Iron included an area along an existing track and a proposed alternative route for a potential haul road in the southwest of survey area. Part of the existing track could not be accessed during the field survey due to asbestos contamination, however, with adequate safety precautions the proposed alternative route was surveyed. After the field survey Atlas Iron added another potential haul road route. The vegetation types and condition along the inaccessible part of the survey area and the most recently added route have been extrapolated from the nearby area that was ground-truthed, using aerial imagery interpretation (**Map 6H**). Whilst the level of detail for vegetation types is likely to be less than if the area had been ground-truthed, there is no reason to consider that the vegetation in these areas would be significantly different to nearby, and none is likely to have any conservation significance or other significance according to the Flora and Vegetation Technical Guidance (EPA 2016c).

However, the proposed haul road intersects over 2,000 individual *Acacia aphanoclada* (P1) individuals (**Map 5H**). It is not possible to determine if or where individuals are located nor make an estimate of population in unsurveyed areas. Field observations suggest that the recorded population is likely to extend to the east of the mapped population, and less likely to extent to the west.

5.3 VEGETATION CONDITION

The vegetation of McPhee Creek ranged from Excellent to Degraded condition. Most (86%) of the survey area was recorded to be in Excellent condition with negligible evidence of disturbance. The Degraded condition vegetation was from the interpolated creeklines, and was assessed as this condition category by Woodman over various surveys (Woodman 2014b; 2019a) due to grazing, trampling/soil disturbance and weed invasion, primarily by **Cenchrus ciliaris* (Buffel Grass) and **Aerva javanica* (Kapok).

6 CONCLUSIONS

6.1 FLORA AND VEGETATION FACTOR CONSIDERATIONS

Considerations for EIA for the factor *Flora and Vegetation* (EPA 2016a) include, but are not necessarily limited to:

- application of the mitigation hierarchy to avoid and minimise impacts to flora and vegetation, where possible
- the flora and vegetation affected by the proposal
- the potential impacts and the activities that will cause them, including direct and indirect impacts
- the implications of cumulative impacts
- whether surveys and analyses have been undertaken to a standard consistent with guidance
- the scale at which impacts to flora and vegetation are considered
- the significance of the flora and vegetation, and the risk to the flora and vegetation
- the current state of knowledge of flora and vegetation and the level of confidence underpinning the predicted residual impacts
- whether proposed management and mitigation approaches are technically and practically feasible
- whether the proposal area will be revegetated in a manner that promotes biological diversity and ecological integrity.

Various issues are frequently of significance within the environmental impact assessment process. These issues, and the potential impact from the proposed works, are summarised below.

6.1.1 HABITAT LOSS, DEGRADATION AND FRAGMENTATION

The two pre-European vegetation association associated with the survey area have more than 99% of the original extent remaining. The small scale of clearing for mining within these tenements is unlikely to have a significant effect on the pre-European vegetation association extent.

While degradation of the survey area will undoubtedly occur with the proposed mining development within the survey area, the scale of degradation is unlikely to be significant. Due to the large remaining extents, fragmentation is unlikely to be a significant issue for the vegetation. None of the vegetation types recorded are of conservation significance.

6.1.2 INVASIVE SPECIES

Seven introduced species were recorded from the survey area tenements; one is a Declared Pest plant (**Calotropis procera*), none are WONS species.

Buffel Grass (**Cenchrus ciliaris*), introduced as pastoral species, has significantly affected vegetation condition, mainly in riparian vegetation types. The presence and impact of this species is not a result of mining activities, and mining is unlikely to significantly increase the impact.

Other introduced species currently occur sporadically and are having little effect on vegetation condition (with the exception of the single location of **Calotropis procera*). Whilst mining activities may increase their extent, density and impact it is possible, with management, to minimise these effects.

6.1.3 FIRE REGIMES

Fire occurs naturally in the landscape as a result of lightning strike and vegetation has evolved to recover rapidly. Fire has also been used by Traditional Owners to flush game and generate new growth that attracts herbivores and has been used by pastoralists to generate new growth that is more palatable to livestock.

Any proposed mining activities are unlikely to alter the frequency, intensity or extent of fires.

6.1.4 CHANGING CLIMATE

Climate change in the adjacent Pilbara region of Western Australia is likely to increased frequency and intensity of cyclones and be responsible for increases in temperature (Western Australian Government 2012). No specific information is available for the Gascoyne bioregion, particularly the interior parts, however, the Department of Primary Industries and Regional Development (DPIRD) anticipate that rainfall in the interior Pilbara is expected to increase and, with rising temperatures, evapotranspiration will increase (DPIRD 2019). There is no information available regarding the scale of these changes, or if the anticipated increase in rainfall will be greater than evapotranspiration, or the seasonality of such changes.

Climate change impacts on native flora and vegetation may be of importance as a cumulative impact when taking all changing factors into account, however, on its own, climate change is unlikely to be to be a significant factor in the survey areas.

6.1.5 STATE OF KNOWLEDGE

It is unlikely that any knowledge gaps relating to the vegetation of the survey areas are likely to be of significance.

It is considered the 'application of general ecological principles' are likely to be a reasonable guide to understanding the flora and vegetation of the survey area.

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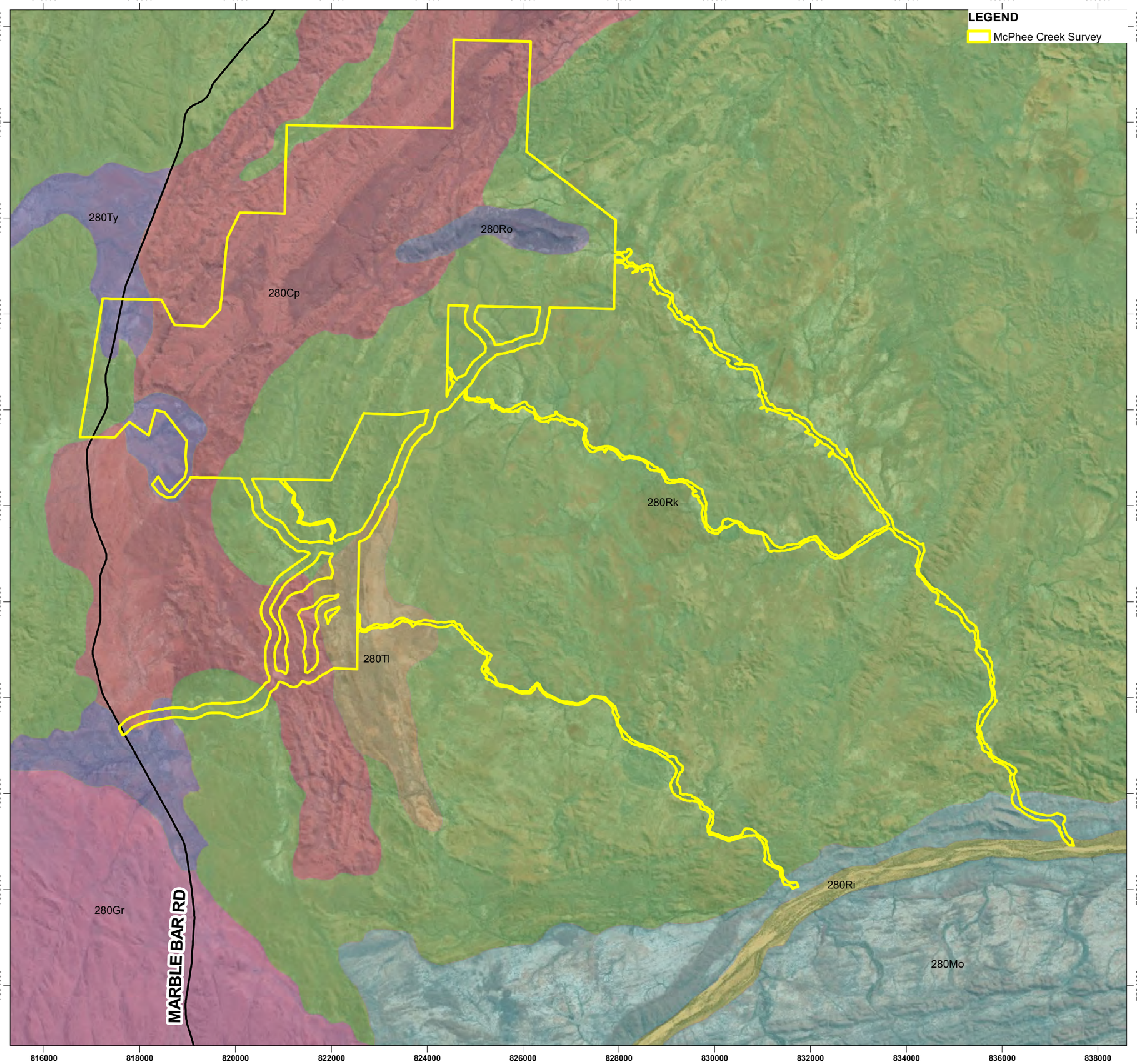
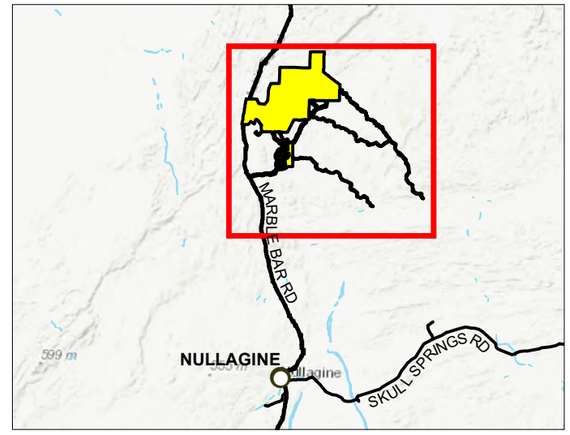
MAPS



