Orebody 31

Flora and Vegetation Environmental Impact Assessment

Prepared for BHP Billiton Iron Ore Pty Ltd
February 2015

Document Status						
Rev No.	**Authors**	**Reviewer/s**	**Date**	**Approved for Issue**		
				Name	**Distributed To**	**Date**
1	D.Brearley	J.Bull	15/04/14	D.Brearley	S.Brunt, S.Pickard, B.Menezies	16/05/14
2	D.Brearley	S.Brunt, S.Pickard, B.Menezies	15/04/14	D.Brearley	S.Brunt, S.Pickard, B.Menezies	16/06/14
3	D.Brearley	S.Brunt, S.Pickard, B.Menezies	27/06/14	D.Brearley	S.Brunt, S.Pickard, B.Menezies	14/07/14
4	D.Brearley	S.Brunt, S.Pickard, B.Menezies	02/08/14	D.Brearley	S.Brunt, S.Pickard, B.Menezies	22/08/14
5	D.Brearley	Additional Field Survey	15/09/14	D.Brearley	S.Brunt, S.Pickard, B.Menezies	29/09/14
6	D.Brearley	B.Menezies	01/10/14	D.Brearley	S.Brunt, S.Pickard, B.Menezies	02/10/14
7	D.Brearley	B.Menezies, S.Brunt	10/10/14	D.Brearley	S.Brunt, S.Pickard, B.Menezies	13/10/14
8	D.Brearley	B.Menezies, S.Brunt	18/02/15	D.Brearley	S.Brunt, S.Pickard, L.Boulden, B.Menezies	20/02/15

Onshore Environmental Consultants Pty Ltd
ACN 095 837 120
PO Box 227
YALLINGUP WA 6282
Telephone / Fax (08) 9756 6206
E-mail: onshoreenv@westnet.com.au

EXECUTIVE SUMMARY

BHP Billiton Iron Ore Pty Ltd (BHP Billiton Iron Ore) is preparing referrals to the Environmental Protection Authority (EPA) under Section 38 of the *Environmental Protection Act 1986* (EP Act) to develop new mining areas at Orebody 31 (OB31). Onshore Environmental Consultants Pty Ltd (Onshore Environmental) was commissioned by BHP Billiton Iron Ore to undertake a flora and vegetation Environmental Impact Assessment (EIA) to assess potential impacts of the proposed development.

There are at least 32 flora and vegetation surveys that have been completed within a 25 km radius of the Proposal Development Envelope, including five baseline surveys and two targeted significant flora survey that cover the entire Proposal Development Envelope. The EIA is informed by recent survey results from within the tenement boundary.

None of the vegetation associations recorded within the Proposal Development Envelope are Commonwealth or State listed Threatened Ecological Communities (TECs), or State listed Priority Ecological Communities (PECs).

Vegetation condition across the Proposal Development Envelope was predominantly rated as very good, with smaller proportions rated as excellent and good.

A number of the vegetation associations support *Acacia aptaneura* (Mulga) as a dominant upperstorey component, and may have local conservation significance owing to the increased sensitivity of Mulga to disturbance at the northern limit of its distribution (i.e. the southern Pilbara). While Mulga is drought tolerant, it is reliant on overland flow of surface water following heavy summer rains to survive. Interruption of surface water flows may impact on the integrity of mulga stands and ultimately lead to tree decline. The area of Mulga vegetation occurring on floodplains within the Proposal Development Envelope for the Infrastructure Corridor is at risk from potential drainage shadow impact.

The majority of the Proposal Development Envelope supports xerophytic plant taxa that have no requirement to access groundwater for survival. In addition, there were no phreatophytic species recorded from the Proposal Development Envelope, i.e. species that rely solely on water sourced directly from the watertable. As such, the Proposal Development Envelope is considered low risk with respect to potential impacts on groundwater dependent vegetation. The south-eastern sector of the Proposal Development Envelope for the Mine and associated infrastructure is the only zone where groundwater depth is shallower than 20 metres below ground level (mbgl), and hence capable of supporting groundwater dependent vegetation. The medium drainage line within this zone supports the vadophytic tree species *Eucalyptus victrix,* which is determined to be at moderate risk to decline resulting from groundwater drawdown.

No plant taxon gazetted as Threatened Flora (T) pursuant to subsection (2) of Section 23F of the *Wildlife Conservation Act 1950* (WC Act) or listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) has been recorded from the Proposal Development Envelope.

There are four conservation significant flora occurring within the Proposal Development Envelope, including three Priority flora and one significant range extension. The potential impact of project development for each taxon is discussed below.

- *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) (Priority 1): two populations supporting approximately 186 plants over 2.5 ha occur within the

Proposal Development Envelope for the Mine and associated infrastructure. This taxon occurs at an additional three populations supporting approximately 348 plants over an area of 5.5 ha situated outside the Proposal Development Envelope. *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) appeared to be habitat specific within the area, occurring on exposed orange rock under eroded BIF ironstone (Woongarra Rhyolite under Boolgeeda Iron Formation). While this geological formation is known to occur regionally, the occurrence of this taxon on this geological formation outside of the Mining Tenement Boundary is unknown.

- *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (Priority 3): seven plants from five point locations on a floodplain within the Proposal Development Envelope for the Infrastructure Corridor may be impacted. These plants have likely established from seed washed down from scree slopes supporting the main populations further south and outside the Proposal Development Envelope.
- *Goodenia nuda* (Priority 4): 63 plants from seven points on a floodplain within the Proposal Development Envelope for the Infrastructure Corridor may be impacted. *Goodenia nuda* is well represented throughout the eastern Pilbara and has been regularly recorded at neighbouring tenements.
- *Acacia clelandii* (significant range extension): recorded from 20 point locations scattered across the northern sector of the Proposal Development Envelope and immediate surrounds (as well as further east and outside of the Mining Tenement Boundary), and occurring both within (eight points) and outside (12 points) of the Proposal Development Envelope for the Mine and associated infrastructure. Plants occurred as scattered individuals (between 1 to 5 plants) from nine of the 20 points recorded. At the remaining eleven point locations plant density was estimated in the range 40 plants per ha to 750 plants per ha and providing up to 30 percent ground cover. *Acacia clelandii* has recently been recorded from an additional seven locations situated approximately 2 km east of the Proposal Development Envelope, occurring on undulating stony plains and eroded lower slopes fringing Jimblebar Creek (Onshore Environmental 2015).

There were three introduced (weed) species recorded as scattered individuals from lower lying landforms within the Proposal Development Envelope, including footslopes, plains and drainage lines; **Bidens bipinnata* (Beggar's Ticks), **Cenchrus ciliaris* (Buffel Grass) and **Malvastrum americanum* (Spiked Malvastrum). None of these taxa are listed as Declared Pests under the *Biosecurity and Agriculture Management Act 2007* (BAM Act). Existing management strategies being successfully implemented at surrounding BHP Billiton Iron Ore operations would be extended to the OB31 operations to minimise any potential impacts.

Surplus water discharge into Jimblebar Creek for a maximum period of three months during the wet season, and in the instance that Ophthalmia Dam is unavailable, is unlikely to have any significant impact on riparian flora and vegetation.

Fire age within the Proposal Development Envelope has been rated as moderate (3-5 years) to old (≥6 years). Fire is a natural occurrence for vegetation associations within the area, and the increased risk posed by mine development at the site is manageable and not considered a significant risk.

There is a minor risk of vegetation decline resulting from increased levels of airborne dust along the edge of unsealed roads and tracks supporting large volumes of traffic. This can be effectively managed by implementing proven dust control measures currently being implemented at surrounding BHP Billiton Iron Ore operations.

ABBREVIATIONS

Abbreviation	Definition
BAM Act	*Biosecurity and Agriculture Management Act (2007)*
BHP Billiton Iron Ore	BHP Billiton Iron Ore Pty Ltd
BoM	Bureau of Meteorology
CID	channel iron deposit
DPaW	Department of Parks and Wildlife
DEWHA	Department of the Environment, Water, Heritage and the Arts
DoE	Department of Environment
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EIA	environmental impact assessment
EC	electrical conductivity
EP Act	*Environmental Protection Act (1986)*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act (1999)*
EPS	Environmental Protection Statement
ha	hectares
HV	heavy vehicle
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for Conservation of Nature
KCT	Key Characteristics Table
km	kilometre
LOM	Life of Mine
LV	light vehicle
m	metre
bgl	below ground level
MS	Ministerial Statement of Approval
Mt	million tonnes
Mtpa	million tonnes per annum
OB31	Orebody 31
OSAs	Overburden Storage Areas
P1	Priority 1
P2	Priority 2
P3	Priority 3
P4	Priority 4
PECs	Priority Ecological Communities
SRE	short-range endemic
T	Threatened Flora
TECs	Threatened Ecological Communities
WA	Western Australia
WAH	Western Australian Herbarium
WC Act	*Wildlife Conservation Act (1950)*

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

1 INTRODUCTION

1.1 Preamble

Onshore Environmental was commissioned by BHP Billiton Iron Ore to undertake a flora and vegetation EIA to assess potential impacts of the proposed development of new mining areas at OB31 (Figure 1). The purpose of the EIA was to provide a project specific assessment of the potential impacts of the proposed development on flora and vegetation.

Orebody 31 is located approximately 40 kilometres (km) east of Newman Township in the Pilbara region of Western Australia (Figure 1). OB31 is situated to the east of the existing Orebody 17/18 (OB17/18) Mine within Mineral Lease ML244SA, which is subject to the *Iron Ore (Mount Newman) Agreement Act 1964* (Newman Agreement Act). OB31 has not previously been developed and as such is considered a greenfields development.

BHP Billiton Iron Ore currently operates a number of iron ore mines and associated rail and port infrastructure within the Pilbara region of Western Australia. Current mining operations in proximity to OB31 include:

- Newman Joint Venture Hub, located approximately 2 km west of Newman Township, which consists of Mount Whaleback and Orebodies 29, 30 and 35;
- OB17/18 Mine, located approximately 30 km east of Newman Township;
- Wheelarra Hill (Jimblebar) Mine, located approximately 40 km east of Newman Township and 5 to 10 km south of OB31; and
- Orebodies 23, 24 and 25, located approximately 8 km northeast of Newman Township.

The closest operations to OB31 are the OB17/18 Mine and Wheelarra Hill (Jimblebar) Mine (Figure 1).

1.2 Project Description

The OB17/18 Mine is reaching the end of its economic life, with available ore reserves expected to be depleted by mid 2017. Additional ore sources are required to provide sufficient blend feed in order to maintain the current level of iron ore production from the Eastern Pilbara mines.

The mineralised resource at OB31 has been estimated at approximately 500 million tonnes (Mt). BHP Billiton Iron Ore is currently considering two development options for this resource. The first is a base option of 15 Mtpa as a long-term replacement for OB18 and the second is a growth option of 30 Mtpa.

Open pits will be developed using conventional drill and blast techniques with ore sent through existing OB18 crusher via heavy vehicle haul road. A possible future plan is also being considered to have a new primary crusher at OB31 and crushed ore will be transported via an overland conveyor. For the base option (15 Mtpa), ore will be sent through existing OB18 crusher via heavy vehicle haul road then railed to the Mount Whaleback Mine, where it will be blended with ore produced by the Newman Joint Venture.

Under the growth option (30 Mtpa), 15 Mtpa will be sent via heavy vehicle haul road (in the short term) and via an overland conveyor (in the long term) to ore stockpiles at the OB17/18 Mine with the remaining 15 Mtpa sent via conveyor to ore stockpiles at the Wheelarra Hill (Jimblebar) Mine. Ore from both the OB17/18 Mine and Wheelarra Hill (Jimblebar) Mine will be railed to the Mt Whaleback Mine and blended with ore produced by the Newman Joint Venture.

Non-mineralised waste rock will be hauled to new OSAs at OB31 and/or back to OB17/18 to backfill empty pits.

1.2.1 Project components

The OB31 project consists of the following:

- one single open pit, based on initial studies (future update subject to final drilling results);
- three new OSAs, based on initial studies (future update subject to final drilling results);
- a primary crushing facility;
- haulage (heavy vehicles (HV)) and light vehicles (LV) access roads linking OB31 to existing OB17/18 Mine infrastructure;
- a potential future overland conveyor to existing infrastructure at the OB17/18 Mine;
- power, water, fibre optic cable and other associated services which may be required along road and/or conveyor alignments;
- topsoil and vegetation stockpiles;
- offices, ablutions, LV and HV parking areas, laydown areas, hydrocarbon storage facilities, Ammonium Nitrate storage facilities and magazine areas and other ancillary facilities; and
- water infrastructure including dewatering/potable/monitoring water bores, diesel generator sets, pipelines, turkeys nests and/or other storage facilities as required.

Figure 2 and Figure 3 show the extent of the Proposal Development Envelope for the Mine and associated infrastructure and for the Infrastructure Corridor for the OB31 project and Figure 4 shows the proximity of the OB31 project to other nearby projects and the Newman Township.

At the time of commissioning this study, BHP Billiton Iron Ore created and provided all technical consultants (including Onshore Environmental) with spatial boundaries around Orebody 31 in order to inform impact assessment studies. These boundaries were called ‘indicative disturbance boundaries’. Throughout the completion of this study, BHP Billiton Iron Ore has since refined and renamed the boundary the ‘Proposal Development Envelope’. Some of the figures within this report may still illustrate an ‘indicative disturbance boundary’ whereas some of the discussion now refers to a Proposal Development Envelope. For the purposes of this report, both names are referring to the same area.

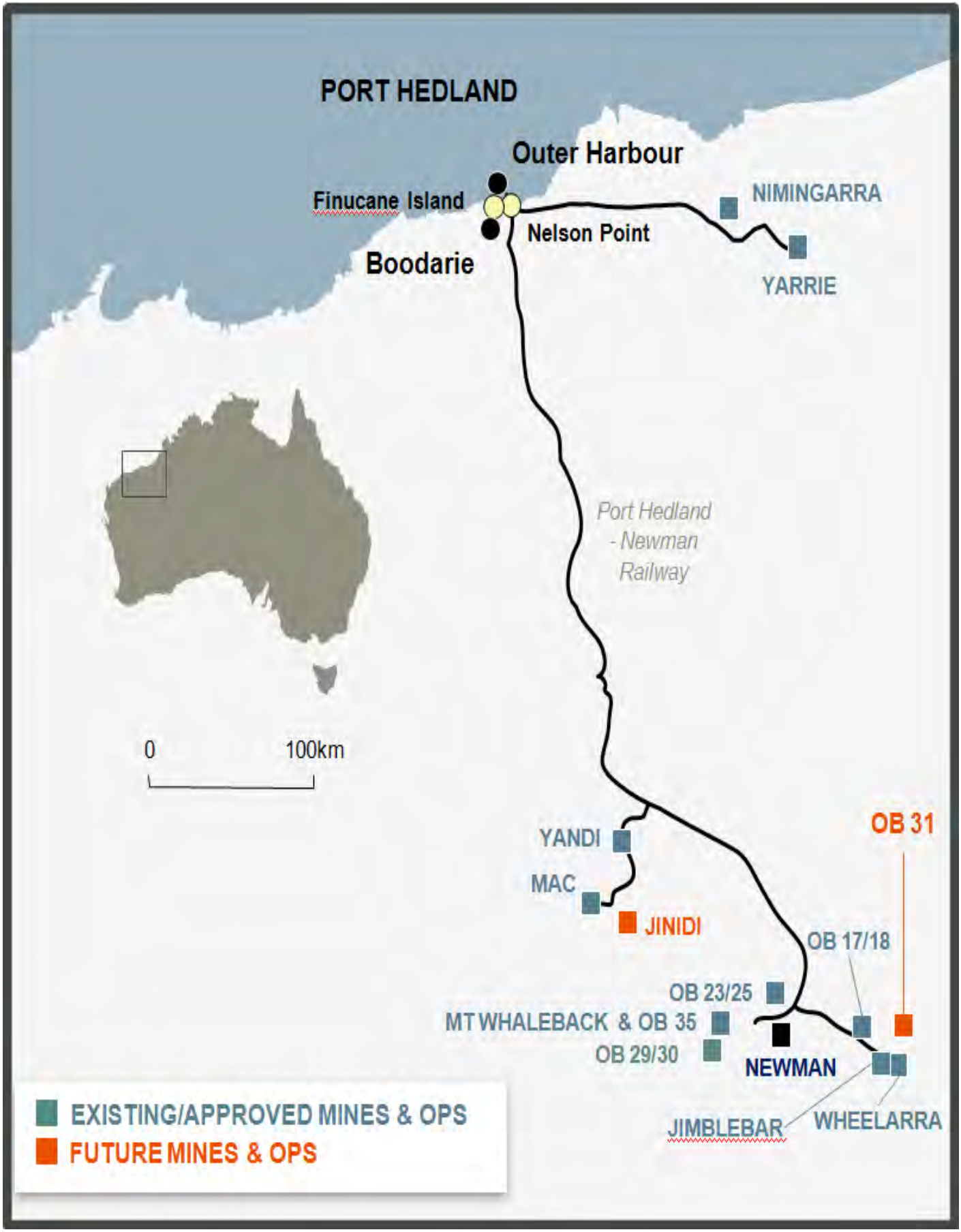
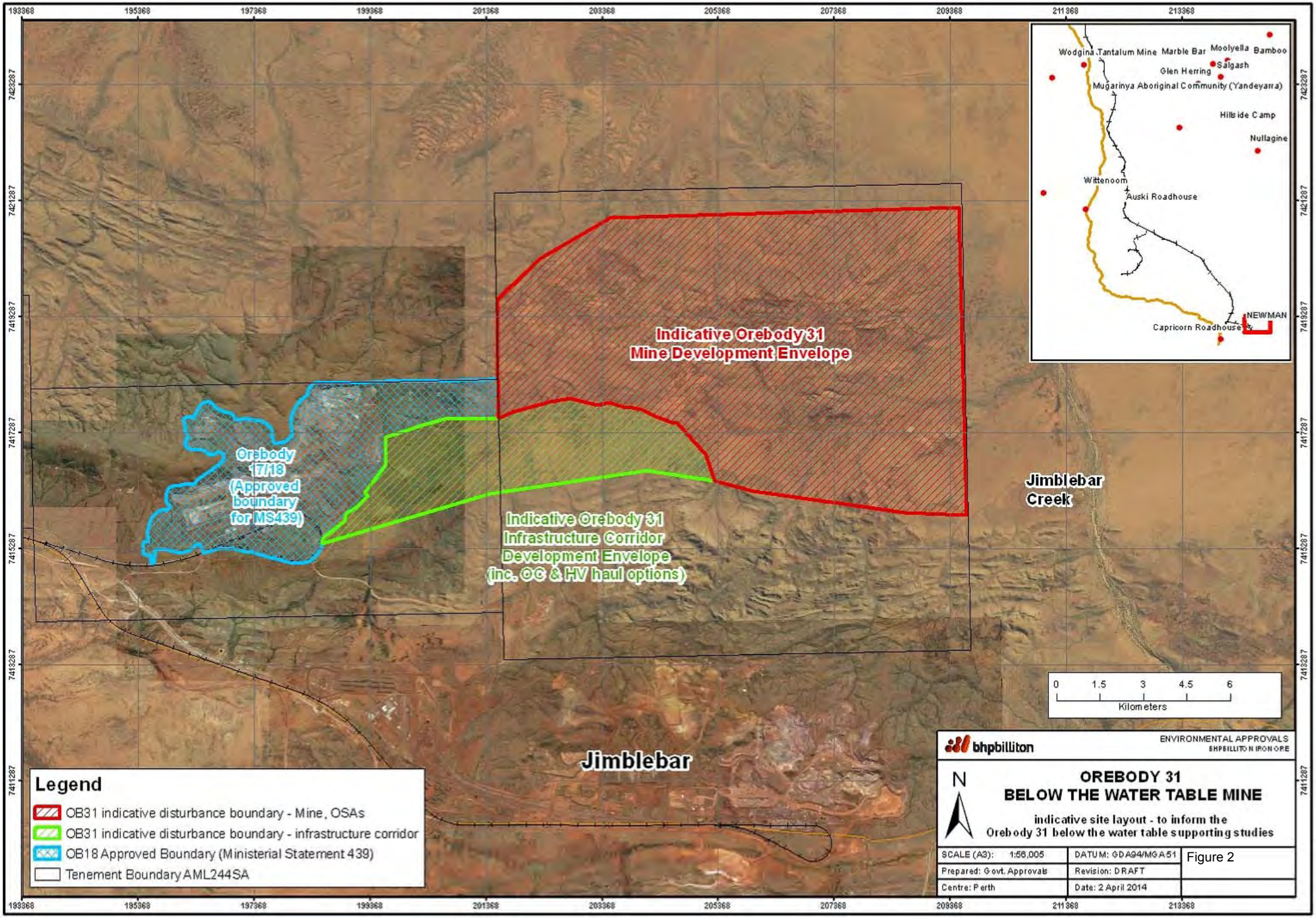


Figure 1 Location plan


Indicative Orebody 31
Mine Development Envelope
Orebody
17/18
(Approved
boundary
for MS439)
Indicative Orebody 31
Infrastructure Corridor
Development Envelope
(inc. OC & HV haul options)
Jimblebar
Creek
Jimblebar
Wodgina Tantalum Mine
Marble Bar
Moolyella
Bamboo
Glen Herring
Salgash
Mugarinya Aboriginal Community (Yandeyarra)
Hillside Camp
Nullagine
Wittenoom
Auski Roadhouse
NEWMAN
Capricorn Roadhouse
0
1.5
3
4.5
6
Kilometers
Legend
OB31 indicative disturbance boundary - Mine, OSAs
OB31 indicative disturbance boundary - infrastructure corridor
OB18 Approved Boundary (Ministerial Statement 439)
Tenement Boundary AML244SA
bhpbilliton
ENVIRONMENTAL APPROVALS
BHPBILLITON IRON ORE
N
OREBODY 31
BELOW THE WATER TABLE MINE
indicative site layout - to inform the
Orebody 31 below the water table supporting studies
SCALE (A3): 1:56,005
DATUM: GDA94/MGA51
Prepared: Govt. Approvals
Revision: DRAFT
Centre: Perth
Date: 2 April 2014
Figure 2

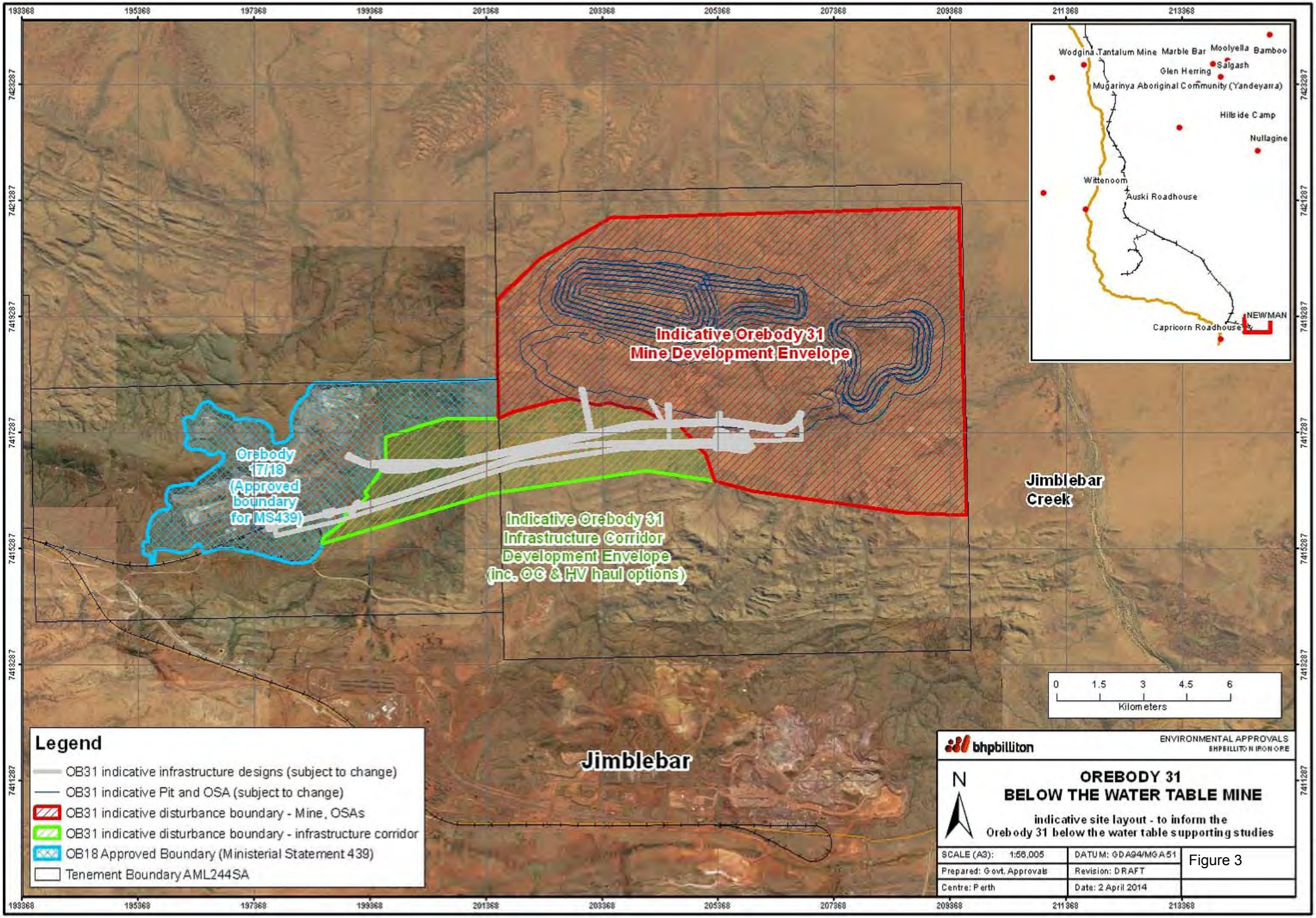
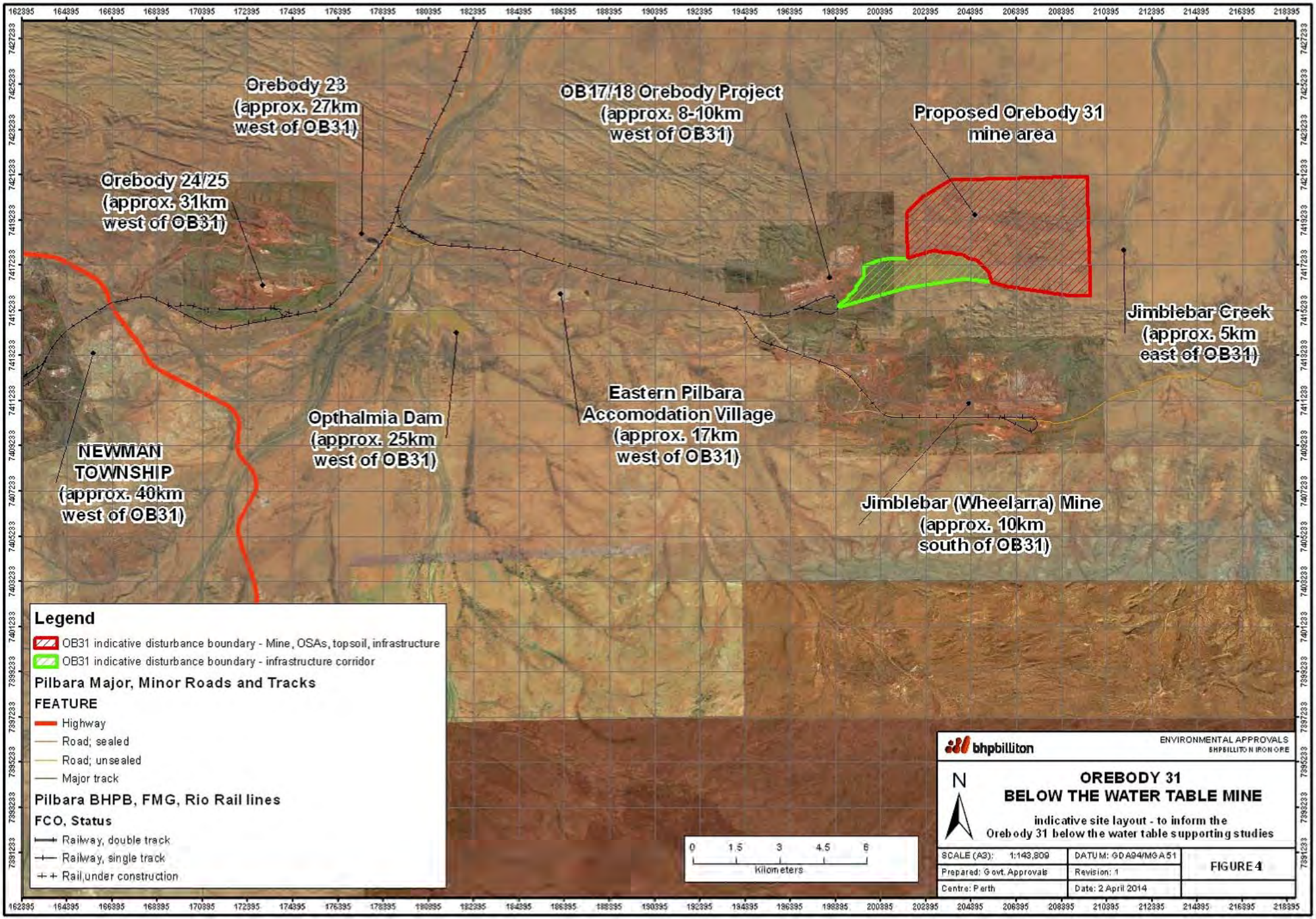

