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Strategen-JBS&G: Mulga Downs Iron Ore Mine, Additional Survey Areas

Flora and Vegetation Assessment, February 2023




8 June 2023

Draft 1

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This document describes the results of a flora and vegetation assessment carried out by Maia Environmental Consultancy Pty Ltd (Maia) for Strategen-JBS&G over areas added to the mine and borefield sections of Hancock Prospecting Pty Ltd (HPPL) Mulga Downs Iron Ore Mine (MDIOM) project area post finalisation of the detailed flora and vegetation assessment for those areas.

Photographs on front page – left to right: *Acacia xiphophylla*, minor drainage channel, *Hakea loreus*, *Triodia* Hummock Grassland (all photographs taken by Maia).

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Acronyms and Abbreviations

ALA	Atlas of Living Australia
ASA	Additional Survey Areas
BAM Act	*Biosecurity and Agriculture Management Act 2007*
BC Act	*Biodiversity Conservation Act 2016*
BOM	Bureau of Meteorology
CSF	Conservation significant flora
DBCA	Department of Biodiversity Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DEC	Former Department of Environment and Conservation (current DBCA)
DIWA	Directory of Important Wetlands in Australia
DPaW	Former Department of Parks and Wildlife (current DBCA)
DPIRD	Department of Primary Industries and Regional Development
DWER	Department of Water and Environmental Regulation
EMA	Extended Mapping Area
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ESA	Environmentally Sensitive Area
Fl, Fr	Flowering, fruiting
GDA94	Geocentric Datum of Australia, 1994
GDE	Groundwater dependent ecosystem
GEW	General environmental weed
GOWA	Government of Western Australia
GPS	Global Positioning System
ha	Hectare
HPPL	Hancock Prospecting Pty Ltd
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for Conservation of Nature
km	Kilometre
LS	Land system
m^2	Metres squared

m	Metre
Maia	Maia Environmental Consultancy Pty Ltd
MBMA	Mine and Borefield Mapping Area
MBSA	Mine and Borefield Study Area
MDIOM	Mulga Downs Iron Ore Mine
mE	Metres East
MGA50	Map Grid of Australia zone 50
mm	Millimetres
mN	Metres North
M-t	Medium-term
NAFI	Northern Australia and Rangelands Fire Information
NC	Not collated (data)
ND	No data
NVE	Native vegetation extent
NVIS	National Vegetation Information System
Opp Coll	Opportunistic collection
P (1-4)	Priority (1 to 4) flora species
PEC	Priority Ecological Community
PIL	Pilbara
RDA	Road Deviation Area
SF	Solar Farm
sp.	Species
S-t	Short-term
subsp.	Subspecies
T	Threatened
TEC	Threatened Ecological Community
TFS	Targeted Flora Survey
TPFL	Threatened and Priority Flora
TOI	Taxon of Interest
VA	Vegetation association
var.	Variety
VSA	Vegetation system association
VT	Vegetation type
WA	Western Australia
WAH / WAHerb	Western Australian Herbarium
WAMA	Wittenoom Asbestos Management Area
WAOL	Western Australian Organism List
WoNS	Weed of National Significance
WP	Water Pipeline

Summary

Introduction

- Hancock Prospecting Pty Ltd (HPPL) proposes to develop the Mulga Downs Iron Ore Mine (MDIOM) on Mulga Downs Station in the Pilbara region of Western Australia. The MDIOM comprises a mine and borefield section, with a separate hub and transport corridors section. Maia Environmental Consultancy Pty Ltd (Maia) surveyed and reported on the Mine and Borefield Study Area (MBSA) for the project in 2022; however, after that report was finalised three additional areas were identified that needed to be surveyed. Therefore, Strategen-JBS&G engaged Maia to carry out a flora and vegetation assessment over these additional areas. The three Additional Survey Areas (ASA) comprise the Road Deviation Area (RDA), the Solar Farm (SF) and the Water Pipeline (WP) and it covers approximately 241.6 hectares (ha). The eastern approximately 3.6 km (34.18 ha) of the WP lies within the Wittenoom Asbestos Management Area (WAMA) and could not be surveyed.

Background Information

- No Threatened flora species protected by the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or the *Biodiversity Conservation Act 2016* (BC Act) have been recorded in the ASA previously. One threatened flora species protected by the EPBC Act - *Seringia exastia,* Critically Endangered, has been recorded previously within 2 km of the RDA.
- Four priority flora species - *Calotis squamigera* (Priority (P) 1), *Triodia veniciae* (P1), *Dolichocarpa* sp. Hamersley Station (A.A. Mitchell PRP 1479) (P3), *Rhynchosia bungarensis* (P4), and one taxon of interest (TOI) - *Santalum spicatum* have been recorded previously within 3 km of the ASA.
- No threatened ecological community (TEC) is known to occur in or close to the ASA.
- The eastern- 0.21 km of the WP intersects a buffered occurrence of a Priority Ecological Community (PEC) - the 'Freshwater claypans of the Fortescue Marsh - Goodiadarrie Hills on Mulga Downs Station' P1 PEC. The section of the WP that lies over the buffer is in the WAMA and was not surveyed; however, it is part of the MBSA, which was surveyed and reported on previously.
- Parts of the unsurveyed WAMA section of the WP lie over an Environmentally Sensitive Area (ESA) and a Schedule One Area that are associated with the Directory of Important Wetlands in Australia (DIWA) wetland – the Fortescue Marshes. The Fortescue Marsh has also been proposed as a Ramsar wetland and approximately 4.1 km of the southeastern section of the WP lies within the proposed Ramsar wetland, although, the Fortescue Marsh proper lies to the southeast of the MDIOM (east of the Great Northern Highway and the Goodiadarrie Hills).

The Survey

- The detailed flora and vegetation assessment and targeted flora survey (TFS) was carried out between February 25 and 27, 2023. Maia assessed 10 quadrats and walked multiple traverses in the RDA and SF and walked traverses on both sides of the existing road within the WP corridor.

Survey Results – Flora

- Excluding some of the taxonomically uncertain and queried collections, 79 taxa from 45 genera and 22 families were recorded collectively from the ASA. They comprised 97% perennial taxa and 3% annual taxa, and 30% of the 79 species were fertile (i.e., they were identified from either flowering or fruiting material).
- The families with the highest number of taxa were Fabaceae (29), Poaceae (10) and Malvaceae (9), and the genera with the most taxa were *Acacia* (19), *Hibiscus* (4), *Senna* (6) and *Triodia* (3).
- One threatened flora species protected by the EPBC Act was located in the SF - *Seringia exastia*, Critically Endangered. Twelve plants were recorded at two locations in the SF. Before October 6, 2022, *S. exastia* was also listed as a Critically Endangered, threatened flora species under the BC Act; however, in the most recent Biodiversity Conservation (Flora) Order and Threatened and Priority Flora List it is no longer listed.
- No confirmed or queried priority flora species were located in the ASA.

- No range extension or regional endemic species were recorded in the ASA.
- No nationally or WA listed weed species were recorded in the ASA. Four general weed species were located in the WP: *Cenchrus ciliaris* (Buffel Grass), *C. setiger* (Birdwood Grass), *Malvastrum americanum* (Spiked Malvastrum) and *Vachellia farnesiana* (Mimosa Bush). All four have both a high ecological impact and rapid invasiveness rating and they have been located in the MDIOM previously.

Survey Results - Vegetation

- Ten vegetation types were mapped in the following habitats in the ASA: stony and hardpan plains, gentle hills, major drainage lines and banks and associated cracking clay floodplains and claypans and broad flowlines, stony washout flats, and minor drainage lines and rises. The 10 vegetation types comprised six *Acacia* Shrubland/Woodland vegetation types, two Tussock Grassland and two *Triodia* Grassland types. Disturbed areas were also mapped in the WP section of the ASA.
- One vegetation type was mapped over less than 2% of the ASA, a mixed tussock grassland - MTG (3). This vegetation type was mapped in the wider Extended Mapping Area (EMA) and the MBSA and occurs outside the boundaries of the ASA and MDIOM.
- The condition of the vegetation was mostly Very Good (53.9%), followed by Good (30.3%) and Excellent (11.5%), while Degraded or Completely Degraded areas were mapped over 4.3% of the EMA. The Degraded and Completely Degraded areas are those already cleared for roads, tracks, or other infrastructure. WP corridor vegetation condition has been affected by clearing for the road and associated tracks and by large populations of weeds in that area.

Significant Flora and Ecological Communities and Potential Sheet Flow and Groundwater Dependent Vegetation

- While *Seringia exastia* (T) is currently listed under and protected by the EPBC Act, a taxonomic revision of *Seringia* species resulted in it being combined with *Seringia elliptica*, which is a widespread species in WA. It is locally significant because of its historic listing under the EPBC Act rather than because it is threatened and scarce in WA and in the local area.
- None of the surveyed sections of the ASA lie within or close to a currently listed TEC or PEC; however, the eastern-most 0.21 km section of the WP lies over a buffered occurrence of the Freshwater claypans downstream of the Fortescue Marsh - Goodiadarrie Hills on Mulga Downs Station P1 PEC. That section of the WP lies within the WAMA and could not be surveyed, although, it was part of Maia's MBSA and was included in the report on that area. None of the vegetation types mapped in a more distinctive clay pan PEC area to the southeast of the ASA buffer were mapped in the eastern section of the WP.
- Nine of the 10 vegetation types mapped in the ASA (all except AaAxSL) are potentially locally significant for different reasons (threatened flora located in them, drainage areas, sheet flow vegetation, being in an ESA (the Fortescue River) or a part of a Ramsar wetland addition). However, the 10 vegetation types have been mapped in other parts of the MDIOM assessed by Maia and also occur outside the boundaries of the ASA and the MDIOM.
- The ASA comprises some gently sloping hardpan gravelly or stony plains of the Jurrawarrina land system. Groves and bands of mulga can be seen in the WP extended mapping area and vegetation types AWL (1), AWL (2) and AWL (3) are mapped in these areas. Any groved or banded mulga within the WP could be potentially affected by any alteration to sheet flow in these areas.

Strategen-JBS&G: Mulga Downs Iron Ore Project, Additional Survey Areas

Flora and Vegetation Assessment, February 2023

1 Introduction

1.1 Scope of Work

Maia Environmental Consultancy Pty Ltd (Maia) carried out a detailed flora and vegetation assessment for the mine and borefield sections of Hancock Prospecting Pty Ltd's (HPPL) Mulga Downs Iron Ore Mine (MDIOM) in the Pilbara region of Western Australia (WA) (**Map 9.1, Section 9**).

Post Maia finalising the report on the mine and borefield study areas(MBSA) (Maia, 2022), three additional areas needing to be surveyed were identified outside of but close to the boundaries of the MBSA:

1. The Road Deviation Area (RDA) on tenement E 47/2044.
2. The Solar Farm (SF) on E 47/2044.
3. The Water Pipeline (WP) on E 47/1315, R47/14 and E 47/4760.

These areas are referred to collectively as the Additional Survey Areas (ASA) in this report and their locations are shown on **Maps 9.1 and 9.2 (Section 9)**; this report presents the results of the survey carried out by Maia in the ASA.

1.2 ASA Location and Size

The ASA are in the Shire of Ashburton administrative region of WA. The closest polygon is approximately 15 kilometres (km) north of the Wittenoom historic town site and 85 km northeast of Tom Price (**Map 9.1, Section 9**). The areas covered by the ASA are listed in **Table 1.1**. The southern approximately 3.6 km section (34.18 ha) of the approximately 13.7 km long Water Pipeline is within the Wittenoom Asbestos Management Area (WAMA) (Government of Western Australia (GOWA), 2022b; **Map 9.2**) and consequently could not be surveyed.

Table 1.1: Additional Survey Areas (ASA)

Areas surveyed	Area (ha)
Road Deviation Area (RDA)	**13.23**
Solar Farm (SF)	**101.34**
Water Pipeline (WP) (approximately 13.7 km long)	**127.04**
WP surveyed section	92.86
WP unsurveyed section	34.18
Total	**241.61**

2 Background Information

Information on the bioregion, subregion, conservation significant flora species (CSF), taxa of interest (TOI) and introduced / weed species previously recorded in the vicinity of the ASA, threatened and priority ecological communities (TEC and PEC), pre-European vegetation associations, protected and significant areas, surface geology,

land systems, watercourses and wetlands, and potentially sheet flow dependent vegetation is summarised in **Table 2.1**. More detailed background information for the wider MDIOM was included in Maia, 2022.

Table 2.1: Survey background information

<table>
<tr><th colspan="2">Survey background information</th></tr>
<tr><td>IBRA bioregion and subregion (Map 9.3A, Section 9)</td><td>The ASA are in the Pilbara IBRA (Interim Biogeographic Regionalisation for Australia) bioregion. The WP and RDA Survey Areas are in the Fortescue subregion (PIL02) and the SF Survey Area is in the Chichester subregion (PIL01) Department of Climate Change, Energy, the Environment and Water (DCCEEW) (2021a).</td></tr>
<tr><td>Surface Geology (1:1 000 000) (Map 9.3B)</td><td>The ASA are in four surface geological units, mapped at a scale of 1:1 000 000, and they are listed by survey area below (Stewart et al., 2008). Czims is mapped in the unsurveyed WAMA section of the WP Survey Area.
<table>
<tr><th>Code</th><th>Survey Area</th><th>Description</th></tr>
<tr><td>Awfj</td><td>RDA and SF</td><td>Shale, sandstone, siltstone, mudstone, dolomite, local microbanded chert, jaspilite, conglomerate; fine-grained massive rhyolite; mafic tuff with local accretionary lapilli and agglomerate; thin basalt/dolerite and andesitic basalt flows.</td></tr>
<tr><td>Czims</td><td>WAMA section (in WP)</td><td>Dolomite, calcareous dolomite, calcrete; with silcrete, clay, chert breccia, and local basal conglomerate.</td></tr>
<tr><td>Qa</td><td>WP</td><td>Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted.</td></tr>
<tr><td>Qrc</td><td>WP</td><td>Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite.</td></tr>
</table></td></tr>
<tr><td>Land systems (Map 9.3C)</td><td>The ASA lie over five land systems (LS) (DPIRD, 2022). The Boolgeeda LS is mapped in all three parts of the ASA, the McKay in two and the remainder are in the WP section.
<table>
<tr><th>LS</th><th>Survey Area</th><th>Description</th></tr>
<tr><td>Boolgeeda</td><td>RDA, SF and WP</td><td>Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands.</td></tr>
<tr><td>Brockman</td><td>WAMA section (WP)</td><td>Gilgai alluvial plains with cracking clay soils supporting tussock grasslands and low woodlands.</td></tr>
<tr><td>Hooley</td><td>WP</td><td>Alluvial clay plains supporting a mosaic of snakewood shrublands and tussock grasslands.</td></tr>
<tr><td>Jurrawarrina</td><td>WP</td><td>Hardpan plains and alluvial tracts supporting mulga shrublands with tussock and spinifex grasses.</td></tr>
<tr><td>McKay</td><td>SF and WP</td><td>Hills, ridges, plateaux remnants and breakaways of meta sedimentary and sedimentary rocks supporting hard spinifex grasslands with Acacias and occasional Eucalypts.</td></tr>
</table></td></tr>
</table>

Survey background information	
Pre-European vegetation associations and system associations (**Map 9.3D**)	The ASA are in four pre-European vegetation associations (VAs) and four vegetation system associations (VSAs) mapped in the Pilbara bioregion (DPIRD, 2021; GOWA, 2019): • **VA 29 / VSA 29**: Sparse low woodland; mulga, discontinuous in scattered groups. • **VA 173 / VSA 173.2**: Hummock grasslands, shrub steppe; kanji over soft spinifex & *Triodia wiseana* on basalt. • **VA 175 / VSA 175.3**: Short bunch grassland - savanna/grass plain (Pilbara). • **VA 562 / VSA 562**: Mosaic: Low woodland; mulga in valleys / Hummock grasslands, open low tree-steppe; snappy gum over *Triodia wiseana* The pre-European bioregional and subregional extent of the VAs and VSAs of the ASA along with their current extent, the percentage remaining, the current extent as a proportion of the pre-European extent protected for conservation, and the percentage of the current extent in all DBCA Managed Land as a proportion of the pre-European extent, are listed in **Table 2.2**. The remaining extent of the VAs and VSAs in the Pilbara bioregion and the Fortescue and Chichester subregions ranges between 99.72% and 100%. The percentage of the pre-European extent of the VAs protected for conservation in the bioregion and subregions ranges between 0.26% (VA 29 in the Fortescue subregion) and 7.52% (VA 173 in the Chichester subregion), while the remaining extent of the VSAs ranges between 99.90% and 100% and the extent protected for conservation between 0.26% (VSA 29.0 in the Fortescue subregion) and 11.69% (VSA 173.2 in the Chichester subregion) (GOWA, 2019).
Conservation significant flora (CSF) and taxa of Interest (TOI) previously located in the vicinity of the ASA (**Map 9.4**)	No threatened flora species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), or *Biodiversity Conservation Act 2016* (BC Act) or Priority (P) species listed by DBCA have been recorded within the boundaries of the ASA previously. The closest record for a threatened flora species protected by the EPBC Act (*Seringia exastia,* Critically Endangered (DCCEEW, 2023)) is within 2 km of the centre of the RDA. Four priority flora species and one TOI have been recorded previously within 3 km of different parts of the ASA: • **RDA**: *Triodia veniciae* (P1), *Dolichocarpa* sp. Hamersley Station (A.A. Mitchell PRP 1479) (P3), *Rhynchosia bungarensis* (P4) and *Santalum spicatum* (TOI). • **SF**: *Triodia veniciae* (P1) and *Dolichocarpa* sp. Hamersley Station (A.A. Mitchell PRP 1479) (P3). • **WP**: *Calotis squamigera* (P1). Three of the Department of Biodiversity, Conservation and Attractions (DBCA) WA Herbarium database records were within 3 km of the WP - *Calotis squamigera* (P1), *Teucrium pilbaranum* (P2) and *Iotasperma sessilifolium* (P3). The closest DBCA Threatened and Priority Flora (TPFL) database record was *Glycine falcata* (P3), approximately 5.6 km southwest of the WP (DBCA search reference #07-0323FL). These DBCA search result species are shown by rank rather than name on **Map 9.4**.
Introduced species (weeds) previously recorded in the vicinity of the ASA (**Map 9.5**)	No introduced species have been recorded within the ASA previously. Collectively, 22 weed species have been recorded previously in the MDIOM (Maia, 2022). None of them is on any of the national weed lists or is listed as a declared pest in WA. Nine weed species have been recorded within 3 km of the ASA previously: • **RDA** and **SF**: *Bidens bipinnata, Cenchrus ciliaris, Malvastrum americanum* and *Portulaca oleracea*. • **WP**: *Bidens bipinnata*, *Cenchrus ciliaris, C. setiger, Citrullus amarus, C. colocynthis, Malvastrum americanum, Portulaca oleracea, Setaria verticillata* and *Vachellia farnesiana.*

Survey background information	
Threatened and priority ecological communities (TECs and PECs) occurring in the vicinity of the ASA (**Map 9.6**)	A search of the DBCA's Threatened Ecological Communities (TEC) database was requested in March 2023, for an area encompassing the ASA (search reference #01-0323EC). No TECs protected by the EPBC Act, or the BC Act occur in or close to the ASA (DCCEEW, 2021b; DBCA, 2018). The closest is the Themeda grasslands on cracking clays (Hamersley Station, Pilbara) community, approximately 52 km southwest of the WP (DBCA, 2018) (outside the extent of **Map 9.6**). The eastern-most end of the WP intersects the buffer for a P1 Priority ecological community (PEC) - Freshwater claypans downstream of the Fortescue Marsh - Goodiadarrie Hills on Mulga Downs Station (DBCA, 2022b). This area is in the unsurveyed WAMA section of the WP area; however, the vegetation in that area was mapped as part of the MBSA surveyed by Maia (2022). The closest PEC to the RDA and SF areas is the Four plant assemblages of the Wona land system P1 PEC; however, none of the ASA are in that land system.
Protected and significant areas (**Map 9.7**)	No DBCA Legislated Lands and Waters (DBCA, 2022e) or DBCA Lands of Interest (DBCA, 2022f) occur within 10 km of the ASA. The closest conservation area is Mungaroona Range Nature Reserve, approximately 12.5 km north of the SF. The closest Lands of Interest is a former Mount Florence area, approximately 13.5 km southwest of the WP. A small section of the eastern arm of the WP lies over an Environmentally Sensitive Area (ESA) and a Schedule One Area (the Fortescue River and associated floodplains and claypans) (Department of Water and Environment Regulation (DWER), 2021 and 2022) (**Map 9.8**).
Watercourses and wetlands (**Map 9.8**)	A small part of the eastern section of the WP lies over some of a listed Directory of Important Wetlands in Australia (DIWA) wetland – the Fortescue Marshes (DBCA, 2021a). The Fortescue Marshes proper are east of the Goodiadarie Hills to the east of the Great Northern Highway; to the west of the Goodiadarrie Hills the wetland includes the Fortescue River and associated floodplains and claypans. None of the ASA lies in a current Ramsar Site; however, the Fortescue Marshes are a proposed Ramsar addition, and the southern approximately 4.25 km of the WP lies within its boundary (DBCA, 2021b). Minor non-perennial drainage lines associated with the Fortescue River run through all three sections of the ASA (Geoscience Australia, 2017). The Fortescue River is approximately 140 m south of the WP.
Sheet Flow Dependent Vegetation	Mulga is the common name for *Acacia aneura,* but it is also applicable to closely related species that often co-occur with mulga e.g., *A. ayersiana*, *A. minyura* and *A. paraneura.* The mulga species complex has many distinct growth forms, phyllodes and pod characteristics. Mulga communities cover approximately 20% of the Australian continent and are one of the dominant vegetation types in semi-arid and arid Australia. Their distribution incorporates the Chichester, Fortescue and Hamersley subregions of the Pilbara bioregion (Page and Grierson, 2010). Mulga vegetation has been shown to be dependent on sheet flow (Winkworth, 1973; Tongway and Hindley, 2004) and is sensitive to alterations in sheet flow (Saco et al., 2007). Mulga vegetation, including banded mulga, has been mapped in parts of the MDIOM previously (Maia, 2021a and 2021b and 2022), and could occur in the ASA.

Table 2.2: Vegetation associations and vegetation system associations of the Pilbara bioregion and the Fortescue and Chichester subregions – pre-European and current extent, remaining extent and area in conservation tenure

	Pilbara bioregion	Fortescue subregion	Chichester subregion
Vegetation associations (VAs)			
Pre-European extent (ha)			
29	1,133,219.76	893,394.62	
173	1,752,520.89		1,744,029.51
175	507,860.16	69,513.33	
562	103,606.82	99,723.21	
Current extent (ha)			
29	1,131,712.01	893,221.87	
173	1,747,677.63		1,739,189.58
175	507,466.80	69,479.26	
562	103,606.82	99,723.21	
Remaining (%)			
29	99.87	99.98	
173	99.72		99.72
175	99.92	99.95	
562	100	100	
Current extent of VA protected (IUCN 1-4) for conservation (proportion of pre-European extent) (%)			
29	1.91	0.26	
173	7.49		7.52
175	4.37	-	
562	-	-	
Vegetation system associations (VSAs)			
Pre-European extent (ha)			
29	877,822.10	872,485.64	
173.2	1,125,813.10		1,122,547.28
175.3	68,175.03	67,282.96	
562	103,351.05	99,721.08	
Current extent (ha)			
29	877,652.90	872,316.44	
173.2	1,124,734.22		1,121,471.73
175.3	68,175.03	67,282.96	
562	103,351.05	99,721.08	
Remaining (%)			
29	99.98	99.98	
173.2	99.90		99.90
175.3	100	100	
562	100	100	
Current extent of VSA protected (IUCN 1-4) for conservation (proportion of pre-European extent) (%)			
29	0.27	0.26	
173.2	11.66		11.69
175.3	-	-	
562	-	-	

Source: GOWA (2019).

3 METHODS –SURVEY, TAXONOMY AND VEGETATION MAPPING

3.1 SURVEY METHODS

The survey methodology was developed to comply with the following:

- Environmental Factor Guideline: Flora and Vegetation (Environmental Protection Authority (EPA), 2016a); and,
- Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016b).

Maia was engaged to carry out a single-phase detailed survey in the RDA and SF sections of the ASA and a targeted flora survey (TFS) along the WP section with notes to be taken on the vegetation of that area.

Before undertaking the survey, the botanists familiarised themselves with any CSF species with records in areas around the ASA. The survey was carried out between February 25 and 27, 2023.

Quadrats measuring 50 m x 50 m were sampled in the RDA and SF. When sampled in linear habitats (e.g., along drainage areas), where a 50 m x 50 m quadrat would not fit, the area surveyed was amended to fit into that habitat and the same area (2,500 m^2) was assessed. Quadrat locations were selected before going to site using aerial imagery, RDA and SF boundaries, and vegetation previously mapped in adjacent areas. While quadrats were placed to capture the different habitats visible on the aerial imagery, the final placement of the quadrats was selected by the botanists while at site.

The following information was recorded at each quadrat assessed:

- Location details including GPS (global positioning system) co-ordinates for the four corners at each site.
- Site parameters such as soil description, topography and general habitat description, rock type and cover.
- At least one photograph of the site.
- Vegetation condition using the scale and criteria in EPA (2016b) for the Eremaean and Northern Botanical Province.
- Notes on any disturbance to the vegetation.
- Fire history.
- A description of the vegetation structure including the height, percentage cover and dominant species within each stratum.
- The name, height, percentage cover and any other significant recording details for each species located at the site.

Traverses were walked between quadrats assessed in the RDA and SF and their path was either chosen by the botanists while walking from quadrat to quadrat or selected from aerial imagery before carrying out the survey. When walking traverses each botanist surveyed a band of vegetation approximately 15 m wide. CSF species known to occur in the area and surrounds, any novel species and introduced species were targeted while walking. The botanists also recorded information when any apparently different vegetation types were encountered - the vegetation type boundaries were noted, and georeferenced photographs were taken.

The TFS was carried out along the WP by walking meandering traverses on both sides of the existing road within the WP survey area boundaries; however, the section of the WP lying within the WAMA was not surveyed. When carrying out the TFS, if known or suspected CSF or weed species were encountered a waypoint was taken to mark the location and their numbers were counted.

3.2 Taxonomy and Nomenclature

At least one specimen from each taxon encountered while carrying out the survey was collected for taxonomic verification. In some cases, multiples of flowering or fruiting specimens were collected to assist with identification. Most of the specimens collected were identified by Conrad Slee, using taxonomic keys and reference specimens at the WA Herbarium; however, some of the specimens were sent to specialists at the WA Herbarium for verification.

The species names used in this report are those adopted by the WA Herbarium, and they have been checked against current Florabase records (WAH, 1998-). Species, subspecies and varieties are referred to as sp. or spp. (single and multiple species respectively), subsp. and var..

3.3 Statistical Analyses

No statistical analyses were carried out on the quadrat data collected from the RDA and SF because: a) the areas assessed were small, b) only 10 quadrats were sampled in the RDA and SF, c) both areas are adjacent to the MBSA, which has been extensively surveyed and for which comprehensive statistical analyses have been carried out to define the vegetation of the area. The quadrat data collected in February 2023 were therefore compared to quadrat data previously collected from sites in the vegetation types already mapped in the MBSA assessed by Maia.

3.4 Vegetation Type Mapping

Aerial imagery captured in 2022 was used to map the vegetation at a scale of 1:10,000. The presence and absence of taxa and structural information (height, growth form and cover) recorded at quadrats assessed in February 2023 were compared with the data collected from quadrats assessed in vegetation types mapped in areas adjacent to the ASA. February 2023 quadrats with the same dominant taxa as at previously assessed quadrats were grouped with those quadrats and mapped as the vegetation type that the older quadrats belonged to.

No quadrats were assessed in the WP in February 2023, however, data from eight quadrats previously assessed by Maia or other practitioners within 0.5 km of the WP corridor were used to map the vegetation types along the sections of the WP not already mapped by Maia (2022) (more transparent vegetation type mapping on **Map 9.15, Section 9**). Vegetation types mapped in adjacent areas, notes made on the vegetation types and photographs taken at photo points while carrying out the TFS in the WP section were also used.

To be consistent with vegetation mapped along an adjacent MDIOM road corridor, vegetation mapping for the WP section was extended out to a wider corridor, in this instance a 1 km wide corridor. As a result, vegetation types are mapped over an area much larger than the ASA and this larger area is referred to as the Extended Mapping Area (EMA) to differentiate it from the ASA (**Table 3.1**). An approximately 5.15 km long section of the WP was mapped as part of the MBSA leaving an approximately 8.56 km long section needing to be mapped following the 2023 survey.