LEGEND

Soil Landscape Systems (DPIRD, 2018)

- 280Cp: Capricorn System – rugged sandstone hills, ridges, stony footslopes and interfluves supporting low acacia shrublands or hard spinifex grasslands with scattered shrubs.
- 280Gr: Granitic System – rugged granitic hills supporting shrubby hard and soft spinifex grasslands.
- 280Mo: Mosquito System – stony plains and prominent ridges of schist and other metamorphic rocks supporting shrubby hard spinifex grasslands.
- 280Ri: River System – narrow, seasonally active flood plains and major river channels supporting moderately close, tall shrublands or woodlands of acacias and fringing communities of eucalypts sometimes with tussock grasses or spinifex.
- 280Rk: Rocklea System – basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex and occasionally soft spinifex grasslands with scattered shrubs.
- 280Ro: Robe System – low plateaux, mesas and buttes of limonite supporting soft spinifex and occasionally hard spinifex grasslands.
- 280Tl: Talga System – hills and ridges of greenstone and chert and stony plains supporting hard and soft spinifex grasslands.
- 280Ty: Taylor System – stony plains and isolated low hills of sedimentary rocks supporting hard and soft spinifex shrubby grasslands.



DATA SOURCES:
BASEMAP: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS,

ecoscape

SOIL LANDSCAPE SYSTEMS

MCPHEE CREEK
FLORA AND VEGETATION SURVEY

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

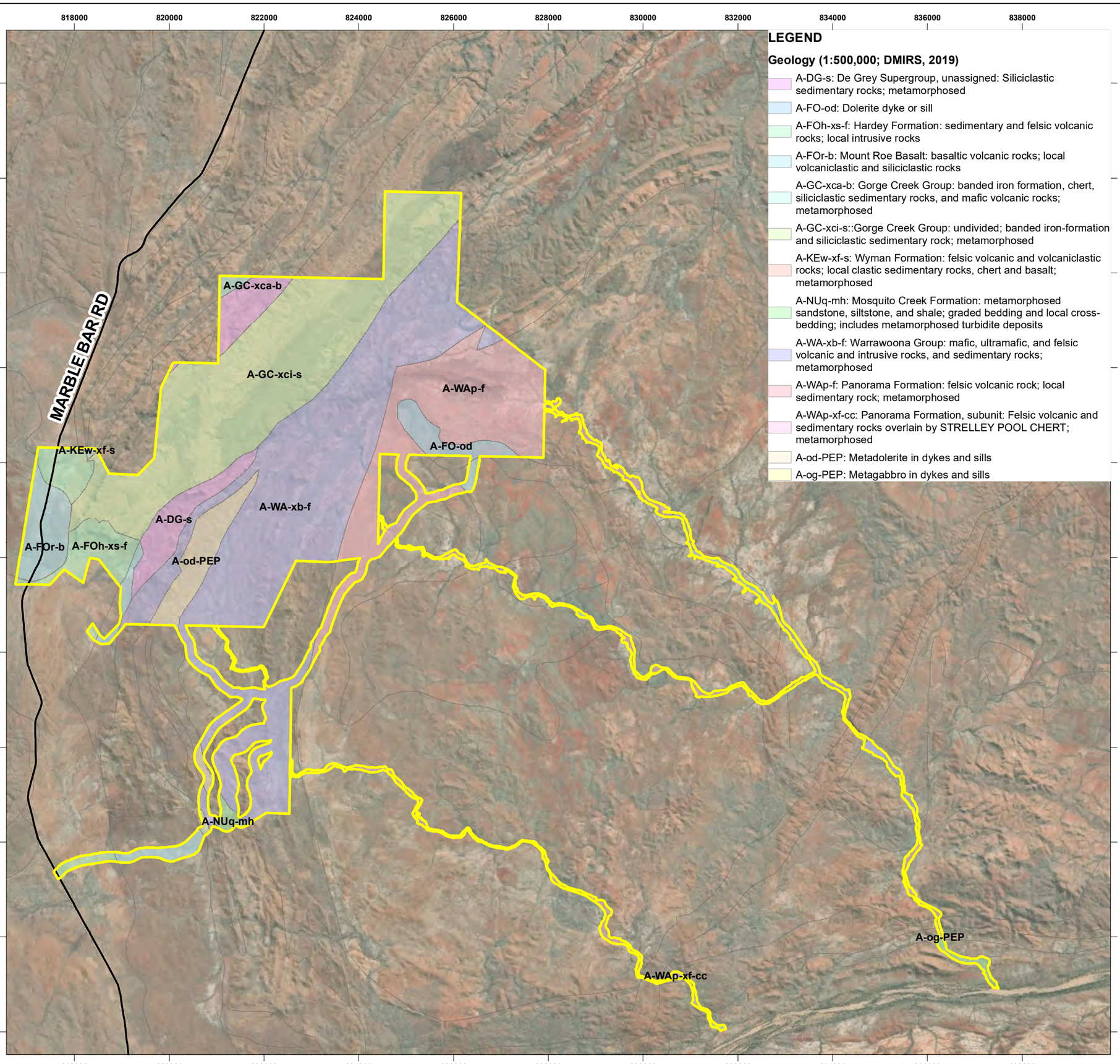
SCALE: 1:80,000 @ A3

0 1.5 3 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	10/07/2020

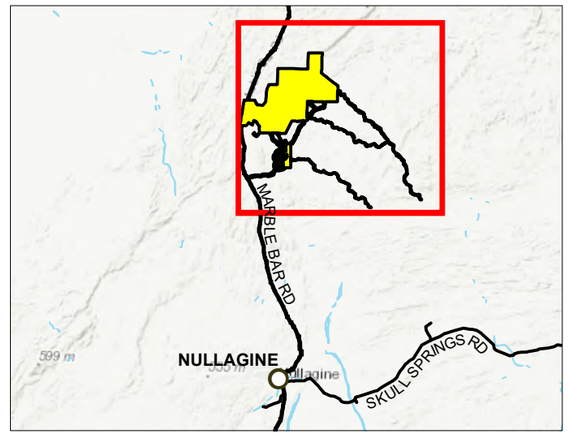
MAP
1



LEGEND

McPhee Creek Survey Area

*Surface Geology legend only shows units intersecting with the Survey Area



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SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS,

ecoscape

GEOLOGY

MCPHEE CREEK FLORA AND VEGETATION SURVEY

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

SCALE: 1:80,000 @ A3

0 1.5 3 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	10/07/2020

MAP 2

816000 818000 820000 822000 824000 826000 828000 830000 832000 834000 836000 838000

7614000 7612000 7610000 7608000 7606000 7604000 7602000 7600000 7598000 7596000 7594000

LEGEND

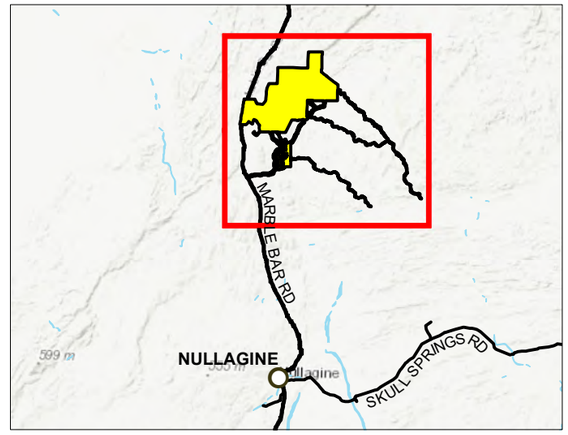
McPhee Creek Survey Area

Pre European Vegetation (DPRID, 2018)

171: Hummock grasslands, low tree steppe, snappy gum over soft spinifex and *Triodia brizioides*

173: Hummock grasslands, shrub steppe, kanji over soft spinifex and *Triodia wiseana* on basalt

190: Hummock grasslands, sparse shrub steppe; *Acacia bivenosa* and *A. trachycarpa* over hard spinifex, *Triodia wiseana*, Very poor rocky country on gneiss