Indicative Orebody 31
Mine Development Envelope
Orebody
17/18
(Approved
boundary
for MS439)
Indicative Orebody 31
Infrastructure Corridor
Development Envelope
(inc. OC & HV haul options)
Jimblebar
Creek
Jimblebar
Wodgina Tantalum Mine
Marble Bar
Moolyella
Bamboo
Glen Herring
Salgash
Mugarinya Aboriginal Community (Yandeyarra)
Hillside Camp
Nullagine
Wittenoom
Auski Roadhouse
NEWMAN
Capricorn Roadhouse
0
1.5
3
4.5
6
Kilometers
Legend
OB31 indicative infrastructure designs (subject to change)
OB31 indicative Pit and OSA (subject to change)
OB31 indicative disturbance boundary - Mine, OSAs
OB31 indicative disturbance boundary - infrastructure corridor
OB18 Approved Boundary (Ministerial Statement 439)
Tenement Boundary AML244SA
bhpbilliton
ENVIRONMENTAL APPROVALS
BHPBILLITON IRON ORE
N
OREBODY 31
BELOW THE WATER TABLE MINE
indicative site layout - to inform the
Orebody 31 below the water table supporting studies
SCALE (A3): 1:56,005
DATUM: GDA94/MGA51
Prepared: Govt. Approvals
Revision: DRAFT
Centre: Perth
Date: 2 April 2014

Figure 3


Orebody 23
(approx. 27km
west of OB31)
OB17/18 Orebody Project
(approx. 8-10km
west of OB31)
Proposed Orebody 31
mine area
Orebody 24/25
(approx. 31km
west of OB31)
Jimblebar Creek
(approx. 5km
east of OB31)
Eastern Pilbara
Accomodation Village
(approx. 17km
west of OB31)
Opthalmia Dam
(approx. 25km
west of OB31)
NEWMAN
TOWNSHIP
(approx. 40km
west of OB31)
Jimblebar (Wheelarra) Mine
(approx. 10km
south of OB31)
Legend
OB31 indicative disturbance boundary - Mine, OSAs, topsoil, infrastructure
OB31 indicative disturbance boundary - infrastructure corridor
Pilbara Major, Minor Roads and Tracks
FEATURE
Highway
Road; sealed
Road; unsealed
Major track
Pilbara BHPB, FMG, Rio Rail lines
FCO, Status
Railway, double track
Railway, single track
Rail,under construction
0 1.5 3 4.5 6
Kilometers
N
bhpbilliton
ENVIRONMENTAL APPROVALS
BHPBILLITON IRON ORE
OREBODY 31
BELOW THE WATER TABLE MINE
indicative site layout - to inform the
Orebody 31 below the water table supporting studies
SCALE (A3): 1:143,809
DATUM: GDA94/MGA51
Prepared: Govt. Approvals
Revision: 1
Centre: Perth
Date: 2 April 2014
FIGURE 4

2 EXISTING ENVIRONMENT

2.1 Climate

The Pilbara region is characterised by an arid-tropical climate resulting from the influence of tropical maritime and tropical continental air masses, receiving summer rainfall. Cyclones can occur during this period, bringing heavy rain, causing potential destruction to coastal and inland towns.

The nearest Bureau of Meteorology (BoM) weather station to the OB31 project is located approximately 45 km west south-west at Newman Airfield, 8 km southeast of Newman. Additional meteorological data is available from a former BOM weather station at Newman that was operational for 38 years between 1965 and 2003. Both of these weather stations have statistical records of temperature, rainfall, relative humidity and wind speed and direction for periods of greater than ten years.

Regional temperatures are warmest from October through to April, with average monthly maximum temperatures at both stations exceeding 30°C during this period. Temperatures are coolest from May to September with average monthly minimum temperatures below 12°C. The average daily maximum temperature in January is approximately 39°C, while average daily minimum temperatures are as low as 5.7°C in July.

The total annual average precipitation is approximately 310 mm at Newman and 316 mm at Newman Airfield. The majority of precipitation occurs between December and March, peaking in February at an average of approximately 81 mm. September and October exhibit the driest conditions with an average rainfall below 4 mm.

The Wittenoom BoM station is located approximately 190 km north-west of Newman and is the closest station that records evaporation. Annual average evaporation for Wittenoom is 3,142 mm per year, which exceeds annual rainfall by as much as 2,500 mm per year.

2.2 Biogeographic Regions

The latest version of the Interim Biogeographic Regionalisation for Australia (IBRA7) divides Australia into 89 bioregions based on climate, geology, landform, native vegetation and species information (DoE 2012) and includes 419 sub-regions. The bioregions and sub-regions are the reporting unit for assessing the status of native ecosystems and their level of protection in the National Reserve System.

The OB31 project is located in the Pilbara bioregion. The Pilbara bioregion consists of four sub-regions: Chichester, Fortescue, Hamersley and Roebourne. The tenement boundary is located on the southern edge of the Fortescue sub-region (PIL2), adjacent to the boundary of the Hamersley sub-region (PIL3). Therefore the site is located in the transition zone between these two sub-regions in terms of vegetation assemblages and flora diversity.

The Fortescue sub-region is described as consisting of alluvial plains and river frontage with extensive salt marsh, mulga-bunch grass, and short grass

communities on alluvial plains in the east (Kendrick 2001a). River gum woodlands fringe the drainage lines and it contains the northern limit of Mulga. It also contains a broad calcrete aquifer (originating within a paleo-drainage valley) that feeds many permanent springs in the central Fortescue, supporting large permanent wetlands with extensive stands of River Gum *(Eucalyptus camaldulensis)* and Cadjeput *(Melaleuca argentea)* woodlands (Kendrick 2001a). The OB31 project is located within the Jimblebar Creek catchment which is a tributary of Fortescue River Upper Catchment and in turn, drains into the Fortescue Marsh.

The Hamersley sub-region is described as a mountainous area of Proterozoic sedimentary ranges and plateaux, dissected by gorges (basalt, shale and dolerite) (Kendrick 2001b). It contains Mulga low woodland over bunch grasses on fine textured soils in valley floors, and *Eucalyptus leucophloia* over *Triodia brizoides* on skeletal soils of the ranges. The OB31 project encompasses mountainous and valley communities more in line with the Hamersley sub-region.

2.3 Existing Land Use

The current use of lands surrounding the OB31 project is predominantly for mineral exploration, iron ore mining and dry land agriculture, specifically pastoralism, cattle grazing and rangelands. Conservation lands amount to less than 10% of the total area of the Pilbara Bioregion, with the major reserves being Karijini National Park (approximately 150 km to the northwest) and Rudall River National Park (approximately 160 km to the east). These Parks are supplemented by lesser conservation estates such as Cane River and Meentheena Conservation Parks. Wetlands of National significance include the permanent pools of Millstream-Chichester and Karijini National Parks and the Fortescue Marsh (approximately 90 km to the north).

2.4 Landforms

The OB31 Project is located on the eastern end of the Ophthalmia Range, which together with the Hamersley Range encompass the Hamersley Plateau. The Hamersley Plateau is characterised by long strike ridges rising 300 m or more above valley floors and flats. Other characteristic landforms of the general area include stony plains and some alluvial plains and sandplains (Tille 2007). The entire region contains mainly rounded ranges and hills in contrast to the characteristic 'mesa form' hills that are located further north. The dissected rounded ranges occur through the northern sector of the Proposal Development Envelope, draining out onto sloping plains to the north and south. An un-named medium drainage line in the southern sector of the Proposal Development Envelope forms an east flowing tributary of Jimblebar Creek.

2.5 Soils

The following CSIRO Atlas of Australia soil types occur within the Proposal Development Envelope:

- Fa13 - Ranges of banded jaspilite and chert along with shales, dolomites, and iron ore formations; some areas of ferruginous duricrust as well as occasional narrow winding valley plains and steeply dissected pediments. This unit is largely associated with the Hamersley and Ophthalmia Ranges.

The soils are frequently stony and shallow and there are extensive areas without soil cover: chief soils are shallow stony earthy loams (Um5.51) along with some (Uc5.11) soils on the steeper slopes. Associated are (Dr2.33, Dr2.32) soils on the limited areas of dissected pediments, while (Um5.52) and (Uf6.71) soils occur on the valley plains; and

- Mz25 - Plains associated with the Fortescue valley; there is a surface cover of stony gravels close to the ranges and hills: chief soils are acid red earths (Gn2.11) with some neutral red earths (Gn2.12); red-brown hardpan is absent. Associated are areas of calcareous earths (Gc) and loams (Um1) on calcrete (kunkar) and some hard red (Dr) soils around creek lines.

2.6 Geology

The OB31 deposit is an east-west elongated deposit that extends ~4.8 km along strike and is ~1 km wide. The easternmost extent of OB31 is truncated by sub-parallel splays of the north-east trending Wheelarra Fault.

The proposed pit will intersect the following main rock units; the Mt Sylvia and Mt McRae Formations (Hs), Dales Gorge, Whaleback Shale and Joffre Members of the Brockman Iron Formation (Hb), as well as a small portion of the Yandicoogina Member and Weeli Wolli Formation (Hj). The majority of the mineralisation occurs in the Dales Gorge and Joffre Members. Portions of the upper Colonial Chert Member of the Mount McRae Formation, locally defined by BHP Billiton Iron Ore as the D1 unit of the Dales Gorge Member, is also mineralised.

Mineralisation appears to be continuous along strike, with the majority being described as a martite-goethite 'biscuit' mineralisation, with occasional intersections of microplaty hematite. The Joffre Member is also mineralised, with similar grades to that of the Dales Gorge Member.

Where outcrop is present, the geology is dominated by hardcapped Dales Gorge or Joffre Member units. Drilling from 1985, suggests that the hardcap thickness varies from 10 to 30m. The Mt Sylvia and Mt McRae Formations outcrop towards the south-western and southern-eastern ends of OB31, whilst the Weeli Wolli Formation outcrops to the north.

The large-scale structure at OB31 comprises an open, east-west striking anticline-syncline pair with southerly dipping axial-planes. The anticline is situated south of the syncline, with the common limb dipping ~40° north, whilst the dips of the southerly limbs are shallower. Smallerscale, parasitic (F2) folding is also reported to be present. The described fold system displays a gentle westerly plunge towards OB17, where a plunge reversal at the boundary between OB17 and OB31 suggests an overprinting.

2.7 Hydrology

2.7.1 Surface water hydrology

The OB31 project is located within the Jimblebar Creek catchment which is a tributary of Fortescue River upper catchment and in turn, drains into the Fortescue Marsh. OB31 is located adjacent to an east flowing tributary of Jimblebar Creek. This creek is a temporary, inland, dryland water course that flows east through the 16 km long valley to join Jimblebar Creek downstream of Innawally Pool. The creek

has a catchment area of 67 km^2. The creek is dry outside of seasonal rainfall events. Drainage in the OB31 area is predominately towards the south and east. The proposed pit will be partially located in the floodplain of the creek.

In the upstream part of the valley, water courses enter via the relatively steep rocky ridges on the valley sides, but form deltas and enter the main flow path as sheet flow. The main flowpath on the valley floor is also undefined as a wide shallow flood footprint. The bed slope is 0.3% and bed materials are minimal (some silt and sand on the floodplain surface). The sheet flow path is more vegetated in parts and typical of the flood plain in others.

As sheet flow, the stream is not classified. At a point near the eastern end of the OB31 indicative pit, the geomorphology of the creek changes markedly, where a broad wash enters from the north, and 500 m downstream, a large defined stream (8 m wide, with gravel bed) enters from the south. At this point, the OB31 creek takes on characteristics of this smaller tributary (i.e. that of the higher energy stream). The stream is then defined by a single channel with moderate sinuosity and a typical bankfull width : depth of 8 m : <1 m. Vegetation is generally absent from the channel with the exception of the occasional tree, fallen timber and grass on point bars. The creek also intersects caprock in places. The bed slope remains at 0.3% and bed materials range from silt to coarse gravel (50 mm diameter).

2.7.2 Hydrogeology

The main local aquifer at OB31 is the Brockman orebody. This aquifer extends for some distance along strike but is eventually bounded by unmineralised Brockman. To the north and south, the orebody aquifer is bounded by lower permeability BIF and shales of the Weeli Wolli Formation (hanging wall) and Mt McRae Shale (footwall). The orebody appears to be largely fully contained within these lower permeability units. However, significant airlift yields (1ML/d and higher) have been recorded in bores targeting the footwall (Mt McRae Shale) during recent hydrogeological investigations. These high airlift yields appear to be related to a series of faults which may provide hydraulic connection through to the orebody aquifer and/or regional aquifers.

Groundwater elevations range between 495 and 498 mRL at OB31, with a steep 40m hydraulic change observed between the Brockman (OB31) and Weeli Wolli Formation / Woongarra Volcanics (aquitards) to the north (~460mRL). This suggests limited flow from OB31 to the north. Assuming a final pit depth of about 351mRL then a significant portion (~75%) of the orebody is below the water table.

The salinity of the groundwater at OB31 varies between fresh to brackish, with electrical conductivity (EC) values recorded during drilling ranging from 0.4 to 2.2mS/cm. EC values generally increase with depth, especially after ~50m below the water level. The EC of water in the orebody aquifer varies between 0.6 and 1.2mS/cm, whilst that in the Mt Sylvia Formation and Bee Gorge Member along the southern margin of the Stage-1 pit varies between 1.8 and 2.2 mS/cm.

2.8 Flora and Vegetation

The OB31 project is located within the Fortescue Botanical District and close to the border of the Hamersley Botanical District (both within the Pilbara IBRA region) which is part of the Eremaean Province (Beard 1990). It is dominated by tree and shrub – steppe communities consisting mainly of *Eucalyptus* and *Acacia* species;

Triodia pungens and *Triodia wiseana* and some Mulga occur within valley areas and short grass plains occur on alluvia.

The original vegetation mapping was undertaken by Beard (1975) and refined by Shepherd *et al.* (2002). There were two vegetation associations described from the Proposal Development Envelope (Table 1). While the Pre-European extent for each vegetation association is 100 %, less than 10 percent of each association occurs within formal or informal reserves (Table 1).

Table 1 Pre-European extent of vegetation associations occurring within the Project Development Envelope (Shepherd *et al.* 2002).

Vegetation Sub-Association	Pre-Euro. Extent Remaining	Extent within tenement boundary	% remaining IUCN Class I-IV Reserves
Fortescue - Valley 82: Hummock grasslands, low tree steppe; Snappy gum over *Triodia wiseana*	2,290,910 ha (100 %)	4,626.4 ha	10.3
Fortescue - Valley 216: Low woodland; mulga (with spinifex) on rises	298,549 ha (100 %)	1,852.1 ha	0.0

In recent years there has been numerous small-scale surveys completed throughout the Pilbara, predominantly associated with mining approvals. A literature review confirmed seven previous flora and vegetation surveys covering at least part of the Proposal Development Envelope were completed between 2011 and 2014. An additional 28 surveys have been completed at surrounding BHP Billiton Iron Ore tenements.

2.9 Land Systems

The Department of Agriculture has conducted inventory and condition surveys of the Pilbara (van Vreeswyk *et al.* 2004) using an integrated survey method involving the land system approach to rangeland description evaluation. The primary objective of the surveys was to provide comprehensive descriptions and mapping of the biophysical resources of the region as well as an evaluation on the condition of soils and vegetation. The mapping is based on patterns in topography, soils and vegetation.

A total of 102 land systems were defined in the Pilbara at a scale of 1:250,000 (van Vreeswyk *et al.* 2004), with four land systems occurring within the tenement boundary (Table 2). The Boolgeeda, McKay and Newman Land Systems are all well represented in the Pilbara covering between 2.3% and 8.0% of the Pilbara bioregion. The Washplain Land System is restricted to the south-east Pilbara and covers 0.5% of the Pilbara bioregion. It is characterised by hardpan plains that support groved Mulga shrublands.

Table 2 Land systems occurring within the Proposal Development Envelope (descriptions from van Vreeswyk *et al.* 2004).

Land System	Distribution in the Pilbara	Area in Proposed Development Envelope (km²)	Area in Pilbara (km²)	% of Pilbara
Boolgeeda: Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands and mulga shrublands	Wide, common	16.86	7,748	0.22
McKay: Hills, ridges, plateaux remnants and breakaways of meta sedimentary and sedimentary rocks supporting hard spinifex grasslands	Wide, common	0.35	4,202	0.01
Newman: Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands	Southern half, very common	19.92	14,580	0.14
Washplain: Hardpan plains supporting groved mulga shrublands	Restricted to southeast Pilbara	3.42	917	0.37

3.0 REVIEW OF BASELINE REPORTS

There are at least 33 previous flora and vegetation surveys that have been completed within a 25 km radius of the OB31 project, including seven surveys that intersect the Proposal Development Envelope. Table 3 summarises findings of the literature review, tabulating timing, survey intensity, and the main findings including total flora, conservation significant flora and introduced weeds.

Relevant findings from the seven previous surveys completed within, or partly within, the tenement boundary are summarised below.

Wheelarra Hill North Level 2 Flora and Vegetation Assessment (Syrinx Environmental 2012a)

- *Aristida ?jerichoensis* var. *subspinulifera*[1] (Priority 1) was recorded as a few scattered plants at three points in the south-west corner of the study area; and
- A potentially significant range extension 400 km south of the nearest known populations was recorded at one location in the northern central sector of the study area, *Hibiscus* aff. *apodus*[2].

OB 31 First Season Level 2 Flora and Vegetation Assessment (Syrinx Environmental 2011)

- No Threatened or Priority flora taxa recorded from the study area.

OB 31 Second Season Level 2 Flora and Vegetation Assessment (Onshore Environmental 2014a)

- *Rhagodia* sp. Hamersley (M. Trudgen 17794) (Priority 3) was recorded as scattered plants at two locations at the north-western fringe of the study area;
- *Triodia* ?sp. Mt Ella (M.E. Trudgen 12739) (Priority 3) was recorded as one plant from the south-western sector of the study area[3];
- A new taxon *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) was recorded as scattered shrubs from three locations at the north-west sector of the study area; and
- *Acacia clelandii* was recorded as a significant range extension 400 km north of the nearest known populations, occurring at three locations at the central sector of the study area.

OB 31 / Wheelarra Hill North Targeted Flora Survey (Onshore Environmental 2014b)

- *Rhagodia* sp. Hamersley (M. Trudgen 17794) (Priority 3) was recorded as scattered plants at two locations at the north-western fringe of the study area;
- *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (Priority 3) was recorded as six scattered plants from four spot locations on floodplains at the central-western sector of the study area. Two larger populations comprising 50 spot location points were associated with steep scree slopes, cliff lines and

[1] This was later confirmed to be *Aristida inaequiglumis* (Onshore Environmental 2014b).
[2] These locations were re-visited during the targeted survey and confirmed not to be *Hibiscus apodus*.
[3] The identification was confirmed as *Triodia* sp. Mt Ella (M.E. Trudgen 12739) during the targeted survey.

gorges at the south-west sector of the study area. Within these main populations, *Triodia* sp. Mt Ella (M.E. Trudgen 12739) was recorded as >10,000 plants and providing up to 80 percent ground coverage;
- *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) was recorded as 534 plants from five populations occurring across approximately 8 ha at the north-west sector of the study area;
- *Goodenia nuda* (Priority 4) was recorded as 13 plants from two spot locations on floodplains at the central-western sector of the study area; and
- *Acacia clelandii* was recorded as a significant range extension 400 km north of the nearest known populations. There were 12 locations scattered across the northern sector of the study area.

OB18 to OB 31 Proposed Infrastructure Corridor Targeted Flora Survey (Onshore Environmental 2014c)

- *Goodenia nuda* (Priority 4) was recorded as 50 plants from five closely located points on the south-western fringe of the proposed infrastructure corridor; and
- *Triodia* sp. Mt Ella (M.E. Trudgen 12739) was recorded as a sole plant in the central southern sector of the proposed infrastructure corridor.

OB 18 Level 2 Flora and Vegetation Assessment (ENV Australia 2007)

- No Threatened or Priority flora taxa recorded from the study area.

Mesa Gap Biological Survey (GHD 2008)

- No Threatened or Priority flora taxa recorded from the study area.

Table 3 Summary of results from previous flora and vegetation surveys within, or in close proximity to, the OB31 project Proposal Development Envelope.