Sections of the WP corridor mapped previously by Maia (2022) are not included in the vegetation type area calculations for the ASA. This means that the area of vegetation mapped in the ASA itself (and excluding the previously mapped areas in the WP) totals 193.80 ha; **Table 3.1**), while the ASA covers 241.61 ha (**Table 1.1**)). Note that while the WAMA section of the WP was not surveyed, vegetation types were mapped in the section not already mapped by Maia by using data from quadrats previously assessed in that area.

The boundaries of the vegetation types mapped in the different sections of the ASA align with the boundaries of the vegetation types previously mapped in adjacent areas, and the vegetation type codes used in this report are consistent with those used for the adjacent previously mapped areas (**Maps 9.14 and 9.15, Section 9**).

The growth form, height classes and cover characteristics of the vegetation have been described using the current National Vegetation Inventory System (NVIS) methodology at the association level. At this level up to three strata

and a maximum of three taxa per stratum are used to describe the association (NVIS Technical Working Group, 2017).

Table 3.1: Survey and vegetation mapping areas

Area mapped	Description	Size (ha)
ASA (Additional Survey Areas)	Road Deviation Area (RDA), Solar Farm (SF) and Water Pipeline (WP).	193.80
EMA (Extended Mapping Area): vegetation types and vegetation condition	RDA, SF and WP areas with mapping extended to a 1 km wide corridor along sections of the WP not previously mapped.	911.36

3.5 Vegetation Condition

Vegetation condition was assessed using the vegetation condition scale for the Eremaean and Northern Botanical Provinces (EPA, 2016b) (**Table A3.1**, **Appendix 3**). Vegetation condition noted in the description for each vegetation type (**Table 4.6**) is based on vegetation condition at the quadrats assessed by Maia in the relevant vegetation type. The ratings on the vegetation condition map are derived from several information sources (data collected at quadrats and at photo points, notes recorded while walking from quadrat to quadrat or carrying out the TFS, any disturbance visible on aerial imagery, and any weeds located at quadrats and along traverses).

4 Survey Results

4.1 Rainfall

The MDIOM is in the Pilbara Province of the Sub-Eremaean bioclimate (Fortescue Botanical district) representing a tropical semi-desert climate with 9-11 dry months a year (Beard, 1975). The area receives on average between 250 and 350 millimetres (mm) of rainfall per annum with a greater chance of summer rainfall (Tille, 2006).

The closest Bureau of Meteorology (BOM) weather station to the ASA, with complete monthly rainfall data sets before 2019, is Wittenoom (station number 5026) - approximately 15 km south of the WP; however, this station closed on August 31, 2019. The Karijini North weather station (station number 5098) opened in September 2018 and is now the closest operating weather station to the ASA, however, it is approximately 21.5 km south of the WP.

Monthly and annual rainfall totals from Wittenoom (January 2009 to August 2019) and Karijini North (September 2018 to April 2023) are listed in **Table 4.1** (BOM, 2023a and 2023b). The short-term (s-t) (Wittenoom and Karijini North) and medium-term (m-t) (Wittenoom) mean monthly and mean annual total rainfall data are also listed in **Table 4.1**.

Total rainfall recorded at Karijini North over the three months before the survey (November 2022 to January 2023) was 106 mm. This was 4.4 mm lower than the Karijini North s-t mean total (110.4 mm), 76.0 mm lower than the Wittenoom s-t mean total (182.0 mm), and 144.8 mm lower than the Wittenoom m-t mean total (250.8 mm) for the same three months (BOM, 2023a and 2023b). The BOM rainfall deciles map for November 1, 2022 to January 31, 2023 shows the ASA lying in an area with an average rainfall deciles range (**Figure 4.1**) (BOM, 2023c).

Although Hancock Exploration has a rainfall gauge at Mulga Downs exploration camp, the equipment malfunctioned, and no rainfall data was collected between October 30, 2022 and March 20, 2023.

Table 4.1: Rainfall (mm) data from Wittenoom and Karijini North weather stations (BOM, 2023a and 2023b)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall (mm) Wittenoom (station number 5026)													
2009	162.6	171	40	3.4	0	14.5	4	0	0	0	50.2	5.6	451.3
2010	68.8	8.4	15.1	0	3.2	2	11	7	61.2	0	12.4	92	281.1
2011	79.9	294	52.6	27	41.3	14.2	6.9	0	0	0	49.3	0.8	566
2012	469.8	2	28.8	1.8	0	13	0	0	0	24.2	0	64.4	604
2013	430.6	20.6	23.4	11.2	15.8	87.2	0	0	0	3.8	2	110.2	704.8
2014	214.6	5.4	58.6	3.6	18.4	2.4	34.2	0	0	2	31.2	24.4	394.8
2015	67.2	16.4	167.6	64.8	112.6	0	24.8	0	0	12	16.2	0.8	482.4
2016	82.2	14.2	3	21.4	11.2	104.4	25.6	0.4	0	0	11.2	43	316.6
2017	137	138.6	104.2	27.4	0.4	0	0	0	0	0.6	7.4	35.4	451
2018	238.8	56.6	43.6	0	0	88.6	0	0	0	0	0	0.4	428
2019	91.6	16.2	34	2.8	0	16.4	0	2.2	**Station closed**				NC
S-t mean	148.0	46.2	75.4	23.4	28.5	39.1	16.9	0.1	0.0	2.9	13.2	20.8	414.6
M-t mean	195.2	72.7	53.7	16.1	20.3	32.6	10.7	0.7	6.1	4.3	18.0	37.7	468.0
Rainfall (mm) Karijini North (station number 5098)													
2018	**Station not yet open**								0	0.2	0	2.8	NC
2019	77.6	13.0	84.0	3.2	0	18.2	0	1.2	0	1.6	2.2	9.0	210.0
2020	75.8	131.6	24.4	12.8	34.6	0	22.0	5.4	0	2.2	4.6	141.8	455.2
2021	35.4	164.2	38.2	78.0	46.6	16.4	0	0	0	0	8.8	5.0	392.6
2022	79.0	112.0	31.2	21.0	98.6	12.6	0	0.8	67.2	3.8	0	2.4	428.6
2023	103.6	4.8	38.4	11.8	ND	ND	ND	ND	ND	ND	ND	ND	NC
S-t mean	67.0	105.2	44.5	28.8	45.0	11.8	5.5	1.9	16.8	1.9	3.9	39.6	371.6

Note: M-t = medium-term mean rainfall (Wittenoom: 2009 – 2018, 10 years with complete data); S-t = short-term mean rainfall (Wittenoom: 2014 – 2018, 5 years with complete data; Karijini North: 2019 – 2022, 4 years with complete data) (BOM, 2023a and 2023b), ND = no data, NC = not collated; survey month highlighted orange, the three months before the survey highlighted blue.

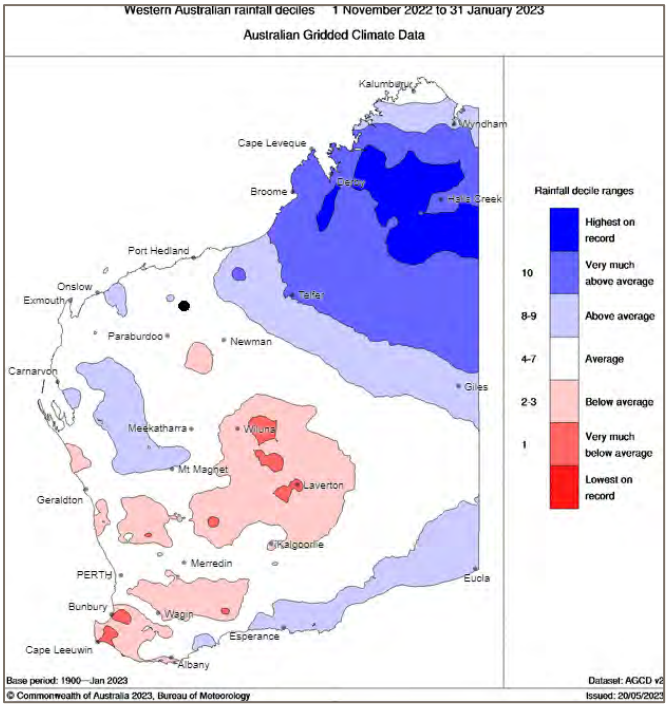


Figure 4.1: Western Australian rainfall deciles, 1 November 2022 to 31 January 2023 (BOM, 2023c) (approximate location of ASA shown by solid black dot)

4.2 Survey Effort

Ten quadrats were assessed in the RDA and SF in February 2023; their locations and the traverses walked in them are shown on **Map 9.9, Section 9**. Traverses walked in the WP are shown on **Map 9.10**, along with the quadrats previously assessed and used to map the vegetation along the WP.

Survey coverage achieved over the ASA is listed in **Table 4.2**. The coverage along traverses is calculated using the length of the traverse walked multiplied by 15 m, which was the approximate width of the band of vegetation that the botanists were able to survey while walking. While not surveyed, the area of the ASA in **Table 4.2** still includes the 3.5 km (34.18 ha) section of the pipeline within the WAMA; even including this section, approximately 38% of the ASA was directly assessed by the botanists in February 2023.

Table 4.2: ASA survey effort

		Quadrats		Traverses (ha)
Date	Survey Area	Number	Size (ha)	
February 25, 2023	Road Diversion Area (RDA)	3	0.75	5.66
February 26, 2023	Water Pipeline (WP)	0	0	58.36
February 27, 2023	Solar Farm (SF)	7	1.75	25.37
Coverage achieved (ha)		2.50		89.39
Total area of ASA (ha)		**241.61**		
Total area surveyed (ha)		**91.89**		
Total coverage achieved (%)		**38.03**		

Note: Coverage achieved calculations were derived using the area surveyed divided by the area of the ASA (241.61 ha).

4.3 Flora

4.3.1 General Flora

While the eight regional quadrats within the WP were not reassessed in February 2023, the species recorded in them when they were originally assessed are included in the species list. Although they are included in the species list, as they were used to map the vegetation types along the WP corridor and associated EMA (because a TFS was carried out along the WP), they are not included in any other tables and are not used in the counts in this section.

Seventy-nine (79) vascular flora taxa were recorded in February 2023 and another 103 taxa were recorded at the eight previously assessed regional quadrats (**Table A5.1, Appendix 5**). General information on the flora of the ASA recorded by Maia in February 2023 is presented in **Table 4.3**.

Two taxonomically uncertain collections were removed from the species list and counts (*Acacia* ? *aptaneura* and *Acacia* ? *atkinsiana*; **Table A5.2, Appendix 5**), as they were recorded in the same quadrat as their respective confirmed species (*Acacia aptaneura* and *Acacia atkinsiana*). Three queried taxa (*Eucalyptus* ? *leucophloia*, *Eriachne* ? *mucronata* and *Triodia* ? *basedowii*) were included in the species list but not in the counts in **Table 4.3**, as their respective confirmed collections were recorded in the same area (either RDA and/or SF areas). Five other queried taxa were included in both the species list and counts because they either could be the species queried to or could be other species that occur in the area not already in the species list (**Table A5.3, Appendix 5**.

The low number of taxa collected from the ASA in February 2023 is likely a reflection of the relatively small area assessed, the time of year of survey, and the below average rainfall received in the general area over November, December and early January. While above average rainfall was recorded at Karijini North in January 2023, most of the 103.6 mm recorded at the station fell between the 19th and 31st and the first day of the three-day ASA survey

was February 25th, just over three weeks later. This will likely not have been enough time for annual species to have germinated and grown post the good rains. Even if they had germinated, only 4.8 mm was recorded at Karijini North in February and so seedlings could have died post germination. This could explain why only 3% of the species list comprises annual species. Although, localised heavy rain fell at Mulga Downs over some days before the ASA survey, and it was enough to prevent access to some areas along the WP, it would not have affected the number of annual species present so soon afterwards.

Table 4.3: General flora of the ASA

Parameter	ASA, all areas combined (excluding regional quadrat data)
Number of taxa	79
Number of families	22
Number of genera	45
Perennials (%)	97
Annuals (%)	3
Specimens collected with flowers, fruit, or both flowers & fruit (%)	7, 5, 7 30% were fertile
Most common families (all taxa)	Fabaceae (29), Poaceae (10), Malvaceae (9)
Most common genera (all taxa)	*Acacia* (19), *Hibiscus* (4), *Senna* (6), *Triodia* (3)

4.3.2 Threatened and / or Priority Listed Flora

Threatened Flora

Two *Seringia exastia* plants, a Critically Endangered flora species protected by the EPBC Act (DCCEEW, 2023), were recorded at quadrat SFQ02 in the SF area in February 2023. Another 10 plants were recorded at a location approximately 100 m southwest of quadrat SFQ02 when walking between quadrats (**Map 9.11, Section 9**): the coordinates for the two locations are listed in **Table A1.1, Appendix 1**. Up to October 6, 2022, *Seringia exastia* was also listed as Critically Endangered under the BC Act; however, in the most recent Biodiversity Conservation (Flora) Order and Threatened and Priority Flora List (GOWA, 2022a; DBCA, 2022c) it is no longer listed.

***Seringia exastia* – Malvaceae (Threatened)**

S. exastia (**Figure 4.2**) is an erect, compact, and multi-stemmed shrub with hairy stems growing to 0.9 m tall (DCCEEW, 2023; WAH, 1998-). The leaves are grey-green, oblong and 15-20 mm long (DCCEEW, 2023). Purple flowers are produced between April and December (WAH, 1998-): the plants were not flowering in February 2023. *S. exastia* is typically recorded on Pindan (red soil) heathland with open shrub mallee of *Eucalyptus* over open hummock grassland of *Triodia* (WAH 1998-). Most of the *S. exastia* in the SF area were recorded along a drainage line, while SFQ02 is on a stony plain. These plants are approximately 3 km east of the closest current Florabase record (WAH, 1998-).

Figure 4.2: *Seringia exastia* (T) (Maia photographs not from this survey)

Because of the large WA flora, many species are known from only a few collections, or a few sites, and have not been adequately surveyed, or are adequately known are rare but not threatened, or meet criteria for near threatened, or have been recently removed from the threatened list for other than taxonomic reasons and these species can be placed on a priority species list (listed as Priority 1 to 4). Categories and definitions for threatened and priority flora species are provided in **Appendix 1.**

Priority Flora

No confirmed or queried priority flora species were located in the ASA.

4.3.3 Other Significant Flora - Regional Endemic and Range Extension Species

The distribution for each of the species located in the ASA was checked on Atlas of Living Australia (ALA, 2023):

- None of them is endemic to the Pilbara bioregion.

Species have a typical range which is indicated by their known distribution records. Sometimes species are recorded during a survey and their distribution records show that they have not been found in the area previously. The new records can either extend the range of a species out from its known distribution or fill a gap in the distribution records. The new distribution records can be a result of: few surveys having been carried out in an area; the degree of coverage achieved previously and of the habitats surveyed; and the time of year of the survey with respect to season and rainfall (or a result of seed being carried into the area by cattle if transported to the MDIOM from other regions). However, range extensions and gap fillers can also reflect a lack of submission of flora records to the WA Herbarium, as relatively common species or those not classified as significant are often not submitted.

Using 100 km as the minimum distance from an existing record to define a range extension:

- No range extension species were collected from the ASA.

4.3.4 Introduced Flora

Information on weeds of national interest, declared pests and the DBCA weed prioritisation process is provided in **Appendix 2**.

National Weeds Lists and Plants Declared in Western Australia

No weeds on any of the national lists or declared as a pest in WA were located in the ASA.

Environmental Weeds

Four general environmental weed species were recorded in the WP corridor: *Cenchrus ciliaris* (Buffel Grass), *Cenchrus setiger* (Birdwood Grass), *Malvastrum americanum* (Spiked Malvastrum) and *Vachellia farnesiana* (Mimosa Bush) (**Map 9.12, Section 9**). All four weed species have been recorded in the MDIOM previously (Maia, 2022).

The DBCA prioritises weeds in each region based on their invasiveness, ecological impact, potential and current distribution, and feasibility of control. The resulting priorities focus on weeds considered to be high impact, rapidly invasive, and still at a population size that can feasibly be eradicated or contained to a manageable size (DBCA, 2023). The Pilbara Region Species Prioritisation Process 2014 impact and invasiveness ratings spreadsheet lists 90 weed species for which the impact and invasiveness have been ranked, and a further 15 weed species that have been listed as priority alert species (DBCA, 2014).

The ecological impact and invasiveness ratings for the four weed species located in the ASA are listed in **Table 4.4**. All four weed species have both a high ecological impact and rapid invasiveness rating.

The coordinates for the four weed species are listed in **Table A2.2, Appendix 2**.

Table 4.4: Weeds located in the ASA, with ecological impact and invasiveness ratings (DBCA, 2014)

Taxon (Common Name)	Number of plants located in the ASA	Ecological impact rating	Invasiveness rating
Cenchrus ciliaris (Buffel Grass)	230	High	Rapid
Cenchrus setiger (Birdwood Grass)	3,570	High	Rapid
Malvastrum americanum (Spiked Malvastrum)	62	High	Rapid
Vachellia farnesiana (Mimosa Bush)	79	High	Rapid

4.4 VEGETATION

A species by site and vegetation type matrix for the ten quadrats assessed by Maia in the RDA and SF is included as **Table A6.1, Appendix 6**, and a species by vegetation type matrix as **Table A6.2, Appendix 6**. This table has only the four vegetation types recorded at the RDA and SF Survey Areas in it because it is based on information collected at the ten quadrats assessed by Maia in those areas during this survey. Detailed information collected at the 10 quadrats assessed in February 2023 is provided in **Table A7.1, Appendix 7**.

4.4.1 Vegetation Types

Ten vegetation types were mapped in the ASA.

The area and cover for each vegetation type mapped in the ASA and EMA is listed in **Table 4.5** (see **Table 3.1** for information on EMA and ASA). Each of the vegetation types is described in **Table 4.6**, their distribution is shown on **Maps 9.14 and 9.15, Section 9**, and the vegetation type legend is on **Map 9.13, Section 9**. Area and cover data for the 10 vegetation types mapped in the ASA / EMA for the MBSA (Maia, 2022) are also included in **Table 4.5**. The area and cover of vegetation types in both the ASA (not including the wider EMA) and in the MBSA were combined to produce a total for each vegetation type mapped in the areas surveyed by Maia in the MDIOM (**Table 4.5**).

The vegetation condition noted in **Table 4.6** is based on the condition of the vegetation at the quadrats assessed or traverses walked in each vegetation type; it is not the same as the vegetation condition in **Table 4.7**, which uses a range of information sources (data collected at Maia quadrats and photo points, notes recorded while walking traverses or between sites, and any disturbance visible on aerial imagery). CSF species found during this detailed

and targeted survey are listed in the vegetation type in which they occur. **Maps 9.14 and 9.15, Section 9** show vegetation types mapped along with the quadrats assessed in them.

The regional and local significance of the vegetation types mapped in the ASA is discussed in **Section 5**.

Table 4.6 includes the following information on each vegetation type:

- The vegetation code and its broad floristic formation e.g., ASL (2) *Acacia* Tall Shrubland.
- A broad floristic formation description of the vegetation type and the habitat/s in which it occurs along with any other salient information relating to the vegetation type e.g., any CSF located in the vegetation type.
- The average vegetation condition (using Maia quadrat vegetation condition ratings), and a comment on any disturbances recorded in the vegetation type (e.g., weeds, cattle grazing, cattle trampling).
- A detailed description of the vegetation type.
- Associated species for the vegetation type.
- The quadrats assessed in and/or the distribution of the vegetation type.
- A photograph typical of the vegetation type.

The vegetation type descriptions and associated species in each vegetation type in **Table 4.6** are based on the descriptions for the same vegetation types mapped within the MDIOM areas assessed by Maia (Maia, 2022). Taxa that are underlined in **Table 4.6** were not recorded at the quadrats assessed by Maia or at the eight regional quadrats used to map the vegetation over the extended WP corridor. However, these taxa are characteristic of the vegetation type and have been commonly recorded in the relevant vegetation types in the MDIOM.

Vegetation types are described using the current NVIS methodology at the association level (Level 5). At this level up to three strata and a maximum of three taxa per stratum are used to describe a vegetation type (NVIS Technical Working Group, 2017). The NVIS structural formation terminology is outlined in the three tables in **Appendix 4**; the structural formation terminology utilises height classes (**Table A4.1**), growth forms (**Table A4.2**) and structural formation (**Table A4.3**) characteristics.

Vegetation type descriptions are ordered using the dominant cover class as the indicator and not the dominant stratum so that they correlate with the broad floristic formation descriptions e.g., Tussock Grassland of *Eriachne flaccida* with *E. benthamii* with isolated trees of *Eucalyptus victrix*. For the same reason vegetation type descriptions have been ordered using the dominant genera in each structural class e.g. THG (1) broad floristic formation is described as *Triodia* Hummock Grassland, and its vegetation type description is: Mixed Hummock Grassland mainly of *Triodia basedowii*, *T. brizoides* and *T. vanleeuwenii* with a Tall Sparse Shrubland of mixed *Acacia* species mainly *Acacia atkinsiana*, *A. maitlandii*, *A. ancistrocarpa* with Low Isolated Trees of *Eucalyptus leucophloia* subsp. *leucophloia* and/or *Corymbia hamersleyana*.

Vegetation type codes include the first letter from the genus and species of the dominant taxon or taxa in the vegetation type along with the first letters of the dominant stratum e.g., *AaAx*SL is an *Acacia aneura* (complex) and *A. xiphophylla* Shrubland, while THG is a *Triodia* Hummock Grassland.

Table 4.5: Vegetation types and their area (ha) and cover (%) in the EMA, the ASA, the MBSA and mapped by Maia in the MDIOM

Column 1	2	3	4	5	6	7	8	9
Vegetation type code: broad floristic formation	Mapped in the EMA		Mapped in the ASA		Mapped in the MBSA		Mapped by Maia in the MDIOM	
	Area (ha)	Cover (%)	Area (ha)	Cover (%)	Area (ha)	Cover (%)	Area (ha)	Cover (%)
*AaAx*SL: *Acacia* Tall Sparse Shrubland	10.30	1.13	10.30	5.31	1,854.63	4.18	1,864.93	4.18
*A*SL (2): *Acacia* Tall Shrubland	31.69	3.48	31.69	16.35	1,990.27	4.48	2,021.96	4.53
*A*WL (1): *Acacia* Low Woodland or Tall Shrubland	169.61	18.61	15.12	7.80	7,134.51	16.06	7,149.63	16.03
*A*WL (2): *Acacia* Low Woodland or Tall Shrubland	101.01	11.08	8.74	4.51	4,841.39	10.90	4,850.13	10.87
*A*WL (3): *Acacia* Low Woodland	51.62	5.66	4.87	2.51	3,945.87	8.88	3,950.74	8.86
*AxAs*SL: *Acacia* Tall Shrubland	185.97	20.41	17.48	9.02	6,968.19	15.69	6,985.68	15.66
*EfEb*TG: *Eriachne* Tussock Grassland	49.74	5.46	5.19	2.68	874.50	1.97	879.69	1.97
MTG (3): Mixed Tussock Grassland	51.63	5.66	2.64	1.36	604.90	1.36	607.54	1.36
*T*HG (1): *Triodia* Hummock Grassland	107.18	11.77	55.65	28.72	11,235.00	25.29	11,290.66	25.31
*T*HG (2): *Triodia* Hummock Grassland	116.12	12.74	26.41	13.63	4,611.78	10.38	4,638.19	10.40
Disturbed	36.49	4.00	15.71	8.11	358.02	0.81	373.74	0.84
Total area mapped (ha) / Cover (%)	**911.36**	**100**	**193.80**	**100**	**44,419.06**	**100.00**	**44,612.89**	**100**

Note: EMA = Extended Mapping Area, ASA = Additional Survey Areas, MBSA = Mine and Borefield Study Area (Maia, 2022), MDIOM = Mulga Downs Iron Ore Project (Maia, 2022). The mapping was extended beyond the original ASA boundary in the WP area to map a corridor approximately 1 km wide; therefore, the area of the vegetation types mapped in the EMA (911.36 ha) is not the same as the area of vegetation mapped in the ASA (193.80 ha). In addition, three sections of the WP were excluded from the mapping in this report as they were previously mapped by Maia (Maia, 2022) and therefore, the area of vegetation mapped in the ASA (193.80 ha) is not the same as the total of the ASA (241.61 ha).

Note: Columns 1 -5 data are from this survey. Column 6 is from (Maia, 2022. Column 7 is Column 6/Total area mapped in the MBSA * 100. Column 8 is the Combined MDIOM area (Columns 4 (ASA) and 6 (MBSA)). Column 9 is Column 8/Total area mapped in the Combined MDIOM * 100.

Table 4.6: Vegetation type (VT) descriptions

VT code	Vegetation type details		Photograph
***AaAx*SL**	**Broad floristic formation**: *Acacia* Sparse Tall Shrubland. **Vegetation type**: Tall Sparse Shrubland of *Acacia aneura* (alliance) and *A. xiphophylla* with a Low Sparse Shrubland of *Eremophila cuneifolia* and a Sparse Hummock Grassland of *Triodia epactia* and/or *T. basedowii*.	**Habitat**: Stony basalt gravel plains. **Associated species**: *Acacia ayersiana, A. incurvaneura, A. tetragonophylla, Dodonaea petiolaris, Duperreya commixta, Exocarpos aphyllus, Hibiscus coatesii, Psydrax suaveolens, Ptilotus obovatus, Senna glutinosa* subsp. x *luerssenii* and *Trianthema glossostigmum.*	
	Quadrat: SFQ03. **Distribution**: RDA and SF.	**Vegetation condition**: Excellent. No disturbances were noted.	

<table>
<tr><th>VT code</th><th colspan="2">Vegetation type details</th><th>Photograph</th></tr>
<tr><td rowspan="2">ASL (2)</td><td>Broad floristic formation:

Acacia Tall Shrubland.

Vegetation type:

Mixed Tall Acacia Shrubland mainly of Acacia tumida var. pilbarensis, A. pyrifolia and A. maitlandii with a Sparse Tussock Grassland of Themeda triandra and Low Isolated Trees of Corymbia hamersleyana and/or <u>Eucalyptus victrix</u>.</td><td>Habitat:

Minor channels and drainage lines including banks.

Associated species:

Acacia adoxa var. adoxa, A. acradenia, A. atkinsiana, A. monticola, Afrohybanthus aurantiacus, Bonamia rosea, Corchorus lasiocarpus subsp. parvus, Eriachne mucronata, Eucalyptus leucophloia subsp. leucophloia, Grevillea wickhamii, Indigofera monophylla, Petalostylis labicheoides and Triodia epactia.</td><td rowspan="2">  </td></tr>
<tr><td>Quadrats:

HXQ02, SFQ01 and SFQ04.

Distribution:

RDA and SF.</td><td>Vegetation condition:

Very Good. Vegetation trampled by cattle.</td></tr>
</table>

<table>
<tr><th>VT code</th><th colspan="2">Vegetation type details</th><th>Photograph</th></tr>
<tr><td rowspan="2">AWL (1)</td><td>Broad floristic formation:

Acacia Low Woodland or Tall Shrubland.

Vegetation type:

Low Woodland / Tall Shrubland to Low Isolated Trees / Shrubs of Acacia aneura (complex) with a mixed Low Sparse Shrubland mainly of Dodonaea petiolaris, Eremophila forrestii and Abutilon otocarpum and Isolated Low Trees of A. pruinocarpa.</td><td>Habitat:

Stony washout flats.

Associated species:

Acacia aptaneura, A. aneura, *Bidens bipinnata, Cheilanthes sieberi subsp. sieberi, Chrysopogon fallax, Cucumis argenteus, Psydrax latifolia, Pterocaulon sphacelatum, Spermacoce brachystema and Sporobolus australasicus.</td><td rowspan="2">  </td></tr>
<tr><td>Distribution:

The northern section of WP.</td><td>Vegetation condition:

Very Good. Weeds recorded.</td></tr>
</table>

<table>
<tr><th>VT code</th><th colspan="2">Vegetation type details</th><th>Photograph</th></tr>
<tr><td rowspan="2">AWL (2)</td><td>Broad floristic formation:

Acacia Low Woodland or Tall Shrubland.

Vegetation type:

Low Woodland / Tall Shrubland to Low Isolated Trees / Tall Shrubs of Acacia aneura (complex) A. synchronicia and A. tetragonophylla with a mixed Low Sparse Shrubland mainly of Solanum lasiophyllum, Abutilon otocarpum and Sida platycalyx and a Sparse Tussock Grassland to Isolated Tussock to Isolated Tussock Grasses mainly of Sporobolus australasicus, Enneapogon cylindricus and Aristida contorta.</td><td>Habitat:

Hardpan and stony plains close to the Fortescue River and can occur in groves.