DATA SOURCES:
BASEMAP: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS,

ecoscape

PRE EUROPEAN VEGETATION

MCPHEE CREEK FLORA AND VEGETATION SURVEY

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

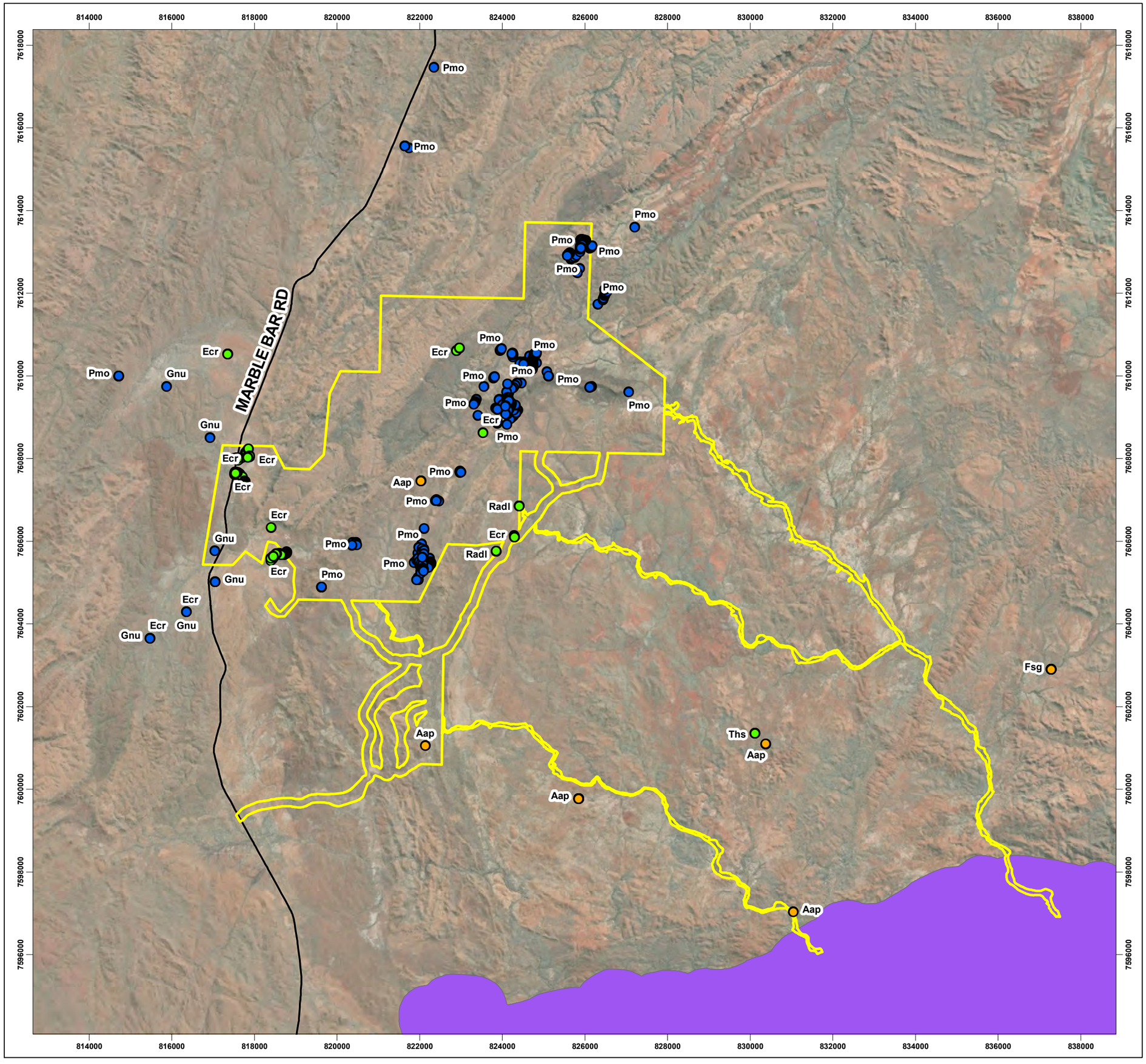
SCALE: 1:80,000 @ A3

0 1.5 3 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	13/07/2020

MAP 3



LEGEND

McPhee Creek Survey Area

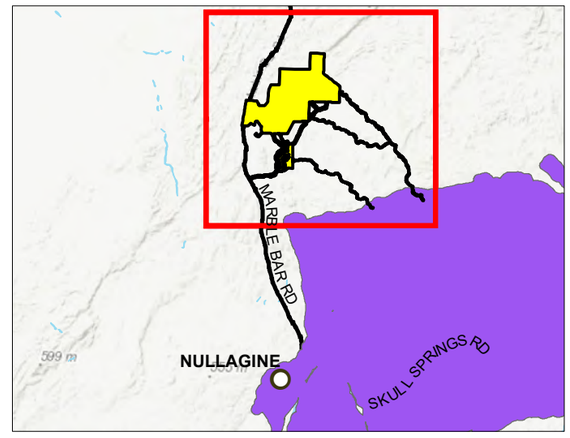
Conservation-listed flora (Atlas Iron & DBCA, 2020)

- Priority 1
- Priority 3
- Priority 4

Threatened and Priority Ecological Communities (DBCA, 2020)

Stony saline clay plains of the Mosquito Land System

CODE	Species
Aap	*Acacia aphanoclada*
Ecr	*Eragrostis crateriformis*
Fsg	*Fimbristylis* sp. Shay Gap (K.R. Newbey 10293)
Gnu	*Goodenia nuda*
Pmo	*Ptilotus mollis*
Radl	*Rostellularia adscendens* var. *latifolia*
Ths	*Themeda* sp. Hamersley Station (M.E. Trudgen 11431)



DATA SOURCES:
BASEMAP: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS,

ecoscape

ATLAS AND DBCA DATABASE RESULTS

MCPHEE CREEK FLORA AND VEGETATION SURVEY

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

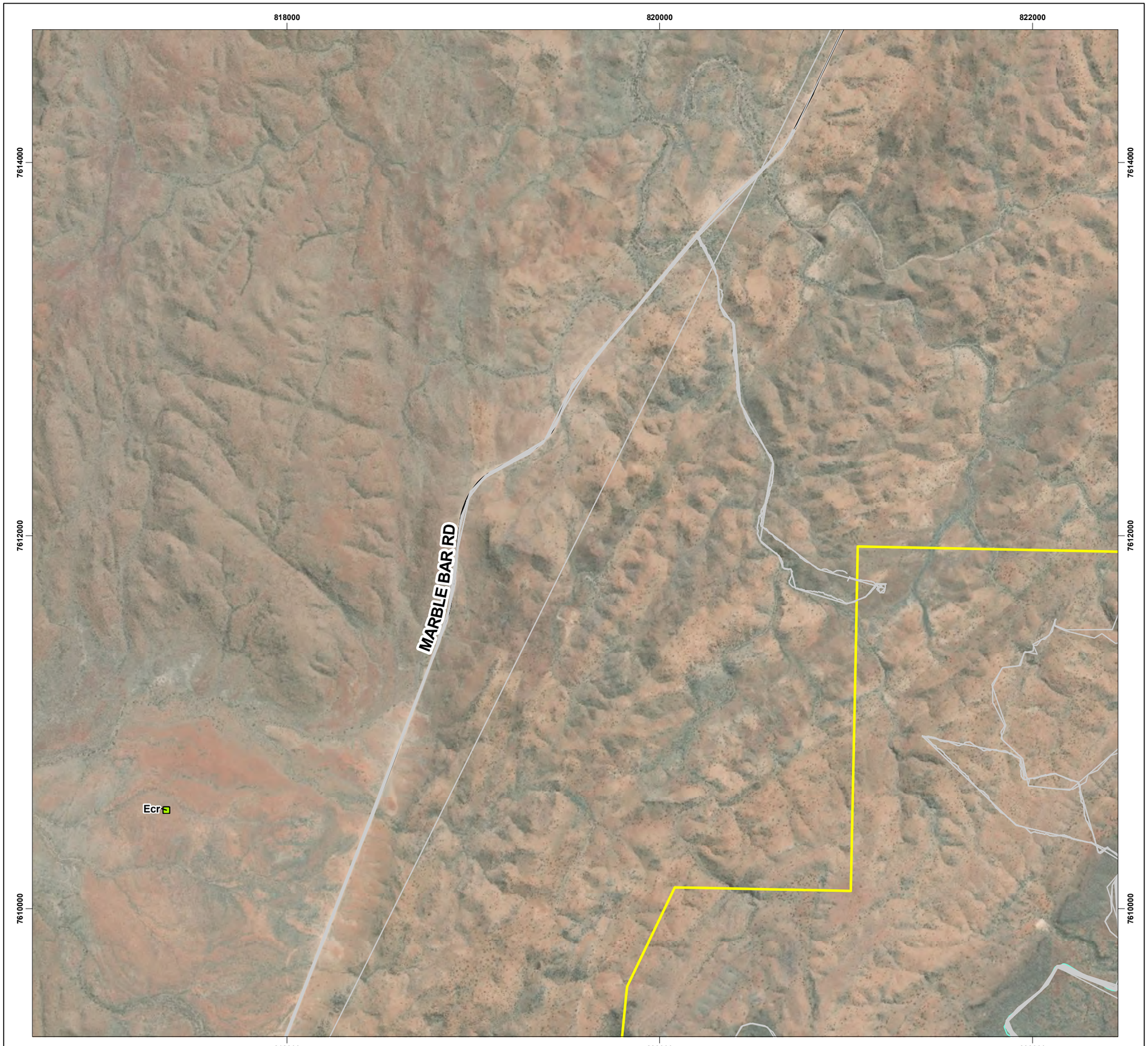
SCALE: 1:90,000 @ A3

0 1.5 3 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	13/07/2020

MAP 4



LEGEND

McPhee Creek Survey Area

Survey Tracks

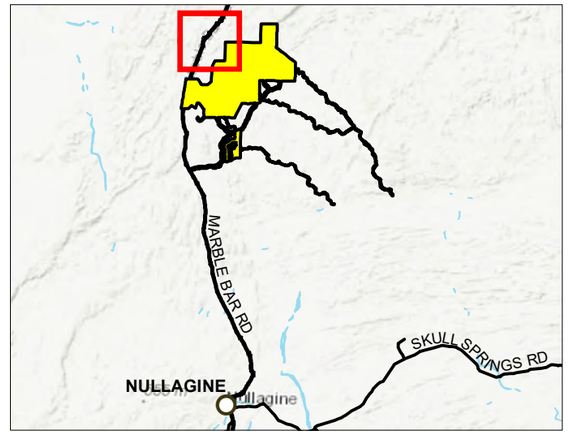
Ecoscape (2020)