Report	Proximity to OB31 Project	Survey Timing & Intensity	Vegetation Associations & Landform	Floristics	Significant Flora
Onshore Environmental (2014a) Orebody 31 / Wheelarra Hill North Targeted Flora Survey	Overlays the entire tenement boundary footprint	24-30 April 2014 Targeted searches under excellent seasonal conditions	Not recorded	Not recorded	*Rhagodia* sp. Hamersley (M. Trudgen 17794) (P3), *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (P3), *Goodenia nuda* (P4), *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01), *Acacia clelandii* (range extension)
Onshore Environmental (2014b) Orebody 31 Level 2 Flora and Vegetation Survey	Overlays the northern-most three quarters of the tenement boundary	1-14 October 2013 45 quadrats and 146 relevés	35 vegetation associations within 15 broad floristic formations	280 plant taxa from 35 families and 110 genera. Most commonly recorded families were Fabaceae, Poaceae, Malvaceae and Chenopodiaceae. The dominant genus was *Acacia* (40 taxa) followed by *Senna* (11 taxa), *Sida* (11 taxa) and *Eremophila* (10 taxa). There were two introduced species recorded; **Cenchrus ciliaris, *Malvastrum americanum*	*Rhagodia* sp. Hamersley (M. Trudgen 17794) (P3), *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (P3), *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
Onshore Environmental (2014c) Orebody 18 to Orebody 31 Proposed Infrastructure Corridor Targeted Flora Survey	Overlays the western corridor extension of the tenement boundary	13 September 2014 Targeted Flora Survey	Not relevant	**Cenchrus ciliaris* was recorded from eight point locations providing between 1% and 10% ground cover	*Triodia* sp. Mt Ella (M.E. Trudgen 12739) (P3), *Goodenia nuda* (P4)

Report	Proximity to OB31 Project	Survey Timing & Intensity	Vegetation Associations & Landform	Floristics	Significant Flora
Syrinx (2011) OB 31 Flora and Vegetation Assessment	Overlays the northern-most three quarters of the tenement boundary	10-15 February and 9-13 March 2011 29 quadrats	21 vegetation associations classified into 12 broad floristic formations	206 plant taxa from 36 families and 93 genera, with dominant families being the Fabaceae (10 taxa), Malvaceae (20 taxa) and Chenopodiaceae (12 taxa). Four introduced weed species; **Bidens bipinnata, *Cenchrus ciliaris, *Malvastrum americanum, *Portulaca oleracea*	No Threatened or Priority flora
Syrinx (2012a) Wheelarra Hill North Level 2 Flora and Vegetation Assessment	Overlaps the southern portion of the tenement boundary, and extends immediately south outside of the tenement boundary	Two season survey. First season from 17-29 May 2011 and second season from 4-12 October 2011 83 quadrats and 19 relevés	25 vegetation associations were recorded within nine broad floristic formations	411 taxa from 49 families and 145 genera. The most commonly recorded families were Fabaceae (78 taxa), Poaceae (58 taxa) and Malvaceae (47 taxa). The dominant genera were *Acacia* (40 taxa), *Ptilotus* (16 taxa) and *Senna* (15 taxa). Four introduced species; **Bidens bipinnata, *Cenchrus ciliaris, *Malvastrum americanum, *Portulaca oleracea*	No Threatened Flora. One Priority 1 flora *Aristida ?jerichoensis* var. *subspinulifera* Nine range extensions: *Sclerolaena minuta, Eragrostis olida, Oldenlandia galioides, Evolvulus alsinoides* var. *decumbens, Phyllanthus erwinii, Phyllanthus maderaspatensis, Santalum spicatum, Cyperus ixiocarpus, Abultilon cunninghamii,* and two possible range extensions; *Tephrosia* aff. *sphaerospora*, *Hibiscus* aff. *apodus*

Report	Proximity to OB31 Project	Survey Timing & Intensity	Vegetation Associations & Landform	Floristics	Significant Flora
Onshore Environmental (2013a) Orebody 17/18 Derived Vegetation Association Mapping Report	Small area of OB 17/18 located directly northwest of the tenement boundary.	Desktop survey	Five of the 27 vegetation associations described by ENV (2007)	Not recorded	No Threatened or Priority Flora
ENV Australia (2007) OB18 Flora and Vegetation Assessment Phase 2	Covers the western sector of the infrastructure corridor area	25 July – 2 August 2006 71 quadrats	A total of 27 vegetation associations classified into six broad landforms	276 plant taxa including 46 families; dominant families were Poaceae (41 taxa), Mimosaceae (30 taxa), Amaranthaceae (19 taxa) and Malvaceae (18 taxa); two weed species were recorded, **Acetosa vesicaria* and **Cenchrus ciliaris*	No Threatened Flora. No Priority flora taxa.
GHD (2008b) Mesa Gap Biological Survey	Situated between OB 18 and Jimblebar Mines (overlaps south-west corner of the tenement boundary)	September/October 2007 40 quadrats	Eight vegetation associations from 7 landforms	133 plant taxa from 32 families with dominant families being the Fabaceae (15 species), Poaceae (9 species) and Myrtaceae (6 species); there were no introduced weed species	No Threatened or Priority flora

Report	Proximity to OB31 Project	Survey Timing & Intensity	Vegetation Associations & Landform	Floristics	Significant Flora
Syrinx (2012b) South West Jimblebar Flora and Vegetation Survey	South West Jimblebar is located 40 km east of Newman, and is adjacent to the existing Jimblebar Mine. It is approximately 8 km south-west of the tenement boundary.	14-8 March 2011 19 quadrats and four relevés	17 vegetation associations within ten broad floristic formations	202 plant taxa from 33 families and 93 genera. Most commonly recorded families were Poaceae (42 taxa), Fabaceae (38 taxa) and Malvaceae (14 taxa). The dominant genus was *Acacia* (23 taxa) followed by *Eremophila* (10 taxa) and *Ptilotus* (9 taxa). There were four introduced species recorded; **Bidens bipinnata, *Cenchrus ciliaris, *Cucumis melo, *Portulaca oleracea*	No Threatened Flora. Two Priority flora taxa; *Aristida ?jerichoensis* var subspinulifera (P1), *Goodenia ?nuda* (P4) Five range extensions: *Alloteropsis cimicina, Brachyscome ciliaris* var. *ciliaris, Evolvulus alsinoides* var. *decumbens, Tephrosia sphaerospora* and *Tribulopis angustifolia*
Astron (2012) Eastern Mines Weed Survey, Jimblebar	Situated immediately south of the tenement boundary	22-30 May 2012 25 project monitoring sites and 6 reference monitoring sites	Not recorded	13 weed spcies; **Acetosa vesicaria, *Aerva javanica, *Bidens bipinnata, *Cenchrus ciliaris, *Chloris barbata, *Chloris virgata, *Citrullus colocynthis, *Cynodon dactylon, *Malvastrum americanum, *Portulaca oleracea, *Solanum nigrum, *Sochus asper, *Vachellia farnesiana*	N/A
Eco Logical (2012) Level 1 flora and fauna surveys along the Great Northern Highway for Jimblebar mine module transport.	Site 1: 3.8 km southeast of Newman townsite Site 2: 9 km north-west of Newman Site 3: 98 km north-west of Newman	18-19 August 2011	Seven vegetation associations	52 flora taxa comprising 14 families; the most commonly occurring families were: Poaceae, (12 taxa), Fabaceae (12 taxa), Amaranthaceae (8 taxa) and Myrtaceae (5 taxa). One introduced weed species, **Cenchrus ciliaris*	No Threatened or Priority flora

Report	Proximity to OB31 Project	Survey Timing & Intensity	Vegetation Associations & Landform	Floristics	Significant Flora
ENV (2010a) RGP6 Jimblebar Hub (Water Pipeline) Flora and Vegetation Assessment	Situated immediately south of the tenement boundary	November 2009 16 quadrats and seven relevés	14 vegetation associations	166 plant taxa comprising 33 families and 81 genera. The most common families were Poaceae (29 taxa), Mimosaceae (25 taxa) and Malvaceae (15 taxa). The common genera were *Acacia* (25 taxa), *Senna* (10 taxa) and *Ptilotus* (8 taxa). Two introduced flora species were recorded; **Cenchrus ciliaris, *Malvastrum americanum*	No Threatened or Priority flora
ENV (2010b) Jimblebar Wye Targeted Declared Rare Flora and Priority Listed Flora Assessment	Situated approximately 20 km directly west of the tenement boundary.	3-5 March 2010 and 8-11 June 2010 Transects in habitats known to support targeted flora	Not recorded	Not recorded	No Threatened flora One Priority flora; *Gymnanthera cunninghamii* (P3)
ENV (2009a) Ammonium Nitrate Storage Facility Flora and Vegetation Assessment	Situated approximately 15 km southeast of the tenement boundary	17 September 2009 seven quadrats and one relevé	Eight vegetation associations	123 taxa comprising 34 families and 70 genera. Common families were Poaceae (23 taxa), Mimosaceae (16 taxa), Malvaceae (10 taxa). The most common genera were *Acacia* (16 taxa), *Ptilotus* (7 taxa) and *Senna* (6 taxa). Two introduced flora species; **Cenchrus ciliaris, *Portulaca oleracea*	No Threatened or Priority flora

Report	Proximity to OB31 Project	Survey Timing & Intensity	Vegetation Associations & Landform	Floristics	Significant Flora
ENV (2009b) Construction Water Supply Pipeline and Ammonium Nitrate Storage Facility Flora and Vegetation Assessment	Situated approximately 15 km southeast of the tenement boundary	17 September and 4-6 November 2009 23 quadrats and 8 relevés	19 vegetation associations	213 taxa comprising 38 families and 91 genera The most common families were Poaceae (38 taxa), Mimosaceae (32 taxa) and Malvaceae (20 taxa). The most common genera were *Acacia* (32 taxa), *Senna* (11 taxa) and *Ptilotus* (10 taxa). Three introduced flora species were recorded; **Cenchrus ciliaris, *Malvastrum americanum, *Portulaca oleracea*	No Threatened Flora One current Priority flora *Goodenia nuda* (P4)
Outback Ecology (2009a) Eastern Pilbara Accommodation Camp Flora and Fauna Assessment	Situated approximately 15 km southeast of the tenement boundary.	30 October – 4 November 2008 15 quadrats	16 vegetation associations	115 taxa from 23 families and 44 genera; dominant families were: Mimosaceae (23 taxa), Poaceae (17 taxa), Caesalpinaceae (13 taxa), Myrtaceae (9 taxa), Papilionaceae (7 taxa), Myoporaceae (8 taxa) and Chenopodiaceae (7 taxa); dominant genera were *Acacia* (23 taxa), *Senna* (12 taxa) and *Eremophila* (8 taxa); no weed species	No Threatened or Priority flora
Outback Ecology (2009b) Wheelarra Hill Iron Ore Mine Modification Flora and Fauna Assessment	Situated approximately 8 km southeast of the tenement boundary.	October and November 2008 and January 2009. 22 quadrats	Five broad vegetation associations	146 plant taxa from 29 families and 62 genera; one introduced weed, **Cenchrus ciliaris*	No Threatened Flora One current Priority 4 flora, *Goodenia nuda,* recorded from one location

Report	Proximity to OB31 Project	Survey Timing & Intensity	Vegetation Associations & Landform	Floristics	Significant Flora
ENV (2008a) Rapid Growth Project 5: Repeater 9 Access Road Flora and Vegetation Assessment	Situated approximately 20 km directly west of the tenement boundary	12-13 June 2008 six quadrats and one relevé	Six broad vegetation communities were mapped	163 taxa comprising 95 genera; most common families were Poaceae (28 taxa), Mimosaceae (14 taxa), Amaranthaceae (11 taxa) and Malvaceae (11 taxa); the most common genera were *Acacia* (13 taxa), *Eremophila* (9 taxa) and *Senna* (7 taxa); 14 introduced species were recorded: **Acetosa vesicaria, *Aerva javanica, *Brassica tournefortii, *Cenchrus ciliaris, *Citrullus lanatus, *Cucumis melo* subsp. *agrestis, *Cynodon dactylon, *Datura leichhardtii, *Malvastrum americanum, *Portulaca oleracea, *Setaria verticillata, *Sonchus asper, *Sonchus oleraceus* and **Vachellia farnesiana*	No Threatened Flora recorded One current Priority flora species, *Rostellularia adscendens* var. *latifolia* (P3) A second Priority 1 flora recorded *Eremophila* sp. Ophthalmia Range (R. Brearley s.n. 20/3/2004) has since been renamed *Eremophila margarethae* (not Threatened)
GHD (2008a) Draft Report for Wheelarra Hill (Jimblebar Mine Site) Priority Species Verification – *Goodenia hartiana*	Situated immediately south of the tenement boundary	25-26 September 2007 12 quadrats	Not recorded	Not recorded	No Threatened or Priority flora

Report	Proximity to OB31 Project	Survey Timing & Intensity	Vegetation Associations & Landform	Floristics	Significant Flora
ENV (2008b) Jimblebar Access Road Flora and Vegetation Assessment	Situated 15 km southwest of the tenement boundary	20-23 May 2007 22 quadrats	Ten distinct vegetation communities were described	112 taxa were recorded from 28 families; three introduced weed species were **Cenchrus ciliaris,* **Aerva javanica* and **Citrullus lanatus*	No Threatened or Priority flora
Pilbara Flora (2008) OB17 Flora and Vegetation Survey	Situated approximately 5 km southwest of the tenement boundary	October 2008	Six vegetation associations from four landforms	61 plant taxa from 39 genera and 23 families, with dominant families being the Fabaceae (35 species), Poaceae (20 species) and Myrtaceae (8 species). There were no introduced weed species	No Threatened or Priority flora
ENV (2007a) West Jimblebar Exploration Lease Flora and Vegetation Assessment – Management Recommendations	Situated approximately 15 km southeast of the tenement boundary	14-18 May 2007 29 quadrats	Not recorded	318 taxa were recorded from 113 genera and 44 families. Most frequently represented families were Poaceae, Mimosaceae and Malvaceae Three introduced weeds were recorded	No Threatened flora One current Priority flora species, *Goodenia nuda* (P4) One range extension was recorded, *Thyridolepis xerophila*

Report	Proximity to OB31 Project	Survey Timing & Intensity	Vegetation Associations & Landform	Floristics	Significant Flora
Ecologia (2007) Hashimoto Exploration Project Biological Survey: Flora and Vegetation	Situated directly southeast of the tenement boundary	August/September 2005 and February 2006 44 quadrats	Nine vegetation / landform associations.	372 species, representing 42 families and 129 genera were recorded. Thirty eight (38) collections could not be identified beyond family level. The most commonly recorded genera were *Acacia* (26 species), *Ptilotus* (20 species), *Eremophila* (16 species), and *Sida* (15 species). Three introduced species were recorded: **Cenchrus ciliaris, *Bidens bipinnata* and **Sonchus oleraceus*	No Threatened Flora One current Priority 4 flora, *Goodenia nuda.* A Priority 2 flora taxon *Goodenia hartiana* has since been split into a number of new entities including *Goodenia* sp. Sandy Creek (not Threatened).
ENV (2007c) Jimblebar Stage 2, Levee Banks and Communications Tower Redevelopment Flora and Vegetation Assessments	Situated immediately south of the tenement boundary	April – June 2007 Four quadrats	Six vegetation associations	103 plant taxa from 24 families; most common families were Poaceae (30 taxa), Mimosaceae (17 taxa) and Papilionaceae (8 taxa)' five weed species were **Cenchrus ciliaris, *Cenchrus setiger, *Citrullus lanatus, *Bidens bipinnata* and **Cynodon dactylon*	No Threatened or Priority flora
ENV (2007d) RGP4 Jimblebar Rail Loop Flora and Vegetation Assessment	Situated approximately 5 km south of the tenement boundary	27 November – 1 December 2006 Four quadrats	Four vegetation associations classified into three landform types; creekline, floodplain and plain.	65 plant taxa (44 genera) with most common families being Poaceae (14 taxa), Mimosaceae (11 taxa) and Malvaceae (5 taxa); two introduced weeds were **Bidens bipinnata* and **Cenchrus ciliaris*	No Threatened or Priority flora

Report	Proximity to OB31 Project	Survey Timing & Intensity	Vegetation Associations & Landform	Floristics	Significant Flora
Ecologia (2006) Jimblebar Marra Mamba Exploration Biological Survey	Situated approximately 5 km south of the tenement boundary	22-28 May 2006 105 quadrats	Four vegetation types	267 plant taxa with most common families being Poaceae (33 species) and Malvaceae (22 species); two introduced weeds were **Acetosa vesicaria* and **Cenchrus ciliaris*	No Threatened Flora recorded. One current Priority 4 flora *Goodenia nuda.* A second Priority 3 flora recorded, *Triumfetta leptacantha* is no longer Threatened
Ecologia (2005) Jimblebar East Exploration Project Biological Survey	Situated approximately 15 km southeast of the tenement boundary	8-14 Feb 2005 26 quadrats	Seven vegetation / landform associations	155 plant taxa with most common families being Poaceae (27 taxa), Caesalpiniaceae (13 taxa) and Mimosaceae (12 taxa); one weed species was **Cenchrus ciliaris*	No Threatened or Priority flora
Ecologia (2004a) OB 18 Flora and Fauna Review	Situated directly southwest of the tenement boundary	Targeted searches in July 2004	Not recorded	Not recorded	No Threatened Flora One Priority 2 Flora *Rhodanthe frenchii* identified from one gorge site[4].

[4] It is noted that the original identification was not confirmed through the WAH and represents a 300 km range extension to the east. It has not been recorded locally during numerous surveys over a 17 year period since the original record.

Report	Proximity to OB31 Project	Survey Timing & Intensity	Vegetation Associations & Landform	Floristics	Significant Flora
Ecologia (2004b) Jimblebar-Wheelarra Hill Expansion Biological Study	Situated approximately 10 km directly south of the tenement boundary	9 Feb - 4 March 2004 A total of 44 quadrats were sampled, each measuring 100 x 100 m.	Nine vegetation associations	181 plant species from 47 families and 80 genera; dominant genera were *Acacia* (30 species), *Senna* (10 species) and *Eremophila* (7 species); one weed species, **Cenchrus ciliaris*	No Threatened or Priority flora *Goodenia hartiana* (P2) recorded but this taxon later split and now confirdetermined to be *Goodenia* sp. Sandy Creek (not Threatened).
Biota (2004) Jimblebar - Wheelarra Hill 3 Flora and Fauna Assessment	Situated approximately 10 km directly south of the tenement boundary	August 2003. The survey was conducted to review and update existing botanical information and recording supplementary floristic data.	Six vegetation types described were based on the Ecologia (1999) flora survey of the area	227 taxa from 42 families and 99 genera; dominant genera were *Acacia* (29 taxa), *Senna* (15 taxa) and *Ptilotus* (9 taxa); one weed species was **Acetosa vesicaria*	No Threatened or Priority flora One Priority species, *Tephrosia* sp. Pilbara Ranges (P3). This species has been re-named *Tephrosia* sp. Cathedral Gorge (F.H. Molleman 2420) and is no longer Threratened

Report	Proximity to OB31 Project	Survey Timing & Intensity	Vegetation Associations & Landform	Floristics	Significant Flora
Ecologia (1996) Jimblebar Rail Spur Biological Assessment Survey	Situated approximately 5 km directly south of the tenement boundary.	6-8 June 1995 Two detailed floristic survey sites were assessed (100 m x 100 m in size) with additional opportunistic vegetation sampling.	The survey area encompassed the breadth of a creekline, but did not extend to surrounding hills. Two vegetation types were recorded.	106 taxa from 32 families and 71 genera; common families were Poaceae (13 taxa), Mimosaceae and Chenopdiaceae (9 taxa each) and Caesalpiniaceae and Malvaceae (7 taxa each); common genera were *Acacia* (9 taxa), *Senna* (6 taxa), *Eucalyptus* (5 taxa) and *Ptilotus* (4 taxa); four weed species were **Cenchrus ciliaris, *Acetosa vesicaria, *Malvastrum americanum* and **Sonchus oleraceaus.*	No Threatened or Priority flora
BHP IO (1994) Jimblebar Mine Site Biological Survey	Situated approximately 5 km directly south of the tenement boundary.	11-22 June 1994 22 plotless sampling areas (covering approx. 100m^2 each)	Five broad vegetation assemblages	132 species, representing 30 families; dominant families were Mimosaceae (19 taxa), Poaceae (10 taxa), Myrtaceae (9 taxa) and Caesalpiniaceae (8 taxa); dominant genera were *Triodia, Acacia, Senna* and *Eremophila*. One weed species, **Rumex vesicarius* (now **Acetosa vesicaria)*	No Threatened Flora One Priority 3 taxon, *Cryptandra* sp. Mt Meharry (S. van Leeuwen 682). This is now known as *Cryptandra monticola* and no longer considered to be Threatened
Dames and Moore (1993) Ecological Observations Jimblebar Railway Line	Situated approximately 5 km directly south of the tenement boundary.	19 - 22 November 1992 39 borrow pits and 2 control areas	The report assessed disturbed borrow pit areas the vegetation data provided is not applicable.	Not recorded	No Threatened or Priority Flora

4.0 METHODOLOGY

4.1 Legislation and Guidance Statement

The previous flora and vegetation surveys completed within the Proposal Development Envelope and surrounds were carried out in a manner that was compliant with Environmental Protection Authority (EPA) requirements for the environmental surveying and reporting of flora and vegetation in Western Australia:

- Environmental Protection of Native Vegetation in Western Australia: Clearing of Native Vegetation with Particular Reference to Agricultural Areas. Position Statement No. 2 (EPA 2000);
- Terrestrial Biological Surveys as an Element of Environmental Protection. Position Statement No. 3 (EPA 2002); and
- EPA Guidance for the Assessment of Environmental Factors: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia No. 51 (EPA 2004).

All surveys were also conducted in accordance with BHP Billiton Iron Ore's Guidance for Flora and Vegetation Surveys in the Pilbara (BHP Billiton Iron Ore 2010).

4.2 Desktop Searches

Desktop searches of three databases were completed for information relating to significant flora (DPaW 2013a, see Appendix 1), TECs and PECs (DPaW 2013b) previously collected or described within, or in close proximity to, the Proposal Development Envelope. For this report a database search covering the entire Proposal Development Envelope was completed. The search was extended beyond the immediate envelope to place flora values into a local and regional context. The search co-ordinate used was a 50 km radius around the point location 193000mE 7417000mN (50K GDA94). The State database search investigated three DPaW databases (DPaW 2013a):

1. The Threatened (Declared Rare) Flora Database;
2. The Threatened (Declared Rare) and Priority Flora List; and
3. The Western Australian Herbarium (WAH) Specimen Database for Priority flora species opportunistically collected in the area of interest.

A search of the EPBC Act Protected Matters database was undertaken [Department of Environment (DoE) 2014, see Appendix 2], as well as a search of the International Union for Conservation of Nature (IUCN) database (IUCN 2014). A comprehensive literature review of surveys previously completed within or in close proximity to the tenement boundary was also undertaken.

4.3 Field Survey Methodology

4.3.1 Timing and Personnel

There are seven flora and vegetation surveys that have previously been completed within, or partly within, the Proposal Development Envelope between July 2006

and September 2014, with survey effort spread across a variety of seasons (Table 4). The surveys are described further in Section 3.

The most recent Level 2 flora and vegetation survey at OB31 was completed by Onshore Environmental (2014a) under excellent seasonal conditions and included a review of all previous survey data. Two subsequent targeted significant flora surveys were completed by Onshore Environmental (2014b, 2014c) to refine known population boundaries and search for additional populations of significant plant taxa.

Table 4 Summary of previous flora and vegetation surveys completed within, or partly within, the Proposal Development Envelope.

Report	Survey Field Date	Survey Intensity
Onshore Environmental (2014c) Orebody 18 to OB31 Infrastructure Corridor Targeted Flora Survey	13 September 2014	Targeted searches under good seasonal conditions
Onshore Environmental (2014b) Orebody 31 / Wheelarra Hill North Targeted Flora Survey	24-30 April 2014	Targeted searches under excellent seasonal conditions
Onshore Environmental (2014a) Orebody 31 Level 2 Flora and Vegetation Survey	1-14 October 2013	45 quadrats and 146 relevés
Syrinx Environmental (2011) OB 31 Flora and Vegetation Assessment	10-15 February 2011 9-13 March 2011	29 quadrats
Syrinx Environmental (2012) Wheelarra Hill North Level 2 Flora and Vegetation Assessment	17-29 May 2011, 4-12 October 2011	83 quadrats and 19 relevés
GHD (2008) Mesa Gap Biological Survey	September/October 2007	40 quadrats
ENV Australia (2007) OB18 Flora and Vegetation Assessment Phase 2	25 July – 2 August 2006	71 quadrats

4.3.2 Sampling of Study Sites

Field surveys completed within the Proposal Development Envelope involved systematic sampling using quadrats. Relevé vegetation descriptions were made to increase the accuracy of vegetation mapping and targeted searches were completed in areas supporting significant plant taxa, or within habitats where it was anticipated significant flora may occur.

Quadrats were generally 50 m by 50 m in dimension or an equivalent area (2,500 m^2) along narrow associations such as minor drainage lines. The area sampled for each quadrat is standard for the Pilbara bioregion. The number of study sites sampled was determined by the size and heterogeneity of the tenement boundary, with a minimum density of one quadrat per square kilometre.

The sampling sites were assessed to provide a list of the total flora occurring within the area and a description of the vegetation structure. Data collected covered a range of environmental parameters including:

- Landform and habitat;
- Aspect;
- Soil colour and soil type;
- Rock type;

- Slope (angle);
- Percentage of bare ground, logs, twigs and leaves;
- Vegetation condition;
- Disturbance (caused by fire, clearing, grazing etc.);
- Age since fire;
- Broad floristic formation;
- Vegetation association description; and
- Height and percentage ground cover provided by individual plant taxa.

Other parameters recorded for each study site were:

- Study site number and date of assessment;
- Names of the botanists undertaking the assessment;
- Location (waypoint) – GPS coordinate (GDA94) using a handheld GPS; and
- Photograph number.

4.3.3 Targeted Surveys for Conservation Significant Species

The location of significant flora identified from the Proposal Development Envelope and surrounds during desktop searches and the literature review were re-visited during field surveys completed by Onshore Environmental during excellent seasonal conditions at April and September 2014 (Onshore Environmental 2014b, 2014c). The additional ground truthing provided the opportunity to undertake closer examination of specific landforms where significant flora may be expected to occur. These landforms included medium drainage lines, floodplains, gorges and cliff lines and areas supporting eroded Woongarra rhyolite under Boolgeeda Iron Formation[5].

4.3.4 Weed Survey and Mapping

Introduced weed species were recorded from formal quadrats assessed within the Proposal Development Envelope and surrounds. Opportunistic collections were also made while moving between study sites and targeted weed searches were completed in high moisture habitats, including drainage lines and flood plains. The location of weed species identified from the area during desktop searches and the literature review were re-visited during a field survey completed by Onshore Environmental under excellent seasonal conditions at April and September 2014 (Onshore Environmental 2014b, 2014c).

4.3.5 Vegetation Association Mapping

Prior to field survey work commencing vegetation association polygons were delineated using high resolution aerial photography (at a scale of 1:20,000) and digitised on a Geographic Information System (GIS) to form a mosaic of shapes across the landscape that formed the basis for a vegetation association map.

The position of quadrats to be surveyed in the field was then allocated prior to survey commencement, with quadrats distributed across the variety of different shading patterns evident. The formal survey effort was made at a minimum density of one site per km^2. However, numerous relevé vegetation descriptions were also made along the field transects to increase accuracy of vegetation association boundaries.