Associated species:

Abutilon otocarpum, Acacia aptaneura, A. pteraneura, Cheilanthes sieberi, Dodonaea petiolaris, Eremophila forrestii subsp. forrestii, Eremophila lanceolata, Eremophila latrobei subsp. filiformis, Grevillea berryana, Hakea lorea subsp. lorea, Maireana villosa, Psydrax latifolia, Sclerolaena cornishiana, S. costata and Trianthema triquetrum.</td><td rowspan="2">  </td></tr>
<tr><td>Distribution:

Northern half of WP.</td><td>Vegetation condition:

Very Good. Weeds recorded.</td></tr>
</table>

<table>
<tr><th>VT code</th><th colspan="2">Vegetation type details</th><th>Photograph</th></tr>
<tr><td rowspan="2">AWL (3)</td><td>Broad floristic formation:

Acacia Low Woodland.

Vegetation type:

Low Woodland of Acacia aneura (complex) mainly Acacia aptaneura, A. aneura and A. incurvaneura with a mixed Tall Shrubland mainly of A. synchronicia, A. tetragonophylla and Hakea lorea subsp. lorea with a Sparse Tussock Grassland to Isolated Tussock Grasses mainly of Sporobolus australasicus, Enneapogon cylindricus and Aristida contorta.</td><td>Habitat:

Broad drainage lines, drainage basins and hardpan and stony plains.

Associated species:

Abutilon otocarpum, Arivela viscosa, Boerhavia coccinea, Chrysopogon fallax, Eriachne mucronata, Grevillea berryana, Hibiscus sturtii var. platychlamys, Ipomoea muelleri and Maireana villosa.</td><td rowspan="2">  </td></tr>
<tr><td>Distribution:

The northern section of WP.</td><td>Vegetation condition:

Very Good. Weeds recorded.</td></tr>
</table>

<table>
<tr><th>VT code</th><th colspan="2">Vegetation type details</th><th>Photograph</th></tr>
<tr><td rowspan="2">AxAsSL</td><td>Broad floristic formation:

Acacia Tall Shrubland.

Vegetation type:

Tall Sparse Shrubland of Acacia xiphophylla and/or A. synchronicia with a mixed Sparse Chenopod Shrubland mainly of <u>Sclerolaena cuneata</u>, <u>S. bicornis</u>, S. cornishiana and a Sparse Tussock Grassland of Eragrostis xerophila.</td><td>Habitat:

Hardpan and stony plains.

Associated species:

Aristida contorta, Arivela viscosa, Eriachne benthamii, <u>Portulaca oleracea</u>, and Sporobolus australasicus.</td><td rowspan="2">  </td></tr>
<tr><td>Distribution:

Along the WP.</td><td>Vegetation condition:

Good. Weeds recorded.</td></tr>
</table>

<table>
<tr><th>VT code</th><th colspan="2">Vegetation type details</th><th>Photograph</th></tr>
<tr><td rowspan="2">EfEbTg</td><td>Broad floristic formation:

Eriachne Tussock Grassland.

Vegetation type:

Tussock Grassland of Eriachne flaccida and E. benthamii with Isolated Trees of <u>Eucalyptus victrix</u>.</td><td>Habitat:

Slightly raised claypans.

Associated species:

Acacia tetragonophylla, <u>Alternanthera nodiflora</u>, Arivela viscosa, <u>Eragrostis dielsii</u>, E. tenellula, and Gomphrena affinis subsp. pilbarensis.</td><td rowspan="2">  </td></tr>
<tr><td>Distribution:

Southern section of WP.</td><td>Vegetation condition:

Very Good. Weeds recorded.</td></tr>
</table>

<table>
<tr><th>VT code</th><th colspan="2">Vegetation type details</th><th>Photograph</th></tr>
<tr><td rowspan="2">MTG (3)</td><td>Broad floristic formation:

Mixed Tussock Grassland.

Vegetation type:

Sparse to Open mixed Tussock Grassland mainly of Eragrostis xerophila, Eriachne benthamii, and Astrebla lappacea with a mixed Forbland, mainly of Stemodia kingii, Operculina aequisepala and Cullen cinereum with Isolated shrubs of Acacia synchronicia or *Vachellia farnesiana.</td><td>Habitat:

Gilgai and stony plains.

Associated species:

Alysicarpus muelleri, Arivela viscosa, Gomphrena kanisii, Portulaca oleracea, Ptilotus gomphrenoides, Sida sp. Supplejack Station (T.S. Henshall 2345), and Sporobolus australasicus.</td><td rowspan="2">  </td></tr>
<tr><td>Distribution:

Southern section of WP</td><td>Vegetation condition:

Good. Weeds recorded.</td></tr>
</table>

<table>
<tr><th>VT code</th><th colspan="2">Vegetation type details</th><th>Photograph</th></tr>
<tr><td rowspan="2">THG (1)</td><td>Broad floristic formation:

Triodia Hummock Grassland.

Vegetation type:

Mixed Hummock Grassland mainly of Triodia basedowii, Triodia brizoides and <u>T. vanleeuwenii</u> with a Tall Sparse Shrubland of mixed Acacia species mainly Acacia atkinsiana, A. maitlandii, A. ancistrocarpa with Low Isolated Trees of Eucalyptus leucophloia subsp. leucophloia and/or Corymbia hamersleyana.</td><td>Habitat:

Gentle hills (footslope and midslope) and stony plains.

Associated species:

Acacia adoxa var. adoxa, A. acradenia, A. tenuissima, A. bivenosa, Codonocarpus cotinifolius, Corchorus lasiocarpus subsp. lasiocarpus, Grevillea wickhamii, Indigofera monophylla, Senna glutinosa subsp. glutinosa, Senna glutinosa subsp. x luerssenii, and Triodia epactia.</td><td rowspan="2">  </td></tr>
<tr><td>Quadrats:

SFQ05 and SFQ06 and SFQ07.

Distribution:

SF and northern section of WP.</td><td>Vegetation condition:

Excellent. No disturbances were noted.

Seringia exastia (T) has been located in this vegetation type in the SF.</td></tr>
</table>

<table>
<tr><th>VT code</th><th colspan="2">Vegetation type details</th><th>Photograph</th></tr>
<tr><td rowspan="2">THG (2)</td><td>Broad floristic formation:

Triodia Hummock Grassland.

Vegetation type:

Mixed Hummock Grassland mainly of Triodia basedowii, T. epactia and <u>T. pungens</u> with a Sparse mixed Shrubland of mulga species mainly Acacia aneura, A. aptaneura and A. incurvaneura and Isolated Low Trees of Eucalyptus leucophloia subsp. leucophloia and/or A. pruinocarpa.</td><td>Habitat:

Broad drainage line with basalt stones.

Associated species:

Acacia arida, A. atkinsiana, A. bivenosa, A. marramamba, A. tetragonophylla, Capparis lasiantha, Corchorus lasiocarpus subsp. lasiocarpus, Eragrostis eriopoda, Eremophila forrestii, Hibiscus sturtii, Petalostylis labicheoides, Senna glutinosa subsp. glutinosa and Sida sp. dark green fruits (S. van Leeuwen 2260).</td><td rowspan="2">  </td></tr>
<tr><td>Quadrats:

HXQ01, HXQ03 and SFQ02.

Distribution: RDA, SF and northern half of WP.</td><td>Vegetation condition:

Excellent. No disturbances were recorded.

Seringia exastia (T) was located in this vegetation type at quadrat SFQ02.</td></tr>
</table>

Note: ***** = environmental weed, RDA = Road Deviation Area, SF = Solar Farm, WP = Water Pipeline, VT = Vegetation Type, T = Threatened, sp. = species, subsp. = subspecies, var. = variety, x = crossed with. Nomenclature based on current WA Herbarium terminology and confirmed on Florabase (WAH, 1998-). Taxa <u>underlined</u> = not recorded during this survey or in any of the eight regional quadrats within 500 m from the WP area; from the same vegetation type in Maia (2022) report.

4.4.2 Vegetation Condition

The EMA vegetation condition ratings are shown on **Maps 9.16 and 9.17, Section 9**; the earlier MBMA vegetation condition mapping (Maia, 2022) is also included on these maps.

Vegetation condition in the EMA is predominantly Very Good (53.91%), Good (30.30%) and Excellent (11.50%). Approximately 4.28% of the EMA is mapped as Completely Degraded or Degraded in areas that have been cleared for roads (Roebourne-Wittenoom Rd and Mulga Downs Rd), access tracks, rail lines, drill lines, fence lines and existing infrastructure.

Additional comments on vegetation condition and the EMA are included in **Table 4.7**.

Table 4.7: Vegetation condition in the EMA

Vegetation condition rating	Area (ha) / cover (%) in the EMA	Vegetation types	Comments
Excellent	104.85 / 11.51	AaAxSL, ASL (2), THG(1), THG(2)	Includes all the RDA and most of the SF, which is uncleared with no significant weeds. One part of the northwestern section of the WP is mapped as Excellent, and the area is not adjacent to any roads or tracks.
Very Good	491.33 / 53.91	ASL(2), AWL (1), AWL (2), AWL (3) AxAsSL, Disturbed, EfEbTG, THG (1), THG (2)	Areas mapped as Very Good include the majority of the WP and some of the SF. The two areas mapped as Very Good in the SF are adjacent to drainage lines in the area; no weeds were recorded in these areas. The structure of the Very Good condition vegetation mapped in the WP has been altered; however, with time, it could return to the state of the vegetation around the road. Weeds were recorded in these areas adjacent to the Roebourne-Wittenoom Rd.
Good	276.15 / 30.30	AWL (1), AWL (2), AxAsSL, Disturbed, EfEbTG, MTG (3), THG (2)	Good condition vegetation is mapped only in the WP corridor and EMA, mostly around intersections of roads and access tracks. There are few to no understorey plants present in these areas and large numbers of all four weed species (*Cenchrus ciliaris*, *C. setiger*, *Malvastrum americanum* and *Vachellia farnesiana*). In many areas along the Roebourne-Wittenoom Rd at least one of these weeds is a dominant species.
Degraded	2.54 / 0.28	AWL (1), Disturbed	A small area of the WP corridor and EMA is mapped as Degraded, and it is a small patch of vegetation between two access tracks that connect to Roebourne-Wittenoom Rd.
Completely Degraded	36.49 / 4.00	AWL (1), AWL (2), AWL (3), AxAsSL, Disturbed, EfEbTG, MTG (3), THG (2)	Areas mapped as Completely Degraded are only in the WP corridor and associated EMA. They are areas cleared for roads (Roebourne-Wittenoom Rd and Mulga Downs Rd), access tracks, drill lines, fence lines and existing infrastructure, including an old borrow pit.
Total	911.36 / 100		

5 DISCUSSION

A discussion of the conservation significance of the flora and vegetation of the Survey Area follows. As per the vegetation and flora technical guidance (EPA, 2016b), significance is assessed at both regional and local scales.

5.1 FLORA OF CONSERVATION SIGNIFICANCE

5.1.1 Significant Flora

Flora may be considered significant for a range of reasons (EPA, 2016b), including being:

- Threatened or priority species.
- Locally endemic or associated with a restricted habitat type.
- New species or anomalous features that indicate a potential new species.
- Representative of a range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range).
- Unusual species, including restricted subspecies, varieties or naturally occurring hybrids.
- Relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

Threatened of priority species are discussed in **Section 5.1.1**. The remaining significant flora dot points are addressed below:

- None of the flora species collected from the ASA is a regional endemic species.
- Mulga species are associated with a restricted habitat (potential sheet flow areas), and this is discussed further in **Section 5.5.4**.
- No new species or collections with anomalous features were collected from the ASA.
- No range extension species were collected from the ASA.
- No unusual species were collected from the ASA.
- No species with relictual status were collected from the ASA.

5.1.2 Threatened or Priority Flora Species - Regional and Local Significance

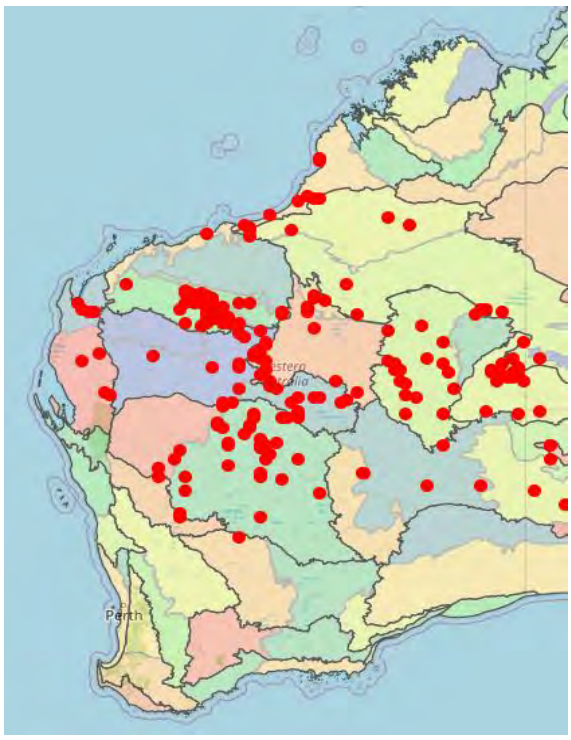
Regional Significance

The regional significance of the threatened flora species *Seringia exastia* located in the ASA is indicated by its current conservation listing. However, in 2020, *Seringia elliptica* (a common and widespread Pilbara species and not listed as conservation significant) was synonymised with *Seringia exastia* (a Kimberley species restricted to the Broome area and listed as threatened) under *Seringia exastia* (Binks et al., 2020). *S. exastia* is still listed as a Critically Endangered under the EPBC Act; however, it was delisted from protection under the BC Act, and this will likely occur re the EPBC Act. The distribution of the Atlas of Living Australia *Seringia exastia* records is shown in **Table 5.1,** and information is included on the bioregional and subregional occurrence of *S. exastia* records in WA; although, DCCEEW still shows its distribution as only in the Broome area in the Kimberley (DCCEEW, 2023).

Local Significance

The number of plants and populations of confirmed collections of *Seringia exastia* from the ASA and MDIOM are listed in **Table 5.2**. As five populations are known to Maia in the MDIOM and only one population was recorded in the SF these plants are locally significant; however, this is based on the local distribution of this species and its current listing under the EPBC Act. Given its widespread distribution in WA (and into the eastern states) the species is not scarce and not conservation significant.

Table 5.1: Regional distribution of *Seringia exastia*

***Seringia exastia* (EPBC Act, Threatened, Critically Endangered)**	
	*S. exastia* (T) has 295 records on Florabase (WAH, 1998-). The Atlas of Living Australia has 296 confirmed records in WA and 304 records in Australia; these records occur in 13 bioregions and 25 subregions (ALA, 2023). WA map source (ALA, 2023): red dots indicate plant records, dark lines indicate IBRA bioregions, pastel colours indicate IBRA subregions.

5.2 Vegetation of Conservation Significance

5.2.1 Land Systems and Pre-European Vegetation

The regional and local significance of the land systems and pre-European vegetation of the ASA is discussed in the following sections.

Regional Significance

Land Systems

The remaining Pilbara extent of the land systems of the ASA is presented in **Table 5.3**, and the originally mapped extent for each is shown on **Map 9.18, Section 9**. Currently, between 99.31% and 100% remains in the Pilbara bioregion of each of the five land systems of the ASA. Based on these remaining extents, their regional significance is low.

Pre-European vegetation

The remaining extent of the pre-European vegetation associations (VAs) and system associations (VSAs) of the ASA is listed in **Table 2.4** and the pre-European extent of each is shown on **Map 9.19, Section 9**. Currently, between 99.72% and 100% of the four VAs and VSAs of the ASA remains in the Pilbara bioregion, and also in the Chichester and Fortescue subregions (GOWA, 2019). This is also the case for the remaining extents in the Shire of Ashburton. Based on these current remaining extents, the regional significance of the VAs and VSAs of the ASA is low.

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Table 5.2: *Seringia exastia* located in the ASA and MDIOM

Conservation significant species	Rank	Plants in MDIOM						Populations		Distribution	ALA records (WA only)
		ASA DS	ASA TFS	Maia DS (2022)	*ecologia* (2008)	DBCA (excluding Maia and other duplicates)	Total	ASA	MDIOM		
Seringia exastia	T	2	10	7	4	0	23	1	4	Much of WA (**Table 5.1)**	296

Notes: Rank – T = Threatened. ASA = Additional Survey Areas, MDIOM = Mulga Downs Iron Ore Mine; ALA = Atlas of Living Australia (ALA, 2023). DS = detailed survey, TFS = targeted flora surveys. Population numbers were determined by buffering records for a particular species in the ASA and MDIOM by 500 m. Discrete, non-touching polygons are counted as separate populations.

Table 5.3: Remaining Pilbara bioregion extent of the land systems of the ASA

Column 1	2	3	4	5	6
Land system	Mapped extent in Pilbara bioregion (ha)	Current extent in the Pilbara bioregion (ha)	Remaining extent (%)	Current extent protected for conservation IUCN I-IV (ha)	Current extent protected for conservation IUCN I-IV against mapped extent (%)
Boolgeeda	961,637.09	955,011.33	99.31	134,033.02	13.94
Brockman	74,108.02	74,102.33	99.99	1.72	0.00
Hooley	59,081.14	59,081.14	100.00	0.00	-
Jurrawarrina	66,474.69	66,431.76	99.94	557.18	0.84
McKay	426,144.89	424,812.89	99.69	32,634.28	7.66

Note: Column 2 - Pilbara IBRA 7 bioregion (DCCEEW, 2021a) intersected with Land Systems (LS) (DPIRD, 2022). Column 3 - LS shapefile (DPIRD, 2022) intersected with NVE shapefile (DPIRD, 2020). Column 4 = Column 3 / Column 2 * 100. Hectares (ha) - rounded up or down to nearest two decimal numbers.

Local Significance

Local significance of the land systems and VSAs occurring in the ASA is based on the cover of each land system or VSA in the ASA with respect to how much of its current Pilbara extent is in the ASA.

Land Systems

The percentage of the current Pilbara extent of the five land systems that occur in the ASA (**Table 5.4**) is less than 0.1% (ranging from 0.01% (Boolgeeda) to 0.08% (Hooley)). Based on this data the local significance of the land systems in the ASA is not high.

Pre-European Vegetation

The percentage of the current Pilbara extent of the four VSAs in the ASA (**Table 5.5**) ranges from 0.01% (VSAs 29 and 173.2) to 0.03% (VSA 562). Based on this data the local significance of the VSAs of the ASA is not high.

Table 5.4: Proportion of mapped and local extent of the land systems of the ASA

Column 1	2	3	4	5
Land system	Current extent in Pilbara bioregion (ha)	Current extent in the ASA (ha)	Percent of current Pilbara extent in the ASA	Cover of LS in the ASA (%)
Boolgeeda	955,011.33	49.00	0.01	20.28
Brockman	74,102.33	13.53	0.02	5.60
Hooley	59,081.14	44.45	0.08	18.40
Jurrawarrina	66,431.76	42.37	0.06	17.54
McKay	424,812.89	92.26	0.02	38.19
Total		**241.61**		**100**

Note: ASA = Additional Survey Areas; LS = Land System. Column 2 - Pilbara IBRA 7 bioregion (DCCEEW, 2021a) intersected with LS (DPIRD, 2022) and intersected with Native Vegetation Extent (NVE) (DPIRD, 2020). Column 3 - LS shapefile (DPIRD, 2022) intersected with NVE shapefile (DPIRD, 2020) and then with the ASA. Column 4 = Column 3 / Column 2 * 100. Column 5 = Column 3 / total area of the ASA * 100. Hectares (ha)- rounded up or down to nearest two decimal numbers.

Table 5.5: Proportion of mapped and local extent of the pre-European vegetation system associations of the ASA

Column 1	2	3	4	5
Pre-European VSA	Current extent in the Pilbara (ha)	Current extent in the ASA (ha)	Percentage of current Pilbara extent in the ASA	Cover of VSA in the ASA (%)
29	877,652.90	103.89	0.01	43.00
173.2	1,124,734.22	100.78	0.01	41.71
175.3	68,175.03	10.26	0.02	4.25
562	103,351.05	26.68	0.03	11.04
Total		**241.61**		**100**

Note: ASA = Additional Survey Areas; VSA = vegetation system association. Column 2 data from GOWA (2019). Column 3 = pre-European vegetation mapping shapefile (DPIRD, 2021) intersected with NVE shapefile (DPIRD, 2020) and then with the ASA. Column 4 = Column 3 / Column 2 * 100. Column 5 = Column 3 / total area of ASA * 100. Hectares (ha) - rounded up or down to nearest two decimal numbers.

5.2.2 Vegetation Types Mapped by Maia in the ASA

Nine of the 10 vegetation types mapped in the ASA could be considered locally significant for different reasons (currently listed threatened flora located in them, drainage areas, sheet flow vegetation, being in an ESA (the Fortescue River) or a part of a Ramsar wetland addition). **Table 5.6** lists the key attributes for each of the vegetation types mapped in the ASA. AaAxSL does not have any attributes to raise its local significance.

Vegetation type ASL (2) is mapped along major and minor drainage lines and associated flood plains of the RDA and SF.

Vegetation types AWL (1), AWL (2) and AWL (3) are dominated by mulga. AWL (1) is mapped over areas of both banded and non-banded mulga, while AWL (2) and AWL (3) is mapped over areas of non-banded mulga. Mulga, and especially areas of banding could be susceptible to changes in surface water flow during high rainfall events.

Vegetation types AxAsSL and EfEbTG are mapped within the Fortescue River system ESA section of the WP and in the area proposed to be added to the Ramsar wetland and are therefore regarded as significant. The habitat is low-lying and can be seasonally inundated and the riparian vegetation type is considered locally significant because it is habitat specific. EfEbTg is also mapped in the eastern section of the WP in the WAMA and some of this area is in the buffer for the P1 PEC Freshwater Claypans of the Fortescue Valley'. This area was part of Maia's MBSA and was assessed and mapped for that work (Maia, 2022). EfEbTg was not one of the vegetation types mapped in the more obvious clay pan PEC area to the southeast of the eastern section of the WP, which was predominantly Acacia and Eucalyptus Low Open Woodland and Bergia Forbland (and a mosaic of the two), rather than Tussock Grassland.

Each of the 10 vegetation types occurs outside the ASA and outside of the larger MBSA assessed by Maia previously.

5.2.3 Other Significant Vegetation

Significant vegetation is defined in EPA Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016b) as vegetation:

- Being identified as threatened or priority ecological communities.
- Restricted distribution.
- Degree of historical impact from threatening processes.
- A role as a refuge.
- Providing an important function required to maintain ecological integrity of a significant ecosystem.

These dot points are discussed with respect to the vegetation of the ASA in the following sections.

Significant Ecological Communities and the ASA

The ASA does not lie in or close to a federally listed TEC, and none of the Pilbara TECs protected by the BC Act occur in or close to the ASA.

The eastern-most 0.21 km section of the WP lies over a small part of a large polygon indicating an occurrence of the P1 PEC 'Freshwater claypans of the Fortescue Valley' PEC (**Map 9.6, Section 9**). However, that section of the WP was assessed as part of the MBSA (Maia, 2022; and see text above).

Table 5.6: Key attributes of the vegetation types mapped in the ASA

Vegetation type (VT) code	Cover in the ASA		Conservation significant flora in VT	Average VT condition (quadrats)	Pre-European vegetation system association/s	Land system/s	Any other key attributes increasing conservation value?	Does VT occur outside the ASA and MDIOM?
	ha	%						
AaAxSL	10.30	5.31	None	Excellent	173.2, 562	Bgd, Mck	No	Yes
ASL (2)	31.69	16.35	None	Excellent	173.2, 562	Bgd, Mck	Drainage	Yes
AWL (1)	15.12	7.80	None	Degraded	29	Jur	Mulga, sheet flow	Yes
AWL (2)	8.74	4.51	None	Good	29, 562	Bgd, Jur, Mck	Mulga, ?sheet flow	Yes
AWL (3)	4.87	2.51	None	Good	29, 562	Bgd, Jur, Mck	Mulga, ?sheet flow	Yes
AxAsSL	17.48	9.02	None	Good	29, 175.3	Bro, Hoy, Jur	ESA (Fortescue River), proposed Ramsar wetland addition	Yes
EfEbTG	5.19	2.68	None	Good	29, 175.3	Bro, Hoy	ESA (Fortescue River), proposed Ramsar wetland addition, P1 PEC	Yes
MTG (3)	2.64	1.36	None	Good	29, 175.3	Bro, Hoy	Proposed Ramsar wetland addition	Yes
THG (1)	55.65	28.72	Se	Excellent	29, 173.2, 562	Bgd, Jur, Mck	No	Yes
THG (2)	26.41	13.63	Se	Very Good	29, 173.2, 562	Bgd, Jur, Mck	No	Yes
Disturbed	15.71	8.11	NA	Degraded				
Total	**193.80**	**100**						

Notes: ASA = Additional Survey Areas. Se (T) = *Seringia exastia* (Threatened). Land system codes: Bgd = Boolgeeda; Bro = Brockman; Hoy = Hooley; Jur = Jurrawarrina; Mck = McKay. MDIOM = Mulga Downs Iron Ore Project areas assessed by Maia.

Restricted Distribution, Historical Impact and Refugia

Restricted Distribution

MTG (3) is the only vegetation type mapped over less than 2% of the ASA (in the WP corridor only). However, it is mapped over 5.7% of the EMA and 1.4% of the combined MDIOM areas mapped by Maia (i.e., the MBSA and ASA, excluding additional bits of the EMA); the only vegetation type mapped over less than 2% of the EMA is AaAxSL (mapped over 1.1%). Both of these vegetation types have been recorded by Maia outside the MDIOM and ASA and are not restricted to the ASA or EMA. Vegetation similar to MTG (3) with mixed tussock grasslands dominated by *Eragrostis xerophila* and *Eriachne benthamii* and *Acacia synchronicia* and **Vachellia farnesiana* shrubs occurs to the north of the MDIOM and ASA on Mount Florence and Coolawanyah stations. Vegetation similar to AaAxSL with *Acacia xiphophylla* Tall Shrubs and *Eremophila cuneifolia* shrubs has been recorded by Maia on Mulga Downs station north and east of the MDIOM and ASA.

Historical Impact

Historical impact is gauged by the current extent of the pre-European VSAs and land systems mapped in the ASA (and in the wider area). As more than 99% of the VSAs and land systems of the Pilbara currently remain, the historical impact from vegetation clearing is low. However, locally, vegetation has been cleared for roads and tracks and parts of drill lines in the WP and these are not captured in the current native vegetation extent data; no clearing is shown for any of the ASA (or the EMA) on the latest native vegetation extent data layer (DPIRD, 2020). **Table 5.7** presents information on clearing carried out in the different VSAs of the ASA; there has been no clearing in the RDA and SF sections of the ASA and clearing for roads and tracks in the WP section has been digitised. Using this data one of the VSAs (173.2) of the ASA has not been impacted by clearing, while the current extent of VSAs 29, 175.3 and 562 has been impacted by 18.9%, 15.0% and 8.1% respectively; however, the bulk of the clearing has been for the existing tracks and roads in the WP.

Refugia

No refugia are known in the Chichester subregion (Kendrick and McKenzie, 2001), while two are listed for the Fortescue subregion – Millstream wetlands and gorges of the Fortescue River within the Chichester ranges (Kendrick, 2001); these refugia do not occur in or close to the ASA. The drainage lines and SF and to a lesser degree the RDA) Densely vegetated drainage lines and shaded gullies in the SF and RDA could potentially provide refuge; however, the drainage lines are not particularly large, the vegetation is not very dense and there are no steep gorges.

Table 5.7: Current clearing of pre-European vegetation system associations in the ASA

Column 1	2	3	4
Vegetation system association (VSA)	Current extent in the ASA (ha)	Current clearing in the ASA (ha)	Clearing as a percentage of the VSAs current extent in the ASA
29	103.89	19.69	18.95
173.2	100.78	0	0
175.3	10.26	1.54	15.01
562	26.68	2.16	8.10
Total	**241.61**		

Note: ASA = Additional Survey Areas.

Note: Column 2 data as in **Table 5.5**. Column 3 = pre-European vegetation mapping shapefile (DPIRD, 2021) intersected with Maia cleared areas mapped in the ASA. Column 4 = Column 3 / Column 2 * 100.

Groundwater Dependent Ecosystems and Sheet Flow Dependent Vegetation

Groundwater Dependent Ecosystems

As the ASA involves areas to be cleared for a pipeline, road diversion and solar farm, which should not involve any changes to the water table, groundwater dependent ecosystems are not discussed.