Woodman (2014c)

Previous Surveys (Atlas Iron & DBCA, 2020)

Priority 3

CODE	Species
Aap	*Acacia aphanoclada*
Ecr	*Eragrostis crateriformis*
Fsg	*Fimbristylis* sp. Shay Gap (K.R. Newbey 10293)
Gnu	*Goodenia nuda*
Pmo	*Ptilotus mollis*
Radl	*Rostellularia adscendens* var. *latifolia*
Ths	*Themeda* sp. Hamersley Station (M.E. Trudgen 11431)



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CONSERVATION-LISTED FLORA AND SURVEY TRACKS

MCPHEE CREEK FLORA AND VEGETATION SURVEY

DATA SOURCES:
BASEMAP: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS,

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

SCALE: 1:20,000 @ A3

0 0.4 0.8 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	13/07/2020

MAP 5A

824000
826000
828000
7614000
7612000
7610000

Pmo
Ecr

LEGEND

McPhee Creek Survey Area

Survey Tracks

Ecoscape (2020)

Woodman (2014c)

Previous Surveys (Atlas Iron & DBCA, 2020)

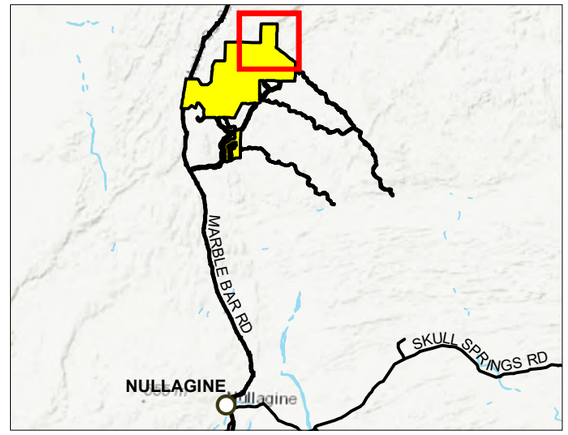
Priority 3

Priority 4

Phase 1 (Ecoscape, 2020)

Priority 4

CODE	Species
Aap	*Acacia aphanoclada*
Ecr	*Eragrostis crateriformis*
Fsg	*Fimbristylis* sp. Shay Gap (K.R. Newbey 10293)
Gnu	*Goodenia nuda*
Pmo	*Ptilotus mollis*
Radl	*Rostellularia adscendens* var. *latifolia*
Ths	*Themeda* sp. Hamersley Station (M.E. Trudgen 11431)



ecoscape

CONSERVATION-LISTED FLORA AND SURVEY TRACKS

MCPHEE CREEK FLORA AND VEGETATION SURVEY

DATA SOURCES:
BASEMAP: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS,

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

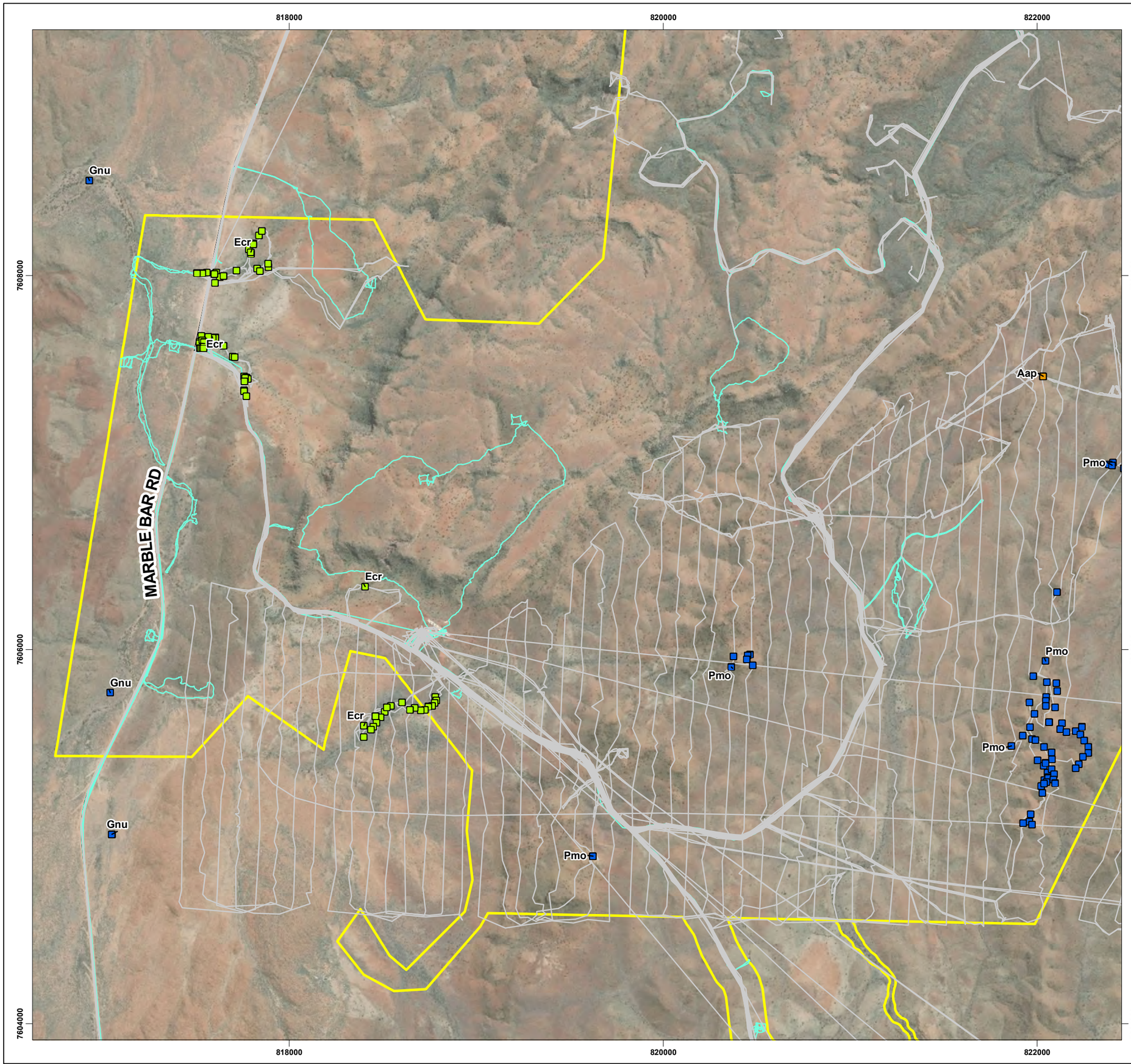
SCALE: 1:20,000 @ A3

0 0.4 0.8 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	13/07/2020

MAP 5B



LEGEND

- McPhee Creek Survey Area

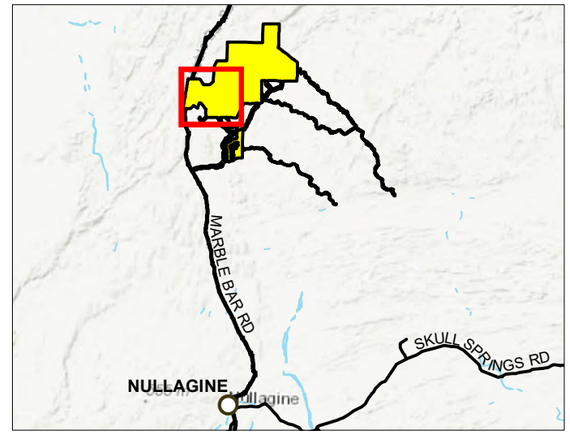
Survey Tracks

- Ecoscape (2020)
- Woodman (2014c)

Previous Surveys (Atlas Iron & DBCA, 2020)