[5] *Acacia* sp. nov (reticulate/anastomosing) appeared to be habitat specific, occurring on eroded orange rock under BIF ironstone crest (Woongarra rhyolite under Boolgeeda Iron Formation)

Vegetation association descriptions were made on the basis of structure and species composition data collected from quadrats and relevés. The description of vegetation structure follows the height, life form and density classes of Specht (1970) as modified by Aplin (1979) and Trudgen (2010) (see Appendix 3). This is largely a structural classification suitable for broader scale mapping, but taking all ecologically significant strata into account. Vegetation condition for each of the sampling sites was determined using a recognised six point rating scale (based on Keighery 1994, see Appendix 4).

Vegetation association mapping of the majority of the Proposal Development Envelope for the Mine and associated infrastructure has most recently been completed by Onshore Environmental as part of the baseline survey completed at OB31 (Onshore Environmental 2014a). The southern fringe of the Proposal Development Envelope for the Mine and associated infrastructure has been mapped by Syrinx Environmental as part of the Wheelarra Hill North baseline survey (Syrinx Environmental 2012). The western sector of the Proposal Development Envelope for the Infrastructure Corridor has previously been mapped as part of the OB18 (ENV Australia 2007) and Mesa Gap (GHD 2008) baseline surveys.

4.3.6 Vouchering

During field surveys completed by Onshore Environmental (2014a, 2014b) at least one voucher specimen was taken for each plant taxon collected to verify field identification. Specimen identifications were confirmed at the WAH by taxonomists, with voucher specimens provided to BHP Billiton Iron Ore's sponsored botanist for confirmation, Mr. Steve Dillon. Use was made of the WAH for confirmation of species identification.

4.3.7 Field Survey Constraints

The EPA Guidance Statement No. 51 for Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004) list twelve potential constraints that field surveys may encounter. These constraints are addressed in Table 5.

Table 5 Relevance of constraints, as identified by EPA (2004), to the flora and vegetation survey.

Constraint	Relevance
Scope	The scope of work for baseline flora and vegetation surveys was established by BHP Billiton Iron Ore in compliance with relevant EPA Guidance Statements.
Proportion of flora collected and identified	A total of 280 plant taxa were recorded during the second season flora and vegetation survey completed by Onshore Environmental (2014a) at April 2014. A large proportion of the total flora present is likely to have been recorded owing to the high level of survey intensity and excellent seasonal conditions. It is estimated that greater than 98% of specimens collected by Onshore Environmental were positively identified, with some sterile material resulting from seasonality.
Sources of information	A total of seven flora and vegetation surveys have previously been completed within all, or part of, the Proposal Development Envelope. Numerous additional surveys (at least 26) have been undertaken in close proximity, providing an extensive local database.

Constraint	Relevance
The proportion of the task achieved and further work which might be needed	There has been a high level of survey intensity over an extended period within the Proposal Development Envelope. All required tasks relating to compliance with Level 2 flora and vegetation survey have been achieved and there are no recommendations for any further work.
Timing / weather / season / cycle	The baseline flora and vegetation survey and follow-up targeted significant flora surveys were both completed following periods of high summer rainfall and under excellent seasonal conditions.
Disturbances, e.g. fire, flood	Minor disturbances related to fire, mine exploration and grazing by domestic stock were noted within the tenement boundary, but did not impact on survey results.
Intensity	The entire Proposal Development Envelope has been surveyed at approximately one quadrat per square kilometer, equating to high survey intensity. In addition, two targeted significant flora surveys have also been completed.
Completeness	Two seasons of Level 2 flora and vegetation surveys and follow-up targeted significant flora surveys have been undertaken, and the survey effort is determined to be complete.
Resources	Appropriate resources have been applied to the baseline and targeted surveys and there were no limitations to survey outcomes identified.
Access problems	The entire Proposal Development Envelope was accessed on foot walking from exploration tracks.
Availability of contextual information	A total of 32 flora and vegetation surveys have previously been completed within a 25 km radius of the Proposal Development Envelope, with seven surveys occurring partly within the envelope, providing an extensive local database.
Experience levels	The Principal Botanist working on the three most recent surveys of the Proposal Development Envelope (Onshore Environmental 2014a, 2014b, 2014c) has over ten years Pilbara experience and has completed numerous surveys at, and in close proximity to the OB31 area.

4.3.8 Assessment of Conservation Significance

The conservation significance of flora and ecological communities are classified on a Commonwealth, State and Local level on the basis of various Acts and Agreements (EPA Guidance Statement No. 51, EPA 2004), including:

Commonwealth Level:

- EPBC Act: DoE lists Threatened Flora and Ecological Communities, which are determined by the Western Australian Threatened Species Scientific Committee according to criteria set out in the Act. The Act lists flora that are considered to be of conservation significance under one of six categories (Appendix 2).

State Level:

- WC Act: At a State level native flora species are protected under the WC Act – Wildlife Conservation (Rare Flora) Notice. A number of plant species are assigned an additional level of conservation significance based on a limited number of known populations and the perceived threats to these locations. Species of the highest conservation significance are gazetted

Threatened Flora (T) under subsection 2 of section 23F of the Act. It is an offence to take or damage Threatened flora without Ministerial approval. Section 23F of the Act defines 'to take' as "to gather, pick, cut, pull up, destroy, dig up, remove or injure the flora or to cause or permit the same to be done by any means".

- DPaW Priority list: DPaW produces a list of Priority species and ecological communities (PECs) that have not been assigned statutory protection under the WC Act. Priority Flora are under consideration for declaration as 'Rare Flora', classified as in urgent need of further survey (Priority One to Three), require monitoring every 5-10 years (Priority Four) or require a specific conservation program to prevent the taxon becoming threatened within five years (Priority 5), see Appendix 1. The list of PECs identifies those that need further investigation before nomination for TEC status.

Local Level:

- Species may be considered of local conservation significance because of their patterns of distribution and abundance. Although not formally protected by legislation, such species are acknowledged to be in decline as a result of threatening processes, primarily habitat loss through land clearing.

4.4 Assessment of Groundwater Dependent Vegetation

Vegetation mapping at a scale of 1:20,000 was collated for BHP Billiton Iron Ore's OB31, Wheelarra Hill North and OB18 baseline surveys. Vegetation associations were then rated for risk to groundwater drawdown on the basis of key indicator tree species, with a risk rating score ranging between one and five (Table 6).

Table 6 Risk rating score and risk level applied to vegetation associations within the Proposal Development Envelope and surrounds, and associated indicator tree species.

GDV Risk Rating	Risk Level	Indicator Species
1	Extreme	*Melaleuca argentea*
2	High	*Eucalyptus camaldulensis* subsp. *refulgens*
3	Moderate	*Eucalyptus victrix*
4	Low	*Eucalyptus xerothermica, Eucalyptus aspera*
5	Negligible	*Corymbia ferriticola, Acacia aptaneura, Corymbia hamersleyana, Eucalyptus socialis* subsp. *eucentrica, Eucalyptus gamophylla, Eucalyptus leucophloia* subsp. *leucophloia, Corymbia deserticola* subsp. *deserticola, Eucalyptus pilbarensis, Eucalyptus kingsmillii* subsp. *kingsmillii, Acacia catenulata* subsp. *occidentalis*

A score of 'one' indicated an extreme risk level corresponding to vegetation associations supporting the true phreatophytic[6] tree species *Melaleuca argentea,* which is restricted to major drainage channels and permanent pools where groundwater is typically within 3 m of natural ground level. *Melaleuca argentea* does not occur within the tenement boundary. A score of 'two' represented high

[6] True Phreatophytes are plant species that rely solely on water sourced directly from the watertable.

risk vegetation associations supporting the facultative phreatophyte[7] *Eucalyptus camaldulensis* subsp. *refulgens,* which is more widely distributed along major incised drainage channels in the Pilbara. *Eucalyptus camaldulensis* subsp. *refulgens* was not recorded from the Proposal Development Envelope or immediate surrounds. A score of 'three' was allocated to vegetation supporting the vadophytic[8] tree species *Eucalyptus victrix,* which occurs along a medium drainage line in the Proposal Development Envelope. Vegetation supporting the tree species *Eucalyptus xerothermica* and *Eucalyptus aspera* was scored a 'four'. Little is known about the water use requirements for *Eucalyptus xerothermica* and *Eucalyptus aspera,* which occur in similar habitats to *Eucalyptus victrix,* but have a wider local distribution. A score of 'five' equated to the lowest risk level for vegetation supporting xerophytic[9] species, representing no groundwater reliance and therefore negligible risk resulting from groundwater drawdown.

[7] Facultative Phreatophytes utilise water sourced directly from the watertable as required, typically during extended dry periods.
[8] Vadophytes - Primarily use water held in the vadose (unsaturated) zone that occurs above the watertable.
[9] Xerophytes are plants that have no reliance on groundwater for survival.

5.0 RESULTS

5.1 Desktop Review

5.1.1 Threatened Flora listed under the EPBC Act

A search of the EPBC Act Protected Matters database was undertaken within a 50 km radius of the Proposal Development Envelope (DoE 2014). The database search listed two Threatened Flora or their habitat as likely to occur within the search area; *Lepidium catapycnon* (Hamersley Lepidium) and *Pityrodia augustensis* (Mt Augustus Foxglove).

5.1.2 Threatened Flora listed under the IUCN Red List database

There were no Threatened Flora records resulting from a search of the International Union for Conservation of Nature (IUCN) database (IUCN 2014).

5.1.3 Threatened Flora listed under the WA Wildlife Conservation (Rare Flora) Notice 2014

The DPaW search identified one Threatened Flora taxon occurring within a 50 km radius of the Proposal Development Envelope, *Lepidium catapycnon* (Table 7).

5.1.4 Priority Flora recognised by the DPaW

The DPaW database search (DPaW 2013a) identified 88 Priority flora taxa as potentially occurring within a 50 km search radius of the Proposal Development Envelope. Priority flora taxa recorded during the database search are listed in Table 7, along with a general habitat description and likelihood of habitat occurring within the Proposal Development Envelope.

Table 7 Significant flora previously recorded from a 50 km search radius around the Proposal Development Envelope (DPaW 2013a).

SCC - State Conservation Code - WC Act and DPaW (2013); FCC – Federal Conservation Code (EPBC Act)

Species	Habitat	Previously Recorded	Habitat Present	SCC	FCC
Acacia bromilowiana	Red skeletal stony loam, orange-brown pebbly, gravel loam, laterite, banded ironstone, basalt. Rocky hills, breakaways, scree slopes, gorges, creek beds.	Y	Y	4	
Acacia daweana	Stony red loamy soils. Low rocky rises, along drainage lines.	N	Y	3	
Acacia subtiliformis	Rocky calcrete plateau.	N	N	3	
Adiantum capillus-veneris	Moist, sheltered sites in gorges and on cliff walls.	N	Y	2	
Amaranthus centralis	-	N	Y	3	
Aristida jerichoensis var. *subspinulifera*	Hardpan plains.	Y	Y	1	
Astrebla lappacea	Clay loam plains.	N	N	3	
Atriplex flabelliformis	Clay loam, loam. Saline flats or marshes.	N	N	3	
Atriplex lindleyi subsp. *conduplicata*	Gilgai plains.	N	N	3	
Barbula ehrenbergii	Iron rich weathered conglomerate on gorge walls.	N	Y	1	
Bothriochloa decipiens var. *cloncurrensis*	-	N	Y	1	
Brachyscome sp. Wanna Munna Flats (S. van Leeuwen 4662)	Sump, low in landscape, flat terrain, red-brown loamy soil with some stone, ironstone hardpan outcropping occasionally.	N	Y	1	
Brunonia sp. Long hairs (D.E. Symon 2440)	Along creeklines.	N	Y	1	
Calotis latiuscula	Rocky hillsides, floodplains, rocky creeks or river beds.	N	Y	3	
Calotis squamigera	Pebbly loam.	N	Y	1	
Cochlospermum macnamarae	Low hills underlain by granite bedrock.	N	Y	1	
Crotalaria smithiana	Floodplain.	N	Y	3	
Dampiera anonyma	Skeletal red-brown to brown gravelly soil over banded ironstone, basalt, shale and jaspilite. Hill summits, upper slopes (above 1000m).	N	Y	3	
Dampiera metallorum	Skeletal red-brown gravelly soil over banded ironstone. Steep slopes, summits of hills.	N	Y	3	
Dicladanthera glabra	Along watercourses, near rock pools.	N	N	2	
Eragrostis sp. Mt Robinson (S.van Leeuwen 4109)	Red-brown skeletal soils, ironstone. Steep slopes, summits.	N	Y	1	
Eremophila appressa	Ironstone gravel. Ridge slopes.	N	Y	1	

Species	Habitat	Previously Recorded	Habitat Present	SCC	FCC
Eremophila forrestii subsp. Pingandy (M.E. Trudgen 2662)	Flat plain with thin soil underlain by partly consolidated colluvium.	N	Y	2	
Eremophila magnifica subsp. *magnifica*	Skeletal soils over ironstone.	Y	Y	4	
Eremophila magnifica subsp. *velutina*	Skeletal soils over ironstone. Summits.	N	Y	3	
Eremophila pilosa	Plains.	N	Y	1	
Eremophila rigida	Hardpan plains, stony clay depressions.	N	Y	3	
Eremophila sp. Hamersley Range (K. Walker KW 136) PN	Undulating hills.	N	Y	1	
Eremophila sp. Rudall River (P.G. Wilson 10512) PN	Drainage line.	N	N	2	
Eremophila sp. Snowy Mountain (S. van Leeuwen 3737)	Undulating hills.	N	Y	1	
Eremophila sp. West Angelas (S. van Leeuwen 4086)	High in landscape, summit of hill, gently undulating to steep terrain, skeletal red gritty soil over massive banded iron of the Brockman Iron Formation.	N	Y	1	
Eucalyptus lucens	Ironstone. Rocky slopes and mountain tops, high in the landscape.	N	Y	1	
Eucalyptus rowleyi	-	N	N	3	
Euphorbia parvicaruncula	-	N	N	1	
Fimbristylis sieberiana	Mud, skeletal soil pockets. Pool edges, sandstone cliffs.	N	N	3	
Geijera salicifolia	Skeletal soils, stony soils. Massive rock scree, gorges.	N	Y	3	
Genus sp. Hamersley Range hilltops (S van Leeuwen 4345)	Skeletal, brown gritty soil over ironstone. Hill summit.	N	Y	1	
Glycine falcata	Drainage depressions in crabhole plains on river floodplains.	N	N	3	
Goodenia hartiana	Sand. Sand dune swales, sandhills.	N	N	2	
Goodenia lyrata	Red sandy loam. Near claypan.	N	Y	3	
Goodenia nuda	Floodplains, drainage lines.	Y	Y	4	
Goodenia sp. East Pilbara (AA Mitchell PRP 727)	Red-brown clay soil, calcrete pebbles. Low undulating plain, swampy plains.	N	N	3	
Grevillea sp. Turee (J. Bull & G. Hopkinson ONS JJ 01.01) PN	Ironstone ridges, upper slopes, breakaway and scree slopes.	N	N	1	

Species	Habitat	Previously Recorded	Habitat Present	SCC	FCC
Gymnanthera cunninghamii	Drainage lines.	N	Y	3	
Hibiscus sp. Gurinbiddy Range (M.E. Trudgen MET 15708)	Ironstone hills.	N	Y	2	
Hibiscus sp. Mt Brockman (E. Thoma ET 1354) PN	Ironstone hills.	N	Y	1	
Indigofera sp. Bungaroo Creek (S. van Leeuwen 4301)	Rocky drainage lines.	N	Y	3	
Indigofera sp. Gilesii (M.E. Trudgen 15869)	Pebbly loam amongst boulders & outcrops. Hills.	N	Y	3	
Iotasperma sessilifolium	Cracking clay, black loam. Edges of waterholes, plains.	N	N	3	
Ipomoea racemigera	-	N	Y	1	
Isotropis parviflora	Valley slope of ironstone plateau, disturbed areas.	N	Y	2	
Lepidium catapycnon	Skeletal soils. Hillsides.	N	Y	T	V
Maireana prosthecochaeta	Gibber plains.	N	N	3	
Myriocephalus scalpellus	Clay. Depressions on flood plain.	N	N	1	
Nicotiana heterantha	Black clay. Seasonally wet flats.	N	Y	1	
Nicotiana umbratica	Shallow soils. Rocky outcrops.	Y	Y	3	
Oldenlandia sp. Hamersley Station (A.A. Mitchell PRP 1479)	Cracking clay, basalt. Gently undulating plain with large surface rocks, flat crabholed plain.	N	N	3	
Olearia mucronata	Schistose hills, along drainage channels.	N	N	3	
Oxalis sp. Pilbara (M.E. Trudgen 12725)	Shaded gully on the lower slopes of a large hill, in the flowline in the gully. Soil: pebbly/gravelly red-brown loam amongst boulders.	N	Y	2	
Pentalepis trichodesmoides subsp. *hispida*	Skeletal soils, sand, loam. Stony grounds, along watercourses.	N	Y	2	
Peplidium sp. fortescue marsh (S. van Leeuwen 4865)	Clay. Marsh.	N	N	1	
Pilbara trudgenii	Skeletal, red stony soil over ironstone. Hill summits, steep slopes, screes, cliff faces.	N	Y	2	
Polymeria distigma	Sandy soils. Plains.	N	Y	3	
Ptilotus subspinescens	Gentle rocky slopes, screes and the bases of screes.	N	Y	3	
Rhagodia sp. Hamersley (M. Trudgen 17794)	Floodplains, hardpan plains.	Y	Y	3	

Species	Habitat	Previously Recorded	Habitat Present	SCC	FCC
Rhynchosia bungarensis	Pebbly, shingly coarse sand amongst boulders. Banks of flow line in the mouth of a gully in a valley wall.	N	Y	4	
Rostellularia adscendens var. *latifolia*	Ironstone soils. Near creeks, rocky hills.	Y	Y	3	
Scaevola sp. Hamersley Range basalts (S. van Leeuwen 3675)	Skeletal, brown gritty soil over basalt. Summits of hills, steep hills.	N	N	2	
Sida sp. Barlee Range (S van Leeuwen 1642)	Skeletal red soils pockets. Steep slope.	N	Y	3	
Sida sp. Hamersley Range (K. Newbey 10692)	Ironstone hills.	N	N	1	
Solanum albostellatum	-	N	Y	3	
Solanum kentrocaule	Ironstone hills.	N	Y	3	
Spartothamnella puberula	Rocky loam, sandy or skeletal soils, clay. Sandplains, hills.	Y	Y	2	
Stemodia sp. Battle Hill (A.L. Payne 1006)	Cracking clay. Floodplain.	N	N	1	
Swainsona thompsoniana	Floodplains. Seasonally wet flats.	N	Y	3	
Tecticornia medusa	Clay. Marsh.	N	N	3	
Tecticornia sp. Christmas Creek (K.A. Shepherd & T. Colmer et al. KS 1063)	Clay. Marsh.	N	N	1	
Tetratheca fordiana	Shale pocket amongst ironstone.	N	Y	1	
Teucrium pilbaranum	Clay. Crab hole plain in a river floodplain, margin of calcrete table.	N	N	1	
Stylidium weeliwolli	Gritty sand soil, sandy clay. Edge of watercourses.	N	N	2	
Tetratheca fordiana	Shale pocket amongst ironstone.	N	N	1	
Themeda sp. Hamersley Station (M.E. Trudgen 11431)	Red clay. Clay pan, grass plain.	N	Y	3	
Thryptomene wittweri	Skeletal red stony soils. Breakaways, stony creek beds.	N	Y	T	V
Triodia sp. Karijini (S. van Leeuwen 4111) PN	Ironstone hills.	N	Y	1	
Triodia sp. Mt. Ella (ME Trudgen 12739)	Light orange-brown, pebbly loam. Amongst rocks & outcrops, gully slopes.	N	Y	3	
Triodia sp. Robe River (M.E. Trudgen et al. MET 12367)	Ironstone undulating hills.	N	Y	3	
Triodia triticoides	Rocky sandstone and limestone hillslopes.	N	N	1	

Species	Habitat	Previously Recorded	Habitat Present	SCC	FCC
Vittadinia sp. Coondewanna Flats (S van Leeuwen 4684)	Floodplains, hardpan plains.	N	Y	1	
Whiteochloa capillipes	Floodplains.	N	Y	3	

5.1.5 TECs listed under State and Federal Legislation

A search of the EPBC Act Protected Matters database (DoE 2014) confirmed there were no Federal listed TECs previously recorded within, or adjacent to, the Proposal Development Envelope. Similarly, a search of the DPaWs communities database (DPaW 2013b) confirmed there were no State listed TEC records for the immediate Proposal Development Envelope or surrounds.

5.1.6 PECs recognised by DPaW

A search of the State communities database (DPaW 2013b) confirmed there were no PECs within a 50 km radius of the Proposal Development Envelope.

5.2 Conservation Significant Flora Species

5.2.1 Threatened Flora listed under the WC Act and EPBC Act

No plant taxon gazetted as Threatened Flora (T) pursuant to subsection (2) of Section 23F of the WC Act or listed under the EPBC Act was recorded from the Proposal Development Envelope.

5.2.2 Priority Flora

There were three Priority flora recorded from the Proposal Development Envelope; *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) (Priority 1), *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (Priority 3) and *Goodenia nuda* (Priority 4). A fourth Priority flora taxon was recorded from just outside the Proposal Development Envelope, *Rhagodia* sp. Hamersley (M. Trudgen 17794) (Priority 3). The locations of all records for the four Priority flora taxa are provided in Figure 5 and Appendix 5.

Acacia sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)

Acacia sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) is a new species recorded for the first time at OB31. It occurs as a shrub between 1.5 m and 4.0 m tall and 2.5 m wide (Plate 1). It has five diagnostic characters:

- flat phyllodes with anastomosing nerves (Plate 2);
- cylindrical spike;
- calyx lobes separated;
- gland about 10mm above pulvinus; and
- dense red brown glandular trichomes on new growth and edges of phyllodes (small hairlets).

It is so odd that its affinities are unknown (B. Maslin, pers. comm.). It is currently listed as a Priority 1 flora, but the conservation code may be increased to the status of Threatened Flora in the near future if no additional populations are recorded during targeted searches planned for May 2015.

Acacia sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) was recorded as 534 plants from five populations occurring across approximately 8 ha situated along the north-west boundary of the Proposal Development Envelope and extending outside of this envelope (Figure 5, Table 8). It occurred on rocky low hill crests and hill slopes amongst low undulating hills that had been burnt within the past three years. It appeared to be habitat specific, restricted to areas where the Boolgeeda Iron Formation was overlying Woongarra Rhyolite. Associated vegetation was

described as 'Hummock Grassland of *Triodia* sp. Shovelanna Hill (S. Van Leeuwen 3835) with Open Shrubland of *Grevillea berryana* and *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) over Low Open Shrubland of *Senna stricta, Ptilotus rotundifolius* and *Ptilotus calostachyus'.*

Table 8 Representation of *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) within the Tenement Boundary and immediate surrounds.

Population	MGA94 Easting	MGA94 Northing	No. sub-popns	No. plants	Approx. area (m)	Approx. area (ha)
1	202763	7420207	4	114	200 by 100	2
2	201663	7420296	3	209	200 by 100	2
3	201922	7420539	5	105	300 by 100	3
4	202307	7420698	2	34	100 by 50	0.5
5	204014	7420180	2	72	100 by 50	0.5

Plate 1 Habit of *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01).

Plate 2 Close-up view of the reticulate/anastomosing venation in the phyllode.

Triodia sp. Mt Ella (M.E. Trudgen 12739)

The undescribed *Triodia* sp. Mt Ella (M.E. Trudgen 12739) was first discovered on Mt Ella (west of Mining Area C) in 1995, where it occurs on upper hill slopes below Mulga and in an east to south-east facing gully (Trudgen 1998). It is a perennial hummock grass to 1.0 m in height (Plate 3), which could be easily confused with *Triodia pungens*. It occurs amongst rocks and outcrops on hill slopes and gullies on light orange brown pebbly loam. *Triodia* sp. Mt. Ella (M.E. Trudgen 12739) is considered to be geographically restricted and uncommon, but unlikely to be rare (Trudgen 1998).

Triodia sp. Mt Ella (M.E. Trudgen 12739) has been previously recorded at West Angelas (Trudgen 1998) and more recently from a suite of BHP Billiton Iron Ore leases surrounding Mining Area C. In 2013 it was recorded for the first time in the far south-east Pilbara at BHP Billiton Iron Ore's Orebody 19 (OB19) tenement boundary (Onshore Environmental 2014d). It was recorded from 43 locations, occurring in gullies, drainage lines and hills in red silty loam. Ground cover was variable ranging from one percent to sixty percent (Onshore Environmental 2014d).

Triodia sp. Mt Ella (M.E. Trudgen 12739) (Priority 3) was recorded as seven scattered plants from five spot locations on floodplains within the Proposal Development Envelope for the Infrastructure Corridor (Table 9, Figure 5). Two larger populations comprising 50 spot location points were associated with steep scree slopes, cliff lines and gorges further south-west and outside of the Proposal Development Envelope (Figure 5). Within these main populations, *Triodia* sp. Mt Ella (M.E. Trudgen 12739) was recorded as >10,000 plants and providing up to 80 percent ground coverage.

Table 9 Representation of *Triodia* sp. Mt Ella (M.E. Trudgen 12739) within the Tenement Boundary.

Population	MGA94 Easting	MGA94 Northing	No. sub-popns	No. plants	Approx. area (m)	Approx. area (ha)
1	200677	7416456	1	1	1m by 1m	0.0001
2	206174	7415213		>10,000	400m by 100m	4
3	202943	7414169		>10,000	1,000m by 250m	25
4	202542	7417486	4	6	500m by 50m	2.5

Plate 3 Close up view of panicle for *Triodia* sp. Mt Ella (M.E. Trudgen 12739).

Goodenia nuda

Goodenia nuda (Priority 4) is an erect annual or biennial herb to 0.3 m in height that occurs on drainage levees, flood plains and sand plains (Plate 4). *Goodenia nuda* is widespread throughout the Pilbara, with records also from the northern Carnarvon and eastern Gascoyne bioregions. It is typically recorded from relatively mesic habitats, such as floodplains and drainage zones. Within the south-east Pilbara it has been collected from a number of BHP Billiton Iron Ore tenements including Tandanya (Onshore Environmental 2013b), South Flank (Onshore Environmental 2012a), Area C and Surrounds (Onshore Environmental 2011a), Jinidi (Onshore Environmental 2011b), Mount Whaleback (Onshore Environmental 2014e) and OB31 (Onshore Environmental 2014a).