Sheet Flow Dependent Vegetation

Maslin and Reid (2012) recognise 12 mulga species and three of the 12 have been recorded in the ASA: *Acacia aptaneura, A. ayersiana*, *A. incurvaneura,* (**Appendix 5**). The WP section of the ASA comprises some gently sloping hardpan gravelly or stony plains of the Jurrawarrina land system (**Map 9.3C, Section 9**), and groves and bands of mulga can be seen in the EMA in this section of the WP (**Map 9.15**). Vegetation types AWL (1), AWL (2) and AWL (3) are mapped in these areas. While very little banded mulga can be seen in the WP, it is mostly in the EMA beyond the WP, any alteration to sheet flow in these areas could affect the health of the mulga, particularly down slope of any sheet flow altering structures. As the main track already exists in the WP, it has been there for many years, and its alignment is almost at right angles to the obvious bands of mulga (rather than parallel to them), it is unlikely that a pipeline would affect the mulga more than the existing track already does (although Maia has no detailed information on the actual pipeline proposed).

6 Limitations, Project Team and Licences

6.1 Limitations

Technical Guidance, Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016b) states that any survey-specific issues / limitations should be addressed in a limitations section and that the limitations should be addressed as standard, whether they were a limitation of the survey or not. **Table 6.1** addresses any survey-specific issues / limitations.

Table 6.1: Survey limitations

Limitation	Comment
Availability of contextual information at a regional and local scale	**No limitation**
	The surrounding areas have been well surveyed via detailed and other surveys carried out for a number of projects including the MDIOM. Maia has carried out desktop assessments for and detailed surveys in the adjacent tenements (Maia, 2021a, 2021b and 2022). DBCA database searches were carried out to gather recent data on CSF and significant vegetation known to occur in the area. Pre-European vegetation mapping and land system mapping are also available for the Pilbara.
Competency /experience of the team carrying out the survey, including experience in the bioregion surveyed	**No limitation**
	Scott Hitchcock has more than 12 years of experience in the Pilbara bioregion and of carrying out surveys on Mulga Downs Station and in the surrounding areas. He has been the field team leader on all surveys carried out by Maia in the MDIOM and associated transport corridors. Botanists with less than five years of experience either accompanied Scott while assessing quadrats or worked close by. The specimens collected were identified by Conrad Slee who has about 20 years of experience in taxonomy of the WA flora generally and the Pilbara flora specifically.

Limitation	Comment
Proportion of flora recorded and/or collected, any identification issues	**Potential limitation**
	Seventy-nine taxa from 22 families and 45 genera were collected during the February survey in the ASA. Of these 3% were annual taxa and 97% perennial, and 30% of the species list was identified from specimens collected with reproductive material (flowers / fruit). A specimen, or in some cases multiple specimens, for each of these taxa was collected from the ASA. Vascular flora taxa were recorded during the surveys, and most of the collections were determined to species, variety or subspecies level. As the survey was carried out in February and after only average rainfall in the preceding months the proportion of annual taxa is low.
Was the appropriate area fully surveyed (effort and extent)	**Minor limitation**
	A detailed flora and vegetation survey was carried out over the RDA and SF areas and a targeted flora along the WP. Vegetation types were mapped in the WP and a wider EMA using data from quadrats previously assessed within the wider EMA.
Access restrictions within the survey area	**Minor limitation**
	Most of the ASA was accessed using existing station tracks, exploration tracks and drill lines. However, the southern section of the WP is in the Wittenoom Asbestos Management Area and could not be surveyed. Localised heavy rainfall affected the area just before and on the first day of the survey, and this meant that some low-lying areas along the WP were under water and could not be assessed.
Survey timing, rainfall, season of survey	**Potential limitation**
	Rainfall deciles mapped for the three months before the survey month were average in and around the ASA. Only 2.4 mm of rain was recorded at Karijini North in November and December but 103.6 mm in January; however, most of this fell over the last two weeks of January. This is probably why the percentage of annual species in the species list is low; there was not enough time between the rain falling and the survey being carried out in late February for seeds to germinate and grow – and on top of this only 4.8 mm was recorded at Karijini North in February. While the survey was scheduled to be carried out in summer, project timelines had to be considered and it could not be postponed until later, and, even if it had been postponed, rainfall over the following months was lower than the short-term mean for those months. Mulga Downs received more localised rain in early February and over the days before the survey; however, the Mulga Downs rain gauge malfunctioned and the local rainfall records are not available.
Disturbances (fire, flood, accidental human intervention etc.)	**Minor limitation**
	The localised heavy rainfall just before and on the first day of the survey meant that some parts of the WP could not be walked because they were flooded. In flooded areas the botanists walked along the road and as close to the vegetation as they could get to assess it. Fire has affected the vegetation in areas where quadrats were assessed and traverses walked in the ASA; however, not recently. The northern section of the WP was last burnt in 2018 and the SF in 2016 (Northern Australia and Rangelands Fire Information (NAFI), 2023).

6.2 Project Team

The survey was carried out and the report prepared by the botanists listed in **Table 6.2**.

Table 6.2: Project team

Project team			
Name	**Qualification**	**Project role**	**Flora licence numbers (expiry date)**
Christina Cox	PhD	Report	Not applicable
Zoe Benham	BSc Hons	Report	Not applicable
Ryan Woodhouse	BSc	Report	Not applicable
Scott Hitchcock	BSc	Report and field survey	FB62000064-2 (30/04/2023)
Eva Karikis	BSc	Report and field survey	FB62000324 (21/03/2024)
Conrad Slee	BSc	Plant taxonomy	Not applicable

7 Conclusions

7.1 Flora

- Seventy-nine taxa from 45 genera and 22 families were recorded in the ASA. The flora recorded reflects the small areas, the 10 quadrats assessed and the time of year of survey.
- One threatened flora species protected by the EPBC Act was recorded in the SF – *Seringia exastia*, Critically Endangered. However, *S. exastia* as it is now taxonomically described is a widespread species and is listed as Critically Endangered as a result of earlier taxonomy and not scarcity of the currently described *S. exastia*.
- No confirmed or queried priority flora species were located in the ASA.
- No weed species on any of the national weed lists or listed as a declared pest in WA were found in the ASA. Four general environmental weed species were recorded in the WP corridor: *Cenchrus ciliaris* (Buffel Grass), *Cenchrus setiger* (Birdwood Grass), *Malvastrum americanum* (Spiked Malvastrum) and *Vachellia farnesiana* (Mimosa Bush).

7.2 Vegetation

- Six *Acacia* Shrubland/Woodland vegetation types, two Tussock Grassland, two *Triodia* Grassland and disturbed areas were mapped in the ASA.
- The condition of the vegetation was mostly Very Good (53.9%), followed by Good (30.3%) and Excellent (11.5%), while Degraded or Completely Degraded areas were mapped over 4.3% of the EMA. The Degraded and Completely Degraded areas are those already cleared for roads, tracks, or other infrastructure.

7.3 Regional and Local Significance Flora and Vegetation

- While *Seringia exastia* (T) is currently listed under and protected by the EPBC Act, a taxonomic revision of *Seringia* species resulted in it being combined with *Seringia elliptica*, which is a widespread species in WA. It is locally significant because of its historic listing under the EPBC Act rather than because it is threatened and scarce in WA and in the local area.
- The regional and local significance of all five land systems of the ASA is rated as low, as over 99.3% of each currently remains in the Pilbara and less than 0.1% of each of their current Pilbara extents is in the ASA.
- The regional and local significance of the four VSAs mapped in the ASA is rated as low, as over 99.7% of each VSA currently remains in the Pilbara and less than 0.1% of each of their current Pilbara extents is in the ASA.

- Nine of the 10 vegetation types mapped by Maia in the ASA and EMA are potentially locally significant for a variety of reasons (threatened flora located in them, associated with drainage areas, sheet flow vegetation, being in an ESA (the Fortescue River) or a part of a Ramsar wetland addition); however, the 10 vegetation types have been mapped in the parts of the MDIOM assessed by Maia previously and also occur outside the ASA and MDIOM.

7.4 Ecological Communities and Other Significant Areas

- None of the surveyed sections of the ASA lie within or close to a currently listed TEC or PEC; however, the eastern-most 0.21 km section of the WP lies over a buffered occurrence of the Freshwater claypans downstream of the Fortescue Marsh - Goodiadarrie Hills on Mulga Downs Station P1 PEC. That section of the WP lies within the WAMA and could not be surveyed, although, it was part of Maia's MBSA and was included in the report on that area. None of the vegetation types mapped in a more distinctive clay pan PEC area to the southeast of the ASA buffer were mapped in the eastern section of the WP.
- None of the vegetation types recorded in the ASA are the same as any of the currently listed TECs or PECs in the subregion.
- No ESAs, Schedule One Areas, Legislated Lands and Waters or Lands of Interest occur within the surveyed sections of the ASA; however, parts of the unsurveyed WAMA section of the WP lie within an ESA and a Schedule One Area - the Fortescue River DIWA wetland. Some of that area and of the surveyed area to the north lie in the Fortescue Marshes Draft Proposed Ramsar Addition Area.
- The ASA comprises some gently sloping hardpan gravelly or stony plains of the Jurrawarrina land system. Groves and bands of mulga can be seen in the WP extended mapping area and vegetation types AWL (1), AWL (2) and AWL (3) are mapped in these areas. Any groved or banded mulga within the WP could be potentially affected by any alteration to sheet flow in these areas.

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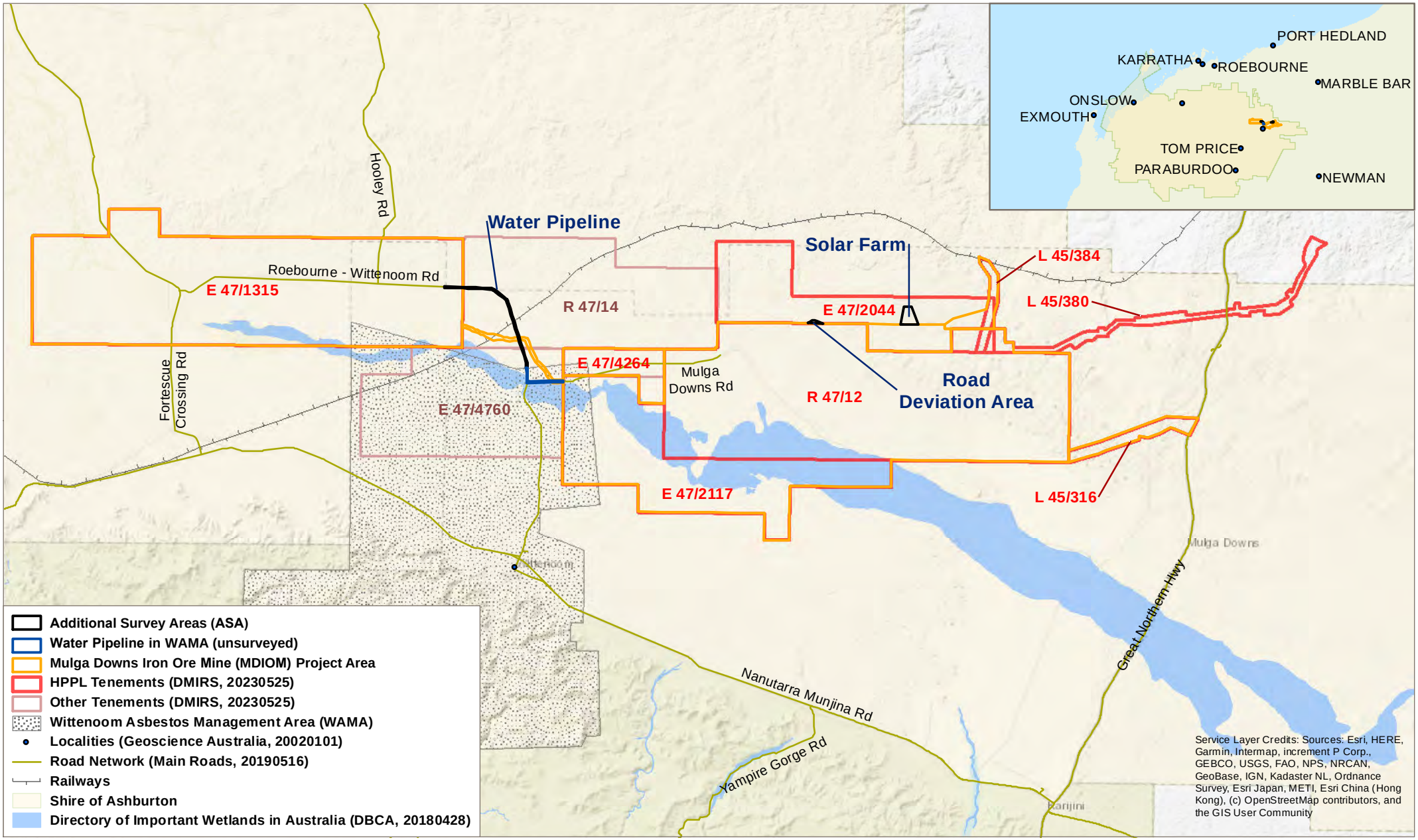
9 MAPS



General Location

N

0 7.5

Kilometres

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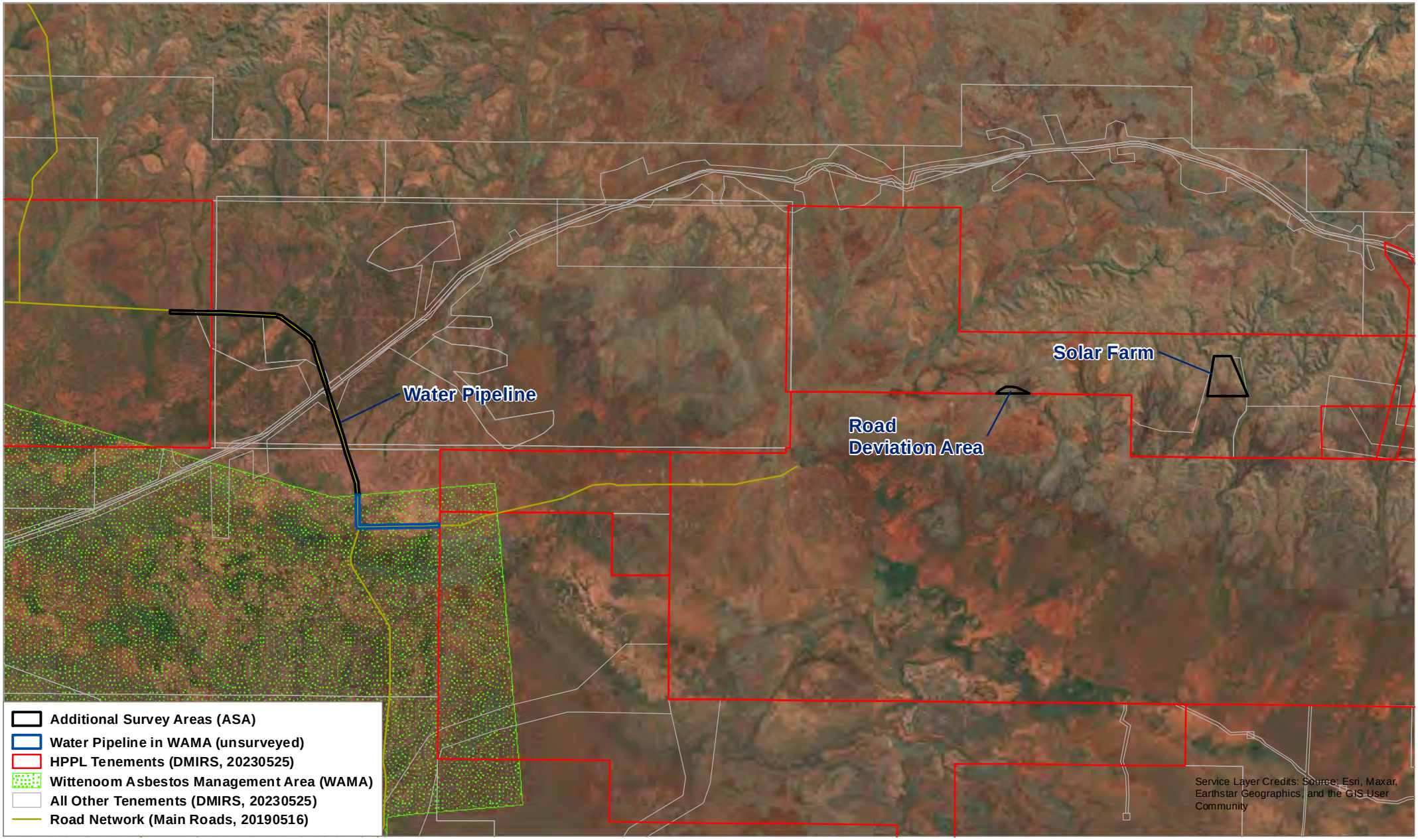
Map: 9.1 **Version:** 1

Prepared for: JBSG

Drawn by: RH

Date: 25/05/2023

Project: 2303 **Size:** A4



Location Map

Additional Survey Areas and the Wittenoom Asbestos Management Area

maia

N

0 3.25

Kilometres

Datum: GDA 1994, MGA 50

Map: 9.2 **Version:** 1

Prepared for: JBSG

Drawn by: RH

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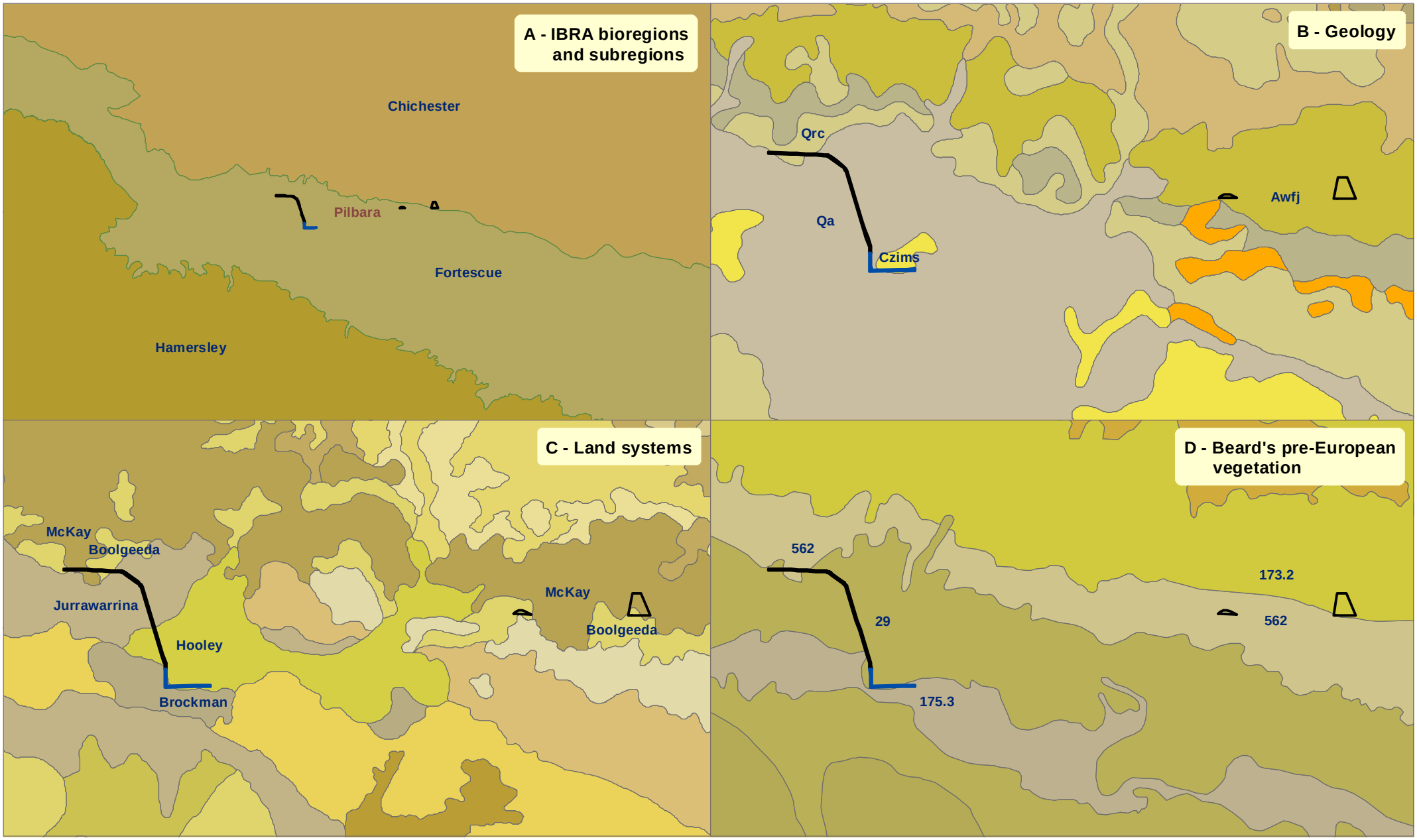
Project: 2303 **Size:** A4



Location Map

Additional Survey Areas (ASA)

ASA in WAMA (unsurveyed)

IBRA Bioregions and Subregions, Geology, Land Systems and Beard's Pre-European Vegetation (Vegetation System Associations)

maia

N

Datum: GDA 1994, MGA 50

Map: 9.3 **Version:** 1

Prepared for: JBSG

Drawn by: RH

Date: 25/05/2023

Project: 2303 **Size:** A4

Previous Maia CSF:

- *Seringia exastia* (T)
- *Calotis squamigera* (P1)
- *Helichrysum oligochaetum* (P1)
- *Triodia veniciae* (P1)
- *Teucrium pilbaranum* (P2)
- *Dolichocarpa* sp. Hamersley Station (A.A. Mitchell PRP 1479) (P3)
- *Eragrostis crateriformis* (P3)
- *Eragrostis* sp. Erect spikelets (P.K. Latz 2122) (P3)
- *Euphorbia australis* var. *glabra* (P3)
- *Glycine falcata* (P3)
- *Rostellularia adscendens* var. *latifolia* (P3)
- *Themeda* sp. Hamersley Station (M.E. Trudgen 11431) (P3)
- *Bulbostylis burbidgeae* (P4)
- *Rhynchosia bungarensis* (P4)
- *Hibiscus* sp. Mulga Downs (TOI)
- *Santalum spicatum* (TOI)

WA Herb 07-0323FL CSF:

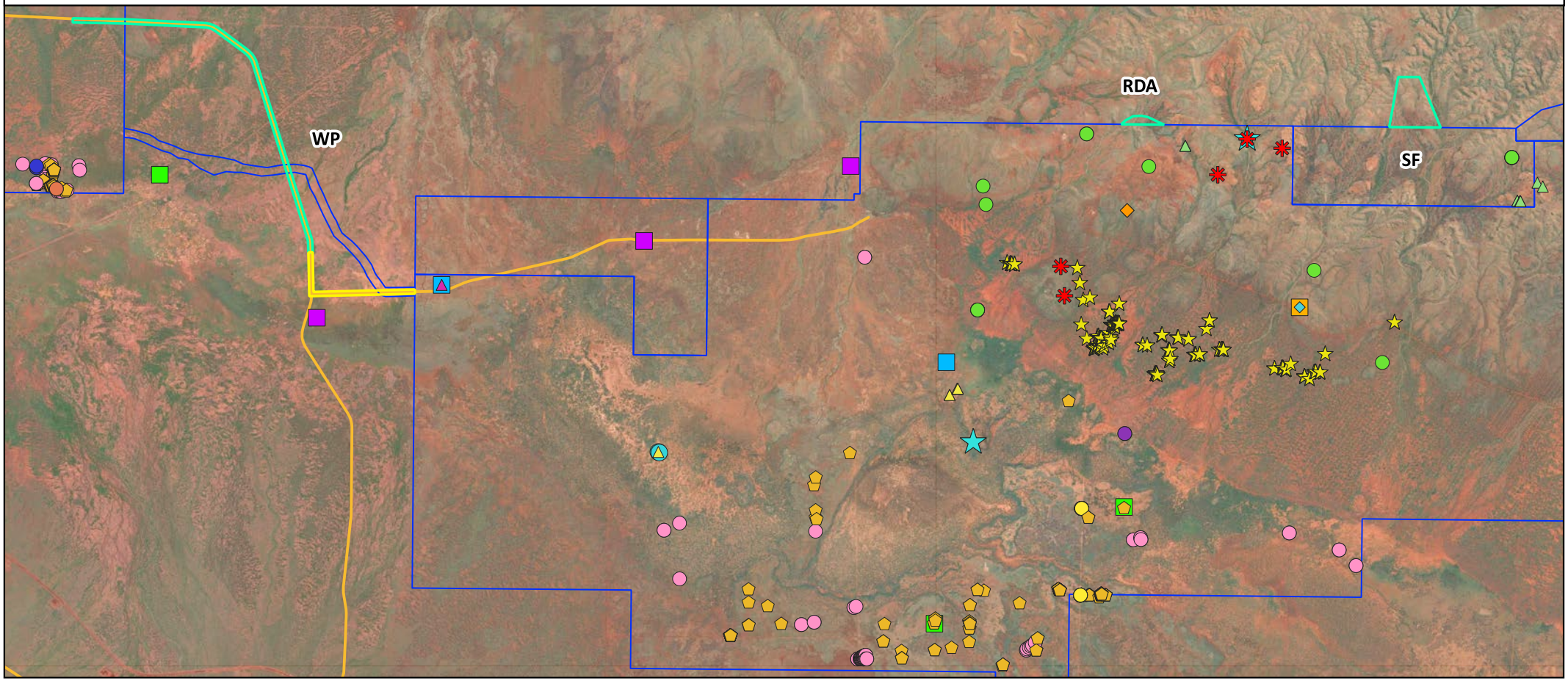
- P1
- P2
- P3
- P4

Additional Survey Areas: (WP = Water Pipeline, RDA = Road Deviation Area, SF = Solar Farm)

WP in WAMA (unsurveyed)

Mulga Downs Iron Ore Project (MDIOP) project area

Road Network (Main Roads, 20190516)



Location Map

Conservation Significant Flora (CSF) Species - Previously Located

maia

N

0 3

Kilometres

Datum: GDA 1994, MGA 50

Map: 9.4 **Version:** 1

Prepared for: JBSG

Drawn by: RW

Date: 21/03/2023

Project: 2303 **Size:** A4

Previous Weeds:

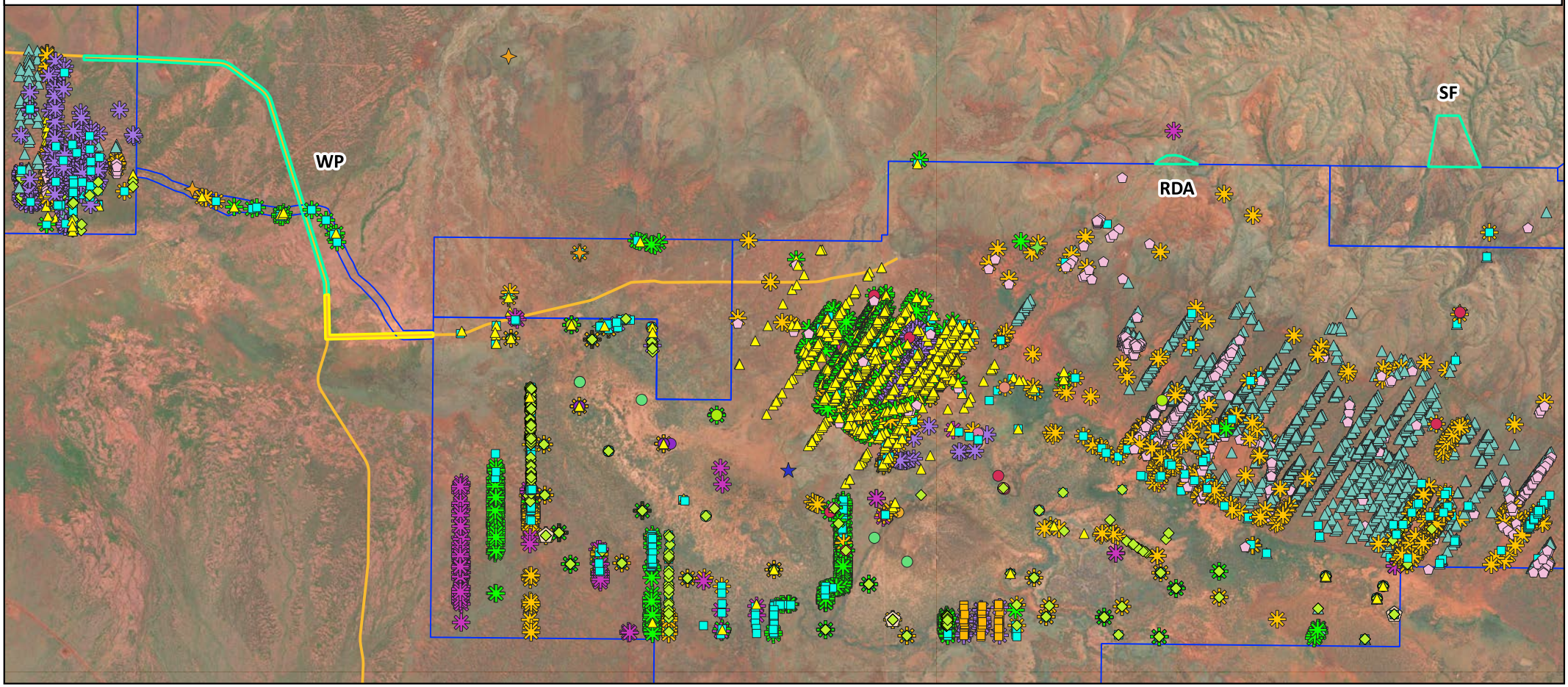
- *Aerva javanica*
- *Bidens bipinnata*
- *Cenchrus ciliaris*
- *Cenchrus ciliaris* and *Cenchrus setiger*
- *Cenchrus setiger*
- *Cenchrus* spp.
- *Chloris virgata*
- *Citrullus amarus*
- *Citrullus colocynthis*
- *Cynodon dactylon*
- *Echinochloa colona*
- *Flaveria trinervia*
- *Malvastrum americanum*
- *Malvastrum americanum* and *Setaria verticillata*
- *Medicago polymorpha*
- *Portulaca oleracea*
- *Portulaca pilosa*
- *Setaria verticillata*
- *Solanum nigrum*
- *Sonchus oleraceus*
- *Tribulus terrestris*
- *Vachellia farnesiana*