- Priority 1
- Priority 3
- Priority 4

CODE	Species
Aap	*Acacia aphanoclada*
Ecr	*Eragrostis crateriformis*
Fsg	*Fimbristylis* sp. Shay Gap (K.R. Newbey 10293)
Gnu	*Goodenia nuda*
Pmo	*Ptilotus mollis*
Radl	*Rostellularia adscendens* var. *latifolia*
Ths	*Themeda* sp. Hamersley Station (M.E. Trudgen 11431)



ecoscape

CONSERVATION-LISTED FLORA AND SURVEY TRACKS

MCPHEE CREEK FLORA AND VEGETATION SURVEY

DATA SOURCES:
BASEMAP: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS,

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

SCALE: 1:20,000 @ A3

0 0.4 0.8 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	13/07/2020

MAP 5C

824000
826000
828000
7608000
7606000
7604000

Pmo
Pmo
Ecr
Pmo
Pmo
Radl
Radl
Ecr
Radl

LEGEND

McPhee Creek Survey Area

Survey Tracks

Ecoscape (2020)

Woodman (2014c)

Previous Surveys (Atlas Iron & DBCA, 2020)

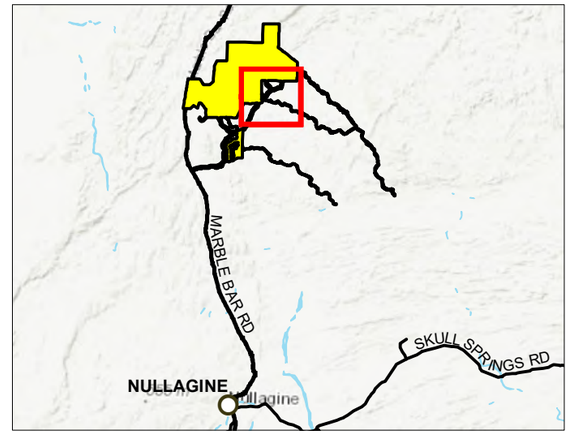
Priority 3

Priority 4

Phase 1 (Ecoscape, 2020)

Priority 3

CODE	Species
Aap	*Acacia aphanoclada*
Ecr	*Eragrostis crateriformis*
Fsg	*Fimbristylis* sp. Shay Gap (K.R. Newbey 10293)
Gnu	*Goodenia nuda*
Pmo	*Ptilotus mollis*
Radl	*Rostellularia adscendens* var. *latifolia*
Ths	*Themeda* sp. Hamersley Station (M.E. Trudgen 11431)



ecoscape

CONSERVATION-LISTED FLORA AND SURVEY TRACKS

MCPHEE CREEK FLORA AND VEGETATION SURVEY

DATA SOURCES:
BASEMAP: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS,

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

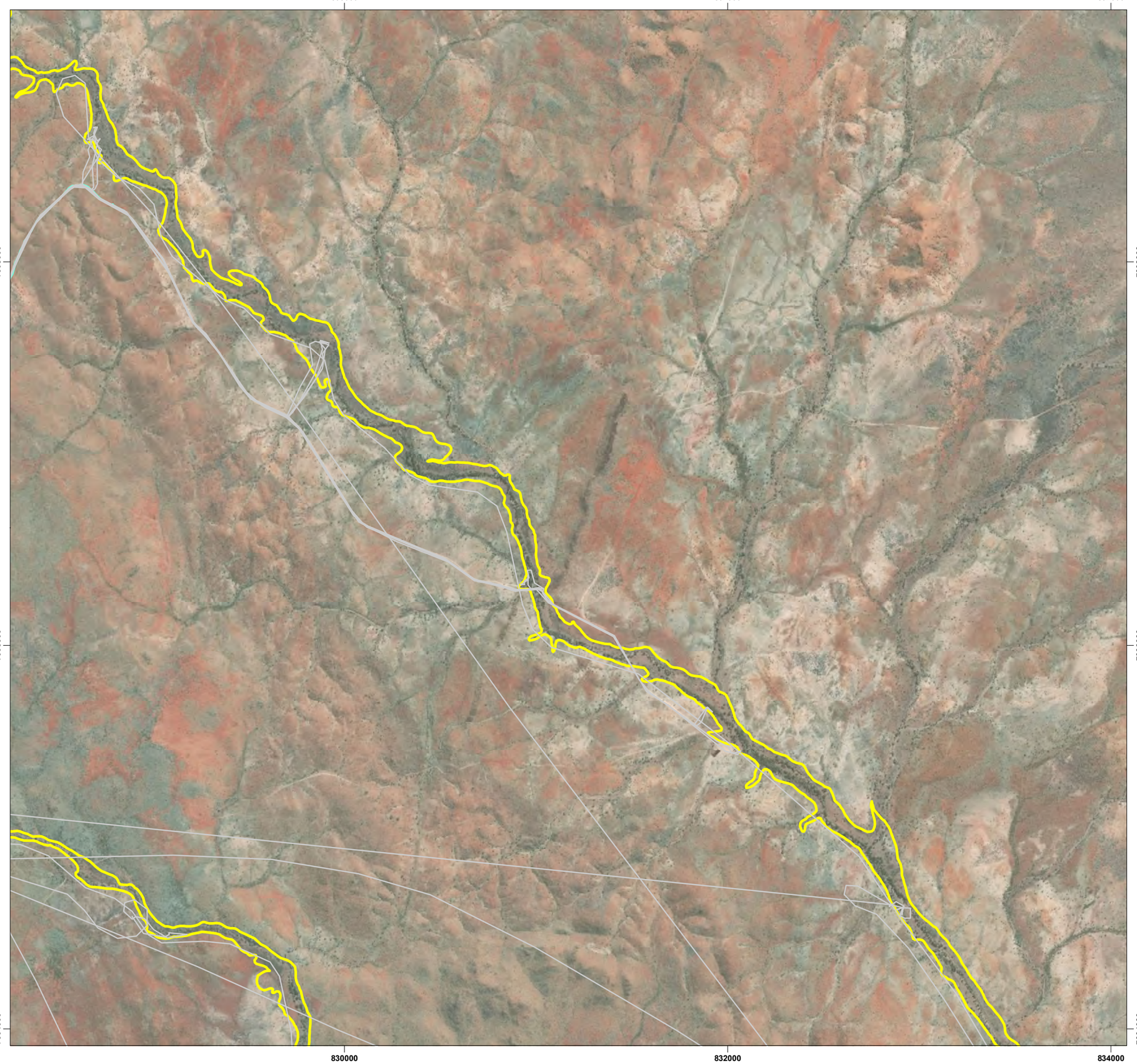
SCALE: 1:20,000 @ A3

0 0.4 0.8 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	13/07/2020

MAP 5D



LEGEND

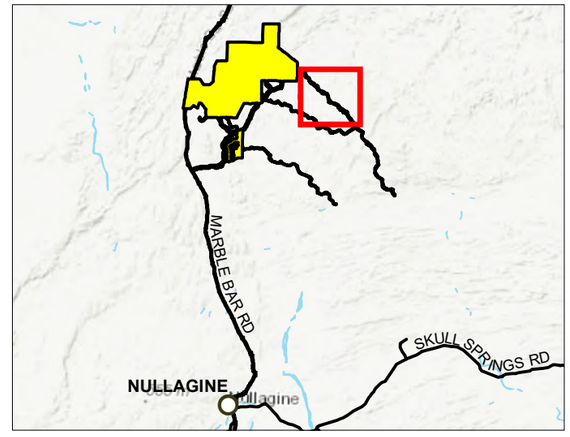
McPhee Creek Survey Area

Survey Tracks

Ecoscape (2020)

Woodman (2014c)

CODE	Species
Aap	*Acacia aphanoclada*
Ecr	*Eragrostis crateriformis*
Fsg	*Fimbristylis* sp. Shay Gap (K.R. Newbey 10293)
Gnu	*Goodenia nuda*
Pmo	*Ptilotus mollis*
Radl	*Rostellularia adscendens* var. *latifolia*
Ths	*Themeda* sp. Hamersley Station (M.E. Trudgen 11431)



ecoscape

CONSERVATION-LISTED FLORA AND SURVEY TRACKS

MCPHEE CREEK FLORA AND VEGETATION SURVEY

DATA SOURCES:
BASEMAP: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS,

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

SCALE: 1:20,000 @ A3

0 0.4 0.8 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	13/07/2020

MAP 5E

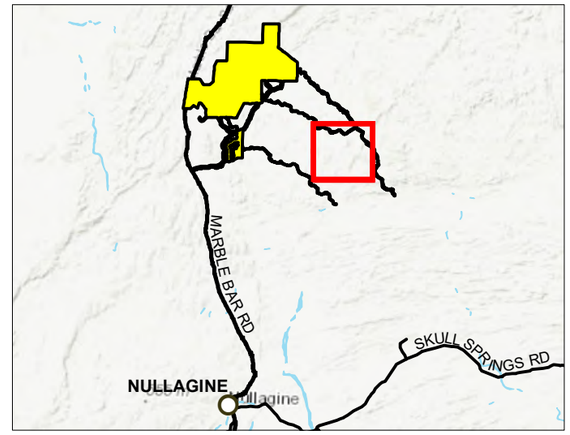
LEGEND

- McPhee Creek Survey Area
- Woodman (2014c)

Previous Surveys (Atlas Iron & DBCA, 2020)