Goodenia nuda was recorded as 63 plants from seven points within the Proposal Development Envelope for the Infrastructure Corridor (Table 10, Figure 5), where it was associated with sandy loam soils on floodplains. Vegetation was described as

'Tussock Grassland of *Aristida inaequiglumis* and *Themeda triandra* with Low Open Woodland of *Corymbia aspera, Corymbia hamersleyana* and *Acacia aptaneura* over Open Shrubland of *Acacia aptaneura* and *Acacia ancistrocarpa'.*

Table 10 Representation of *Goodenia nuda* within the Tenement Boundary.

Population	MGA94 Easting	MGA94 Northing	No. sub-popns	No. plants	Approx. area (m)	Approx. area (ha)
1	202619	7415711	5	50	50m by 100m	0.5
2	202591	7417072	2	13	50m by 100m	0.5

Plate 4 *Goodenia nuda* (Priority 4)

Rhagodia sp. Hamersley (M. Trudgen 17794)

Rhagodia sp. Hamersley (M. Trudgen 17794) (Priority 3) is a perennial chenopod species growing to a height of 2 m in orange to red loam soils on flood plains (Plate 5). The current known distribution is restricted to the Pilbara bioregion with increasing numbers of populations recorded in recent years between Tom Price and Newman. *Rhagodia* sp. Hamersley (M. Trudgen 17794) has previously been recorded extensively over floodplains adjacent to BHP Billiton Iron Ore's Mining Area C operations, occurring adjacent to the Great Northern Highway and extending eastwards to the Packsaddle Village (Onshore Environmental 2011a), south into the South Flank exploration tenements (Onshore Environmental 2012a) and further east to the Jinidi tenements (Onshore Environmental 2011b). It was recently recorded during a review of vegetation mapping at BHP Billiton Iron Ore's Carramulla tenements, situated approximately 25 km east of the tenement boundary (Onshore

Environmental 2014c). This record is the most south-eastern extent of the known distribution.

Rhagodia sp. Hamersley (M. Trudgen 17794) was recorded from two point locations just outside the north-western fringe of the the Proposal Development Envelope (Table 11, Figure 5). Plants occurred as scattered tall shrubs on flood plains in association with *Acacia ancistrocarpa* and *Acacia aptaneura* High Shrubland over *Triodia basedowii* Hummock Grassland.

Table 11 Representation of *Rhagodia* sp. Hamersley (M. Trudgen 17794) within the Tenement Boundary.

Population	MGA94 Easting	MGA94 Northing	No. sub-popns	No. plants	Approx. area (m)	Approx. area (ha)
1	204040	7421274	2	8	1,000m by 500m	50

Plate 5 *Rhagodia* sp. Hamersley (M. Trudgen 17794).

5.2.3 Flora of Interest

One taxon recorded from the Proposal Development Envelope was determined to be a significant range extension, *Acacia clelandii. Acacia clelandii* is a spreading multi-stemmed and rounded shrub reaching 5 m in height, occurring in sandy soils on dunes or rocky hills (Plate 6). It has characteristic terete or subterete phyllodes, occasionally flat, straight or slightly curved. It is know from populations situated approximately 150 km east of Wiluna in the Gascoyne and Murchison subregions. The recent collections made from the OB31 area represent a 400 km range extension north of the nearest known populations.

Acacia clelandii was recorded from 20 point locations scattered across the northern sector of the Proposal Development Envelope for the Mine and associated infrastructure (eight points), as well as extending north-west outside the envelope and further east outside of the tenement boundary (12 points) (Table 12, Figure 5). Plants were between 1.5 m and 4 m in height and 2.5 m to 6 m in width and occurred as scattered individuals (between 1 to 5 plants) from nine of the 20 points recorded. At the remaining eleven point locations plant density was estimated in the range 40 plants per ha to 750 plants per ha and providing up to 30 percent ground cover.

Plants occurred on highly weathered ironstone on stony undulating low hills, footslopes and rocky drainage lines. *Acacia clelandii* occurred with a variety of vegetation associations including:

- Hummock Grassland of *Triodia* sp. Shovelanna Hill (S. Van Leeuwen 3835) with Low Open Shrubland of *Acacia hilliana, Halgania solanacea* var. Mt Doreen (G.M. Chippendale 4206) and *Acacia adoxa* var. *adoxa* over Scattered Tussock Grasses of *Amphipogon sericeus* and *Eriachne lanata;*
- Hummock Grassland of *Triodia angusta* and/or *Triodia* sp. Shovelanna Hill with Shrubland of *Acacia sibirica, Acacia bivenosa* and *Acacia wanyu* over Open Shrubland of *Eremophila exilifolia, Senna stricta* and *Acacia sibirica* with Low Open Woodland of *Acacia aptaneura;* and
- Low Open Mallee of *Eucalyptus gamophylla* over Open Scrub of *Acacia bivenosa* (with minor component of *Acacia wanyu, Acacia ancistrocarpa* and *Acacia adsurgens*) over Hummock Grassland of *Triodia basedowii.*

Acacia clelandii has recently been recorded from an additional seven locations situated approximately 2 km east of the Proposal Development Envelope, occurring on undulating stony plains and eroded lower slopes fringing Jimblebar Creek (Onshore Environmental 2015).

Table 12 Representation of *Acacia clelandii* within the Tenement Boundary.

Population	MGA94 Easting	MGA94 Northing	No. sub-popns	No. plants or % Cover	Approx. area (m)	Approx. area (ha)
1	202287	7420396	5	19	1,600m by 250m	4
2	203837	7420389	1	3	50m by 50m	0.25
3	203950	7419634	1	20 per $50m^2$	on footslopes	on footslopes
4	204533	7418443	1	10		
5	204976	7417718	1	<2% cover		
6	207548	7419549		10-30% cover on steep scree slopes	750m by 250m	20
7	206732	7417197	2	10 per $50m^2$ (10-30% cover)	500m by 50m	2.5
8	209812	7417936	6	ranging from 15-30 plants per $50m^2$	750m by 250m	20

Plate 6 Habit of *Acacia clelandii* within the tenement boundary.

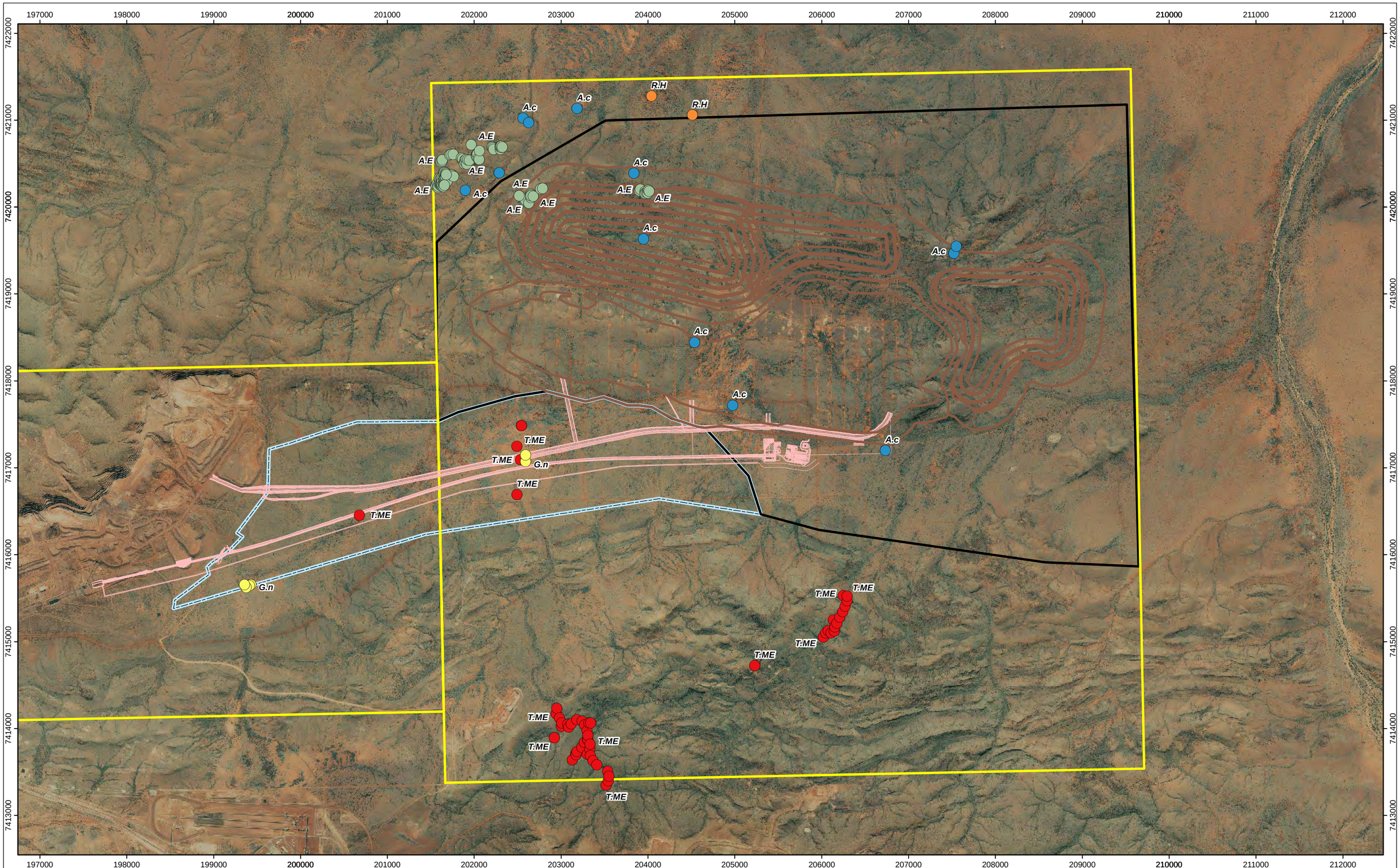


Figure:	5	Date:	18 Sept 2014
Sheet Size:	A3	Status:	Final
Drawn by GSM	Requested by GSM	GSM Reference OB31_Sig Flora	

N

0 250 500 1,000 1,500 2,000

Meters
1:40,000

Datum: GDA94
Projection: MGA Zone 51

BHPBIO

FIGURE 5

Location of significant flora within the Proposed Development Envelope

Legend

- OB31 Indicative Disturbance Boundary – Mine, OSAs
- OB31 indicative disturbance boundary – infrastructure corridor
- Tenement Boundary
- OB31 Indicative Pit and OSA
- OB31 Indicative Infrastructure Designs

Significant

- *Acacia clelandii* (A.c)
- *Acacia*sp. East Fortescue (J. Bull and D. Roberts ONS A 27.01) *(A.E)*
- *Goodenia nuda* (G.n)
- *Rhagodia* sp Hamersley (M.E. Trudgen 17794) *(R.H)*
- *Triodia* sp. Mt Ella (M.E. Trudgen 12739) *(T.ME)*

GRIFFIN SPATIAL & MAPPING
PO Box 7215
Eaton WA 6232
admin@griffinspatial.com.au
+61 8 9725 3213

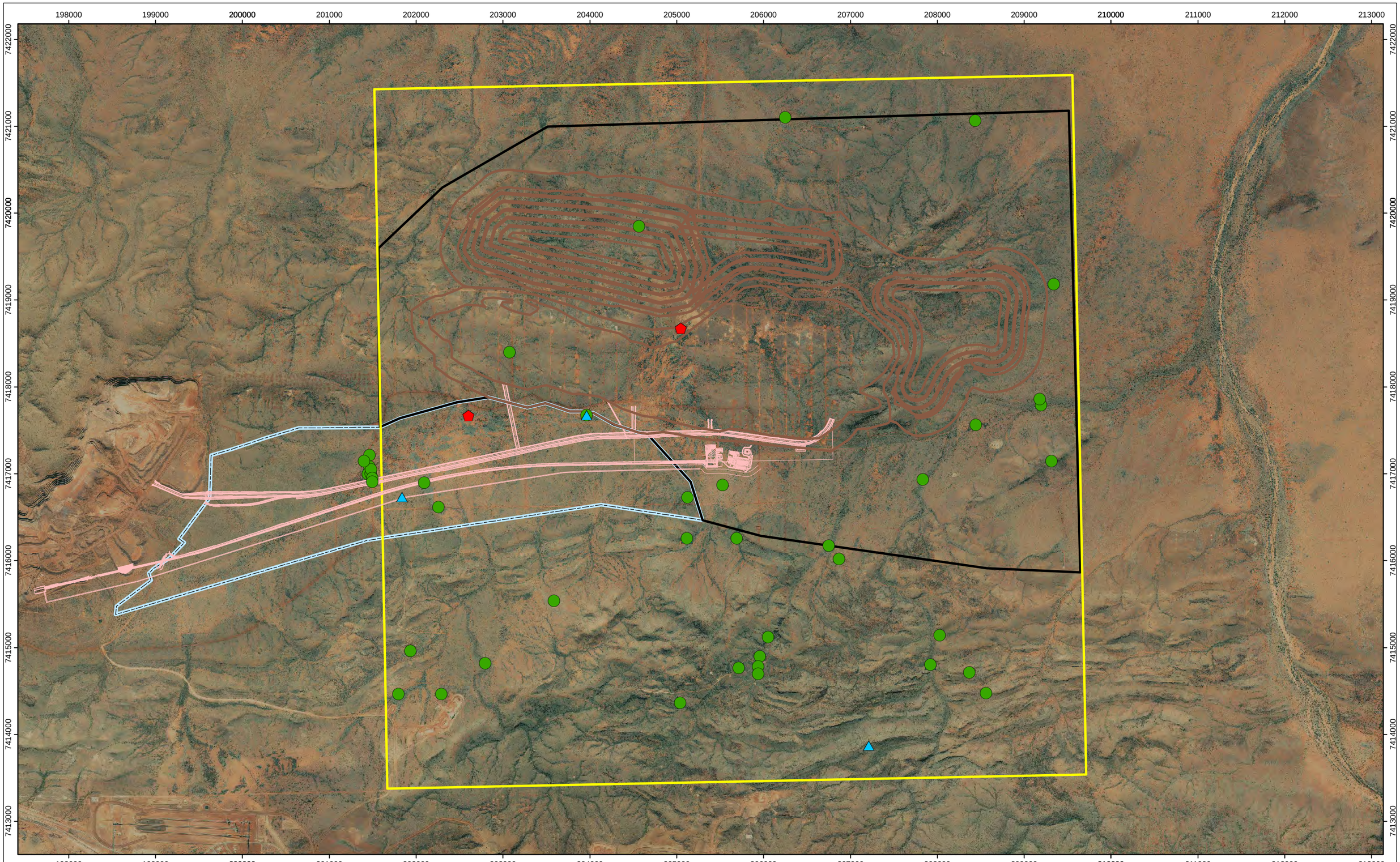
5.3 Introduced Flora

There were three introduced (weed) species recorded as scattered individuals from lower lying landforms in the Proposal Development Envelope, including footslopes, plains and drainage lines; **Bidens bipinnata* (Beggar's Ticks), **Cenchrus ciliaris* (Buffel Grass) and **Malvastrum americanum* (Spiked Malvastrum) (Table 13, Figure 6, Appendix 6). None of these taxa are listed as a Declared Pest under the BAM Act.

Table 13 Introduced weed species recorded from the Proposal Development Envelope.

Taxon (Common Name)	Photograph	Description	Occurrence in tenement boundary
**Bidens bipinnata* (Beggar's Ticks)		Erect annual herb with deeply lobed bipinnate leaves, flowering heads in terminal panicles, and black fruits with barbed awns at one end. Is widespread north of Kalbarri.	Scattered plants from one location within the Proposal Development Envelope for the Infrastructure Corridor (Figure 6). Occurring as scattered plants under tree canopies and providing ground cover of less than 2%.
**Cenchrus ciliaris* (Buffel Grass)		Tufted perennial grass originating from the Middle East as a fodder species by pastoralists. It grows in dense tussocks up to 1 m tall and typically occurs in monospecific stands on loamy plains and creekline levee banks. It is an aggressive colonising species that has become well established throughout the Pilbara, Gascoyne and Murchison regions of Western Australia, and is continuing to spread in the south west (Hussey *et al.* 1997).	Occurs as 24 widely spread records distributed across the majority of the Proposal Development Envelope; 13 points within the envelope for the Mine and associated infrastructure, and 11 points within the envelope for the Infrastructure Corridor (Figure 6). Occurring as scattered plants at each location and providing ground cover of less than 2% with the exception of two locations within the Proposal Development Envelope for the Infrastructure Corridor (5% and 10%).

Taxon (Common Name)	Photograph	Description	Occurrence in tenement boundary
**Malvastrum americanum* (Spiked Malvastrum)		Erect perennial herb or shrub, ranging from 0.5 m to 1.3 m in height. It grows in a variety of soil types on stony ridges and hill sides, flood plains and along drainage lines.	Two records of scattered plants providing less than 2% ground cover. One record from the Proposal Development Envelope for the Mine and associated infrastructure, and the second point from the Proposal Development Envelope for the Infrastructure Corridor (Figure 6).



ONSHORE ENVIRONMENTAL

Figure:	6	Date:	18/09/2014
Sheet Size:	A3	Status:	DRAFT
Drawn by GSM	Requested by GSM	GSM Reference OB31__Intro_flora	

N

0 250 500 1,000 1,500 2,000

Meters
1:40,000

Datum: GDA94
Projection: MGA Zone 51

BHPBIO

OB31
INTRODUCED FLORA
FIGURE 6

Legend

- Tenement Boundary
- OB31 Indicative Disturbance Boundary – Mine, OSAs
- OB31 indicative disturbance boundary – infrastructure corridor
- OB31 Indicative Pit and OSA
- OB31 Indicative Infrastructure Designs

Introduced Flora

- *Bidens bipinnata*
- *Cenchrus ciliaris*
- *Malvastrum americanum*

GRIFFIN SPATIAL & MAPPING
PO Box 7215
Eaton WA 6232
admin@griffinspatial.com.au
+61 8 9725 3213

5.4 Threatened Ecological Communities

No TECs were recorded within or adjacent to the Proposal Development Envelope. The nearest known TEC is the Endangered Ethel Gorge aquifer stygobiont community located approximately 40 km west of the Proposal Development Envelope.

5.5 Priority Ecological Communities

None of the vegetation associations described and mapped from the Proposal Development Envelope were found to have affiliations with any PECs documented within the Pilbara.

5.6 Vegetation

Vegetation across the majority of the Proposal Development Envelope was mapped by Onshore Environmental as part of the OB31 baseline survey (Onshore Environmental 2014a), with smaller portions being mapped by Syrinx Environment (Syrinx Environmental 2012) and ENV Australia (ENV Australia 2007). The Proposal Development Envelope comprised 47 vegetation associations across the three baseline survey areas (Figure 7).

Vegetation within the Proposal Development Envelope is discussed in more detail in Section 6.1.1.

None of the vegetation associations within the Proposal Development Envelope are Commonwealth or State listed TECs, or State listed PECs.

A list of ecosystems considered to be 'at risk' within each IBRA subregion was identified during the biodiversity audit of Western Australia's biogeographical subregions (McKenzie *et al.* 2003). According to this audit, the Proposal Development Envelope occurs in the Pilbara 2 – Fortescue Subregion. Kendrick (2001a) lists the following communities as being 'Ecosystems at risk':

- Ethel Gorge aquifer stygobiont community;
- Permanent wetland communities, Millstream;
- Foretscue Marsh saltbush community;
- Perennial grassland communities in the Fortescue Valley; and
- Grove-intergrove Mulga communities at southern and northern apron of Hamersley Range.

One of the above communities is analogous to vegetation association 10f (26 ha) recorded from a floodplain within the Proposal Development Envelope for the Mine and associated infrastructure (Figure 8). Vegetation was described as 'Hummock Grassland of *Triodia basedowii, Triodia pungens* and *Triodia* sp. Shovelanna Hill with Low Woodland of *Acacia aptaneura, Acacia pruinocarpa* and *Acacia paraneura* over Shrubland of *Eremophila fraseri* and *Eremophila forrestii* subsp. *forrestii* on sandy drainage zones'.

Beard (1975) vegetation associations within each subregion were ranked as Low, Medium or High priority for reservation in the conservation estate (Kendrick 2001a). The two Beard associations represented within the Proposal Development

Envelope (82 and 216) were rated as being of medium reservation priority (Kendrick 2001a).

Vegetation condition within the Proposal Development Envelope ranged from excellent to good, with the largest area surveyed by Onshore Environmental (2014b) (71%) rated as very good (Figure 9). Three vegetation associations were rated in excellent condition (2a, 10k, 11c); these were associated with stony plains, footslopes and cliffs/ravines. Seven vegetation associations were rated in good condition (5a, 10e, 10f, 10l, 11a, 13a, 15); these were generally associated with lowland habitats such as floodplains, sandy loam plains and sandy drainage zones that were subject to higher levels of grazing by domestic stock, and associated issues such as surface erosion and introduction of weeds.

BHPBIO

OB31 VEGETATION TYPES FIGURE 7

ONSHORE ENVIRONMENTAL

Figure:	7	Date:	11 Aug 2014
Sheet Size:	A3	Status:	DRAFT
Drawn by GSM	Requested by GSM	GSM Reference OB31_Targeted_Veg	

N

0 250 500 1,000 1,500 2,000

Meters
1:40,000

Datum: GDA94
Projection: MGA Zone 51

Legend

- OB31 Indicative Disturbance Boundary – Mine, OSAs
- OB31 indicative disturbance boundary – infrastructure corridor
- Tenement Boundary
- OB31 Indicative Pit and OSA
- OB31 Indicative Infrastructure Designs

GRIFFIN SPATIAL & MAPPING
PO Box 7215
Eaton WA 6232
admin@griffinspatial.com.au
+61 8 9725 3213

Legend

Onshore Environmental Vegetation Mapping

Acacia Low Open Forest

1a Low Open Forest (to Low Woodland) of *Acacia aptaneura*, *Acacia paraneura* and *Eucalyptus leucophloia* subsp. *leucophloia* over Open Scrub (to High Shrubland) of *Acacia balsamea*, *Acacia wanyu* and *Acacia monticola* over Open Hummock Grassland of *Triodia pungens* forming mulga groves on floodplains and on on minor drainage lines through undulating ironstone ridges, hills and valleys

1b Low Open Forest of *Acacia aptaneura*, *Acacia paraneura* and *Eucalyptus leucophloia* subsp. *leucophloia* over Open Scrub of *Acacia wanyu*, *Acacia tetragonophylla* and *Acacia bivenosa* over Open Hummock Grassland of *Triodia pungens* and *Triodia* sp. *Shovelanna Hill* on minor drainage lines through undulating ironstone ridges, hills and valleys

Acacia Low Woodland

2a Low Woodland of *Acacia aptaneura*, *Acacia catenulata* subsp. *occidentalis* and *Acacia ayersiana* over High Shrubland of *Acacia ?cuthbertsonii* over Open Hummock Grassland of *Triodia basedowii* on stony loam plains

2b Low Woodland of *Acacia citrinoviridis*, *Eucalyptus victrix* and *Acacia pruinocarpa* over High Shrubland of *Acacia monticola*, *Acacia pyrifolia* var. *pyrifolia* and *Petalostylis labicheoides* over Open Tussock Grassland of *Themeda triandra* and *Eriachne tenuiculmis* on medium drainage line

Acacia Closed Scrub

3 Closed Scrub (to Closed Low Forest) of *Acacia pteraneura* and *Corymbia aspera* over Tussock Grassland of *Panicum effusum* and *Eragrostis flaccida* and Open Shrubland of *Eremophila fraseri* on gilgai drainage zones and flats

Acacia Open Scrub

4a Open Scrub of *Acacia ancistrocarpa*, *Acacia bivenosa* and *Acacia tenuissima* over Hummock Grassland of *Triodia pungens* with Low Open Mallee of *Eucalyptus gamophylla* on drainage lines and drainage zones

4b Open Scrub of *Acacia monticola* and *Grevillea wickhamii* subsp. *hispidula* over Open Hummock Grassland of *Triodia pungens* and *Triodia* sp. Shovelanna Hill with Scattered Low Trees of *Corymbia deserticola* subsp. *deserticola*, *Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* on minor drainage line dissecting low hills and footslopes

Acacia High Shrubland

5a High Shrubland of *Acacia ancistrocarpa*, *Acacia adsurgens* and *Acacia elachantha* over Open Hummock Grassland of *Triodia schinzii* and Open Tussock Grassland of *Aristida inaequiglumis*, *Eulalia aurea* and *Digitaria brownii* on footslopes

5b High Shrubland of *Acacia ancistrocarpa*, *Acacia adsurgens* and *Acacia elachantha* over Open Tussock Grassland of *Themeda triandra*, *Aristida holathera* var. *holathera* and *Paraneurachne muelleri* with Low Open Woodland of *Corymbia hamersleyana*, *Corymbia aspera* and *Hakea lorea* subsp. *lorea* on sandy drainage zones and floodplains

5c High Shrubland of *Acacia balsamea*, *Acacia wanyu* and *Acacia tetragonophylla* over Open Shrubland of *Senna glutinosa* subsp. x *luerssenii*, *Eremophila platycalyx* and *Senna stricta* over Open Hummock Grassland of *Triodia pungens* and *Triodia* sp. Shovelanna Hill on undulating plateaux and hill slopes

Acacia High Open Shrubland

6 High Open Shrubland of *Acacia aptaneura* and *Acacia paraneura* over Scattered Tussock Grasses of *Aristida contorta* and *Aristida inaequiglumis* and Scattered Hummock Grasses of *Triodia basedowii* and *Triodia pungens* on clay loam flats and stony plains