Additional Survey Areas: (WP = Water Pipeline, RDA = Road Deviation Area, SF = Solar Farm)

WP in WAMA (unsurveyed)

Mulga Downs Iron Ore Project (MDIOP) project area

Road Network (Main Roads, 20190516)



Location Map

Weed Species - Previously Located

maia

N

0 3

Kilometres

Datum: GDA 1994, MGA 50

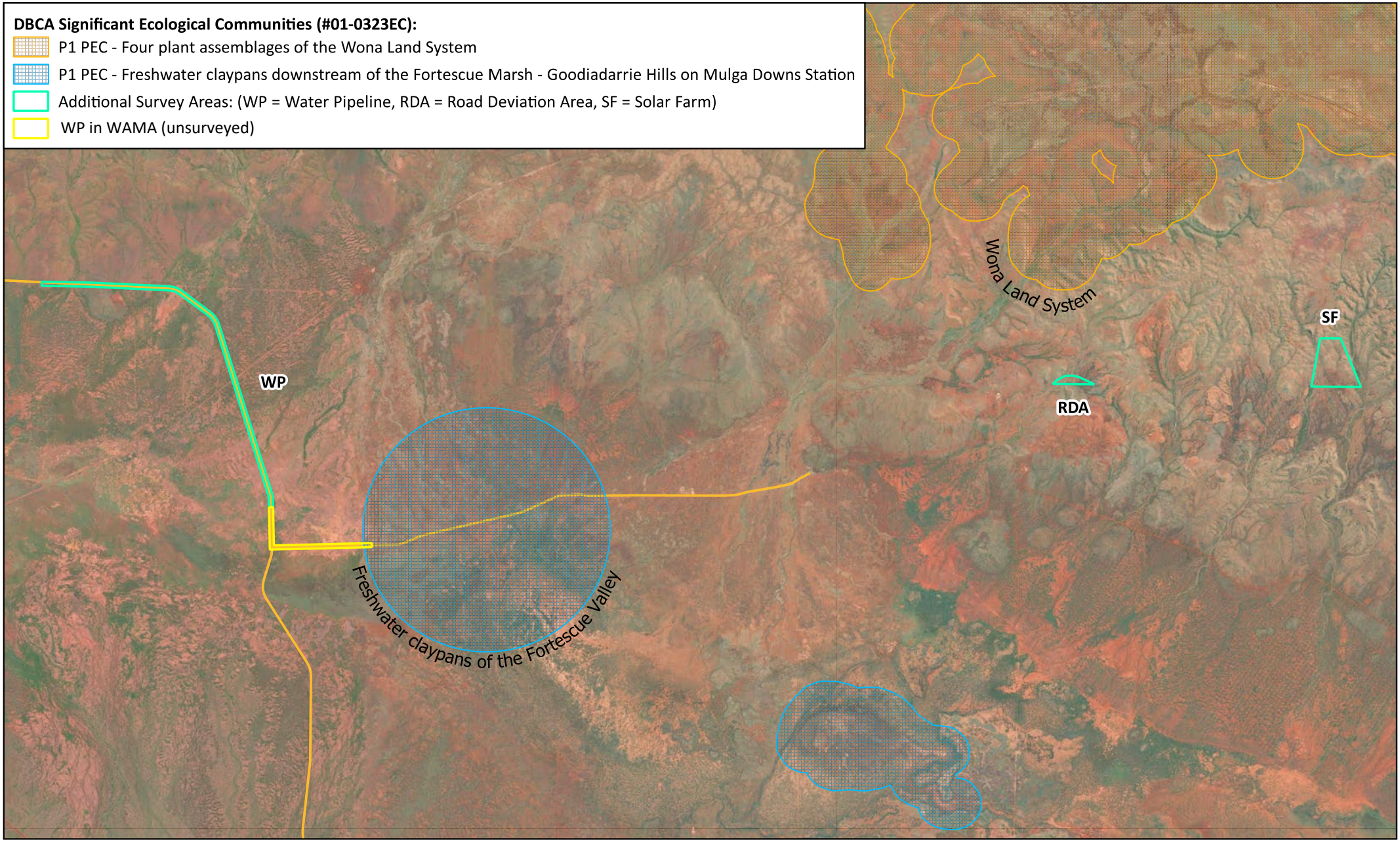
Map: 9.5 **Version:** 1

Prepared for: JBSG

Drawn by: RW

Date: 21/03/2023

Project: 2303 **Size:** A4



Location Map

Service Layer Credits: Sources: Esri, HERE, DeLorme, increment P Corp., NPS, NRCan, Ordnance Survey, © OpenStreetMap contributors, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Significant Ecological Communities (DBCA #01-0323EC)

maia

N

0 3

Kilometres

Datum: GDA 1994, MGA 50

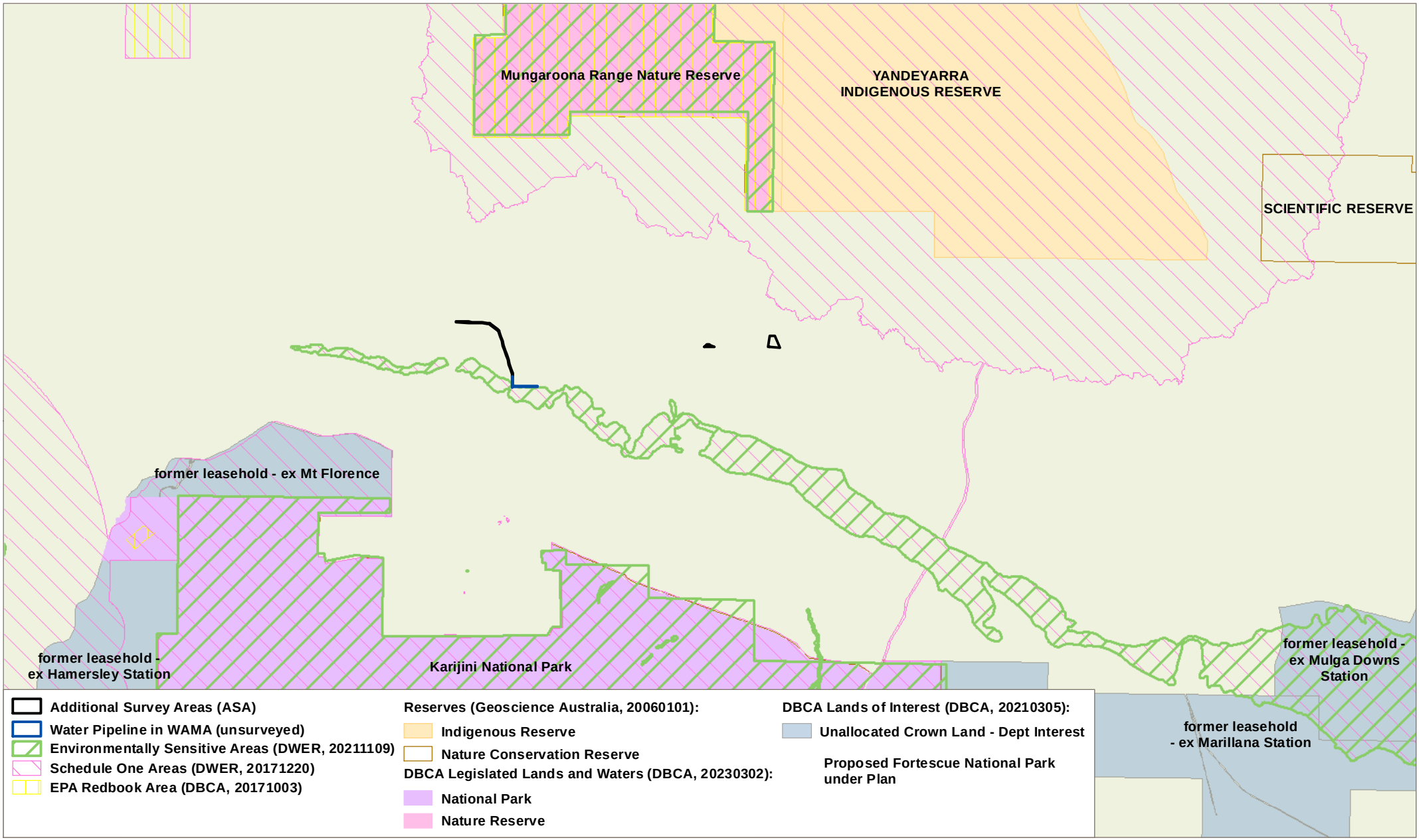
Map: 9.6 **Version:** 1

Prepared for: JBSG

Drawn by: RW

Date: 23/03/2023

Project: 2303 **Size:** A4



Protected and Significant Areas

N

0 10

Kilometres

Datum: GDA 1994, MGA 50

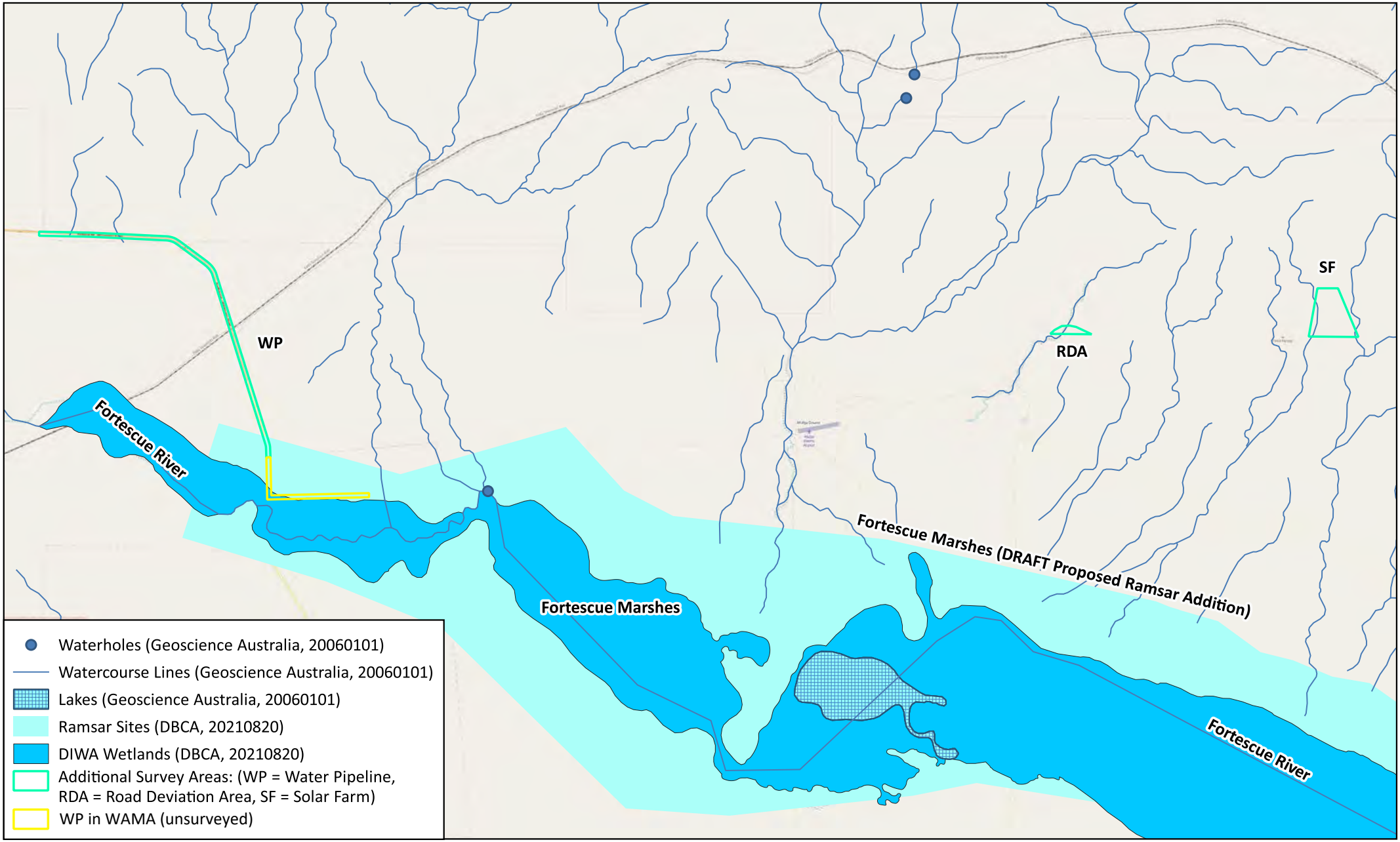
Map: 9.7 **Version:** 1

Prepared for: JBSG

Drawn by: RH

Date: 2/06/2023

Project: 2303 **Size:** A4



Location Map

Service Layer Credits: Sources: Esri, HERE, DeLorme, increment P Corp., NPS, NRCan, Ordnance Survey, © OpenStreetMap contributors, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Watercourses and Wetlands

maia

N

0 3

Kilometres

Datum: GDA 1994, MGA 50

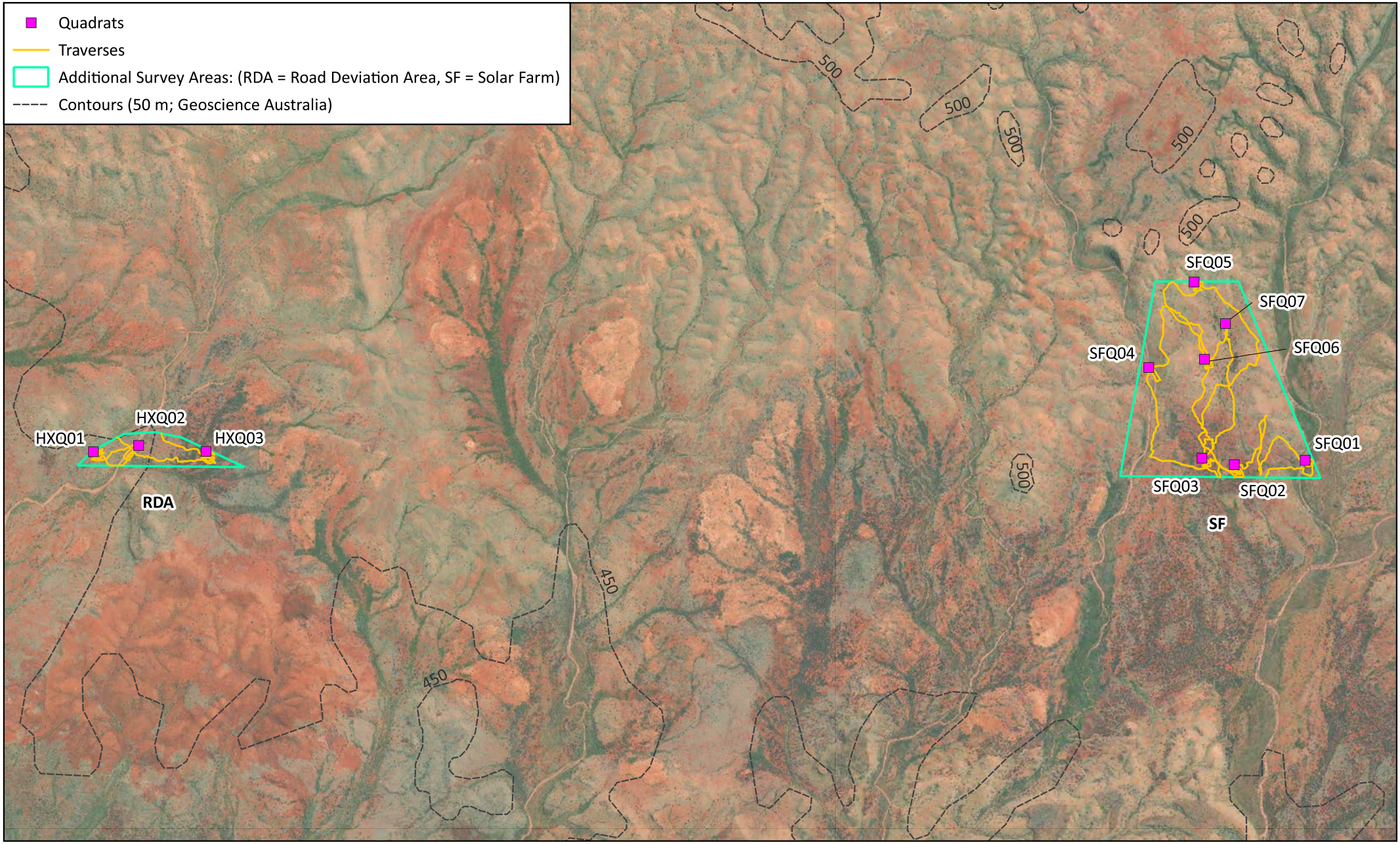
Map: 9.8 **Version:** 1

Prepared for: JBSG

Drawn by: RW

Date: 23/03/2023

Project: 2303 **Size:** A4



Location Map

Service Layer Credits: Sources: Esri, Maxar, earthstar Geographics, and the GIS User Community

Quadrats and Traverses - Road Deviation Area (RDA) and Solar Farm (SF)

maia

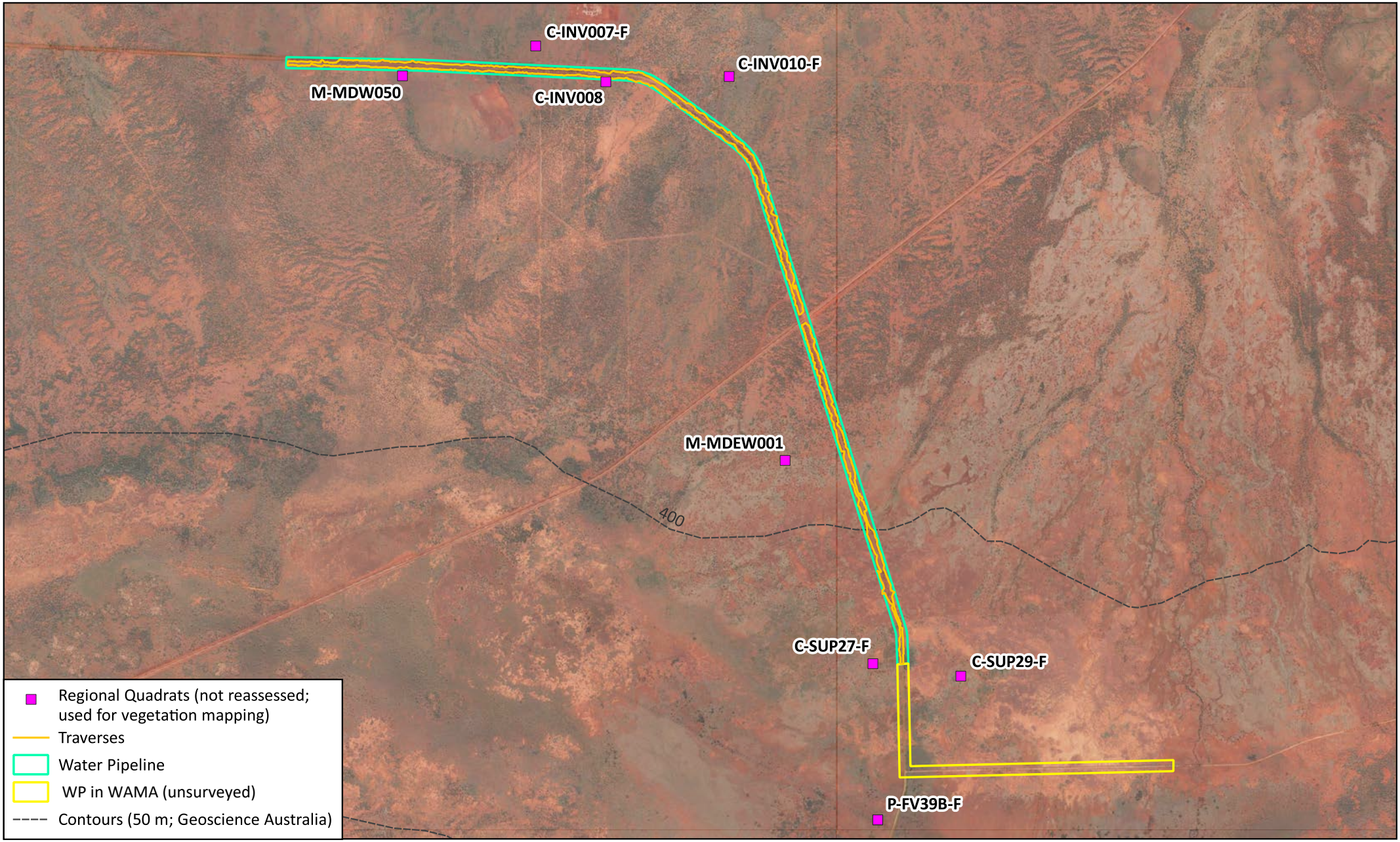
N

0 0.5

Kilometres

Datum: GDA 1994, MGA 50

Map: 9.9 **Version:** 1	
Prepared for: JBSG	
Drawn by: RW	
Date: 23/03/2023	
Project: 2303 **Size:** A4	



Location Map

Service Layer Credits: Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community
Sources: Esri, HERE, DeLorme, increment P Corp., NPS, NRCan, Ordnance Survey, © OpenStreetMap contributors, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS User Community

Regional Quadrats and Traverses - Water Pipeline

maia

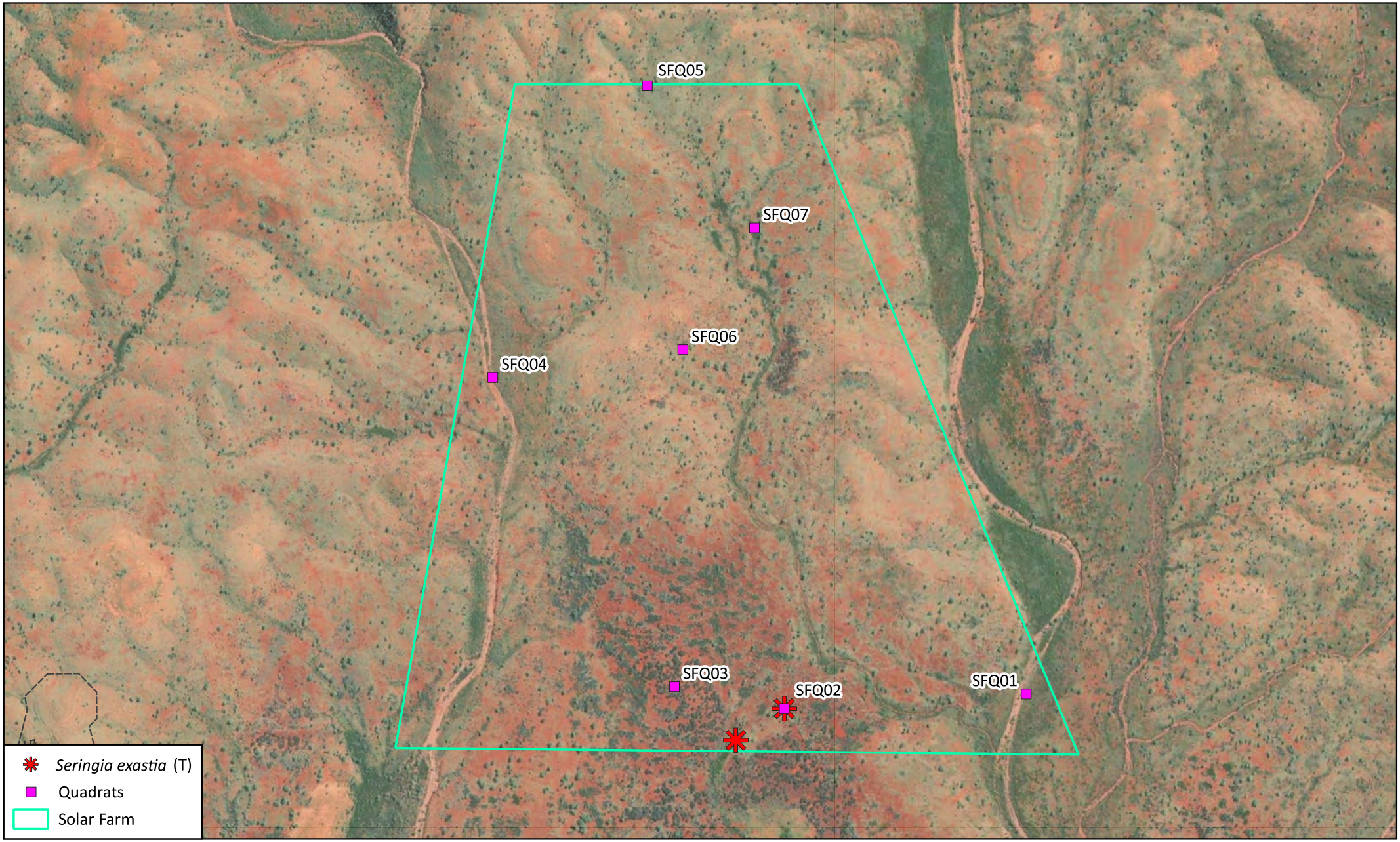
N

0 1

Kilometres

Datum: GDA 1994, MGA 50

Map: 9.10 **Version:** 1
Prepared for: JBSG
Drawn by: RW
Date: 23/03/2023
Project: 2303 **Size:** A4



Location Map

Service Layer Credits: Sources: Esri, Maxar, earthstar Geographics, and the GIS User Community