- Priority 1
- Priority 3

CODE	Species
Aap	*Acacia aphanoclada*
Ecr	*Eragrostis crateriformis*
Fsg	*Fimbristylis* sp. Shay Gap (K.R. Newbey 10293)
Gnu	*Goodenia nuda*
Pmo	*Ptilotus mollis*
Radl	*Rostellularia adscendens* var. *latifolia*
Ths	*Themeda* sp. Hamersley Station (M.E. Trudgen 11431)



ecoscape

CONSERVATION-LISTED FLORA AND SURVEY TRACKS

MCPHEE CREEK FLORA AND VEGETATION SURVEY

DATA SOURCES:
BASEMAP: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS,

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

SCALE: 1:20,000 @ A3

0 0.4 0.8 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	13/07/2020

MAP 5F

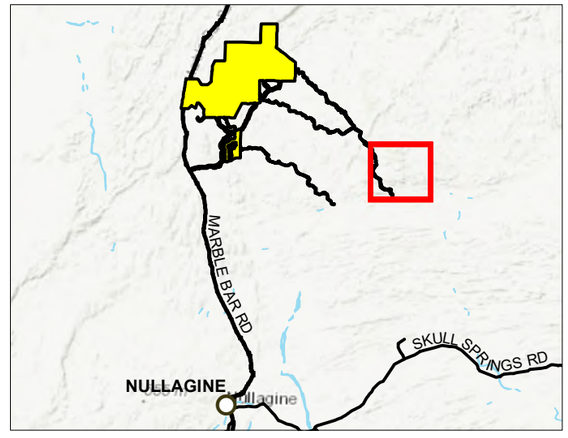
836000
838000
840000
7600000
7598000

LEGEND

McPhee Creek Survey Area

Woodman (2014c)

CODE	Species
Aap	*Acacia aphanoclada*
Ecr	*Eragrostis crateriformis*
Fsg	*Fimbristylis* sp. Shay Gap (K.R. Newbey 10293)
Gnu	*Goodenia nuda*
Pmo	*Ptilotus mollis*
Radl	*Rostellularia adscendens* var. *latifolia*
Ths	*Themeda* sp. Hamersley Station (M.E. Trudgen 11431)



ecoscape

CONSERVATION-LISTED FLORA AND SURVEY TRACKS

MCPHEE CREEK FLORA AND VEGETATION SURVEY

DATA SOURCES:
BASEMAP: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS,

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

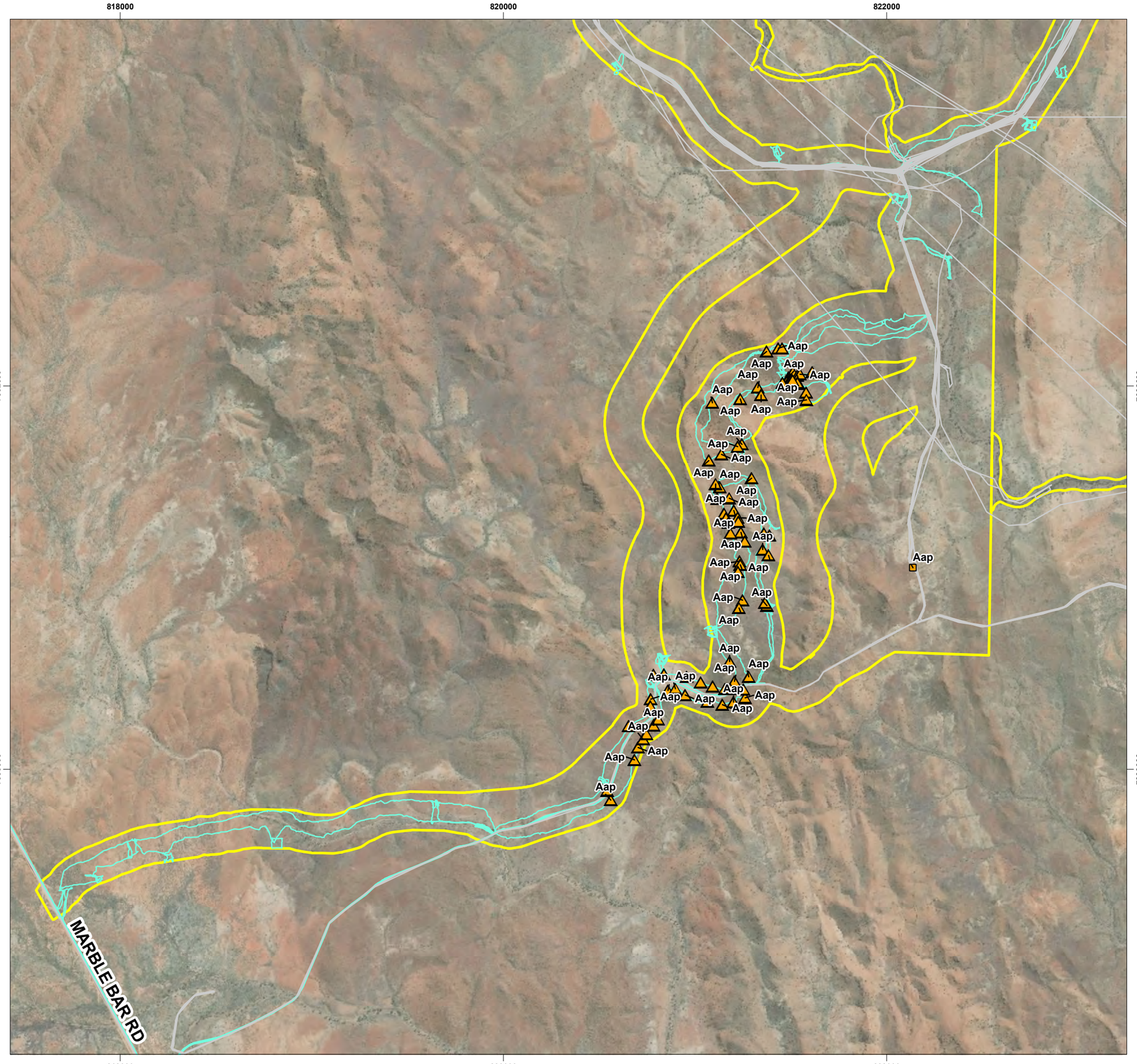
SCALE: 1:20,000 @ A3

0 0.4 0.8 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	13/07/2020

MAP 5G



LEGEND

McPhee Creek Survey Area

Survey Tracks

Ecoscape (2020)

Woodman (2014c)

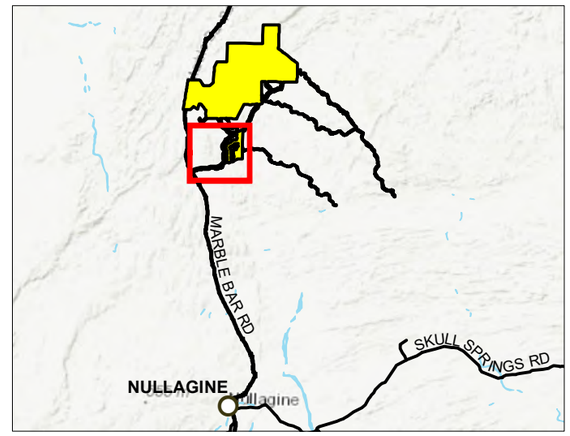
Previous Surveys (Atlas Iron & DBCA, 2020)

Priority 1

Phase 1 (Ecoscape, 2020)

Priority 1

CODE	Species
Aap	*Acacia aphanoclada*
Ecr	*Eragrostis crateriformis*
Fsg	*Fimbristylis* sp. Shay Gap (K.R. Newbey 10293)
Gnu	*Goodenia nuda*
Pmo	*Ptilotus mollis*
Radl	*Rostellularia adscendens* var. *latifolia*
Ths	*Themeda* sp. Hamersley Station (M.E. Trudgen 11431)



ecoscape

CONSERVATION-LISTED FLORA AND SURVEY TRACKS

MCPHEE CREEK FLORA AND VEGETATION SURVEY

DATA SOURCES:
BASEMAP: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS,

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

SCALE: 1:20,000 @ A3

0 0.4 0.8 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	13/07/2020

MAP 5H

824000
826000
828000
7602000
7600000
7598000

Aap

LEGEND

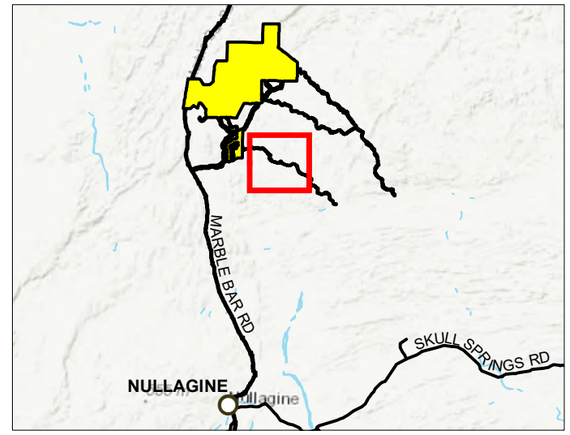
McPhee Creek Survey Area

Woodman (2014c)

Previous Surveys (Atlas Iron & DBCA, 2020)