Acacia Shrubland

7 Shrubland of *Acacia wanyu*, *Acacia tetragonophylla* and *Senna glutinosa* subsp. x *luerssenii* over Low Shrubland of *Senna stricta* , *Eremophila cuneifolia* and *Scaevola spinescens* over Open Hummock Grassland of *Triodia pungens* and *Triodia* sp. Shovelanna Hill on undulating hills, ironstone ridges and valleys

Eremophila Low Shrubland

8 Low Shrubland of *Eremophila compacta*, *Eremophila cuneifolia* and *Lepidium platypetalum* with Low Open Woodland of *Acacia aptaneura* and *Acacia paraneura* and High Open Shrubland of *Acacia wanyu* and *Senna glutinosa* subsp. x *luerssenii* on low hill crests and slopes

Sclerolaena Low Shrubland

9 Low Shrubland of *Sclerolaena cuneata*, *Frankenia setosa* and *Eremophila cuneifolia* with Open Shrubland of *Acacia synchronicia* and Scattered Low Trees of *Acacia aptaneura* and *Acacia paraneura* on gently sloping plains

Triodia Hummock Grassland

10a Hummock Grassland of *Triodia angusta* and *Triodia pungens* with Shrubland of *Acacia bivenosa* and Low Open Mallee of *Eucalyptus socialis* subsp. *eucentrica* and *Eucalyptus gamophylla* on low calcrete hills and rises

10b Hummock Grassland of *Triodia angusta* with Open Shrubland of *Acacia synchronicia*, *Acacia tetragonophylla* and *Acacia wanyu* over Low Open Shrubland of *Eremophila cuneifolia*, *Lepidium platypetalum* and *Maireana pyramidalis* on undulating hills, ironstone ridges and eroded slopes

10c Hummock Grassland of *Triodia basedowii* and *Triodia pungens* with High Shrubland (to Open Scrub) of *Acacia ancistrocarpa*, *Acacia pyrifolia* var. *pyrifolia* and *Acacia bivenosa* and Low Open Woodland of *Corymbia hamersleyana* on sandy floodplains and levee banks

10d Hummock Grassland of *Triodia basedowii* with Low Open Woodland of *Corymbia hamersleyana*, *Hakea lorea* subsp. lorea and High Open Shrubland of *Acacia ancistrocarpa*, *Acacia pachyacra* and *Acacia bivenosa* on stony sandplains

10e Hummock Grassland of *Triodia basedowii* with Low Woodland of *Acacia pteraneura* over Open Shrubland of *Eremophila forrestii* subsp. *forrestii* and *Senna glutinosa* ssp. x *luerssenii* on sandy loam plains

10f Hummock Grassland of *Triodia basedowii*, *Triodia pungens* and *Triodia* sp. Shovelanna Hill with Low Woodland of *Acacia aptaneura*, *Acacia pruinocarpa* and *Acacia paraneura* over Shrubland of *Eremophila fraseri* and *Eremophila forrestii* subsp. *forrestii* on sandy drainage zones

10g Hummock Grassland of *Triodia pungens* with High Shrubland of *Acacia ancistrocarpa* and *Acacia tenuissima* with Low Open Woodland of *Eucalyptus xerothermica*, *Corymbia aspera* and *Corymbia hamersleyana* on clay loam drainage zones

10h Hummock Grassland of *Triodia pungens* with Shrubland (to Open Scrub) of *Acacia pyrifolia* var. *pyrifolia*, *Gossypium robinsonii* and *Acacia maitlandii* with Low Open Woodland of *Corymbia hamersleyana* on sandy floodplain and levee banks

10i Hummock Grassland of *Triodia* sp. *Shovelanna Hill* and *Triodia pungens* with High Shrubland of *Acacia rhodophloia* and Low Shrubland of *Eremophila exilifolia* on ironstone hill slopes

10j Hummock Grassland of *Triodia* sp. Shovelanna Hill with High Shrubland of *Acacia ancistrocarpa*, *Grevillea wickhamii* subsp. *hispidula* and *Acacia bivenosa* over Low Open Shrubland of *Acacia hilliana* on footslopes

10k Hummock Grassland of *Triodia* sp. Shovelanna Hill with High Shrubland of *Acacia wanyu*, *Acacia bivenosa* and *Grevillea wickhamii* subsp. *hispidula* over Open Shrubland of *Senna glutinosa* subsp. x *luerssenii* on footslopes and lower hill slopes

10l Hummock Grassland of *Triodia* sp. Shovelanna Hill with Low Shrubland of *Acacia hilliana*, *Acacia adoxa* var. *adoxa* and *Halgania solanacea* with High Open Shrubland of *Grevillea wickhamii* subsp. *hispidula*, *Acacia marramamba* and *Grevillea berryana* on hill crests and slopes

Triodia Open Hummock Grassland

11a Open Hummock Grassland of *Triodia basedowii* and *Triodia pungens* over Open Tussock Grassland of *Aristida inaequiglumis*, *Themeda triandra*and *Digitaria brownii* with Low Open Woodland of *Corymbia hamersleyana* on loamy drainage zones adjacent to floodplains

11b Open Hummock Grassland of *Triodia basedowii* and *Triodia* sp. Shovelanna Hill with Low Open Woodland of *Acacia aptaneura*, *Acacia pruinocarpa* and *Corymbia hamersleyana* and High Open Shrubland of *Eremophila platycalyx*, *Acacia wanyu* and *Acacia synchronicia* on stony rises, plains and footslopes

11c Open Hummock Grassland of *Triodia pungens* and *Triodia* sp. Shovelanna Hill with Low Open Woodland of *Corymbia ferriticola* and *Eucalyptus leucophloia* subsp. *leucophloia* and Open Shrubland of *Astrotricha hamptonii*, *Dodonaea pachyneura* and *Acacia maitlandii* on faces of large open ravines and occasionally cliffs

Themeda Closed Tussock Grassland

12 Closed Tussock Grassland of *Themeda triandra* and *Eulalia aurea* with Low Open Woodland of*Hakea lorea* subsp. *lorea*, *Acacia aptaneura* and *Corymbia aspera* and Open Shrubland of *Acacia pyrifolia* var. *pyrifolia* and *Acacia ancistrocarpa* on plains and drainage zones

Themeda Tussock Grassland

13a Tussock Grassland of *Themeda triandra*, *Digitaria brownii* and *Aristida inaequiglumis* with Low Woodland of *Acacia aptaneura* and *Corymbia hamersleyana* and Very Open Hummock Grassland of *Triodia basedowii* on clay drainage zones and floodplains

13b Tussock Grassland of *Themeda triandra*, *Eulalia aurea* and *Digitaria brownii* with Low Open Woodland (to Low Woodland) of *Acacia aptaneura* and *Acacia paraneura* and Open Shrubland of *Eremophila fraseri* on floodplains

13c Tussock Grassland of *Themeda triandra*, *Eulalia aurea* and *Digitaria brownii* with Low Woodland (to Low Open Woodland) of *Acacia aptaneura*, *Eucalyptus xerothermica* and *Corymbia hamersleyana* and Low Open Shrubland of *Isotropis forrestii* and *Ptilotus obovatus* on drainage zones and flats

Eragrostis Tussock Grassland

14 Tussock Grassland of *Eragrostis eriopoda*, *Paraneurachne muelleri* and *Aristida contorta* with Low Open Woodland of *Corymbia hamersleyana*, *Hakea lorea* subsp. *lorea* and *Corymbia aspera* and Open Shrubland of *Acacia melleodora* and *Senna artemisioides* subsp. *oligophylla* on gently sloping sandy loam plains

*Cenchrus Tussock Grassland

15 Tussock Grassland of **Cenchrus ciliaris* with Low Open Woodland of *Acacia citrinoviridis*, *Acacia aptaneura* and *Corymbia hamersleyana* and High Shrubland of *Gossypium robinsonii*, *Acacia pyrifolia* var. *pyrifolia* and *Petalostylis labicheoides* on sandy floodplain

ONSHORE ENVIRONMENTAL		**BHPBIO** **OB31 (ONSHORE ENVIRONMENTAL 2014b)** **VEGETATION MAPPING LEGEND 1 of 3** **FIGURE 7**	**LEGEND**
Figure: 7	Date: 11 Aug 2014		
Sheet Size: A3	Status: FINAL		
Drawn by GSM / Requested by GSM	GSM Reference OB31_Targeted_Veg		

GRIFFIN SPATIAL & MAPPING
PO Box 7215
Eaton WA 6232
admin@griffinspatial.com.au
+61 8 9725 3213

Legend

Syrinx Vegetation Mapping

Acacia Low Woodland

2a Low Woodland of *Acacia aptaneura, Acacia ? pteraneura* and *Acacia pruinocarpa* over Open Hummock Grassland of *Triodia epactia* and *Triodia* sp. Shovelanna Hill (S.van Leeuwen 3835) with Shrubland of *Acacia wanyu, Acacia tetragonophylla* and *Senna stricta*

2c Low Woodland of *Acacia aptaneura* and *Corymbia hamersleyana* over Very Open Shrubland of *Acacia wanyu, Acacia ancistrocarpa* and *Eremophila forrestii* subsp.(indet) over Very Open Hummock Grassland of *Triodia epactia* and *Triodia lanigera*

2d Low Woodland of *Acacia ? aptaneura, Acacia mulganeura* and *Ficus brachypoda* over High Open Shrubland of *Acacia monticola, Grevillea wickhamii* subsp. (indet) and *Acacia wanyu* over Very Open Tussock Grassland of *Eragrostis cumingii, Amphipogon sericeus* and *Themeda triandra*

Acacia Low Open Woodland

3a Low Open Woodland of *Acacia aptaneura* and *Acacia pruinocarpa* over High Open Shrubland of *Acacia tetragonophylla* and *Acacia synchronicia* over Very Open Hummock Grassland of *Triodia* sp. Shovelanna Hill (S.van Leeuwen 3835)

Acacia High Shrubland

4a High Shrubland of *Acacia monticola, Rulingia luteiflora* and *Gossypium robinsonii* with Low Woodland of *Corymbia hamersleyana, Eucalyptus victrix* and *Eucalyptus leucophloia* subsp. *leucophloia* over Very Open Tussock Grassland of *Themeda triandra, *Cenchrus ciliaris* and *Cymbopogon procerus*

4b High Shrubland of *Acacia monticola, Acacia hamersleyensis* and *Petalostylis labicheoides* over Open Hummock Grassland of *Triodia melvillei, Triodia epactia* and *Triodia* sp. Shovelanna Hill (S.van Leeuwen 3835) with Low Open Woodland of *Corymbia ferriticola* and *Ficus brachypoda*

Triodia Hummock Grassland

5a Hummock Grassland of *Triodia brizoides, Triodia epactia* and *Triodia angusta* with Open Shrubland of *Acacia tetragonophylla* and *Acacia synchronicia* with Very Open Woodland of *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia ? pteraneura*

5b Hummock Grassland of *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) with Low Open Shrubland of *Acacia hilliana, Acacia adoxa* var. *adoxa* and *Halgania solanacea* var. Mt Doreen (G.M. Chippendale 4206) with Scattered Low Trees of *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia pruinocarpa*

5c Hummock Grassland of *Triodia lanigera* and *Triodia* sp. Shovelanna Hill (S.van Leeuwen 3835) with Open Shrubland of *Hakea lorea* subsp. *lorea, Acacia ancistrocarpa* and *Acacia adsurgens* with Scattered Low Trees of *Corymbia hamersleyana* and *Acacia pruinocarpa*

5d Hummock Grassland of *Triodia brizoides, Triodia* sp. Shovelanna Hill (S.van Leeuwen 3835) and *Triodia epactia* with Open Shrubland of *Acacia tetragonophylla, Eremophila fraseri* subsp. *fraseri* and *Senna glutinosa* subsp. *pruinosa*

5f Hummock Grassland of *Triodia lanigera* and *Triodia epactia* with High Open Shrubland of *Acacia bivenosa, Acacia ancistrocarpa* and *Acacia tenuissima* with Very Open Mallee of *Eucalyptus gamophylla*

5g Hummock Grassland of *Triodia epactia, Triodia brizoides* and *Triodia* sp. Shovelanna Hill (S.van Leeuwen 3835), with Low Open Woodland of *Acacia aptaneura, Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia pruinocarpa* over Scattered Shrubs of *Acacia tetragonophylla, Scaevola acacioides* and *Acacia wanyu*

5h Hummock Grassland of *Triodia* sp. Shovelanna Hill (S.van Leeuwen 3835), *Triodia epactia* and *Triodia brizoides* with High Open Shrubland of *Acacia bivenosa* and *Acacia tetragonophylla* with Scattered Low Trees of *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia aptaneura*

Triodia Open Hummock Grassland

6a Open Hummock Grassland of *Triodia* sp. Shovelanna Hill (S.van Leeuwen 3835) with Low Open Shrubland of *Halgania solanacea* var. Mt Doreen (G.M. Chippendale 4206), *Gompholobium* sp. Pilbara (N.F. Norris 908) and *Acacia adoxa* var. *adoxa*

6d Open Hummock Grassland of *Triodia* sp. Shovelanna Hill (S.van Leeuwen 3835), *Triodia epactia* and *Triodia brizoides* with Low Open Woodland of *Acacia aptaneura, Acacia ? pteraneura* (hybrid?) and *Acacia rhodophloia* over Open Shrubland of *Acacia tetragonophylla, Acacia adsurgens* and *Senna glutinosa* subsp. *glutinosa*

6e Open Hummock Grassland of *Triodia*sp. Shovelanna Hill (S.van Leeuwen 3835) and *Triodia epactia* with Low Open Shrubland of *Acacia hilliana, Sida* sp. *excedentifolia* (J.L. Egan 1925) and *Senna glutinosa* subsp. *pruinosa* with Scattered Trees of *Eucalyptus leucophloia* subsp. *leucophloia*

6f Open Hummock Grassland of *Triodia brizoides* and *Triodia epactia* with Low Open Shrubland of *Eremophila fraseri* subsp. *fraseri, Senna artemisioides* subsp. *oligophylla* and *Senna artemisioides* subsp. *helmsii*

Triodia Very Open Hummock Grassland

7a Very Open Hummock Grassland of *Triodia lanigera* and *Triodia* sp. Shovelanna Hill (S.van Leeuwen 3835) with Scattered Shrubs of *Grevillea wickhamii* subsp. (indet), *Acacia ancistrocarpa* and *Hakea lorea* subsp. *lorea* with Scattered Trees of *Corymbia hamersleyana*

Mixed Tussock Grassland

8a Tussock Grassland of *Eulalia aurea, Themeda triandra* and *Aristida ineaquiglumis* with Low Open Woodland of *Corymbia hamersleyana, Acacia aptaneura* and *Acacia citrinoviridis* over Open Shrubland of *Acacia ancistrocarpa, Gossypium robinsonii* and *Acacia pyrifolia*

Mixed Open Tussock Grassland

9a Open Tussock Grassland of *Themeda triandra, Aristida inaequiglumis* and *Aristida contorta* with Open Shrubland of *Acacia monticola, Acacia ancistrocarpa* and *Grevillea wickhamii* subsp. *aprica* with Scattered Low Trees of *Corymbia hamersleyana*

ONSHORE ENVIRONMENTAL

Figure:	7	Date:	11 Aug 2014
Sheet Size:	A3	Status:	FINAL
Drawn by GSM	Requested by GSM	GSM Reference OB31_Targeted_Veg	

BHPBIO

OB31 (SYRINX 2012)
VEGETATION MAPPING LEGEND 2 of 3

FIGURE 7

LEGEND

GRIFFIN SPATIAL & MAPPING
PO Box 7215
Eaton WA 6232
admin@griffinspatial.com.au
+61 8 9725 3213

Legend

ENV Australia OB 18 Vegetation

Foot Slopes

E21 - Deep sandy soils raised above surrounding flood plain	*Eucalyptus gamophylla, Corymbia hamersleyana* low open woodland over *Hakea lorea subsp. lorea* scattered tall shrubs over *Acacia ancistrocarpa, Acacia dictyophleba, Acacia adsurgens* shrubland over *Bonamia rosea, Scaevola parvifolia* low open shrubland over *Triodia basedowii* hummock grassland.
E72 - Low rises at base of main ridge & extending onto adjacent plains; recently burnt	*Eucalyptus gamophylla, Corymbia hamersleyana* scattered low trees over *Hakea lorea subsp. lorea* scattered shrubs over *Goodenia* sp. 'Sandy Creek' low shrubland over *Fimbristylis simulans* open herbland.
E79 - Low rises at base of main ridge & larger hills	*Triodia basedowii* hummock grassland.
E21 - Orebody 18 side of survey area, around rail line west	*Corymbia hamersleyana* low open woodland over *Hakea lorea subsp. lorea* scattered tall shrubs over *Acacia ancistrocarpa, Acacia dictyophleba, Acacia adsurgens* open shrubland over *Triodia basedowii hummock* grassland.

Drainage Lines

E21 - Narrow, deeply incised & dissecting the gently sloping plains south of Orebody 18 East	*Corymbia hamersleyana, Eucalyptus gamophylla* low woodland over *Petalostylis labicheoides, Gossypium robinsonii* open scrub over *Acacia monticola, Senna glutinosa* subsp. *glutinosa* shrubland over *Scaevola parvifolia, Isotropis atropurpurea* low open shrubland.
E69 - Wide U-shaped drainage lines between low hills in central south of the survey area	*Eucalyptus trivalvis* low open woodland over *Acacia bivenosa, Acacia ancistrocarpa, Acacia adsurgens, Acacia dictyophleba, Acacia tenuissima* shrubland over *Triodia pungens* hummock grassland.

Flood Plains

E17 - Localised areas of mulga woodland on deep sandy soils	*Acacia aneura* low woodland over *Eremophila forrestii* open shrubland over *Triodia basedowii* hummock grassland over *Eragrostis eriopoda, Paraneurachne muelleri* open grassland.
E21 - Lowest point along the flood plain	*Corymbia hamersleyana* low open woodland over *Acacia ancistrocarpa, Acacia dictyophleba, Grevillea wickhamii, Gossypium robinsonii* open shrubland over *Bonamia rosea, Indigofera georgei, Ptilotus obovatus, Scaevola parvifolia* subsp. *pilbarae* low open shrubland over *Paraneurachne muelleri, Aristida holathera, Themeda triandra* closed grassland.
E21 - Moderately deep red/orange loam sand	*Corymbia hamersleyana* low open woodland over *Rulingia luteiflora, Acacia* spp. open shrubland over *Bonamia rosea, Indigofera georgei, Isotropis forrestii, Scaevola parvifolia* subsp. *pilbarae* low open shrubland over *Themeda triandra, Aristida holathera, Paraneurachne muelleri, Chrysopogon fallax* closed grassland.
E17b - Mulga woodland on red earth soils	*Acacia aneura* low woodland over *Eremophila forrestii* open shrubland over *Themeda triandra, Eragrostis eriopoda, Paraneurachne muelleri* grassland.
E21 - Orebody 18 east side of survey area, east	*Corymbia hamersleyana* scattered low trees over *Acacia ancistrocarpa, Acacia dictyophleba, Acacia monticola, Rulingia luteiflora* open shrubland over *Scaevola parvifolia, Sida cardiophylla, Bonamia rosea, Isotropis atropurpurea* low shrubland over *Paraneurachne muelleri, Aristida holathera, Eragrostis eriopoda, *Cenchrus ciliaris* grassland.

Hill Crest

E18 - Unburnt low rises & hills	*Eucalyptus leucophloia, Corymbia hamersleyana, Corymbia deserticola* low open woodland over *Hakea chordophylla* scattered tall shrubs over *Grevillea wickhamii, Acacia bivenosa, Acacia hamersleyana, Acacia marramamba* open shrubland over *Acacia hilliana, Acacia adoxa* low shrubland over *Triodia basedowii* hummock grassland.

ONSHORE ENVIRONMENTAL			
Figure:	7	Date:	11 Aug 2014
Sheet Size:	A3	Status:	FINAL
Drawn by GSM	Requested by GSM	GSM Reference OB31_Targeted_Veg	

BHPBIO

OB31 (ENV AUSTRALIA 2007)

VEGETATION MAPPING LEGEND 3 of 3

FIGURE 7

LEGEND

GRIFFIN SPATIAL & MAPPING
PO Box 7215
Eaton WA 6232
admin@griffinspatial.com.au
+61 8 9725 3213

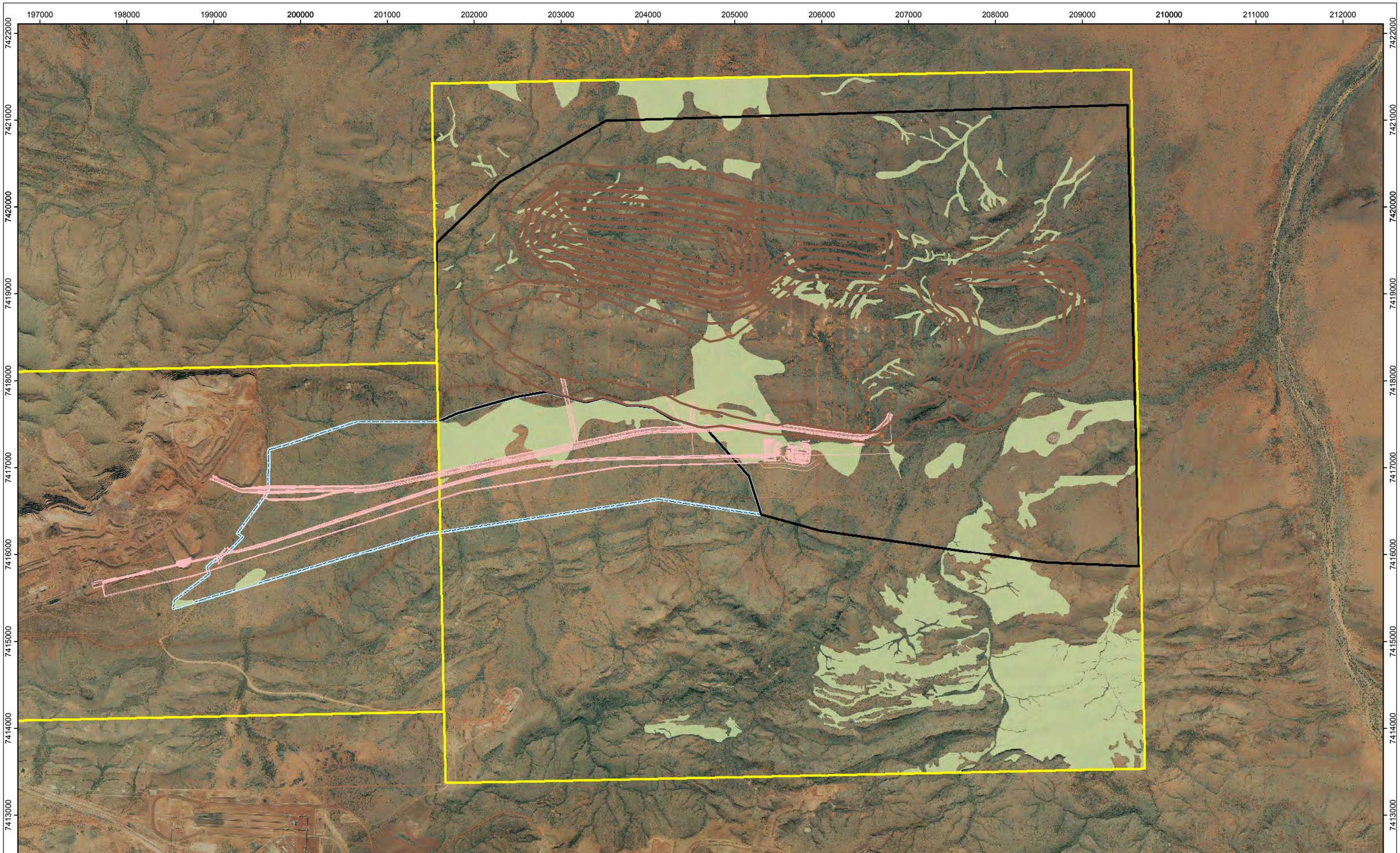


Figure:	8	Date:	30 Sept 2014
Sheet Size:	A3	Status:	DRAFT
Drawn by: GSM	Requested by: GSM	GSM Reference: OB31_Targeted_Veg_Mulga	

N

0 250 500 1,000 1,500 2,000

Meters
1:40,000

Datum: GDA94
Projection: MGA Zone 51

BHPBIO

OB31
FIGURE 8
Distribution of Mulga Vegetation

Legend

- OB31 Indicative Disturbance Boundary – Mine, OSAs
- OB31 indicative disturbance boundary – infrastructure corridor
- Tenement Boundary
- OB31 Indicative Pit and OSA
- OB31 Indicative Infrastructure Designs
- Distribution of Mulga Vegetation

GRIFFIN SPATIAL & MAPPING
PO Box 7215
Eaton WA 6232
admin@griffinspatial.com.au
+61 8 9725 3213

Figure:	9	Date:	23 July 2014
Sheet Size:	A3	Status:	DRAFT
Drawn by: GSM	Requested by: GSM	GSM Reference: OB31_Veg_Condition	

N

0 250 500 1,000 1,500 2,000

Meters
1:40,000

Datum: GDA94
Projection: MGA Zone 51

BHPBIO

OB31
VEGETATION CONDITION

FIGURE 9

Legend

- Study Area
- OB31 Indicative Disturbance Boundary – Mine, OSAs
- OB31 indicative disturbance boundary – infrastructure corridor
- OB31 Indicative Pit and OSA
- OB31 Indicative Infrastructure Designs

Vegetation Condition

- Good
- Very Good
- Excellent

GRIFFIN SPATIAL & MAPPING
PO Box 7215
Eaton WA 6232
admin@griffinspatial.com.au
+61 8 9725 3213

5.7 Mulga Vegetation

Mulga (*Acacia aneura*[10]) is widespread across arid and semi-arid regions of Western Australia, covering approximately 37 percent of the surface area of Western Australia (Fox 1980). However, grove-intergrove Mulga communities at the southern and northern apron of Hamersley Range are considered as "ecosystems at risk" (Kendrick 2001a) because it is thought that sensitivity to disturbance is greatest at the northern limit of its distribution (Fox 1988). The sensitivity of Mulga in the Pilbara may be related to the dominant summer rainfall pattern.