Seringia exastia (T) Locations

maia

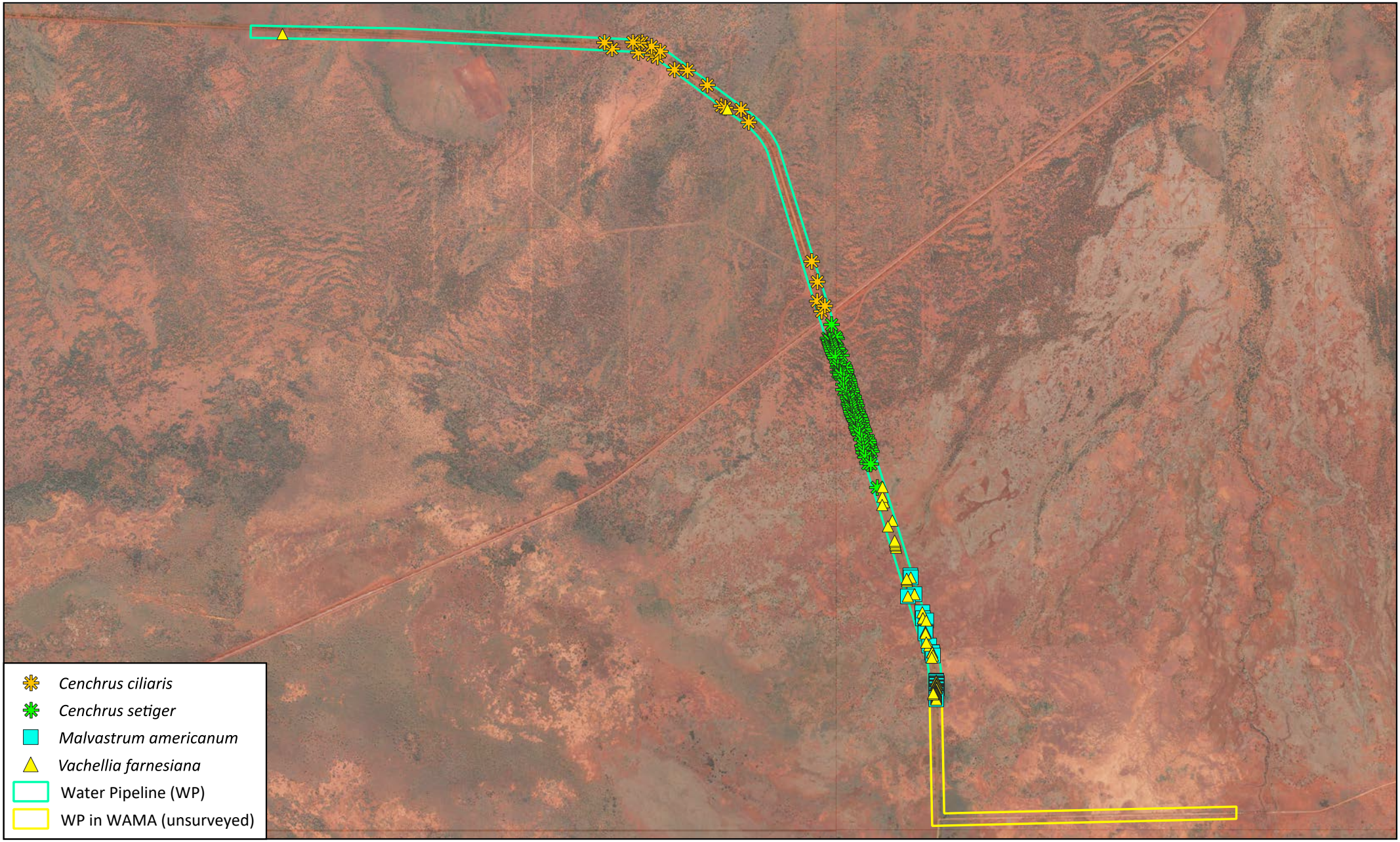
N

0 200

Metres

Datum: GDA 1994, MGA 50

Map: 9.11 **Version:** 1	
Prepared for: JBSG	
Drawn by: RW	
Date: 23/03/2023	
Project: 2303 **Size:** A4	



Location Map

Service Layer Credits: Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Weed Species - Water Pipeline

maia

N

0 1

Kilometres

Datum: GDA 1994, MGA 50

Map: 9.12 **Version:** 1

Prepared for: JBSG

Drawn by: RW

Date: 23/03/2023

Project: 2303 **Size:** A4

Vegetation Mapping:

AaAxSL: Tall Sparse Shrubland of *Acacia aneura* (alliance) and *A. xiphophylla* with a Low Sparse Shrubland of *Eremophila cuneifolia* and a Sparse Hummock Grassland of *Triodia epactia* and/or *T. basedowii.*

ASL (2): Mixed Tall *Acacia* Shrubland mainly of *Acacia tumida* var. *pilbarensis, A. pyrifolia* and A. maitlandii with a Sparse Tussock Grassland of *Themeda triandra* and Low Isolated Trees of *Corymbia hamersleyana* and/or *Eucalyptus victrix.*

AWL (1): Low Woodland / Tall Shrubland to Low Isolated Trees / Shrubs of *Acacia aneura* (complex) *A. maitlandii* Low Sparse Shrubland mainly of *Dodonaea petiolaris, Eremophila forrestii* and *Abutilon otocarpum* and Isolated Low Trees of *A. pruinocarpa.*

AWL (2): Low Woodland / Tall Shrubland to Low Isolated Trees / Tall Shrubs of *Acacia aneura* (complex), *A. synchronicia* and *A. tetragonophylla* with a mixed Low Sparse Shrubland mainly of *Solanum lasiophyllum, Abutilon otocarpum* and *Sida platycalyx* and a Sparse Tussock Grassland to Isolated Tussock Grasses mainly of *Sporobolus australasicus, Enneapogon cylindricus* and *Aristida contorta.*

AWL (3): Low Woodland of *Acacia aneura* (complex), mainly *Acacia aptaneura, A. aneura* and *A. incurvaneura* with a mixed Tall Shrubland mainly of *A. synchronicia, A. tetragonophylla* and *Hakea lorea* subsp. *lorea* with a Sparse Tussock Grassland to Isolated Tussock Grasses mainly of *Sporobolus australasicus, Enneapogon cylindricus* and *Aristida contorta.*

AxAsSL: Tall Sparse Shrubland of *Acacia xiphophylla* and/or *A. synchronicia* with a mixed Sparse Chenopod Shrubland mainly of *Sclerolaena cuneata, S. bicornis, S. cornishiana* and a Sparse Tussock Grassland of *Eragrostis xerophila.*

Disturbed

EfEbTG: Tussock Grassland of *Eriachne flaccida* and *E. benthamii* with Isolated Trees of *Eucalyptus victrix.*

MTG (3): Sparse to Open mixed Tussock Grassland mainly of *Eragrostis xerophylla, Eriachne benthamii,* and *Astrebla lappacea* with a mixed Forbland, mainly of *Stemodia kingii, Operculina aequisepala* and *Cullen cinereum* with Isolated shrubs of *Acacia synchronicia* or *Vachellia farnesiana.*

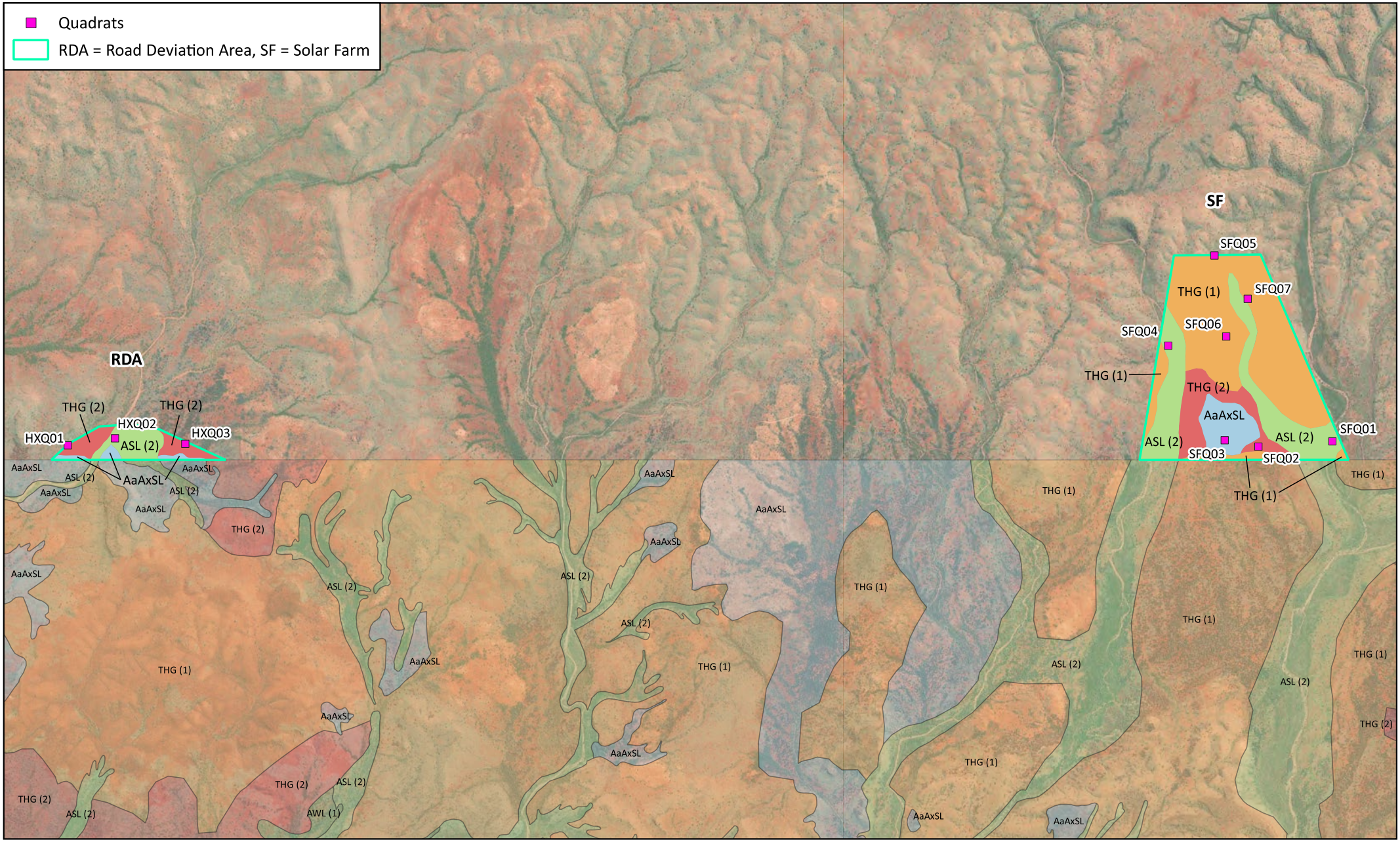
THG (1): Mixed Hummock Grassland mainly of *Triodia basedowii, T. brizoides* and *T. vanleeuwenii,* with a Tall Sparse Shrubland of mixed *Acacia* species mainly *Acacia atkinsiana, A. maitlandii, A. ancistrocarpa* with Low Isolated Trees of *Eucalyptus leucophloia* subsp. *leucophloia* and/or *Corymbia hamersleyana.*

THG (2): Mixed Hummock Grassland mainly of *Triodia basedowii, T. epactia* and *T. vanleeuwenii* with a Sparse mixed Shrubland mainly of *Acacia aneura, A. aptaneura* and *A. atkinsiana* and Isolated Low Trees of *A. pruinocarpa* and/or *Eucalyptus leucophloia* subsp. *leucophloia.*

maia

Vegetation Type Descriptions

Map: 9.13 **Version:** 1
Prepared for: JBSG
Drawn by: RW
Date: 23/03/2023
Project: 2303 **Size:** A4



Location Map

Service Layer Credits: Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Vegetation Types and Quadrats - Road Deviation Area (RDA) and Solar Farm (SF) with Previous Vegetation Mapping

maia

N

0 500

Metres

Datum: GDA 1994, MGA 50

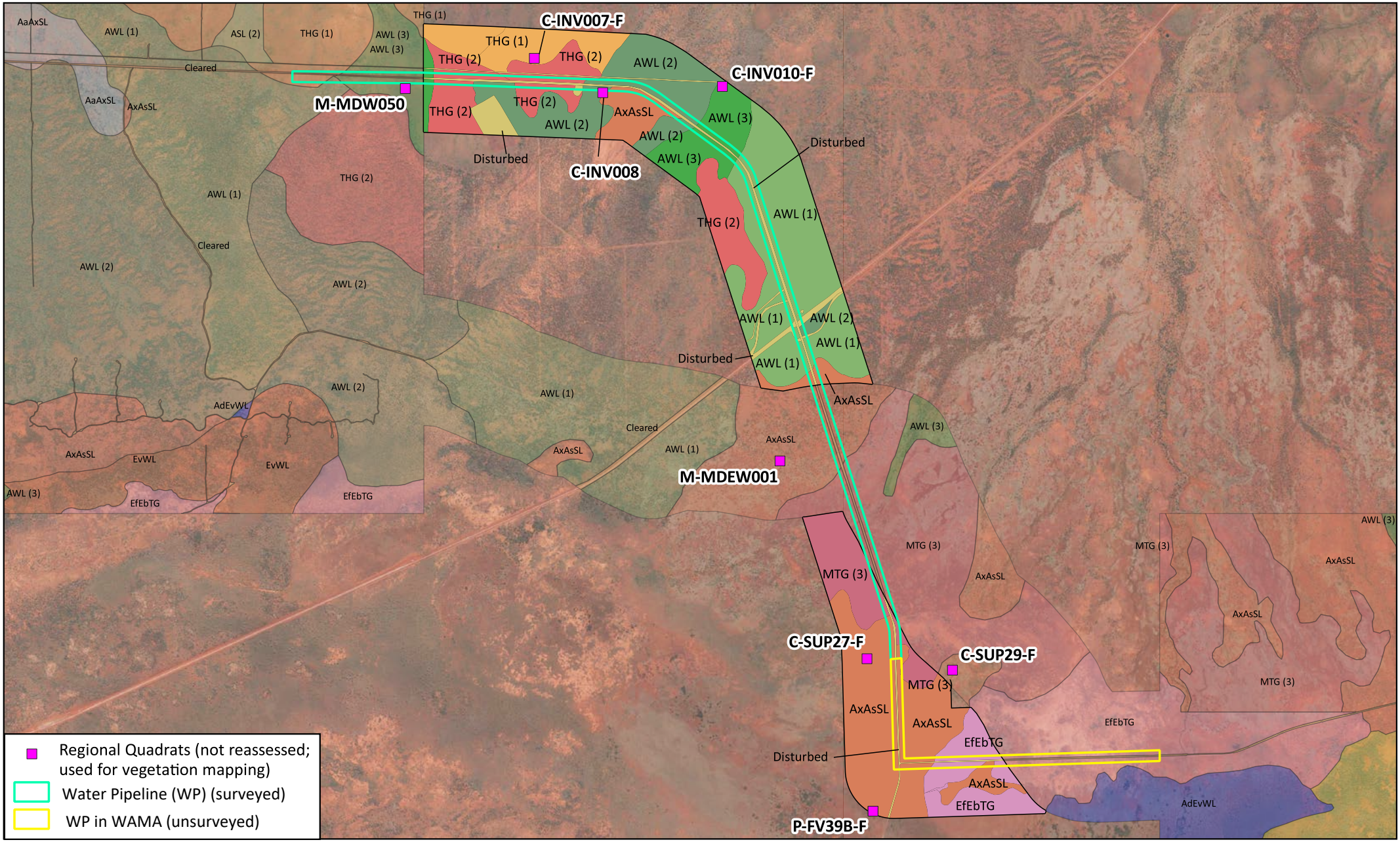
Map: 9.14 **Version:** 1

Prepared for: JBSG

Drawn by: RW

Date: 11/04/2023

Project: 2303 **Size:** A4



Location Map

Service Layer Credits: Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Vegetation Types and Regional Quadrats - Water Pipeline with Previous Vegetation Mapping

N

0 1

Kilometres

Datum: GDA 1994, MGA 50

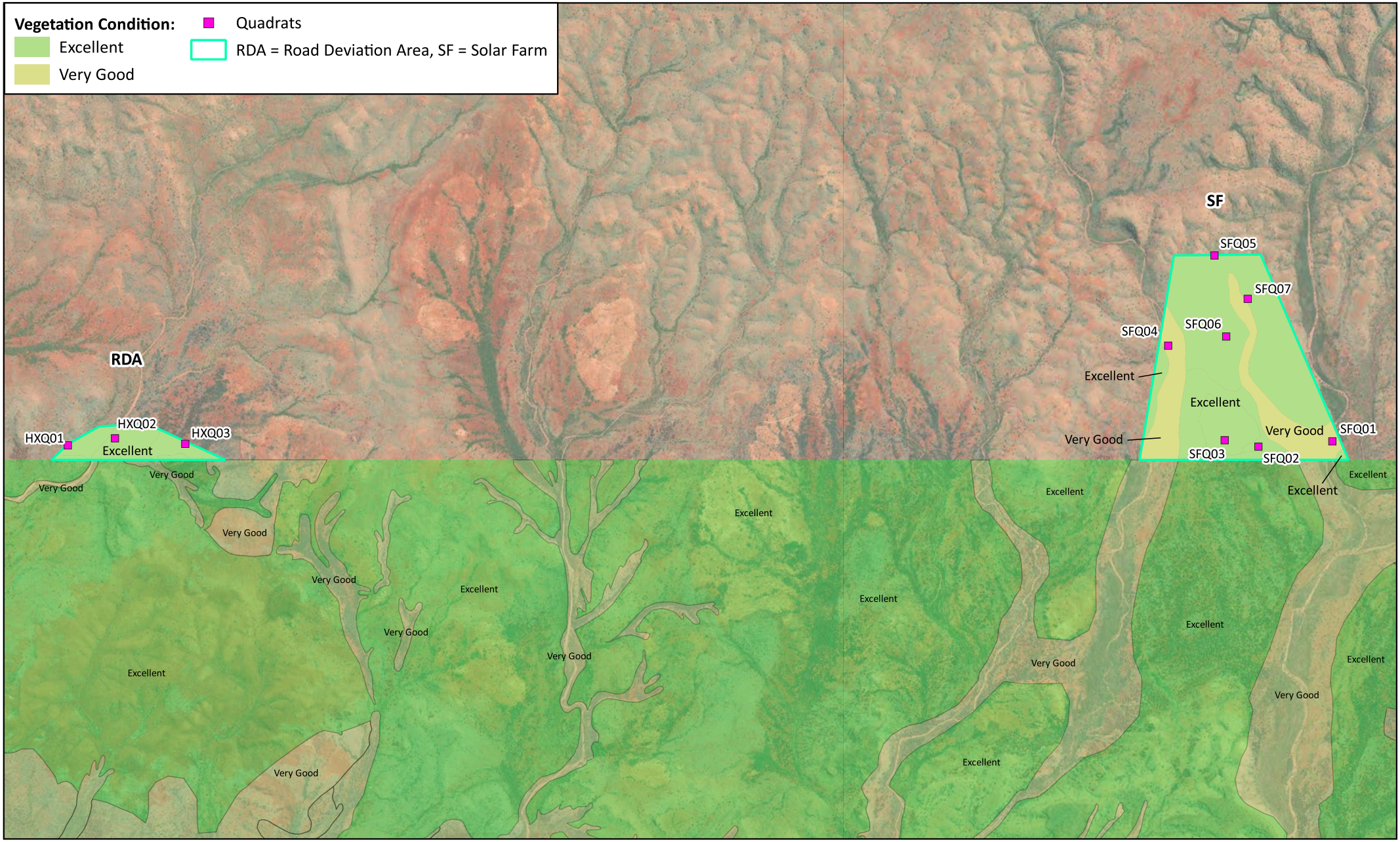
Map: 9.15 **Version:** 1

Prepared for: JBSG

Drawn by: RW

Date: 12/04/2023

Project: 2303 **Size:** A4



Location Map

Service Layer Credits: Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Vegetation Condition and Quadrats - Road Deviation Area (RDA) and Solar Farm (SF) With Previous Condition Mapping

maia

N

0 500

Metres

Datum: GDA 1994, MGA 50

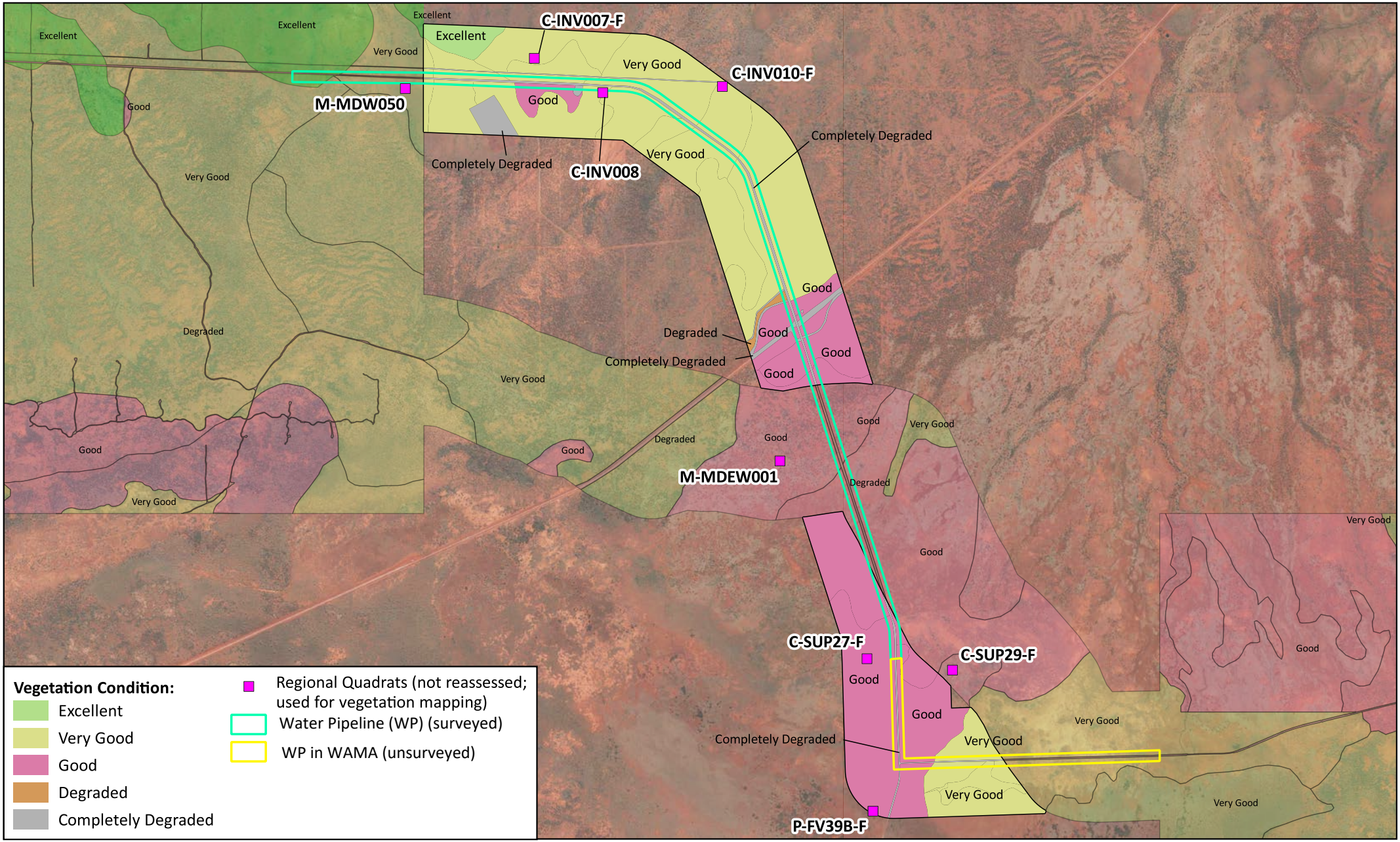
Map: 9.16 **Version:** 1

Prepared for: JBSG

Drawn by: RW

Date: 12/04/2023

Project: 2303 **Size:** A4



Location Map

Service Layer Credits: Sources: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Vegetation Condition and Regional Quadrats - Water Pipeline With Previous Condition Mapping

maia

N

0 1

Kilometres

Datum: GDA 1994, MGA 50

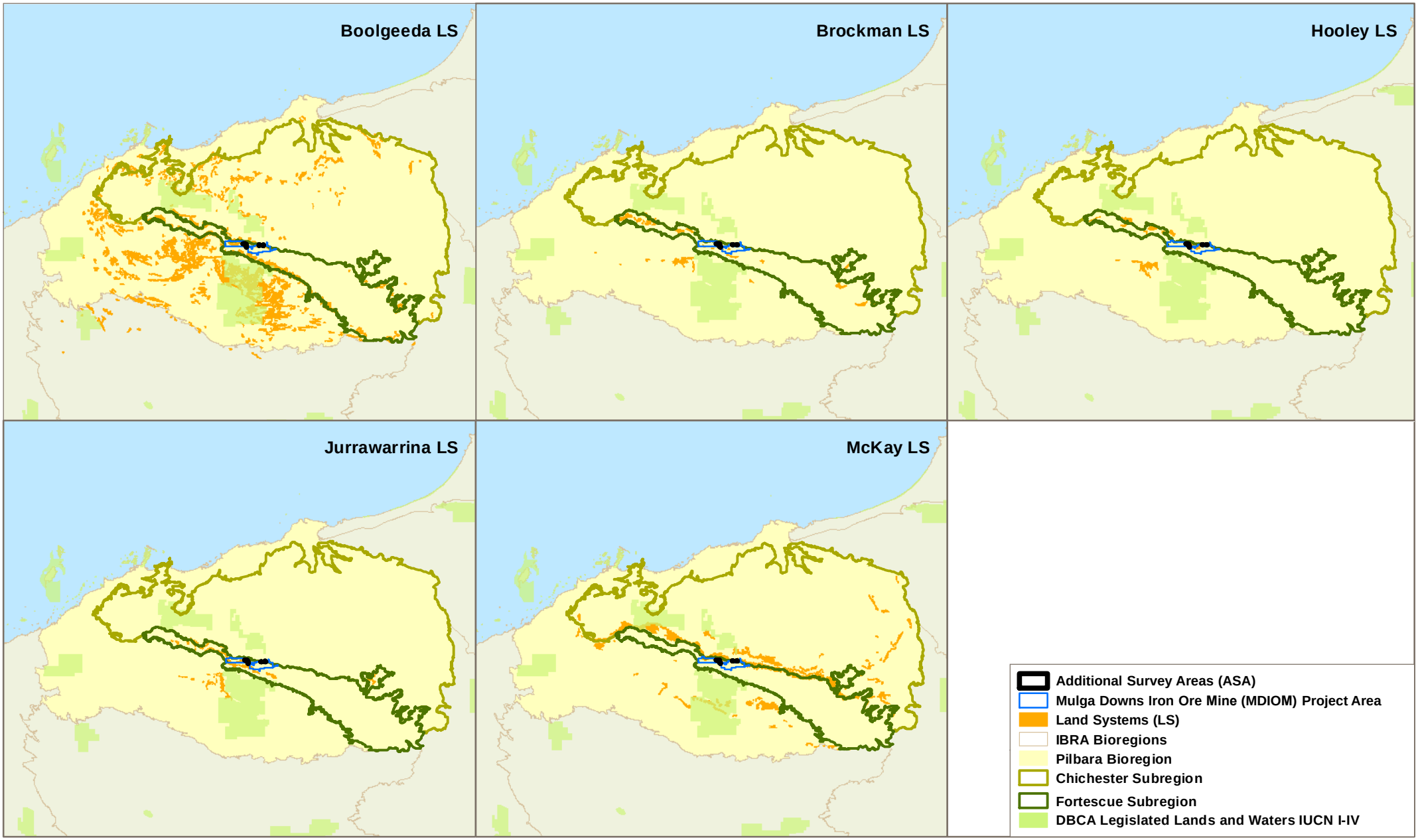
Map: 9.17 **Version:** 1

Prepared for: JBSG

Drawn by: RW

Date: 13/04/2023

Project: 2303 **Size:** A4



Distribution of Land Systems (Pre-European / Originally Mapped Extent) in the Pilbara Bioregion

maia

N

0 42.5

Kilometres

Datum: GDA 1994, MGA 50

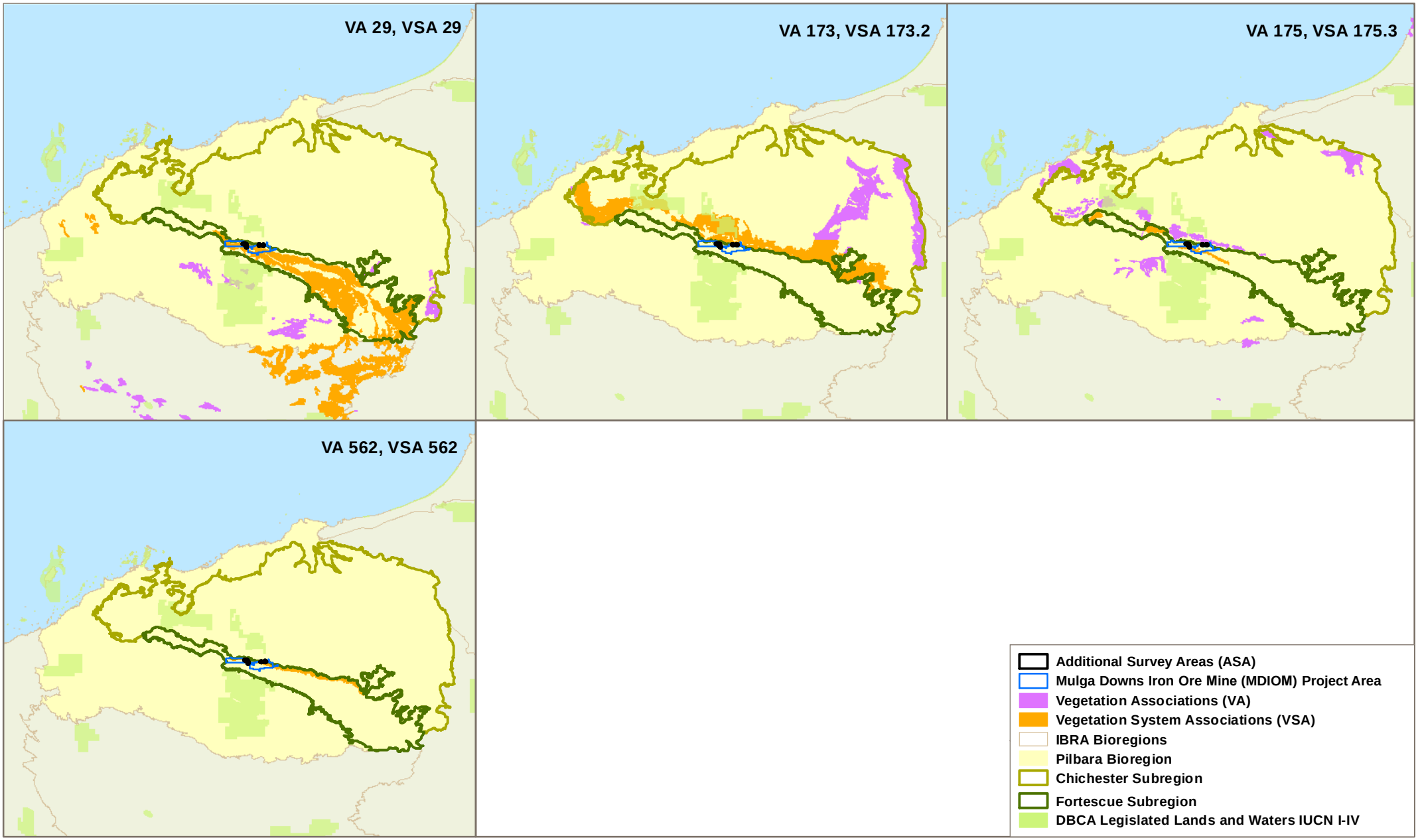
Map: 9.18 **Version:** 1

Prepared for: JBSG

Drawn by: RH

Date: 25/05/2023

Project: 2303 **Size:** A4



Distribution of Vegetation Associations and Vegetation System Associations (Pre-European Extent) in the Pilbara Bioregion

maia

N

0 17.5

Kilometres

Datum: GDA 1994, MGA 50

Map: 9.19 **Version:** 1

Prepared for: JBSG

Drawn by: RH

Date: 25/05/2023

Project: 2303 **Size:** A4

APPENDIX 1: CONSERVATION SIGNIFICANCE (FLORA AND ECOLOGICAL COMMUNITIES)

Threatened Flora

Some flora species can be protected by federal Australian Government legislation (*Environment Protection and Biodiversity Conservation Act 1999*, EPBC Act) or by WA legislation (*Biodiversity Conservation Act 2016*, BC Act) (DCCEEW, 2022a; GOWA, 2016).