Priority 1

CODE	Species
Aap	*Acacia aphanoclada*
Ecr	*Eragrostis crateriformis*
Fsg	*Fimbristylis* sp. Shay Gap (K.R. Newbey 10293)
Gnu	*Goodenia nuda*
Pmo	*Ptilotus mollis*
Radl	*Rostellularia adscendens* var. *latifolia*
Ths	*Themeda* sp. Hamersley Station (M.E. Trudgen 11431)



ecoscape

CONSERVATION-LISTED FLORA AND SURVEY TRACKS

MCPHEE CREEK FLORA AND VEGETATION SURVEY

DATA SOURCES:
BASEMAP: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS,

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

SCALE: 1:20,000 @ A3

0 0.4 0.8 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	13/07/2020

MAP 5I

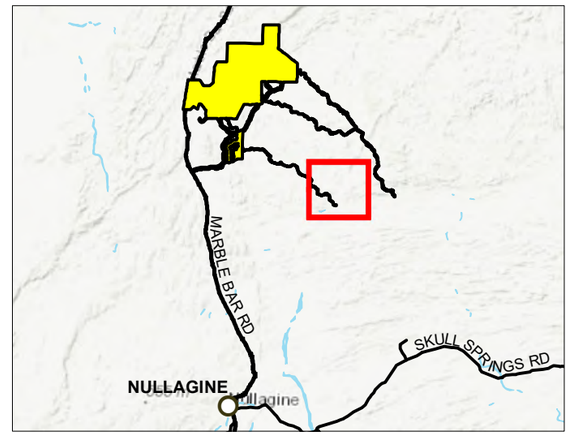
LEGEND

- McPhee Creek Survey Area
- Woodman (2014c)

Previous Surveys (Atlas Iron & DBCA, 2020)

- Priority 1

CODE	Species
Aap	*Acacia aphanoclada*
Ecr	*Eragrostis crateriformis*
Fsg	*Fimbristylis* sp. Shay Gap (K.R. Newbey 10293)
Gnu	*Goodenia nuda*
Pmo	*Ptilotus mollis*
Radl	*Rostellularia adscendens* var. *latifolia*
Ths	*Themeda* sp. Hamersley Station (M.E. Trudgen 11431)



ecoscape

CONSERVATION-LISTED FLORA AND SURVEY TRACKS

MCPHEE CREEK FLORA AND VEGETATION SURVEY

DATA SOURCES:
BASEMAP: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS,

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

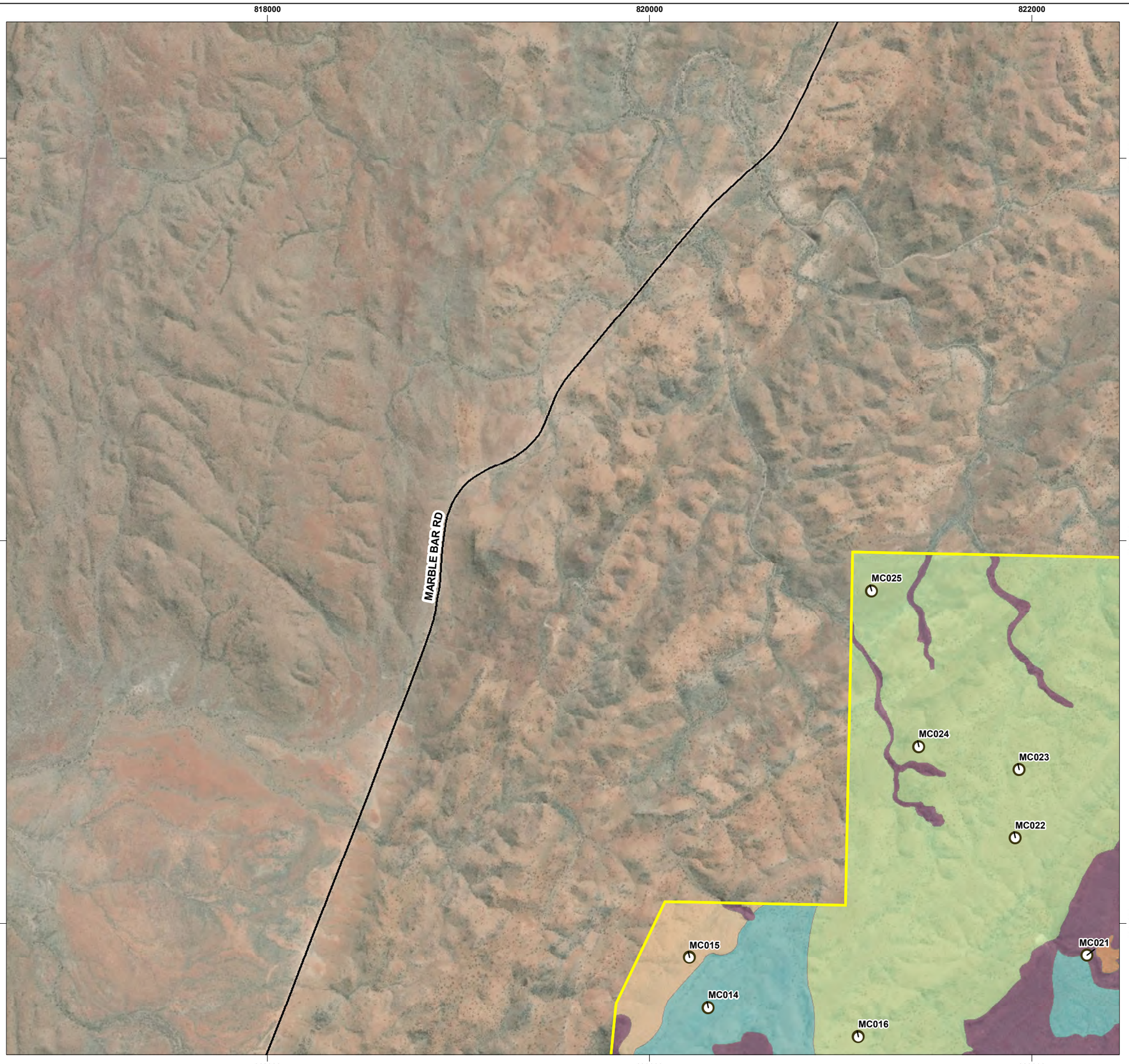
SCALE: 1:20,000 @ A3

0 0.4 0.8 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	13/07/2020

MAP 5J



LEGEND

Survey Area Types

McPhee Creek Survey Area

Quadrat Locations

Existing Quadrats

Vegetation Types

- CcaAiTe: *Corymbia candida* subsp. *dipsodes, C. hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees
- ChAiTe: *Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* low woodland
- ChAmTe: *Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees
- ElAbTe: *Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees
- ElAptTe: *Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia hamersleyana* low woodland

DATA SOURCES:
BASEMAP: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY

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VEGETATION TYPES AND QUADRAT LOCATIONS