One of the vegetation associations recorded within the Proposal Development Envelope is analogous to an ecosystem at risk, vegetation association 10f (26 ha). It formed banded groves over a floodplain within the indicative disturbance boundary for the mine pit.

Over the wider OB31 area Mulga vegetation associations occurred broadly on four landforms:

- floodplains extending west to east along the northern sector of the Proposal Development Envelope for the Infrastructure Corridor, and continuing further east towards Jimblebar Creek along the southern part of the Proposal Development Envelope for the Mine and associated infrastructure (Figure 8);
- minor drainage lines dissecting undulating ironstone ridges, hills and valleys throughout the northern sector of the Proposal Development Envelope for the Mine and associated infrastructure (Figure 8);
- stony loam plains along the north-western fringe of the Proposal Development Envelope for the Mine and associated infrastructure (Figure 8); and
- hill slopes and gullies of breakaway ridges and high hill slopes occurring outside the south-eastern boundary of the Proposal Development Envelope for the Mine and associated infrastructure (Figure 8).

5.8 Groundwater Dependent Vegetation

Onshore Environmental considers any vegetation that uses groundwater is potentially at risk where groundwater drawdown occurs beyond natural seasonal groundwater variation. Furthermore, the impact on vegetation from lowering the groundwater table is likely to be relative to the individual species' dependence on groundwater. An assessment of the species' dependence on groundwater at OB31 is informed by a desktop literature review and an understanding of the groundwater environment.

The groundwater system across the majority of the Proposal Development Envelope is relatively deep, with 88 percent of the area ranging in depth from approximately 35 to 95 mbgl. Groundwater at this depth is not available for plant uptake and hence will not support groundwater dependent vegetation. This is supported by fine-scale vegetation mapping which confirms the absence of phreatophytic species.

[10] A recent taxonomic revision Mulga (*Acacia aneura* and its close relatives) has identified 12 species accommodated in three informal groups (Maslin and Reid 2012).

In the south-eastern sector of the Proposal Development Envelope groundwater depth is much shallower, ranging from 5 to 25 mbgl. At depths less than 20 m it is possible for vegetation to access groundwater. Hence the investigation of groundwater dependent vegetation is focussed within this area (Figure 10).

The majority of vegetation within the Proposal Development Envelope and surrounds comprised xerophytic plant taxa (score 5) which have no reliance on groundwater and negligible risk associated with groundwater drawdown (Figure 10). There were no vegetation associations determined to be at extreme risk (score 1) or high risk (score 2) recorded, with both *Melaleuca argentea* and *Eucalyptus camaldulensis* subsp. *refulgens* absent from the Proposal Development Envelope and surrounds.

Moderate risk vegetation (score 3) included a medium drainage line supporting *Eucalyptus victrix* at the south-east corner of the Proposal Development Envelope for the Mine and associated infrastructure (Figure 10). This formed an upper tributary of Jimblebar Creek. Associated vegetation was described as 'Low Woodland of *Acacia citrinoviridis*, *Eucalyptus victrix* and *Acacia pruinocarpa* over High Shrubland of *Acacia monticola*, *Acacia pyrifolia* var. *pyrifolia* and *Petalostylis labicheoides* over Open Tussock Grassland of *Themeda triandra* and *Eriachne tenuiculmis* on medium drainage line'. The same vegetation association was recorded at the north-west sector of the Proposal Development Envelope and extending outside the envelope, but did not intersect areas where groundwater was near surface. A similar vegetation association was recorded by Syrinx Environmental (2012) south outside of the Proposal Development Envelope for the Mine and associated infrastructure.

Low risk vegetation (score 4) was scattered across the Proposal Development Envelope associated with unincised drainage lines and flood plains where groundwater remained at depth (Figure 10).

197000 198000 199000 **200000** 201000 202000 203000 204000 205000 206000 207000 208000 209000 **210000** 211000 212000

7422000 7421000 7420000 7419000 7418000 7417000 7416000 7415000 7414000 7413000

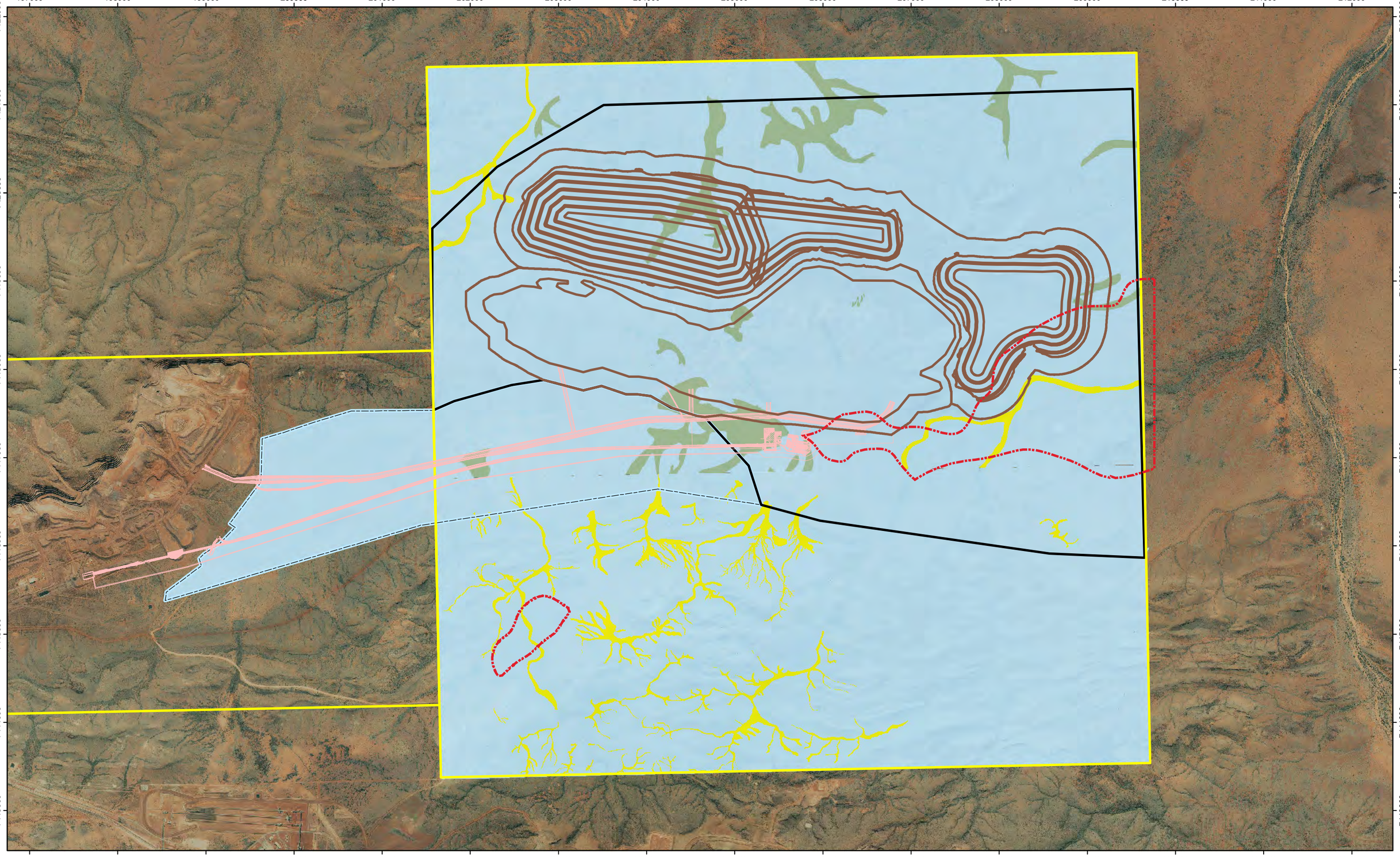


Figure:	10	Date:	11 Aug 2014
Sheet Size:	A3	Status:	DRAFT
Drawn by GSM	Requested by GSM	GSM Reference OB31_Targeted_Veg_GDV_Risk	

N

0 250 500 1,000 1,500 2,000

Meters
1:40,000

Datum: GDA94
Projection: MGA Zone 51

BHPBIO

OB31
Groundwater Dependant Vegetation Risk Rating
FIGURE 10

Legend

- OB31 Indicative Disturbance Boundary – Mine, OSAs
- OB31 indicative disturbance boundary – infrastructure corridor
- Tenement Boundary AML244SA
- OB31 Indicative Pit and OSA
- OB31 Indicative Infrastructure Designs
- Groundwater within 20m of natural surface

GDV Risk Rating

1 2 3 4 5

GRIFFIN SPATIAL & MAPPING
PO Box 7215
Eaton WA 6232
admin@griffinspatial.com.au
+61 8 9725 3213

6.0 EVALUATION OF THE POTENTIAL IMPACTS

Development within the Proposal Development Envelope could potentially impact flora and vegetation through:

- Direct removal of conservation significant flora and vegetation during clearing and earthworks;
- Dewatering triggering a decline to groundwater dependent vegetation;
- Alteration to the volume of surface water flows causing decline to Mulga vegetation;
- Altering the frequency or intensity of wildfire;
- Increasing the density of introduced (weed) species; and
- Increased levels of airborne dust reducing leaf transpiration.

These potential impacts are addressed below.

6.1 Direct Clearing

6.1.1 Vegetation

The Proposal Development Envelope is located within the Fortescue Botanical District and close to the border of the Hamersley Botanical District (both within the Pilbara IBRA region) which is part of the Eremaean Province (Beard 1990). Broad scale vegetation mapping undertaken by Beard (1975) and refined by Shepherd *et al.* (2002) show two vegetation associations occurring within the Proposal Development Envelope; Fortescue Valley 82 and Fortescue Valley 216. The Pre-European extent remaining for each of the two vegetation associations is estimated at 100 percent, or 2,290,910 ha and 298,549ha respectively (Table 1). At a regional scale the area of each vegetation association within the Proposal Development Envelope is 1,660 ha and 2,394 ha, representing 0.56% and 0.10% of the total extent respectively. The potential regional impact from direct clearing at a regional scale will be insignificant.

Based on fine-scale vegetation mapping completed by Onshore Environmental (2014b) 29 vegetation associations mapped and described occur within the Proposal Development Envelope for the Mine and associated infrastructure (Table 14). A total of ten vegetation associations are represented within the Proposal Development Envelope for the Infrastructure Corridor. While none of the vegetation associations recorded within the Proposal Development Envelope are considered to be conservation significant at the Commonwealth or State level, vegetation association 10f (Grove-intergrove Mulga) is analogous to ecosystems considered to be 'at risk' in the Pilbara 2 – Fortescue Subregion (Kendrick 2001a). Vegetation association 10f was mapped over 25.7 ha within the Proposal Development Envelope for the Mine and associated infrastructure. The impact of disturbing this association is considered to be insignificant at a local scale scale given the small area of the isolated grove unit.

Vegetation condition within the Proposal Development Envelope for the Mine and associated infrastructure was predominantly rated as very good (73.9%), with smaller proportions rated as excellent (6.0%) and good (20.1%, Table 14). The same trend was evident within the Proposal Development Envelope for the Infrastructure Corridor, with vegetation condition across 69.8% of the total area rated as very good and lower proportions rated as excellent (2.0%) and good (28.2%, Table 14).

Table 14 Vegetation condition summary within the indicative mine pit and OSAs, and indicative infrastructure corridor.

Vegetation Condition	Area (ha) Intersecting Proposal Development Envelope for the Mine and associated infrastructure	Area (ha) Intersecting Proposal Development Envelope for the Infrastructure Corridor
Pristine	0	0
Excellent	197.8 (6.0%)	14.8 (2.0%)
Very Good	2,439.7 (73.9%)	526.9 (69.8%)
Good	664.2 (20.1%)	212.8 (28.2%)
Degraded	0	0
Completely Degraded	0	0
Total	3,301.7	754.5

6.1.2 Flora

There are four conservation significant flora occurring within the Proposal Development Envelope, including three Priority flora and one significant range extension[11]. The potential impact of the OB31 project for each taxon is discussed below.

Acacia sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) (Priority 1)

Acacia sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) is a Priority 1 flora taxon occurring within the north-west sector of the Proposal Development Envelope, and extending further north-west to the corner of the tenement (outside the Proposal Development Envelope for the Mine and associated infrastructure). *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) was recorded as 534 plants from five populations occurring across approximately 8.0 ha (Table 15). Two of the five populations occur within the Proposal Development Envelope for the Mine and associated infrastructure. It is estimated that approximately 186 plants occurring over 2.5 ha will be directly impacted, noting that approximately 348 plants occurring over 5.5 ha will remain outside the Proposal Development Envelope.

Table 15 Summary of plant numbers and area of occurrence for *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) within and outside of the Proposal Development Envelope.

Population No.	Position in Relation to the Proposal Development Envelope	No. Sub-populations	No. Plants	Approximate Area (ha)
1	Inside	4	114	2.0
5	Inside	2	72	0.5
Total	**Inside**		**186**	**2.5**
2	Outside	3	209	2.0
3	Outside	5	105	3.0
4	Outside	2	34	0.5
Total	**Outside**		**348**	**5.5**

[11] *Rhagodia* sp. Hamersley (M. Trudgen 17794) was is not discussed within the impact assessment as it does not occur within the Proposal Development Envelope.

Acacia sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) appeared to be habitat specific within the OB31 area, occurring at the intersection of two geological formations that occur within the Hamersley Group BIFs; Boolgeeda Iron Formation and Woongarra Rhyolite. The Boolgeeda Iron Formation typically overlies the Woongarra Rhyolite. However, at OB31 *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) was recorded in areas where the Boolgeeda Iron Formation was heavily weathered, exposing the underlying Woongarra Rhyolite at surface.

The Boolgeeda Iron Formation is the youngest BIF in the Hamersley Group and consists predominantly of interbedded shaly BIF. It is described by Trendall (1995) as fine-grained, finely laminated, dark grey-brown to black flaggy iron-formation, minor chert, jaspilite, shale. Rhyolite is an igneous, volcanic rock, of felsic composition with a mineral assemblage of quartz, sanidine and plagioclase. Woongarra Rhyolite has been described as rhyolite, rhyodacite, rhyolitic volcaniclastic breccia and banded iron formation (Trendall 1995).

Broad scale geological mapping confirms the distribution of the Boolgeeda Iron Formation and Woongarra Rhyolite (Figure 11). There are three broad areas of occurrence:

1. South-east Pilbara - extending along an approximate 100 km strike aligned north-west to south-east from north of Newman to south-east of BHP Billiton Iron Ore's Jimblebar Mine;
2. Karijini National Park - extending east-west (75 km strike) along the southern sector of Karijini National Park and further south into the Mt Channar, Snowy Mountain and Turee Creek East region;
3. Western Pilbara - extending north-west (175 km strike) from BHP Billiton Iron Ore's Rocklea tenement to west of Pannawonica, with a separate large target area situated midway between Tom Price and Pannawonica (Hamersley Range).

BHP Billiton Iron Ore is proposing to undertake targeted searches aimed at extending the current known distribution of *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01). Given the wide extent of the target geology, refinement of potential search locations will be completed utilising fine scale geology mapping, combined with high resolution aerial photography to identify low undulating hills within the geology strike zone. Targeted survey work will focus on the south-east Pilbara initially, with ground truthing commencing at existing known populations and moving progressing outwards following the favoured geology. Targeted searches are proposed for May 2015.

Millstream-Chichester National Park

Karijini National Park

CHICHESTER RANGE

HAMERSLEY RANGE

BHP Yandi

BHP Area C

RIO TINTO Hope Downs

Coondewanna Flats

Mount Robinson

Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community

ONSHORE ENVIRONMENTAL

Figure:	11	Date:	17/02/2015
Sheet Size:	A3	Status:	DRAFT
Drawn by GSM	Requested by GSM	GSM Reference Geology	

N

0 10 20 40 60 80

Kilometers
1:1,500,000

Datum: GDA94
Projection: MGA Zone 51

BHPBIO

FIGURE 11
Distribution of the Boolgeeda Iron Formation and Woongarra Rhyolite

Legend

- BHP Tenure

500k Geology

- BOOLGEEDA IRON FORMATION
- WOONGARRA RHYOLITE

Significant

- *Acacia clelandii* (A.c)
- *Acacia* sp. nov (reticulate/anastomosing) *(A.n)*
- *Goodenia nuda* (G.n)
- *Rhagodia* sp Hamersley (M.E. Trudgen 17794) *(R.H)*
- *Triodia* sp. Mt Ella (M.E. Trudgen 12739) *(T.ME)*

GRIFFIN SPATIAL & MAPPING
PO Box 7215
Eaton WA 6232
admin@griffinspatial.com.au
+61 8 9725 3213

Triodia sp. Mt Ella (M.E. Trudgen 12739) (Priority 3)

Triodia sp. Mt Ella (M.E. Trudgen 12739) (Priority 3) was recorded as seven scattered plants from five spot locations on a floodplain within the Proposal Development Envelope for the Infrastructure Corridor. These scattered plants have likely originated from seeds being washed down from the major populations situated on scree slopes further south. Any direct impact on these seven plants resulting from the proposed development is determined to be negligible. Two larger populations comprising 50 spot location points were associated with steep scree slopes, cliff lines and gorges further south-west and outside of the Proposal Development Envelope. Within these main populations, *Triodia* sp. Mt Ella (M.E. Trudgen 12739) was recorded as >10,000 plants and providing up to 80 percent ground coverage. The main populations will not be impacted by the OB31 project.

Triodia sp. Mt Ella (M.E. Trudgen 12739) is well represented outside of the Proposal Development Envelope. It has recently been recorded at Orebody 19 (OB19), situated less than 5 km west of the OB31 project (Onshore Environmental 2014d). It was recorded from 43 locations, occurring in gullies, drainage lines and hills in red silty loam. Ground cover was variable ranging from one percent to sixty percent (Onshore Environmental 2014d). It has also been previously recorded at West Angelas (Trudgen 1998) and more recently from a suite of BHP Billiton Iron Ore leases surrounding Mining Area C.

Goodenia nuda (Priority 4)

Goodenia nuda was recorded as 63 plants from seven points within the Proposal Development Envelope for the Infrastructure Corridor, where it occurred on floodplains. The Priority 4 flora is widely distributed throughout the Pilbara bioregion, including six neighbouring tenements. Any impact on the small population (63 plants) present within the Infrastructure Corridor envelope is considered to be negligible.

Acacia clelandii

Acacia clelandii was identified as a significant range extension occurring 400 km north of the nearest known population situated approximately 150 km east of Wiluna. The lack of survey data between Wiluna and the OB31 area may explain the disjunct record for *Acacia clelandii.* However, this requires additional survey effort to confirm.

Acacia clelandii was recorded from 20 point locations scattered across the northern sector of the Proposal Development Envelope for the Mine and associated infrastructure (eight points), as well as extending north-west outside the envelope and further east outside of the tenement boundary (12 points). Plants occurred as scattered individuals (between 1 to 5 plants) from nine of the 20 points recorded. At the remaining eleven point locations plant density was estimated in the range 40 plants per ha to 750 plants per ha and providing up to 30 percent ground cover.

Acacia clelandii has recently been recorded from an additional seven locations situated approximately 2 km east of the Proposal Development Envelope, occurring on undulating stony plains and eroded lower slopes fringing Jimblebar Creek (Onshore Environmental 2015).

6.2 Groundwater Dependent Vegetation

Based on recent drilling at OB31, it is estimated that the orebody depth is approximately 190 mbgl, while the pit shell is estimated to be up to 205 mbgl. Based on current estimates, a significant portion (~75%) of the orebody is below the water table and will require dewatering to access the ore.

An assessment of groundwater dependent vegetation confirmed the majority of the Proposal Development Envelope supports xerophytic plant taxa that have no requirement to access groundwater for survival. In addition, there were no phreatophytic species recorded from the Proposal Development Envelope, i.e. species that rely solely on water sourced directly from the water table.

Investigation of groundwater contours confirmed groundwater depths shallower than 20 mbgl were restricted to the south-eastern sector of the Proposal Development Envelope for the Mine and associated infrastructure. This is the only zone within the Proposal Development Envelope with the potential to support groundwater dependent vegetation. The medium drainage line within this at-risk zone supports the vadophytic tree species *Eucalyptus victrix,* which is determined to be at moderate risk to decline resulting from groundwater drawdown.

Groundwater drawdown at this location will make *Eucalyptus victrix* reliant on rainfall and surface runoff water for survival. During extended periods of drought trees may experience canopy decline but it is unlikely to result in death. A small portion of this vegetation association will also be impacted by direct clearing as part of the indicative mine area.

6.3 Alteration to Surface Water Flows

A number of the vegetation associations support *Acacia aptaneura* (Mulga) as a dominant upperstorey component. These associations may have local conservation significance owing to the increased sensitivity of Mulga to disturbance at the northern limit of its distribution (south-eastern Pilbara). While Mulga is drought tolerant, it is reliant on overland flow of surface water following heavy summer rains to survive. Interruption of surface water flows may impact on the integrity of Mulga stands and ultimately lead to tree decline. The general flow of surface water across the Proposal Development Envelope and surrounds is from west to east and eventually in to Jimblebar Creek. The area of Mulga vegetation requiring management from potential drainage shadow impacts occurs on floodplains within the Proposal Development Envelope for the Infrastructure Corridor. The location and design of the Infrastructure Corridor should minimise obstruction to seasonal overland water flows that are currently sustaining the Mulga stands.

6.4 Surplus Water Discharge to Jimblebar Creek

Mining activities at OB31 will result in surplus groundwater that may be discharged into Jimblebar Creek under the following scenarios:

- Surplus water discharge to Jimblebar Creek will only be carried out if discharge to Ophthalmia Dam is unavailable (due to maintenance, wet weather, etc); and

- Surplus water discharge to Jimblebar Creek will only be carried out during the wet season (November to March) for a maximum period of three months.

A recent baseline flora and vegetation survey of riparian vegetation along a 20 km stretch of Jimblebar Creek extending downstream of OB31 confirmed there were no significant flora present (Onshore Environmental 2015). In addition the 19 vegetation associations described and mapped were not affiliated with any TECs or PECs and were well represented regionally. The dominant trees recorded within the riparian zone along Jimblebar Creek were *Eucalyptus camaldulensis, Eucalyptus victrix* and *Acacia citrinoviridis* which are typical along medium and major ephemeral drainage lines throughout the Pilbara (Onshore Environmental 2015).

The short duration period (maximum of three months annually) for surplus water discharge from OB31 coincides with the summer cyclone period when the area typically receives highest intensity rainfall. There is unlikely to be any impact on riparian flora and vegetation resulting from the seasonal discharge of surplus water. Vegetation is well adapted to natural high intensity flows during summer, and there were no significant flora taxa that require specific management.

It is determined that surplus water discharge into Jimblebar Creek for a maximum period of three months during the wet season and in the instance that Ophthalmia Dam is unavailable, is unlikely to have any significant impact on riparian flora and vegetation.

6.5 Fire

Fire age within the Proposal Development Envelope at October 2013 was rated as moderate (3-5 years) to old (≥6 years) (Onshore Environmental 2014a). The sensitivity of Mulga vegetation, in particular, to fire will require ongoing management, noting that stands within the Proposal Development Envelope have been impacted by fire within the past ten years.

Fire is a natural occurrence for vegetation associations within the Proposal Development Envelope, and the increased risk posed by project development is manageable and not considered a significant risk.

6.6 Introduced (Weed) Species

There were three introduced (weed) species recorded from within the Proposal Development Envelope, **Bidens bipinnata* (Beggars Ticks), **Cenchrus ciliaris* (Buffel Grass) and **Malvastrum americanum* (Spiked Malvastrum). Neither of these taxa is listed as a Declared Pest under the BAM Act.

Increasing vehicular access combined with vegetation clearing for the project has the potential to introduce and/or spread weed species that can compete with native vegetation and reduce species diversity. Existing management strategies used at surrounding BHP Billiton Iron Ore operations are important tools for minimising potential impacts.

General and species-specific weed management, hygiene and monitoring would be undertaken in accordance with BHP Billiton Iron Ore's existing weed management procedures. Management measures that would be undertaken to minimise the potential for the spread of weed species would include the following:

- Mobile machinery and equipment would be brought to site in a clean state;
- Regular inspections for the presence of weeds within areas of disturbance would be conducted (particularly in high moisture environments such as drainage lines, floodplains and valleys); and
- Seasonal weed control programmes would be implemented as necessary.

6.7 Dust

Vegetation can be impacted by increased levels of airborne dust in instances where leaf transpiration is impeded. This could occur along unsealed roads and tracks supporting large volumes of traffic, and is pronounced during dry seasonal conditions. Dust control measures such as road watering, use of sprays on the main ore transfer points, and rehabilitation of disturbed areas would be used to minimise dust generation from the site. Dust is not considered a significant risk.

7.0 SUMMARY

None of the vegetation associations recorded within the Proposal Development Envelope are Commonwealth or State listed TECs, or State listed PECs.

Vegetation condition across the Proposal Development Envelope was predominantly rated as very good, with smaller proportions rated as excellent and good.

A number of the vegetation associations support *Acacia aptaneura* (Mulga) as a dominant upperstorey component, and may have local conservation significance owing to the increased sensitivity of Mulga to disturbance at the northern limit of its distribution (southern Pilbara). While Mulga is drought tolerant, it is reliant on overland flow of surface water following heavy summer rains to survive. Interruption of surface water flows may impact on the integrity of Mulga stands and ultimately lead to tree decline. The area of Mulga vegetation requiring management from potential drainage shadow impacts occurs on floodplains within the Proposal Development Envelope for the Infrastructure Corridor. The location and design of the Infrastructure Corridor should minimise obstruction to seasonal overland water flows that may be sustaining the Mulga vegetation.