Flora species can be protected by Australian Government legislation (EPBC Act) based on the perceived levels of threat to the species population at a national level. Threatened fauna and flora may be listed under Section 178 of the EPBC Act in one of six conservation categories: extinct, extinct in the wild, critically endangered, endangered, vulnerable and conservation dependent (DCCEEW, 2022a). An EPBC Act list of threatened flora can be found on the DCCEEW website (DCCEEW, 2022b).

The WA BC Act provides for the listing of threatened native plants (flora), threatened native animals (fauna) and threatened ecological communities that need protection as critically endangered, endangered or vulnerable species or ecological communities because they are under identifiable threat of extinction (species) or collapse (ecological communities). The BC Act provides a statutory basis for the listing of threatened species, specially protected species, threatened ecological communities, critical habitat and key threatening processes (DBCA, 2022a). The most recent threatened flora list was issued in the WA Government Gazette in September 2018 (GOWA, 2018) and they are included in DBCA's most recent threatened and priority flora list (DBCA, 2022c).

Priority Flora

Possible threatened species that do not meet the criteria for listing under the BC Act because of insufficient survey or are otherwise data deficient, are added to the Priority Flora List under Priorities (P) 1, 2, 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora. Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species list for other than taxonomic reasons, are placed in Priority 4 and require regular monitoring (DBCA, 2020). The most recent priority flora list was issued on 6 October 2022 (DBCA, 2022c).

Threatened Ecological Communities

Some ecological communities are protected by Australian Government legislation (the EPBC Act) based on the perceived levels of threat to the community or species population at a national level. They are listed as threatened ecological communities – TECs – and can be listed as critically endangered, endangered or vulnerable: the communities are listed by state on the DCCEEW's website (DCCEEW, 2022c and 2022d).

In WA, the BC Act provides for the statutory listing of TECs by the Minister. The legislation also describes statutory processes for preparing recovery plans for TECs, the registration of their critical habitat, and penalties for unauthorised modification of TECs. These TECs are listed as presumed totally destroyed, critically endangered, endangered or vulnerable (DBCA, 2022d; Department of Environment and Conservation (DEC), 2013). The most recent list was issued in June 2018 (DBCA, 2018).

Priority Ecological Communities

Ecological communities with insufficient information available to be considered a TEC, or which are rare but not currently threatened are placed on a priority list and are referred to as priority ecological communities (PECs). The most recent list was released on December 21, 2022 (DBCA, 2022b). Definitions, categories and criteria for threatened and priority ecological communities can be found on the DBCA's website (DEC, 2013).

Table A1.1: Conservation significant flora locations (GDA94, MGA50)

Taxon	Rank	Easting (mE)	Northing (mN)	Number of plants
Seringia exastia	Threatened	664,498	7,557,108	10
		664,584	7,557,164	2

APPENDIX 2: DECLARED PESTS CATEGORIES, CONTROLS AND WEED LOCATIONS

Weeds of National Interest

A number of lists of weeds of national interest are currently recognised. Several lists and strategies have been created that identify plants of particular concern or plants that have been through an assessment process (WeedsAustralia, 2023). Weeds lists include - Weeds of National Significance (WoNS), Species Targeted for Biological Control, Species permitted entry into Australia, Priority list of exotic weeds, National Environmental Alert List, Sleeper Weeds, Species targeted for eradication and State and territory noxious weed lists (WeedsAustralia, 2023).

Declared Pests in WA

To protect WA agriculture DPIRD regulates harmful plants under the *Biosecurity and Agriculture Management Act 2007* (BAM Act). The Western Australian Organism List (WAOL) provides the status of organisms which have been categorised under the BAM Act (DPIRD, 2023). Under the Biosecurity and Agriculture Management Regulations 2013, declared pests can be assigned to one of three control categories and these are explained in **Table A2.1**.

Table A2.1: Control categories for declared pests (DPIRD, 2023)

Category (C)	Definition
C1 (Exclusion)	Organisms which should be excluded from part or all of Western Australia.
C2 (Eradication)	Organisms which should be eradicated from part or all of Western Australia.
C3 (Management)	Organisms that should have some form of management applied that will alleviate the harmful impact of the organism, reduce the numbers or distribution of the organism or prevent or contain the spread of the organism.
Unassigned	Unassigned: Declared pests that are recognised as having a harmful impact under certain circumstances, where their subsequent control requirements are determined by a Plan or other legislative arrangements under the Act.

DBCA Weed Prioritisation Process

The DBCA prioritises weeds in each region based on their invasiveness, ecological impact, potential and current distribution, and feasibility of control. The resulting priorities focus on weeds considered to be high impact, rapidly invasive and still at a population size that can feasibly be eradicated or contained to a manageable size (DBCA, 2023).

Summaries of the species' ecological impact and invasiveness rankings are provided to help landholders, community groups and private enterprises manage weeds that might impact on the natural environment (DBCA, 2023). Most recent species-led ecological impact and invasiveness ranking summary results are available on DBCA's website for the different government regions in WA.

Table A2.2: Weed locations (GDA94, MGA50) (excluding the WAMA section of the ASA)

Taxa	Easting (mE)	Northing (mN)	Number of Plants	Easting (mE)	Northing (mN)	Number of plants
Cenchrus ciliaris	635858	7559465	10	637490	7557727	10
	636073	7559434	10	636912	7558969	10
	636188	7559413	10	636637	7559168	10
	636230	7559397	10	636475	7559289	10
	636369	7559293	10	636252	7559444	10
	636750	7558998	10	636181	7559485	10
	636784	7558984	10	636105	7559519	10
	636975	7558864	10	636079	7559513	10
	637534	7557402	10	636029	7559519	10
	637571	7557319	10	635797	7559516	10
	637597	7557363	10	637883	7556363	10
	637536	7557560	10			
Cenchrus setiger	637977	7556174	30	637654	7557011	25
	637968	7556192	25	637658	7556995	25
	637952	7556241	25	637667	7556973	25
	637955	7556246	25	637679	7556959	25
	637951	7556265	25	637682	7556940	50
	637919	7556304	25	637708	7556883	100
	637919	7556340	25	637703	7556862	25
	637912	7556357	25	637704	7556823	25
	637895	7556419	25	637718	7556821	25
	637889	7556439	25	637723	7556813	25
	637880	7556463	25	637726	7556801	100
	637861	7556492	25	637753	7556760	400
	637858	7556510	100	637749	7556723	25
	637856	7556549	50	637749	7556678	25
	637846	7556567	20	637773	7556651	50
	637844	7556587	25	637788	7556620	25
	637832	7556606	25	637787	7556607	25
	637833	7556624	25	637795	7556588	25
	637818	7556635	25	637793	7556561	25
	637817	7556665	25	637799	7556550	25
	637811	7556683	100	637806	7556539	25
	637799	7556719	25	637810	7556522	50
	637795	7556736	100	637812	7556499	25
	637792	7556757	25	637818	7556480	25
	637784	7556777	25	637825	7556467	25
	637775	7556789	25	637832	7556457	25
	637759	7556802	200	637839	7556433	25
	637766	7556821	25	637849	7556421	25

Taxa	Easting (mE)	Northing (mN)	Number of Plants	Easting (mE)	Northing (mN)	Number of plants
	637770	7556838	25	637860	7556402	25
	637760	7556861	25	637854	7556370	25
	637733	7556959	25	637860	7556355	100
	637703	7557005	25	637869	7556345	200
	637698	7557015	25	637880	7556313	25
	637693	7557098	25	637898	7556268	25
	637683	7557110	25	637904	7556220	25
	637652	7557211	25	637909	7556193	25
	637622	7557099	25	637914	7556165	100
	637629	7557087	25	637929	7556126	10
	637636	7557081	25	637948	7556074	100
	637640	7557051	25	637972	7556071	100
	637646	7557039	25	638025	7555879	10
	637649	7557027	50			
Malvastrum americanum	638295	7555161	10	638510	7554263	1
	638299	7555144	1	638509	7554246	1
	638329	7555007	1	638510	7554243	1
	638393	7554859	1	638510	7554243	1
	638397	7554811	1	638510	7554242	1
	638398	7554810	1	638510	7554241	1
	638425	7554792	1	638510	7554240	1
	638419	7554701	1	638510	7554239	1
	638418	7554691	1	638510	7554237	1
	638419	7554687	1	638509	7554235	1
	638449	7554587	1	638506	7554217	1
	638473	7554534	1	638506	7554216	1
	638473	7554532	1	638506	7554214	1
	638474	7554531	1	638506	7554211	1
	638480	7554506	1	638506	7554205	1
	638507	7554301	1	638506	7554202	1
	638507	7554297	1	638506	7554198	1
	638507	7554295	1	638506	7554194	1
	638507	7554294	1	638507	7554190	1
	638513	7554281	1	638507	7554178	1
	638508	7554273	1	638507	7554166	1
	638508	7554273	1	638507	7554163	1
	638508	7554273	1	638507	7554162	1
	638508	7554272	1	638507	7554157	1
	638508	7554267	1	638507	7554147	1
	638509	7554265	1	638275	7554989	2

Taxa	Easting (mE)	Northing (mN)	Number of Plants	Easting (mE)	Northing (mN)	Number of plants
Vachellia farnesiana	633166	7559585	2	638510	7554242	1
	638080	7555759	1	638510	7554241	1
	638067	7555804	1	638510	7554240	1
	638068	7555884	1	638510	7554239	1
	638065	7555736	2	638510	7554237	1
	636801	7558972	2	638509	7554235	1
	638148	7555609	1	638506	7554217	1
	638299	7555144	6	638506	7554216	1
	638329	7555007	1	638506	7554214	1
	638393	7554859	1	638506	7554211	1
	638397	7554811	1	638506	7554205	1
	638398	7554810	1	638506	7554202	1
	638425	7554792	1	638506	7554198	1
	638419	7554701	1	638506	7554194	1
	638418	7554691	1	638507	7554190	1
	638419	7554687	1	638507	7554178	1
	638449	7554587	1	638507	7554166	1
	638473	7554534	1	638507	7554163	1
	638473	7554532	1	638507	7554162	1
	638474	7554531	1	638507	7554157	1
	638480	7554506	1	638507	7554147	1
	638507	7554301	1	638482	7554188	1
	638507	7554297	1	638482	7554198	1
	638507	7554295	1	638470	7554489	1
	638507	7554294	1	638425	7554612	1
	638513	7554281	1	638275	7554989	1
	638508	7554273	1	638268	7555113	1
	638508	7554273	1	638268	7555127	1
	638508	7554273	1	638265	7555133	1
	638508	7554272	1	638179	7555388	1
	638508	7554267	1	638175	7555406	1
	638509	7554265	1	638173	7555414	1
	638510	7554263	1	638171	7555433	1
	638509	7554246	1	638167	7555445	1
	638510	7554243	1	638112	7555562	1
	638510	7554243	1			

APPENDIX 3: VEGETATION CONDITION

Table A3.1: Vegetation condition scale (EPA, 2016b)

Vegetation condition	Eremaean and Northern Botanical Provinces
Excellent	Pristine or nearly so, no obvious signs of disturbance or damage caused by human activities since European settlement.
Very Good	Some relatively slight signs of damage caused by human activities since European settlement. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds, or occasional vehicle tracks.
Good	More obvious signs of damage caused by human activity since European settlement, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or slightly aggressive weeds.
Poor	Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of human activities since European settlement, such as grazing, partial clearing, frequent fires or aggressive weeds.
Degraded	Severely impacted by grazing, very frequent fires, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species present including very aggressive species.
Completely Degraded	Areas that are completely or almost completely without native species in the structure of the vegetation, i.e., areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.

APPENDIX 4: NATIONAL VEGETATION INFORMATION SYSTEM VEGETATION CLASSIFICATION

Table A4.1: Height classes defined for the NVIS

Height		Growth Form				
Height Classes	Height Range (m)	Tree, vine (M & U), palm (single-stemmed)	Shrub, Heath Shrub, Chenopod Shrub, Ferns, Samphire Shrub, Cycad, Tree-Fern, Grass-Tree, Palm (multi-stemmed)	Tree Mallee, Mallee Shrub	Tussock Grasses, Sedges, Rushes and Forbs	Bryophyte, Lichen, Seagrass, Aquatic
8	**>30**	tall	NA	NA	NA	NA
7	**10-30**	mid	NA	tall	NA	NA
6	**<10**	low	NA	mid	NA	NA
5	**<3**	NA	NA	low	NA	NA
4	**>2**	NA	tall	NA	tall	NA
3	**1-2**	NA	mid	NA	tall	NA
2	**0.5-1**	NA	low	NA	mid	Tall
1	**<0.5**	NA	low	NA	low	low

Table A4.2: NVIS growth forms and descriptions

Code	Growth Form	Description
T	Tree	Woody plants, more than 2m tall with a single stem or branches well above the base.
M	Tree Mallee	Woody perennial plant usually of the genus *Eucalyptus*. Multi-stemmed with fewer than 5 trunks of which at least 3 exceed 100 mm at breast height (1.3 m). Usually, 8 m or more in
S	Shrub	Woody plants multi-stemmed at the base (or within 200 mm from ground level) or if single stemmed, less than 2 m in height.
Y	Mallee Shrub	Commonly less than 8 m tall, usually with 5 or more trunks, of which at least 3 of the largest do not exceed 100 mm at breast height (1.3 m).
Z	Heath Shrub	Shrub usually less than 2 m, with sclerophyllous leaves having high fibre: protein ratios and with an area of nanophyll or smaller (less than 225 sq. m.). Often a member of the following families: Epacridaceae, Myrtaceae, Fabaceae and Proteaceae. Commonly occur in nutrient-poor
C	Chenopod Shrub	Single or multi-stemmed, semi-succulent shrub of the family Chenopodiaceae exhibiting drought and salt tolerance.
U	Samphire Shrub	Genera (of Tribe Salicornioideae, viz: *Halosarcia*, *Pachycornia, Sarcocornia*, *Sclerostegia*, *Tecticornia* and *Tegicornia*) with articulate branches, fleshy stems and reduced flowers within the Chenopodiaceae family, succulent chenopods. Also, genus *Suaeda*.
G	Tussock Grass	Forms discrete but open tussocks usually with distinct individual shoots, or if not, then forming a hummock. These are common agricultural grasses.
H	Hummock Grass	Coarse xeromorphic grass with a mound-like form often dead in the middle; genera are *Triodia* and *Plectrachne*.
W	Other Grass	Member of the family Poaceae but having neither a distinctive tussock nor hummock appearance. Examples include stoloniferous species such as *Cynodon dactylon*
V	Sedge	Herbaceous, usually perennial erect plant generally with a tufted habit and of the families Cyperaceae (true sedges) or Restionaceae (node sedges).
R	Rush	Herbaceous, usually perennial erect monocot that is neither a grass nor sedge. For the purposes of NVIS, rushes include the monocotyledon families Juncaceae, Typhaceae, Liliaceae, Iridaceae, Xyridaceae and the genus *Lomandra* (i.e., "graminoid" or grass-like genera).

Code	Growth Form	Description
F	Forb	Herbaceous or slightly woody, annual or sometimes perennial plant (usually a dicotyledon).
D	Tree Fern	Characterised by large and usually branched leaves (fronds), arborescent and terrestrial; spores in sporangia on the leaves
E	Fern	Ferns and fern allies, except tree-fern, above. Characterised by large and usually branched leaves (fronds), herbaceous and terrestrial to aquatic; spores in sporangia on the leaves.
B	Bryophyte	Mosses and Liverworts. Mosses are small plants usually with a slender leafbearing stem with no true vascular tissue. Liverworts are often moss-like in appearance or consisting of a flat, ribbon-like green thallus.
N	Lichen	Composite plant consisting of a fungus living symbiotically with algae; without true roots, stems or leaves.
K	Epiphyte	Epiphytes, mistletoes and parasites. Plant with roots attached to the aerial portions of other plants. Can often be another growth form, such as fern or forb.
L	Vine	Climbing, twining, winding or sprawling plants usually with a woody stem.
P	Palm	Palms and other arborescent monocotyledons. Members of the Arecaceae family or the genus Pandanus. (Pandanus is often multi-stemmed).
X	Grass-tree	Australian grass trees. Members of the Xanthorrhoeaceae family
A	Cycad	Members of the families Cycadaceae and Zamiaceae.

Table A4.3: NVIS structural formation terminology (excluding fern, bryophyte, lichen, vine, and aquatic plants)

Growth Form	Height (m)	Foliage Cover (%)					
		>70	**30-70**	**10-30**	**<10**	**≈0**	**0-5**
Tree, palm	**<10,10-30, >30**	Closed forest	Open forest	Woodland	Open woodland	Isolated trees	Isolated clumps of trees
Tree mallee	**<3, <10, 10-30**	Closed mallee forest	Open mallee forest	Mallee woodland	Open mallee woodland	Isolated mallee trees	Isolated clumps of mallee trees
Shrub, cycad, grass-tree, tree-fern	**<1,1-2,>2**	Closed shrubland	Shrubland	Open shrubland	Sparse shrubland	Isolated shrubs	Isolated clumps of shrubs
Mallee shrub	**<3, <10, 10-30**	Closed mallee shrubland	Mallee shrubland	Open mallee shrubland	Sparse mallee shrubland	Isolated mallee shrubs	Isolated clumps of mallee shrubs
Heath shrub	**<1,1-2,>2**	Closed heathland	Heathland	Open heathland	Sparse heathland	Isolated heath shrubs	Isolated clumps of heath shrubs
Chenopod shrub	**<1,1-2,>2**	Closed chenopod shrubland	Chenopod shrubland	Open chenopod shrubland	Sparse chenopod shrubland	Isolated chenopod shrubs	Isolated clumps of chenopod shrubs
Samphire shrub	**<0.5,>0.5**	Closed samphire shrubland	Samphire shrubland	Open samphire shrubland	Sparse samphire shrubland	Isolated samphire shrubs	Isolated clumps of samphire shrubs
Hummock grass	**<2,>2**	Closed hummock grassland	Hummock grassland	Open hummock grassland	Sparse hummock grassland	Isolated hummock grasses	Isolated clumps of hummock grasses
Tussock grass	**<0.5,>0.5**	Closed tussock grassland	Tussock grassland	Open tussock grassland	Sparse tussock grassland	Isolated tussock grasses	Isolated clumps of tussock grasses
Other grass	**<0.5,>0.5**	Closed grassland	Grassland	Open grassland	Sparse grassland	Isolated grasses	Isolated clumps of grasses

Growth Form	Height (m)	Foliage Cover (%)					
		>70	30-70	10-30	<10	≈0	0-5
Sedge	**<0.5,>0.5**	Closed sedgeland	Sedgeland	Open sedgeland	Sparse sedgeland	Isolated sedges	Isolated clumps of sedges
Rush	**<0.5,>0.5**	Closed rushland	Rushland	Open rushland	Sparse rushland	Isolated rushes	Isolated clumps of rushes
Forb	**<0.5,>0.5**	Closed forbland	Forbland	Open forbland	Sparse forbland	Isolated forbs	Isolated clumps of forbs

Source: **Tables A4.1 to A4.3** from NVIS Technical Working Group (2017).

APPENDIX 5: VASCULAR FLORA SPECIES LIST AND TAXONOMICALLY UNCERTAIN COLLECTIONS

Notes re **Tables A5.1 to A5.3**: * = general environmental weed, T = threatened, Fl = flowering material, Fr = fruiting material, sp. = species, subsp. = subspecies, var. = variety, x = crossed with, OppColl = opportunistic collection. Nomenclature based on current WA Herbarium terminology and confirmed on Florabase (WAH, 1998-). Taxa shaded pink = not recorded during this survey; only recorded in one of the eight regional quadrats assessed within 500 m of the WP area (Maia, 2022).

Table A5.1: Vascular flora species list

Family	Taxa	RDA	SF	WP		Fl / Fr
				OppColl	Regional	
Acanthaceae	*Dipteracanthus australasicus* subsp. *australasicus*				•	
Acanthaceae	*Rostellularia adscendens* var. *clementii*				•	
Aizoaceae	*Trianthema glossostigmum*		•		•	Fr
Amaranthaceae	*Alternanthera nana*				•	
Amaranthaceae	*Amaranthus cuspidifolius*				•	
Amaranthaceae	*Gomphrena affinis* subsp. *pilbarensis*				•	
Amaranthaceae	*Ptilotus astrolasius*		•		•	Fl
Amaranthaceae	*Ptilotus calostachyus*				•	
Amaranthaceae	*Ptilotus clementii*				•	
Amaranthaceae	*Ptilotus exaltatus*				•	
Amaranthaceae	*Ptilotus obovatus*		•		•	
Asteraceae	***Bidens bipinnata** *				•	
Asteraceae	*Calotis porphyroglossa*				•	
Asteraceae	*Centipeda minima*				•	
Asteraceae	*Centipeda minima* subsp. *macrocephala*				•	
Asteraceae	***Iotasperma sessilifolium* (P3)**				•	
Asteraceae	*Pterocaulon sphacelatum*				•	
Asteraceae	*Pterocaulon sphaeranthoides*				•	
Asteraceae	*Rutidosis helichrysoides* subsp. *helichrysoides*				•	
Asteraceae	*Streptoglossa* sp.				•	
Asteraceae	*Vittadinia eremaea*				•	
Boraginaceae	*Trichodesma zeylanicum* var. *zeylanicum*				•	
Campanulaceae	*Wahlenbergia tumidifructa*				•	
Capparaceae	*Capparis lasiantha*	•				
Chenopodiaceae	*Maireana villosa*				•	
Chenopodiaceae	*Salsola australis*				•	
Chenopodiaceae	*Sclerolaena cornishiana*				•	
Cleomaceae	*Arivela viscosa*	•			•	Fl
Convolvulaceae	*Bonamia erecta*				•	
Convolvulaceae	*Bonamia rosea*		•			
Convolvulaceae	*Convolvulus clementii*				•	
Convolvulaceae	*Duperreya commixta*		•		•	
Convolvulaceae	*Evolvulus alsinoides* var. *villosicalyx*		•		•	Fl
Convolvulaceae	*Ipomoea muelleri*				•	
Cucurbitaceae	*Cucumis melo*				•	
Cucurbitaceae	*Cucumis variabilis*				•	
Euphorbiaceae	*Euphorbia biconvexa*				•	

Family	Taxa	RDA	SF	WP		Fl / Fr
				OppColl	Regional	
Euphorbiaceae	*Euphorbia coghlanii*				•	
Euphorbiaceae	*Euphorbia* sp.				•	
Fabaceae	*Acacia acradenia*		•			
Fabaceae	*Acacia adoxa* var. *adoxa*	•	•			Fl
Fabaceae	*Acacia ancistrocarpa*	•	•		•	
Fabaceae	*Acacia aptaneura*	•	•			
Fabaceae	*Acacia arida*	•				
Fabaceae	*Acacia atkinsiana*	•	•		•	
Fabaceae	*Acacia ayersiana*		•			
Fabaceae	*Acacia bivenosa*	•	•		•	
Fabaceae	*Acacia coriacea* subsp. *pendens*				•	
Fabaceae	*Acacia incurvaneura*		•			
Fabaceae	*Acacia maitlandii*	•	•		•	
Fabaceae	*Acacia marramamba*	•				
Fabaceae	*Acacia monticola*		•			
Fabaceae	*Acacia pruinocarpa*	•	•		•	
Fabaceae	*Acacia pteraneura*				•	
Fabaceae	*Acacia pyrifolia* subsp. *pyrifolia*	•	•		•	
Fabaceae	*Acacia spondylophylla*		•			
Fabaceae	*Acacia synchronicia*				•	
Fabaceae	*Acacia tenuissima*		•		•	
Fabaceae	*Acacia tetragonophylla*	•	•			
Fabaceae	*Acacia tumida* var. *pilbarensis*	•	•		•	
Fabaceae	*Acacia victoriae*				•	
Fabaceae	*Acacia xiphophylla*		•		•	
Fabaceae	*Alysicarpus muelleri*				•	
Fabaceae	*Cullen graveolens*				•	
Fabaceae	*Indigofera monophylla*		•		•	
Fabaceae	*Isotropis atropurpurea*				•	
Fabaceae	*Lotus cruentus*				•	
Fabaceae	*Petalostylis labicheoides*	•	•			
Fabaceae	*Rhynchosia australis*				•	
Fabaceae	*Rhynchosia minima*				•	
Fabaceae	*Senna* ? *artemisioides*		•			
Fabaceae	*Senna artemisioides* subsp. *helmsii*				•	
Fabaceae	*Senna artemisioides* subsp. *oligophylla*	•			•	
Fabaceae	*Senna glutinosa* subsp. *glutinosa*	•	•		•	
Fabaceae	*Senna glutinosa* subsp. *pruinosa*	•				
Fabaceae	*Senna glutinosa* subsp. x *luerssenii*		•			
Fabaceae	*Senna notabilis*				•	
Fabaceae	*Senna sericea*			•		
Fabaceae	*Tephrosia rosea* var. Fortescue creeks (M.I.H. Brooker 2186)		•			
Fabaceae	***Vachellia farnesiana** *			•	•	
Goodeniaceae	*Dampiera candicans*		•			Fl
Goodeniaceae	*Goodenia connata*				•	
Goodeniaceae	*Goodenia cusackiana*	•				