MCPHEE CREEK FLORA AND VEGETATION SURVEY

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

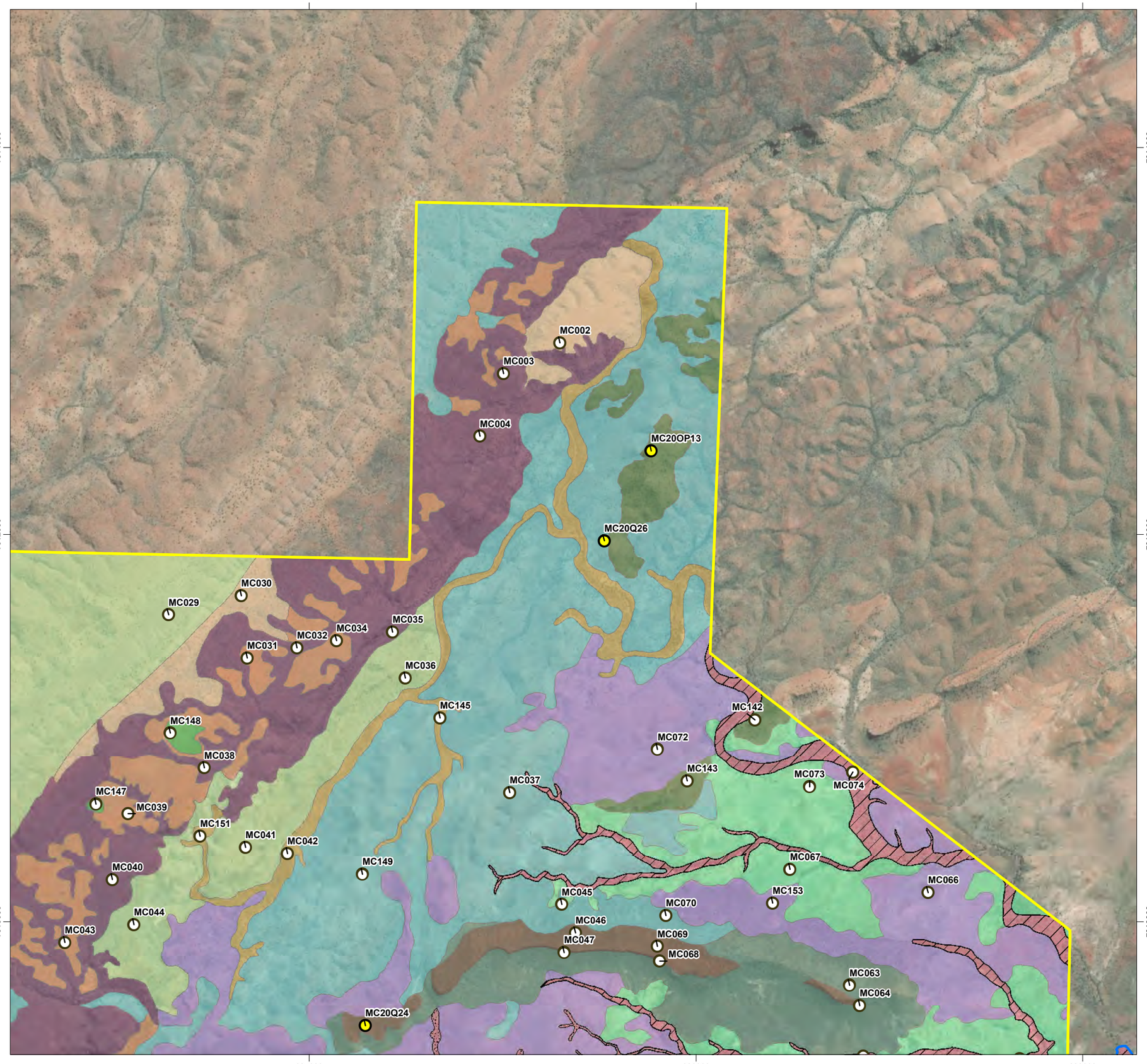
SCALE: 1:20,000 @ A3

0 0.4 0.8 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	16/06/2020

MAP 6A



LEGEND

Survey Area Types

- McPhee Creek Survey Area
- Interpolated (creeklines)

Quadrat Locations

- Existing Quadrats
- New Quadrats (Ecoscape, 2020)

Groundwater Dependent Vegetation Likelihood

- Potential
- Unlikely

Vegetation Types

- AiTw1: *Acacia inaequilatera* and *A. bivenosa* mid isolated shrubs over *Triodia wiseana* mid hummock grassland
- AsTl: *Acacia synchronicia* mid isolated shrubs
- CcaAiTe: *Corymbia candida* subsp. *dipsodes, C. hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees
- ChAiTa: *Corymbia hamersleyana* low isolated trees over *Acacia inaequilatera* tall isolated shrubs
- ChAiTe: *Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* low woodland
- ChAmTe: *Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees
- ChApyTt: *Corymbia hamersleyana* low open woodland over *Acacia pyrifolia* and *Acacia tumida* var. *pilbarensis* tall shrubland
- ElAbTe: *Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees
- ElAmTb: *Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees
- ElAmTe: *Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees
- ElAptTe: *Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia hamersleyana* low woodland
- ElGwTe: *Eucalyptus leucophloia* subsp. *leucophloia* low isolated clumps of trees
- EvApyCci: *Eucalyptus victrix* and *Corymbia hamersleyana* mid open woodland over *Acacia pyrifolia, Acacia trachycarpa* and *Acacia tumida* var. *pilbarensis* tall shrubland

DATA SOURCES:
BASEMAP: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY

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VEGETATION TYPES AND QUADRAT LOCATIONS

MCPHEE CREEK FLORA AND VEGETATION SURVEY

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

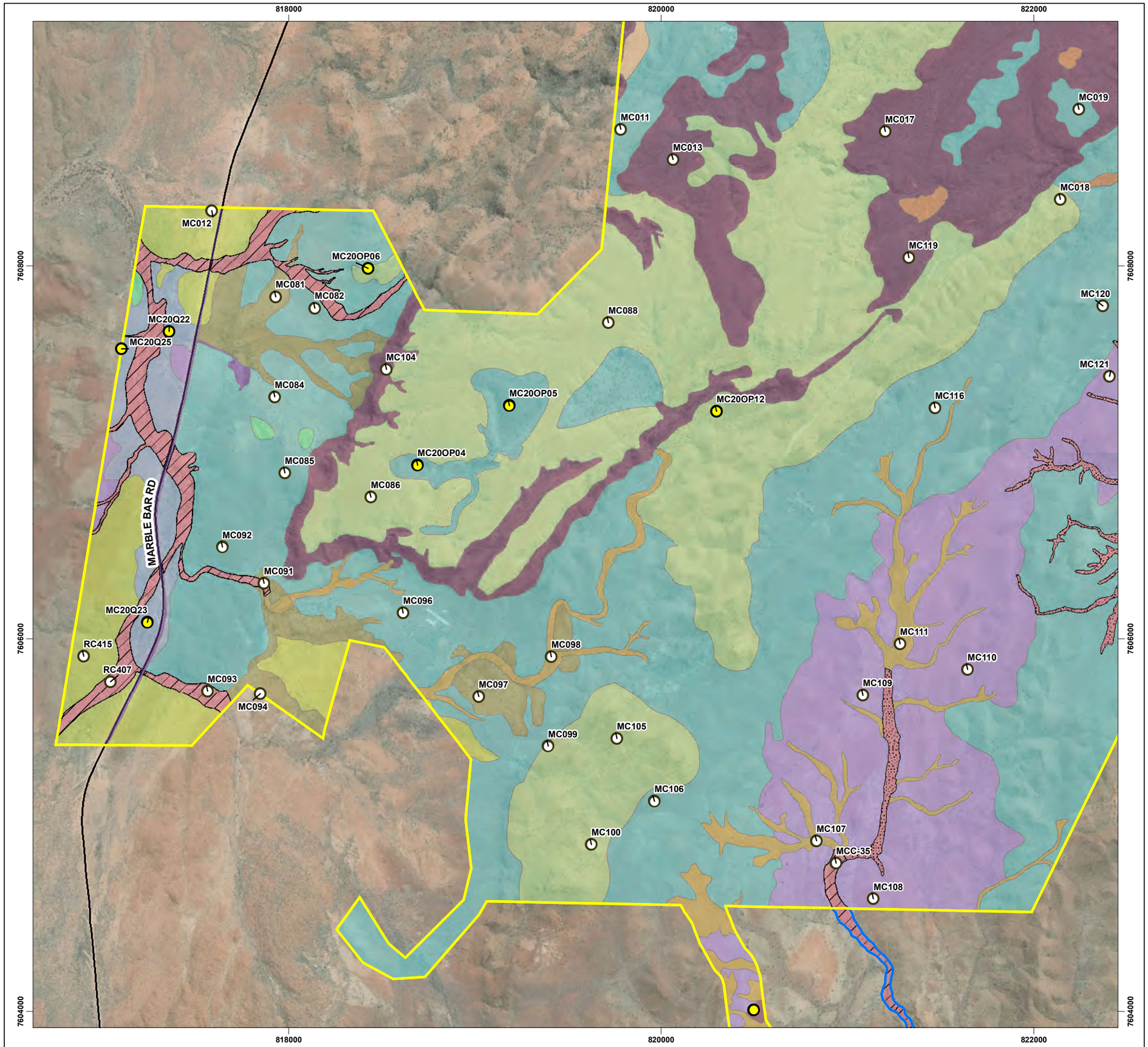
SCALE: 1:20,000 @ A3

0 0.4 0.8 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	16/06/2020

MAP 6B



LEGEND

Survey Area Types

- McPhee Creek Survey Area
- Interpolated (creeklines)

Quadrat Locations

- Existing Quadrats
- New Quadrats (Ecoscape, 2020)

Groundwater Dependent Vegetation Likelihood

- Potential
- Unlikely

Vegetation Types

- AiTw1: *Acacia inaequilatera* and *A. bivenosa* mid isolated shrubs over *Triodia wiseana* mid hummock grassland
- AiTw2: *Acacia inaequilatera* and *A. bivenosa* mid isolated shrubs over *Triodia wiseana* and *T. longiceps* mid hummock grassland
- AoAbTl: *Acacia orthocarpa, A. monticola* and *A. bivenosa* low sparse shrubland
- CcaAiTe: *Corymbia candida* subsp. *dipsodes, C. hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees
- ChAiTa: *Corymbia hamersleyana* low isolated trees over *Acacia inaequilatera* tall isolated shrubs
- ChAiTe: *Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* low woodland
- ChAiTw: *Corymbia hamersleyana* low isolated clumps of trees
- ChAmTe: *Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees
- ChApyTt: *Corymbia hamersleyana* low open woodland over *Acacia pyrifolia* and *Acacia tumida* var. *pilbarensis* tall shrubland
- ElAbTe: *Eucalyptus leucophloia* subsp. *leucophloia* low isolated trees
- ElAptTe: *Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia hamersleyana* low woodland
- EvApyCci: *Eucalyptus victrix* and *Corymbia hamersleyana* mid open woodland over *Acacia pyrifolia, Acacia trachycarpa* and *Acacia tumida* var. *pilbarensis* tall shrubland
- Cleared

DATA SOURCES:
BASEMAP: GEOSCIENCE AUSTRALIA
SERVICE LAYERS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY

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VEGETATION TYPES AND QUADRAT LOCATIONS

MCPHEE CREEK FLORA AND VEGETATION SURVEY

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

ATLAS

N

SCALE: 1:20,000 @ A3

0 0.4 0.8 km

PROJECT NO: 4510-20

REV	AUTHOR	APPROVED	DATE
LJA	JLT	LJA	16/06/2020

MAP 6C