The majority of the Proposal Development Envelope supports xerophytic plant taxa that have no requirement to access groundwater for survival. In addition, there were no phreatophytic species recorded from the Proposal Development Envelope, i.e. species that rely solely on water sourced directly from the water table. As such, the Proposal Development Envelope is considered low risk with respect to potential impacts on groundwater dependent vegetation. The south-eastern sector of the Proposal Development Envelope for the Mine and associated infrastructure is the only zone where groundwater depth is shallower than 25 mbgl, and hence capable of supporting groundwater dependent vegetation. The medium drainage line within this zone supports the vadophytic tree species *Eucalyptus victrix,* which is determined to be at moderate risk to decline resulting from groundwater drawdown.

No plant taxon gazetted as Threatened Flora (T) pursuant to subsection (2) of Section 23F of the WC Act or listed under the EPBC Act has been recorded from the Proposal Development Envelope.

There were four conservation significant flora occurring within the Proposal Development Envelope, including two Priority flora, one taxon of interest, and one significant range extension. The potential impact of project development for each taxon is discussed below.

- *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) (Priority 1): two of the five populations supporting approximately 186 plants over 2.5 ha occur within the Proposal Development Envelope for the Mine and associated infrastructure. This taxon occurs over an area of 5.5 ha situated outside the Proposal Development Envelope. *Acacia* sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01) appeared to be habitat specific within the OB31 area, occurring on exposed orange rock under eroded BIF ironstone (Woongarra Rhyolite under Boolgeeda Iron Formation). While this geological formation is known to occur regionally, the occurrence of this taxon on this geological formation outside of the OB31 area is unknown.
- *Triodia* sp. Mt Ella (M.E. Trudgen 12739) (Priority 3): seven plants on a floodplain within the Proposal Development Envelope for the Infrastructure

Corridor may be impacted. These plants have likely established from seed washed down from scree slopes supporting the main populations further south and outside the Proposal Development Envelope.

- *Goodenia nuda* (Priority 4): 63 plants from seven points on a floodplain within the Proposal Development Envelope for the Infrastructure Corridor may be impacted. *Goodenia nuda* is well represented throughout the eastern Pilbara and has been regularly recorded at neighbouring tenements.
- *Acacia clelandii* (significant range extension): recorded from 20 point locations scattered across the northern sector of the Proposal Development Envelope and immediate surrounds (as well as further east and outside of the Mining Tenement Boundary), and occurring both within (eight points) and outside (12 points) of the Proposal Development Envelope for the Mine and associated infrastructure. Plants occurred as scattered individuals (between 1 to 5 plants) from nine of the 20 points recorded. At the remaining eleven point locations plant density was estimated in the range 40 plants per ha to 750 plants per ha and providing up to 30 percent ground cover. *Acacia clelandii* has recently been recorded from an additional seven locations situated approximately 2 km east of the Proposal Development Envelope, occurring on undulating stony plains and eroded lower slopes fringing Jimblebar Creek (Onshore Environmental 2015).

There were three introduced (weed) species recorded as scattered individuals from lower lying landforms in the Proposal Development Envelope, including footslopes, plains and drainage lines; **Bidens bipinnata* (Beggars Ticks), **Cenchrus ciliaris* (Buffel Grass) and **Malvastrum americanum* (Spiked Malvastrum). None of these taxa are listed as a Declared Pest under the BAM Act. Existing management strategies currently being successfully implemented at surrounding BHP Billiton Iron Ore operations would be extended to OB31 to minimise potential impacts.

Surplus water discharge into Jimblebar Creek for a maximum period of three months during the wet season, and in the instance that Ophthalmia Dam is unavailable, is unlikely to have any significant impact on riparian flora and vegetation.

Fire age within the Proposal Development Envelope has been rated as moderate (3-5 years) to old (≥6 years). Fire is a natural occurrence for vegetation associations within the area, and the increased risk posed by mine development at the site is manageable and is not considered a significant risk.

There is a risk of vegetation decline resulting from increased levels of airborne dust along the edge of unsealed roads and tracks supporting large volumes of traffic. This can be effectively managed by implementing proven dust control measures currently being implemented at surrounding BHP Billiton Iron Ore operations.

8.0 STUDY TEAM

The flora and vegetation impact assessment for the OB31 tenement boundary was planned, co-ordinated and executed by the following personnel:

Onshore Environmental Consultants P/L
ABN 41 095 837 120
PO Box 227
YALLINGUP WA 6282
pf 08 9756 6206 m0427 339 842
Email onshoreenv@westnet.com.au

Project Staff

Dr Darren Brearley	PhD	Project Manager
Mr Todd Griffin		GIS Specialist

9.0 REFERENCES

Aplin T.E.H. (1979). The Flora. Chapter 3 in O'Brien, B.J. (ed.) (1979). Environment and Science. University of Western Australia Press.

Astron Environmental Services (2012) *Eastern Mines Weed Survey, Jimblebar*. Consultants report prepared for BHP Billiton Iron Ore.

Australian Natural Resource Atlas (2008). *Biodiversity Assessment – Pilbara*. Australian Natural Resource Atlas, website. www.anra.gov.au. Available at http://www.environment.gov.au/cgibin/sprat/public/sprat.pl.

Beard, J. S. (1975). Pilbara. Explanatory Notes and Map Sheet 5, 1:1 000 000 series Vegetation Survey of Western Australia. University of Western Australia Press: Nedlands.

Beard J. S. (1990) *Plant Life of Western Australia*. Kangaroo Press, Perth.

BHP Iron Ore (1994) *Jimblebar Mine Site Biological Survey*. Unpublished internal report prepared by BHP Iron Ore.

BHP Billiton Iron Ore (2010) *Guidance for Vegetation and Flora Surveys in the Pilbara Region*. Unpublished guidance statement prepared by BHP Billiton Iron Ore.

Biota (2004) *Jimblebar - Wheelarra Hill 3 Flora and Fauna Assessment*. Consultant report prepared for BHP Billiton Iron Ore.

Bureau of Meteorology (2014), Climate Statistics for Australian Locations: Newman.

Dames and Moore (1993) *Ecological Observations Jimblebar Railway Line.* Consultant report prepared for BHP Iron Ore.

Department of Parks and Wildlife (DPaW) (2013a) Threatened and Priority Flora Database Search.

Department of Parks and Wildlife (DPaW) (2013b) *List of Threatened Ecological Communities on the Department of Parks and Wildlife's Threatened Ecological Community (TEC) Database endorsed by the Minister for the Environment.* WA Threatened Species and Communities Unit, Department of Parks and Wildlife.

Department of Environment (DoE) (2012) Interim Biogeographic Regionalisation for Australia, Revision 7. Online at: http://www.environment. gov.au/parks/nrs/science/bioregion-framework/ibra/ index.html#ibra

Department of Environment (DoE) (2014) Interactive Environmental Database Reporting Tool Search. www.environment.gov.au

Ecologia Environment (1996) *Jimblebar Rail Spur Biological Assessment Survey*. Report prepared for BHP Billiton Iron Ore.

Ecologia Environment (2004a*) OB 18 Flora and Fauna Review*. Report prepared for BHP Billiton Iron Ore.

Ecologia Environment (2004b) *Jimblebar-Wheelarra Hill Expansion Biological Study*. Report prepared for BHP Billiton Iron Ore.

Ecologia Environment (2005) *Jimblebar East Exploration Project Biological Survey*. Report prepared for BHP Billiton Iron Ore.

Ecologia Environment (2006) *Jimblebar Marra Mamba Exploration Biological Survey.* Prepared for BHP Billiton Iron Ore.

Ecologia Environment (2007) *Hashimoto Exploration Project Biological Survey: Flora and Vegetation.* Prepared for BHP Billiton Iron Ore.

EcoLogical (2012) *Level 1 flora and fauna surveys along the Great Northern Highway for Jimblebar mine module transport.* Prepared for BHP Billiton Iron Ore.

ENV Australia (2007a) *West Jimblebar Exploration Lease Flora and Vegetation Assessment – Management Recommendations*. Prepared for BHP Billiton Iron Ore.

ENV Australia (2007b) *OB 18 Flora and Vegetation Assessment Phase II*. Prepared for BHP Billiton Iron Ore.

ENV Australia (2007c) *Jimblebar Stage 2, Levee Banks and Communications Tower Redevelopment Flora and Vegetation Assessments*. Prepared for BHP Billiton Iron Ore.

ENV Australia (2007d) *RGP4 Jimblebar Rail Loop Flora and Vegetation Assessment*. Prepared for BHP Billiton Iron Ore.

ENV Australia (2008a) *Rapid Growth Project 5: Repeater 9 Access Road Flora and Vegetation Assessment.* Report prepared for BHP Billiton Iron Ore.

ENV Australia (2008b) *Jimblebar Access Road Flora and Vegetation Assessment.* Report prepared for BHP Billiton Iron Ore.

ENV Australia (2009a) *Ammonium Nitrate Storage Facility Flora and Vegetation Assessment.* Report prepared for BHP Billiton Iron Ore.

ENV Australia (2009b) *Construction Water Supply Pipeline and Ammonium Nitrate Storage Facility Flora and Vegetation Assessment.* Report prepared for BHP Billiton Iron Ore.

ENV Australia (2010a) *RGP6 Jimblebar Hub (Water Pipeline) Flora and Vegetation Assessment.* Report prepared for BHP Billiton Iron Ore.

ENV Australia (2010b) *Jimblebar Wye Targeted Declared Rare Flora and Priority Listed Flora Assessment.* Report prepared for BHP Billiton Iron Ore.

Environmental Protection Authority (EPA) (2000) Environmental Protection of Native Vegetation in Western Australia: Clearing of Native Vegetation with Particular Reference to Agricultural Areas, Position Statement No. 2, EPA, Perth.

Environmental Protection Authority (EPA) (2002) Terrestrial Biological Surveys as an Element of Biodiversity Protection, Position Statement No. 3, EPA, Perth.

Environmental Protection Authority (EPA) (2004) EPA Guidance for the Assessment of Environmental Factors: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia, No. 51, EPA, Perth.

Fox, J.E.D. (1980) Effects of fire on the mulga *(Acacia aneura)* community. *Mulga Research Centre Ann. Rept. 3 (1979),* 1-19.

Fox, J.E.D. (1988) Guidelines for roadworks in mulga country. Curtin University of Technology. 18pp.

GHD (2008a) *Draft Report for Wheelarra Hill (Jimblebar Mine Site) Priority Species Verification* – Goodenia hartiana. Report prepared for BHP Billiton Iron Ore.

GHD (2008b) *Mesa Gap Biological Survey*. Report prepared for BHP Billiton Iron Ore.

Hussey, B. M. J., Keighery, G. J., Cousens, R. D., Dodd, J. and Lloyd, S. G. (1997) Western Weeds. The Plant Protection Society of Western Australia and Agriculture Western Australia. Kensington, W.A.

International Union for Conservation of Nature (IUCN) (2014) Interactive Environmental Database Reporting Tool Search, performed February 2014. www.iucn.org

Keighery, B. J. (1994) Bushland Plant Survey: a Guide to Plant Community Survey for the Community. Wildflower Society of WA (Inc.), Nedlands, Western Australia.

Kendrick (2001a) Bioregion: Pilbara 2 Subregion (PIL2). Department of Conservation and Land Management, Perth.

Kendrick (2001b) Bioregion: Pilbara 3 Subregion (PIL3). Department of Conservation and Land Management, Perth.

Onshore Environmental (2011a) *Area C and Surrounds Level 2 Flora and Vegetation Survey.* Consultants report prepared for BHP Billiton Iron Ore.

Onshore Environmental (2011b) *Jinidi Study Area Review of Flora and Vegetation.* Consultants report prepared for BHP Billiton Iron Ore.

Onshore Environmental (2012a) *South Flank Study Area Level 2 Flora and Vegetation Survey.* Consultants report prepared for BHP Billiton Iron Ore.

Onshore Environmental (2013a) *Orebody 17/18 Derived Vegetation Association Mapping Report.* Consultants report prepared for BHP Billiton Iron Ore.

Onshore Environmental (2013b) *Tandanya Study Area Review of Flora and Vegetation.* Consultants report prepared for BHP Billiton Iron Ore.

Onshore Environmental (2014a) *OB 31 Level 2 Flora and Vegetation Assessment.* Consultants report prepared for BHP Billiton Iron Ore.

Onshore Environmental (2014b) *OB 31 / Wheelarra Hill North Targeted Significant Flora Survey.* Consultants report prepared for BHP Billiton Iron Ore.

Onshore Environmental (2014c) *Consolidation of Regional Vegetation Mapping.* Consultants report prepared for BHP Billiton Iron Ore.

Onshore Environmental (2014d) *OB 19 Level 2 Flora and Vegetation Assessment.* Consultants report prepared for BHP Billiton Iron Ore.

Onshore Environmental (2014e) *Mt Whaleback Targeted Significant Flora Survey.* Consultants report prepared for BHP Billiton Iron Ore.

Onshore Environmental (2015) *Jimblebar Creek – Riparian Flora and Vegetation Baseline Survey.* Consultants report prepared for BHP Billiton Iron Ore.

Outback Ecology (2009a) *Eastern Pilbara Accommodation Camp Flora and Fauna Assessment.* Consultants report prepared for BHP Billiton Iron Ore.

Outback Ecology (2009b) *Wheelarra Hill Iron Ore Mine Modification Flora and Fauna Assessment.* Consultants report prepared for BHP Billiton Iron Ore.

Pilbara Flora (2008) *OB17 Flora and Vegetation Survey*. Prepared for BHP Billiton Iron Ore.

Shepherd, D.P., Beeston, G.R., and Hopkins, A.J.M. (2002) Native Vegetation in Western Australia. Technical Report 249. Department of Agriculture, Western Australia, South Perth.

Specht R.L. (1970) Vegetation. In The Australian Environment. 4th edn (Ed. G.W. Leeper). Melbourne.

Syrinx Environmental (2011) *OB 31 Flora and Vegetation Assessment.* Prepared for BHP Billiton Iron Ore.

Syrinx Environmental (2012a) *Wheelarra Hill North Level 2 Flora and Vegetation Assessment.* Prepared for BHP Billiton Iron Ore.

Syrinx Environmental (2012b) *South West Jimblebar Flora and Vegetation Survey.* Prepared for BHP Billiton Iron Ore.

Tille, P. (2007) Soil-lanscapes of Western Australia's rangelands and arid interior. Resouce management technical report 313. Department of Agriculture and Food.

Trudgen, M.E. and Casson, N. (1998) Flora and Vegetation Surveys of Orebody A and Orebody B in the West Angela Hill area and area surrounding them, and of rail route options considered to link them to the existing Robe River Iron Associates rail line. Unpublished report prepared for Robe River Iron Associates, Volume 1, March 1998.

Trudgen, M.E. (2009) BHP Billiton Iron Ore – Vegetation classification system for utilisation in the Pilbara Bioregion. Professional advice provided to BHP Billiton Iron Ore.

van Vreeswyk *et. al.* (2004) An inventory and condition survey of the Pilbara region, Western Australia. Western Australian Department of Agriculture Technical Bulletin No. 92.

Western Australian Herbarium (WAH) (2014) *Florabase – Information on the Western Australian flora.* Department of Parks and Wildlife. Online: *http://florabase.dpaw.wa.gov.au* [May 2014].

APPENDIX 1

Conservation Codes for Western Australian Flora.

R: Declared Rare Flora - Extant Taxa

Taxa which have been adequately searched for, and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.

1: Priority One - Poorly Known Taxa

Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.

2: Priority Two - Poorly Known Taxa

Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.

3: Priority Three - Poorly Known Taxa

Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.

4: Priority Four - Rare, Near Threatened and other taxa in need of monitoring

(a) **Rare.** Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.
(b) **Near Threatened**. Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.
(c) Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

5: Priority Five - Conservation Dependent taxa

Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxa becoming threatened within five years.

APPENDIX 2

Conservation categories for flora described under the EPBC Act.

CATEGORY	DESCRIPTION
Extinct	A species is extinct if there is no reasonable doubt that the last member of the species has died.
Extinct in the Wild	A species is categorised as extinct in the wild if it is only known to survive in cultivations, in captivity, or as a naturalised population well outside its past range; or if it has not been recorded in its known/expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered	The species is facing an extremely high risk of extinction in the wild and in the immediate future.
Endangered	The species is likely to become extinct unless the circumstances and factors threatening its abundance, survival, or evolutionary development cease to operate; or its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction.
Vulnerable	Within the next 25 years, the species is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate.
Conservation Dependent	The species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

APPENDIX 3

Vegetation Classifications for the Pilbara based on Specht (1970), as modified by Aplin (1979) and Trudgen (2009).

Height Class	Canopy Cover				
	100 - 70%	70 - 30%	30 - 10%	10 - 2%	< 2%
Trees > 30 m	High Closed Forest	High Open Forest	High Woodland	High Open Woodland	Scattered Tall Trees
Trees 10-30 m	Closed Forest	Open Forest	Woodland	Open Woodland	Scattered Trees
Trees < 10 m	Low Closed Woodland	Low Open Forest	Low Woodland	Low Open Woodland	Scattered Low Trees
Mallee	Closed Mallee	Mallee	Open Mallee	Very Open Mallee	Scattered Mallees
Shrubs > 2 m	Closed Scrub	Open Scrub	High Shrubland	High Open Shrubland	Scattered Tall Shrubs
Shrubs 1-2 m	Closed Heath	Open Heath	Shrubland	Open Shrubland	Scattered Shrubs
Shrubs < 1 m	Low Closed Heath	Low Open Heath	Low Shrubland	Low Open Shrubland	Low Scattered Shrubs
Hummock Grass	Closed Hummock Grassland	Hummock Grassland	Open Hummock Grassland	Very Open Hummock Grassland	Scattered Hummock Grass
Tussock Grass	Closed Tussock Grassland	Tussock Grassland	Open Tussock Grassland	Very Open Tussock Grassland	Scattered Tussock Grass
Bunch Grass	Closed Bunch Grassland	Bunch Grassland	Open Bunch Grassland	Very Open Bunch Grassland	Scattered Bunch Grass
Sedges	Closed Sedges	Sedges	Open Sedges	Very Open Sedges	Scattered Sedges
Herbs	Closed Herbs	Herbs	Open Herbs	Very Open Herbs	Scattered Herbs

Source: S. Van Leeuwen (DEC)

APPENDIX 4

Vegetation condition scale
(as developed by Keighery 1994)

CONDITION	CODE	DESCRIPTION
Pristine	1	Pristine or nearly so, no obvious signs of disturbance.
Excellent	2	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	3	Vegetation structure altered; obvious signs of disturbance.
Good	4	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it.
Degraded	5	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching Very Good condition without intensive management.
Completely Degraded	6	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species.

APPENDIX 5

Location of significant flora within the tenement boundary

MGA_EAST	MGA_NORTH	GENUS	SPECIES
204976	7417718	*Acacia*	*clelandii*
202287	7420396	*Acacia*	*clelandii*
207522	7419465	*Acacia*	*clelandii*
201898	7420191	*Acacia*	*clelandii*
203837	7420389	*Acacia*	*clelandii*
202623	7420971	*Acacia*	*clelandii*
202562	7421023	*Acacia*	*clelandii*
203184	7421134	*Acacia*	*clelandii*
203950	7419634	*Acacia*	*clelandii*
206732	7417197	*Acacia*	*clelandii*
207548	7419549	*Acacia*	*clelandii*
204533	7418443	*Acacia*	*clelandii*
207079	7417300	*Acacia*	*clelandii*
209780	7417908	*Acacia*	*clelandii*
209812	7417936	*Acacia*	*clelandii*
210083	7417929	*Acacia*	*clelandii*
210116	7417968	*Acacia*	*clelandii*
210233	7418131	*Acacia*	*clelandii*
210323	7417972	*Acacia*	*clelandii*
202064	7420222	*Acacia*	*clelandii*
202515	7420127	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0939833	-23.30071667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0942333	-23.30066667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0928667	-23.30121667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0929	-23.3013	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0929	-23.30143333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0928667	-23.3016	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0931333	-23.30146667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0926333	-23.30216667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0921	-23.30185	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0921	-23.30165	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.1062	-23.30118333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.1060833	-23.30108333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.1060333	-23.30121667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.1060333	-23.30136667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.1058667	-23.30128333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.1057333	-23.30138333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.1057167	-23.30118333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)

MGA_EAST	MGA_NORTH	GENUS	SPECIES
120.1051167	-23.30113333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.1052	-23.30098333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0922167	-23.30165	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.09215	-23.30178333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.09225	-23.30181667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0897833	-23.29625	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0842333	-23.29923333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.08955	-23.29615	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0896667	-23.29635	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0895667	-23.29628333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0896667	-23.29616667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.08955	-23.29653333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.08545	-23.29793333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0840833	-23.29911667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0840333	-23.29901667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0834167	-23.29893333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0831333	-23.2989	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0832167	-23.29875	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0833333	-23.29881667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0833167	-23.29923333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0833333	-23.29931667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0835	-23.29973333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0833167	-23.29985	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0832667	-23.29971667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0831167	-23.29956667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0832	-23.29941667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0829	-23.2996	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0828333	-23.29945	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0827	-23.29951667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0826	-23.29946667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)

MGA_EAST	MGA_NORTH	GENUS	SPECIES
120.0826333	-23.29993333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0827333	-23.29995	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0828333	-23.30006667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.08275	-23.30013333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0828833	-23.3002	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0829667	-23.3001	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0830667	-23.30025	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.08315	-23.30005	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0831167	-23.2999	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0829167	-23.29978333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0824833	-23.30018333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0824667	-23.30035	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0822667	-23.30015	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0823833	-23.29991667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.08285	-23.29768333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0829833	-23.29761667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.083	-23.29746667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0838333	-23.29698333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.084	-23.29695	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0842333	-23.29695	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0851667	-23.29733333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0853	-23.29743333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0855667	-23.29758333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0856833	-23.2975	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.08585	-23.29756667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0856	-23.29776667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.08575	-23.29796667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0860667	-23.2976	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0871333	-23.29751667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0870333	-23.29743333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)

MGA_EAST	MGA_NORTH	GENUS	SPECIES
120.0868833	-23.29725	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0868667	-23.29715	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.08685	-23.29701667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.08695	-23.29693333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0871833	-23.29663333	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0863	-23.29596667	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0886167	-23.29625	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0887167	-23.29635	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0887833	-23.2965	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
201656	7420251	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
201677	7420375	*Acacia*	sp. East Fortescue (J. Bull & D. Roberts ONS A 27.01)
120.0917	-23.32896667	*Goodenia*	*nuda*
120.0917	-23.3283	*Goodenia*	*nuda*
120°03.591'	-23°20.479'	*Goodenia*	*nuda*
120°03.630'	-23°20.470'	*Goodenia*	*nuda*
120°03.621'	-23°20.475'	*Goodenia*	*nuda*
120°03.598'	-23°20.485'	*Goodenia*	*nuda*
120°03.586'	-23°20.469'	*Goodenia*	*nuda*
204040	7421274	*Rhagodia*	sp. Hamersley (M.E. Trudgen 17794)
204510	7421057	*Rhagodia*	sp. Hamersley (M.E. Trudgen 17794)
120.0945667	-23.35521667	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0949	-23.35568333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0951667	-23.3562	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0958167	-23.35635	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0959667	-23.35663333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0962333	-23.35631667	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.09685	-23.35585	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.09745	-23.35603333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.09775	-23.35643333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0979833	-23.35703333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0981	-23.3575	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0980833	-23.358	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0983	-23.35843333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0982667	-23.35898333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0979667	-23.35948333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0967333	-23.3595	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0968333	-23.3592	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0951167	-23.3565	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.09465	-23.35466667	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.12595	-23.34606667	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.10025	-23.36231667	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.1000167	-23.36271667	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.10035	-23.36183333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)

MGA_EAST	MGA_NORTH	GENUS	SPECIES
120.1002167	-23.36126667	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0990167	-23.36061667	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0985833	-23.36015	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0983	-23.35961667	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0982167	-23.35625	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0984	-23.35623333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0943	-23.35768333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.117	-23.35063333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0962833	-23.36005	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0966833	-23.3594	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.09735	-23.35873333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0976667	-23.35823333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0980333	-23.35795	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0913	-23.32521667	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0907333	-23.32735	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0911	-23.32876667	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.0906667	-23.33238333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.1256333	-23.3474	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.126	-23.34723333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.1260833	-23.34678333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.1263333	-23.34638333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.1266833	-23.3458	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.1270167	-23.34523333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.12728	-23.344658	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.12755	-23.34408333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.1271333	-23.34355	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.12755	-23.34361667	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.12535	-23.34711667	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.1250667	-23.34736667	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120.1247833	-23.34778333	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
202543	7417485	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)
120°04.373'	-23°20.050'	*Triodia*	sp. Mt Ella (M.E. Trudgen 12739)

APPENDIX 6

Location of introduced weed species within the tenement boundary

MGA_EAST	MGA_NORTH	GENUS	SPECIES
203965	7417672	*Cenchrus	*ciliaris*
203075	7418396	*Cenchrus	*ciliaris*
204565	7419850	*Cenchrus	*ciliaris*
208436	7421064	*Cenchrus	*ciliaris*
202093	7416897	*Cenchrus	*ciliaris*
206250	7421100	*Cenchrus	*ciliaris*
209341	7419181	*Cenchrus	*ciliaris*
120°04.842'	23°19.648'	*Cenchrus	*ciliaris*
120°04.842'	23°19.720'	*Cenchrus	*ciliaris*
120°04.828'	23°19.767'	*Cenchrus	*ciliaris*
120°04.849'	23°19.764'	*Cenchrus	*ciliaris*
120°04.851'	23°19.738'	*Cenchrus	*ciliaris*
120°04.857'	23°19.791'	*Cenchrus	*ciliaris*
120°04.857'	23°19.816'	*Cenchrus	*ciliaris*
120°04.805'	23°19.687'	*Cenchrus	*ciliaris*
205046	7418679	*Malvastrum	*americanum*