Family	Taxa	RDA	SF	WP		Fl / Fr
				OppColl	Regional	
Goodeniaceae	*Goodenia microptera*				•	
Goodeniaceae	*Goodenia nuda*				•	
Goodeniaceae	*Goodenia stobbsiana*				•	
Goodeniaceae	*Scaevola parvifolia* subsp. *pilbarae*				•	
Gyrostemonaceae	*Codonocarpus cotinifolius*	•	•		•	
Lamiaceae	*Teucrium racemosum*				•	
Loranthaceae	*Amyema fitzgeraldii*				•	
Lauraceae	*Cassytha capillaris*			•		Fl
Lythraceae	*Lythrum wilsonii*				•	
Malvaceae	*Abutilon fraseri*				•	
Malvaceae	*Abutilon otocarpum*				•	
Malvaceae	*Corchorus lasiocarpus* subsp. *lasiocarpus*				•	
Malvaceae	*Corchorus lasiocarpus* subsp. *parvus*	•	•			FlFr
Malvaceae	*Corchorus sidoides*				•	
Malvaceae	*Gossypium robinsonii*		•			
Malvaceae	*Hibiscus burtonii*		•			
Malvaceae	*Hibiscus coatesii*		•			
Malvaceae	*Hibiscus leptocladus*		•			
Malvaceae	*Hibiscus sturtii*	•	•			
Malvaceae	*Hibiscus sturtii* var. *platychlamys*				•	
Malvaceae	***Malvastrum americanum* ***			•	•	
Malvaceae	***Seringia exastia* (T)**		•			
Malvaceae	*Sida arenicola*				•	
Malvaceae	*Sida cardiophylla*				•	
Malvaceae	*Sida laevis*				•	
Malvaceae	*Sida* sp.				•	
Malvaceae	*Sida* sp. dark green fruits (S. van Leeuwen 2260)	•	•			Fr
Malvaceae	*Sida* sp. L (A.M. Ashby 4202)				•	
Malvaceae	*Sida* sp. spiciform panicles (E. Leyland s.n.14/8/90)				•	
Malvaceae	*Sida* sp. Supplejack Station (T.S. Henshall 2345)				•	
Malvaceae	*Waltheria indica*				•	
Marsileaceae	*Marsilea hirsuta*				•	
Myrtaceae	*Corymbia candida*				•	
Myrtaceae	*Corymbia deserticola* subsp. *deserticola*				•	
Myrtaceae	*Corymbia hamersleyana*	•				Fr
Myrtaceae	*Eucalyptus gamophylla*	•			•	
Myrtaceae	*Eucalyptus* ? *leucophloia*		•			
Myrtaceae	*Eucalyptus leucophloia* subsp. *leucophloia*	•	•			Fr
Myrtaceae	*Eucalyptus xerothermica*				•	
Oleaceae	*Jasminum didymum* subsp. *lineare*	•				FlFr
Phyllanthaceae	*Nellica maderaspatensis*				•	
Plantaginaceae	*Stemodia kingii*				•	
Plantaginaceae	*Stemodia viscosa*				•	
Poaceae	*Amphipogon sericeus*	•			•	
Poaceae	*Aristida contorta*				•	

Family	Taxa	RDA	SF	WP		Fl / Fr
				OppColl	Regional	
Poaceae	*Aristida holathera*	•				
Poaceae	*Aristida holathera* var. *latifolia*				•	
Poaceae	*Aristida latifolia*				•	
Poaceae	*Aristida pruinosa*				•	
Poaceae	***Cenchrus ciliaris** *			•	•	
Poaceae	***Cenchrus setiger** *			•		
Poaceae	*Chrysopogon fallax*				•	
Poaceae	*Dichanthium sericeum* subsp. *humilius*				•	
Poaceae	*Enneapogon caerulescens*				•	
Poaceae	*Enneapogon polyphyllus*				•	
Poaceae	*Eragrostis eriopoda*	•				
Poaceae	*Eragrostis leptocarpa*				•	
Poaceae	*Eragrostis setifolia*				•	
Poaceae	*Eragrostis* sp.				•	
Poaceae	*Eragrostis tenellula*				•	
Poaceae	*Eragrostis xerophila*				•	
Poaceae	*Eriachne benthamii*				•	
Poaceae	*Eriachne flaccida*				•	
Poaceae	*Eriachne* ? *mucronata*	•	•			
Poaceae	*Eriachne mucronata*		•		•	FlFr
Poaceae	*Eulalia aurea*				•	
Poaceae	*Iseilema membranaceum*				•	
Poaceae	*Panicum australiense*				•	
Poaceae	*Panicum laevinode*				•	
Poaceae	*Paraneurachne muelleri*		•		•	
Poaceae	*Paspalidium rarum*				•	
Poaceae	*Perotis rara*				•	
Poaceae	*Setaria dielsii*				•	
Poaceae	***Setaria verticillata** *				•	
Poaceae	*Sporobolus australasicus*				•	
Poaceae	*Themeda triandra*	•			•	FlFr
Poaceae	*Triodia* ? *basedowii*		•			
Poaceae	*Triodia basedowii*	•	•			FlFr
Poaceae	*Triodia brizoides*	•	•			FlFr
Poaceae	*Triodia epactia*	•	•		•	FlFr
Polygonaceae	*Duma florulenta*				•	
Proteaceae	*Grevillea wickhamii*	•	•			
Proteaceae	*Hakea lorea* subsp. *lorea*				•	
Pteridaceae	*Cheilanthes sieberi*		•			
Rubiaceae	*Psydrax latifolia*	•			•	
Rubiaceae	*Psydrax suaveolens*	•	•			
Santalaceae	*Anthobolus leptomerioides*		•			
Santalaceae	*Exocarpos aphyllus*	•	•			Fl
Santalaceae	*Santalum acuminatum*	•				
Sapindaceae	*Dodonaea petiolaris*		•			
Scrophulariaceae	*Eremophila cuneifolia*		•			
Scrophulariaceae	*Eremophila forrestii*	•	•			

Family	Taxa	RDA	SF	WP		Fl / Fr
				OppColl	Regional	
Scrophulariaceae	*Eremophila forrestii* subsp. *forrestii*				•	
Scrophulariaceae	*Eremophila lanceolata*				•	
Scrophulariaceae	*Eremophila latrobei* subsp. *filiformis*				•	
Scrophulariaceae	*Eremophila longifolia*		•		•	
Solanaceae	*Nicotiana occidentalis*				•	
Solanaceae	*Solanum diversiflorum*				•	
Solanaceae	*Solanum lasiophyllum*	•			•	
Violaceae	*Afrohybanthus aurantiacus*	•	•		•	Fr
Zygophyllaceae	*Tribulus macrocarpus*				•	
Zygophyllaceae	*Tribulus suberosus*		•			

Table A5.2: Taxonomically uncertain collections excluded / included in the species list and counts

Taxonomically uncertain collections that were excluded / included in the species list and counts	
Taxonomic uncertainty combinations or exclusions in the species list	
Acacia ? *aptaneura*	*Acacia aptaneura*
Acacia ? *atkinsiana*	*Acacia atkinsiana*
Taxonomic uncertainty combinations or exclusions in the counts	
Eriachne ? *mucronata*	*Eriachne mucronata*
Eucalyptus ? *leucophloia*	*Eucalyptus leucophloia*
Triodia ? *basedowii*	*Triodia basedowii*

Table A5.3: Queried taxa that were included in the species list and counts

Other taxa included in the species list and counts because they could be the species queried to or other species that occur in the area not already in the species list
Eragrostis sp., *Euphorbia* sp., *Senna* ? *artemisioides, Sida* sp., *Streptoglossa* sp.

Appendix 6: Site, Species and Vegetation Type and Species by Vegetation Type Matrices

Notes re **Tables A6.1** and **A6.2**: * = environmental weed, T = threatened, Fl = flowering material, Fr = fruiting material, sp. = species, subsp. = subspecies, var. = variety, x = crossed with. Nomenclature based on current WA Herbarium terminology and confirmed on Florabase (WAH, 1998-). Only species recorded at quadrats during this survey were used to produce these tables.

Table A6.1: Species by site by vegetation type (RDA and SF quadrat data)

	Vegetation type and quadrat	*AaAx*SL	ASL (2)	ASL (2)	ASL (2)	THG (1)	THG (1)	THG (1)	THG (2)	THG (2)	THG (2)
Family	Taxa	SFQ03	HXQ02	SFQ01	SFQ04	SFQ05	SFQ06	SFQ07	HXQ01	HXQ03	SFQ02
Aizoaceae	*Trianthema glossostigmum*	■									
Amaranthaceae	*Ptilotus astrolasius*				■						
Amaranthaceae	*Ptilotus obovatus*	■									■
Capparaceae	*Capparis lasiantha*									■	
Cleomaceae	*Arivela viscosa*		■								
Convolvulaceae	*Bonamia rosea*			■	■						
Convolvulaceae	*Duperreya commixta*	■									■
Convolvulaceae	*Evolvulus alsinoides* var. *villosicalyx*			■							
Fabaceae	*Acacia* ? *aptaneura*									■	
Fabaceae	*Acacia* ? *atkinsiana*			■							■
Fabaceae	*Acacia acradenia*				■	■		■			
Fabaceae	*Acacia adoxa* var. *adoxa*		■	■	■	■		■			
Fabaceae	*Acacia ancistrocarpa*							■	■		
Fabaceae	*Acacia aptaneura*			■						■	■
Fabaceae	*Acacia arida*									■	
Fabaceae	*Acacia atkinsiana*		■	■				■		■	■
Fabaceae	*Acacia ayersiana*	■									
Fabaceae	*Acacia bivenosa*		■			■	■		■	■	■
Fabaceae	*Acacia incurvaneura*	■									
Fabaceae	*Acacia maitlandii*		■	■	■	■	■				■
Fabaceae	*Acacia marramamba*									■	
Fabaceae	*Acacia monticola*				■			■			
Fabaceae	*Acacia pruinocarpa*									■	■
Fabaceae	*Acacia pyrifolia* subsp. *pyrifolia*		■	■	■						
Fabaceae	*Acacia spondylophylla*					■					
Fabaceae	*Acacia tenuissima*					■	■				
Fabaceae	*Acacia tetragonophylla*	■								■	
Fabaceae	*Acacia tumida* var. *pilbarensis*		■	■	■			■			
Fabaceae	*Acacia xiphophylla*	■									
Fabaceae	*Indigofera monophylla*			■	■	■		■			

	Vegetation type and quadrat	*AaAx*SL	ASL (2)	ASL (2)	ASL (2)	THG (1)	THG (1)	THG (1)	THG (2)	THG (2)	THG (2)
Family	**Taxa**	**SFQ03**	**HXQ02**	**SFQ01**	**SFQ04**	**SFQ05**	**SFQ06**	**SFQ07**	**HXQ01**	**HXQ03**	**SFQ02**
Fabaceae	*Petalostylis labicheoides*										
Fabaceae	*Senna* ? *artemisioides*										
Fabaceae	*Senna artemisioides* subsp. *oligophylla*										
Fabaceae	*Senna glutinosa* subsp. *glutinosa*										
Fabaceae	*Senna glutinosa* subsp. *pruinosa*										
Fabaceae	*Senna glutinosa* subsp. x *luerssenii*										
Fabaceae	*Tephrosia rosea* var. Fortescue creeks (M.I.H Brooker 2186)										
Goodeniaceae	*Dampiera candicans*										
Goodeniaceae	*Goodenia cusackiana*										
Gyrostemonaceae	*Codonocarpus cotinifolius*										
Malvaceae	*Corchorus lasiocarpus* subsp. *parvus*										
Malvaceae	*Gossypium robinsonii*										
Malvaceae	*Hibiscus burtonii*										
Malvaceae	*Hibiscus coatesii*										
Malvaceae	*Hibiscus leptocladus*										
Malvaceae	*Hibiscus sturtii*										
Malvaceae	***Seringia exastia* (T)**										
Malvaceae	*Sida* sp. dark green fruits (S. van Leeuwen 2260)										
Myrtaceae	*Corymbia hamersleyana*										
Myrtaceae	*Eucalyptus* ? *leucophloia*										
Myrtaceae	*Eucalyptus gamophylla*										
Myrtaceae	*Eucalyptus leucophloia* subsp. *leucophloia*										
Oleaceae	*Jasminum didymum* subsp. *lineare*										
Poaceae	*Amphipogon sericeus*										
Poaceae	*Aristida holathera*										
Poaceae	*Eragrostis eriopoda*										
Poaceae	*Eriachne* ? *mucronata*										
Poaceae	*Eriachne mucronata*										
Poaceae	*Paraneurachne muelleri*										
Poaceae	*Themeda triandra*										

	Vegetation type and quadrat	*AaAx*SL	ASL (2)	ASL (2)	ASL (2)	THG (1)	THG (1)	THG (1)	THG (2)	THG (2)	THG (2)
Family	**Taxa**	**SFQ03**	**HXQ02**	**SFQ01**	**SFQ04**	**SFQ05**	**SFQ06**	**SFQ07**	**HXQ01**	**HXQ03**	**SFQ02**
Poaceae	*Triodia ? basedowii*										
Poaceae	*Triodia basedowii*										
Poaceae	*Triodia brizoides*										
Poaceae	*Triodia epactia*										
Proteaceae	*Grevillea wickhamii*										
Pteridaceae	*Cheilanthes sieberi*										
Rubiaceae	*Psydrax latifolia*										
Rubiaceae	*Psydrax suaveolens*										
Santalaceae	*Anthobolus leptomerioides*										
Santalaceae	*Exocarpos aphyllus*										
Santalaceae	*Santalum acuminatum*										
Sapindaceae	*Dodonaea petiolaris*										
Scrophulariaceae	*Eremophila cuneifolia*										
Scrophulariaceae	*Eremophila forrestii*										
Scrophulariaceae	*Eremophila longifolia*										
Solanaceae	*Solanum lasiophyllum*										
Violaceae	*Afrohybanthus aurantiacus*										
Zygophyllaceae	*Tribulus suberosus*										

Table A6.2: Species by vegetation type (RDA and SF quadrats only)

		Vegetation type			
Family	**Taxa**	***AaAxSL***	**ASL (2)**	**THG (1)**	**THG (2)**
Aizoaceae	*Trianthema glossostigmum*	x			
Amaranthaceae	*Ptilotus astrolasius*		x		
Amaranthaceae	*Ptilotus obovatus*	x			x
Capparaceae	*Capparis lasiantha*				x
Cleomaceae	*Arivela viscosa*		x		
Convolvulaceae	*Bonamia rosea*		x		
Convolvulaceae	*Duperreya commixta*	x			x
Convolvulaceae	*Evolvulus alsinoides* var. *villosicalyx*		x		
Fabaceae	*Acacia* ? *aptaneura*				x
Fabaceae	*Acacia* ? *atkinsiana*		x		x
Fabaceae	*Acacia acradenia*		x	x	
Fabaceae	*Acacia adoxa* var. *adoxa*		x	x	
Fabaceae	*Acacia ancistrocarpa*				x
Fabaceae	*Acacia aptaneura*		x		x
Fabaceae	*Acacia arida*				x
Fabaceae	*Acacia atkinsiana*		x	x	x
Fabaceae	*Acacia ayersiana*	x			
Fabaceae	*Acacia bivenosa*		x	x	x
Fabaceae	*Acacia incurvaneura*	x			
Fabaceae	*Acacia maitlandii*		x	x	x
Fabaceae	*Acacia marramamba*				x
Fabaceae	*Acacia monticola*		x	x	
Fabaceae	*Acacia pruinocarpa*				x
Fabaceae	*Acacia pyrifolia* subsp. *pyrifolia*		x		
Fabaceae	*Acacia spondylophylla*			x	
Fabaceae	*Acacia tenuissima*			x	
Fabaceae	*Acacia tetragonophylla*	x			x
Fabaceae	*Acacia tumida* var. *pilbarensis*		x	x	
Fabaceae	*Acacia xiphophylla*	x			
Fabaceae	*Indigofera monophylla*		x	x	
Fabaceae	*Petalostylis labicheoides*		x		x
Fabaceae	*Senna* ? *artemisioides*	x		x	
Fabaceae	*Senna artemisioides* subsp. *oligophylla*				x
Fabaceae	*Senna glutinosa* subsp. *glutinosa*		x	x	x
Fabaceae	*Senna glutinosa* subsp. *pruinosa*				x
Fabaceae	*Senna glutinosa* subsp. x *luerssenii*	x		x	x
Fabaceae	*Tephrosia rosea* var. Fortescue creeks (M.I.H. Brooker 2186)		x		
Goodeniaceae	*Dampiera candicans*		x		
Goodeniaceae	*Goodenia cusackiana*		x		
Gyrostemonaceae	*Codonocarpus cotinifolius*				x
Malvaceae	*Corchorus lasiocarpus* subsp. *parvus*		x	x	x
Malvaceae	*Gossypium robinsonii*				x
Malvaceae	*Hibiscus burtonii*				x
Malvaceae	*Hibiscus coatesii*	x			x

		Vegetation type			
Family	**Taxa**	***AaAxSL***	**ASL (2)**	**THG (1)**	**THG (2)**
Malvaceae	*Hibiscus leptocladus*			x	
Malvaceae	*Hibiscus sturtii*				x
Malvaceae	***Seringia exastia* (T)**				x
Malvaceae	*Sida* sp. dark green fruits (S. van Leeuwen 2260)		x		x
Myrtaceae	*Corymbia hamersleyana*		x		
Myrtaceae	*Eucalyptus* ? *leucophloia*		x		
Myrtaceae	*Eucalyptus gamophylla*				x
Myrtaceae	*Eucalyptus leucophloia* subsp. *leucophloia*		x	x	x
Oleaceae	*Jasminum didymum* subsp. *lineare*		x		
Poaceae	*Amphipogon sericeus*				x
Poaceae	*Aristida holathera*				x
Poaceae	*Eragrostis eriopoda*				x
Poaceae	*Eriachne* ? *mucronata*		x		
Poaceae	*Eriachne mucronata*		x	x	
Poaceae	*Paraneurachne muelleri*			x	
Poaceae	*Themeda triandra*		x		
Poaceae	*Triodia* ? *basedowii*	x			
Poaceae	*Triodia basedowii*			x	x
Poaceae	*Triodia brizoides*		x	x	x
Poaceae	*Triodia epactia*	x	x	x	x
Proteaceae	*Grevillea wickhamii*		x	x	x
Pteridaceae	*Cheilanthes sieberi*				x
Rubiaceae	*Psydrax latifolia*				x
Rubiaceae	*Psydrax suaveolens*	x			x
Santalaceae	*Anthobolus leptomerioides*				x
Santalaceae	*Exocarpos aphyllus*	x	x		
Santalaceae	*Santalum acuminatum*				x
Sapindaceae	*Dodonaea petiolaris*	x			x
Scrophulariaceae	*Eremophila cuneifolia*	x			
Scrophulariaceae	*Eremophila forrestii*				x
Scrophulariaceae	*Eremophila longifolia*		x		x
Solanaceae	*Solanum lasiophyllum*				x
Violaceae	*Afrohybanthus aurantiacus*		x	x	
Zygophyllaceae	*Tribulus suberosus*			x	

APPENDIX 7: QUADRAT DATA

Table A7.1: Quadrat data (Maia RDA and SF quadrats only)

<table>
<tr><th>Quadrat: HXQ01</th><th colspan="3">Described by: SH & EK</th><th colspan="2">Date: 27/02/2023</th><th>Photograph</th></tr>
<tr><td>Location (GDA94):</td><td>MGA50</td><td>657683</td><td>mE</td><td>7557242</td><td>mN</td><td rowspan="8">  </td></tr>
<tr><td>Habitat:</td><td colspan="5">Hill gentle south-east facing slope (footslope)</td></tr>
<tr><td>Soil:</td><td colspan="5">Red-orange sandy-loam loose soil (2%)</td></tr>
<tr><td>Rocks:</td><td colspan="5">Basalt stones (70%)</td></tr>
<tr><td>Mapped as:</td><td colspan="5">THG (2)</td></tr>
<tr><td>Vegetation type:</td><td colspan="5">Hummock Grassland of Triodia brizoides with Sparse Tall Shrubland of Acacia bivenosa</td></tr>
<tr><td>Vegetation condition:</td><td colspan="5">Excellent</td></tr>
<tr><td>Disturbances:</td><td colspan="5">None evident</td></tr>
<tr><td>Fire age:</td><td colspan="5">Moderate (1-5 years)</td></tr>
<tr><td>Species:</td><td colspan="6">Acacia ancistrocarpa, Acacia bivenosa, Amphipogon sericeus, Codonocarpus cotinifolius, Eucalyptus leucophloia subsp. leucophloia, Grevillea wickhamii, Senna glutinosa subsp. glutinosa, Senna glutinosa subsp. pruinosa, Triodia brizoides, Triodia epactia</td></tr>
</table>

Quadrat: HXQ02	Described by: EK			Date: 27/02/2023		Photograph
Location (GDA94):	MGA50	657957	mE	7557280	mN	
Habitat:	Minor channel					
Soil:	Red-brown riverbed soils					
Rocks:	Basalt stones (60%)					
Mapped as:	ASL (2)					
Vegetation type:	Open Tall Shrubland of *Acacia tumida* var. *pilbarensis* with Open Hummock Grassland of *Triodia epactia*					
Vegetation condition:	Very Good					
Disturbances:	None evident					
Fire age:	None evident					
Species:	*Acacia adoxa* var. *adoxa, Acacia atkinsiana, Acacia bivenosa, Acacia maitlandii, Acacia pyrifolia* subsp. *pyrifolia, Acacia tumida* var. *pilbarensis, Afrohybanthus aurantiacus, Arivela viscosa, Corchorus lasiocarpus* subsp. *parvus, Corymbia hamersleyana, Eriachne* ? *mucronata, Eucalyptus leucophloia* subsp. *leucophloia, Exocarpos aphyllus, Goodenia cusackiana, Grevillea wickhamii, Jasminum didymum* subsp. *lineare, Petalostylis labicheoides, Senna glutinosa* subsp. *glutinosa, Themeda triandra, Triodia epactia*					

Quadrat: HXQ03	Described by: SH			Date: 27/02/2023		Photograph
Location (GDA94):	MGA50	658364	mE	7557244	mN	
Habitat:	Drainage lines					
Soil:	Red-orange sandy-loam loose soil (10%)					
Rocks:	Basalt stones (60%)					
Mapped as:	THG (2)					
Vegetation type:	Open Tall Shrubland of *Acacia aptaneura* and *Acacia pruinocarpa* with Open Low Woodland of *Acacia aptaneura* and *Acacia pruinocarpa* with Sparse Mid Shrubland of *Acacia marramamba* and *Acacia tetragonophylla* and Sparse Hummock Grassland of *Triodia basedowii* and *Triodia epactia*					
Vegetation condition:	Excellent					
Disturbances:	None evident					
Fire age:	Moderate (1-5 years)					
Species:	*Acacia aptaneura, Acacia arida, Acacia atkinsiana, Acacia bivenosa, Acacia marramamba, Acacia pruinocarpa, Acacia tetragonophylla, Aristida holathera, Capparis lasiantha, Corchorus lasiocarpus* subsp. *parvus, Eragrostis eriopoda, Eremophila forrestii, Eucalyptus gamophylla, Eucalyptus leucophloia* subsp. *leucophloia, Hibiscus sturtii, Petalostylis labicheoides, Psydrax latifolia, Psydrax suaveolens, Santalum acuminatum, Senna artemisioides* subsp. *oligophylla, Senna glutinosa* subsp. *glutinosa, Sida* sp. dark green fruits (S. van Leeuwen 2260), *Solanum lasiophyllum, Triodia basedowii, Triodia epactia*					

Quadrat: SFQ01	Described by: EK			Date: 25/02/2023		Photograph
Location (GDA94):	MGA50	665013	mE	7557190	mN	
Habitat:	Minor channel (bank)					
Soil:	Red-brown sandy-loam					
Rocks:	Basalt stones (60%), Ironstone stones (5%)					
Mapped as:	ASL (2)					
Vegetation type:	Closed Hummock Grassland of *Triodia epactia* with Mid Shrubland of *Acacia maitlandii, Acacia tumida* var. *pilbarensis* and *Acacia atkinsiana* with Sparse Low Shrubland of *Acacia adoxa* var. *adoxa* and Sparse Tussock Grassland of *Eriachne* ?*mucronata*					
Vegetation condition:	Very Good					
Disturbances:	Vegetation trampled by cattle					
Fire age:	None evident					
Species:	*Acacia adoxa* var. *adoxa, Acacia aptaneura, Acacia atkinsiana, Acacia maitlandii, Acacia pyrifolia* subsp. *pyrifolia, Acacia tumida* var. *pilbarensis, Afrohybanthus aurantiacus, Bonamia rosea, Eremophila longifolia, Eriachne* ? *mucronata, Eucalyptus* ? *leucophloia, Evolvulus alsinoides* var. *villosicalyx, Grevillea wickhamii, Indigofera monophylla, Sida* sp. dark green fruits (S. van Leeuwen 2260), *Triodia epactia*					

Quadrat: SFQ02	Described by: SH			Date: 25/02/2023		Photograph
Location (GDA94):	MGA50	664584	mE	7557164	mN	
Habitat:	Stony plain					
Soil:	Red sandy-loam loose soil (10%), surface crust (10%)					
Rocks:	Basalt stones (40%)					
Mapped as:	THG (1)					
Vegetation type:	Open Hummock Grassland of *Triodia brizoides* with Sparse Tall Shrubland of *Acacia aptaneura* and Sparse Mid Shrubland of *Acacia atkinsiana*					
Vegetation condition:	Excellent					
Disturbances:	None evident					
Fire age:	Moderate (1-5 years)					
Species:	*Acacia aptaneura, Acacia atkinsiana, Acacia bivenosa, Acacia maitlandii, Acacia pruinocarpa, Anthobolus leptomerioides, Cheilanthes sieberi, Codonocarpus cotinifolius, Corchorus lasiocarpus* subsp. *parvus, Dodonaea petiolaris, Duperreya commixta, Eremophila forrestii, Eremophila longifolia, Gossypium robinsonii, Hibiscus burtonii, Hibiscus coatesii, Hibiscus sturtii, Ptilotus obovatus, Senna glutinosa* subsp. *glutinosa, Senna glutinosa* subsp. x *luerssenii,* ***Seringia exastia*** **(T)**, *Sida* sp. dark green fruits (S. van Leeuwen 2260), *Triodia brizoides*					

Quadrat: SFQ03	Described by: EK			Date: 25/02/2023		Photograph
Location (GDA94):	MGA50	664389	mE	7557203	mN	
Habitat:	Stony plain					
Soil:	Red-brown sandy-loam					
Rocks:	Basalt gravel (50%)					
Mapped as:	AaAxSL					
Vegetation type:	Tall Shrubland of *Acacia xiphophylla* with Hummock Grassland of *Triodia* ? *basedowii* with Sparse Mid Shrubland of *Acacia tetragonophylla* and Sparse Low Shrubland of *Psydrax suaveolens*					
Vegetation condition:	Excellent					
Disturbances:	None evident					
Fire age:	None evident					
Species:	*Acacia ayersiana, Acacia incurvaneura, Acacia tetragonophylla, Acacia xiphophylla, Dodonaea petiolaris, Duperreya commixta, Eremophila cuneifolia, Exocarpos aphyllus, Hibiscus coatesii, Psydrax suaveolens, Ptilotus obovatus, Senna* ? *artemisioides, Senna glutinosa subsp. x luerssenii, Trianthema glossostigmum, Triodia* ? *basedowii, Triodia epactia*					

Quadrat: SFQ04	Described by: EK			Date: 25/02/2023		Photograph
Location (GDA94):	MGA50	664067	mE	7557752	mN	
Habitat:	Drainage lines					
Soil:	Red-brown sandy-clay					
Rocks:	stones (70%)					
Mapped as:	ASL (2)					
Vegetation type:	Closed Hummock Grassland of *Triodia epactia* with Mid Shrubland of *Acacia tumida* var. *pilbarensis* and *Acacia maitlandii* with Sparse Low Shrubland of *Acacia adoxa* var. *adoxa* and Sparse Tussock Grassland of *Eriachne mucronata*					
Vegetation condition:	Very Good					
Disturbances:	Vegetation trampled by cattle					
Fire age:	None evident					
Species:	*Acacia acradenia, Acacia adoxa* var. *adoxa, Acacia maitlandii, Acacia monticola, Acacia pyrifolia* subsp. *pyrifolia, Acacia tumida* var. *pilbarensis, Afrohybanthus aurantiacus, Bonamia rosea, Corchorus lasiocarpus* subsp. *parvus, Dampiera candicans, Eriachne mucronata, Grevillea wickhamii, Indigofera monophylla, Petalostylis labicheoides, Ptilotus astrolasius, Tephrosia rosea* var. Fortescue creeks (M.I.H. Brooker 2186), *Triodia brizoides, Triodia epactia*					

<table>
<tr><th>Quadrat: SFQ05</th><th colspan="3">Described by: SH</th><th colspan="2">Date: 25/02/2023</th><th>Photograph</th></tr>
<tr><td>Location (GDA94):</td><td>MGA50</td><td>664341</td><td>mE</td><td>7558269</td><td>mN</td><td rowspan="8">  </td></tr>
<tr><td>Habitat:</td><td colspan="5">Hill gentle south-east facing slope (footslope)</td></tr>
<tr><td>Soil:</td><td colspan="5">Red-orange sandy-loam loose soil (5%)</td></tr>
<tr><td>Rocks:</td><td colspan="5">Basalt stones (60%), Ironstone stones (5%)</td></tr>
<tr><td>Mapped as:</td><td colspan="5">THG (1)</td></tr>
<tr><td>Vegetation type:</td><td colspan="5">Hummock Grassland of Triodia brizoides with Sparse Mid Shrubland of Acacia maitlandii with Sparse Low Shrubland of Acacia adoxa var. adoxa and Isolated Low Trees of Eucalyptus leucophloia subsp. leucophloia</td></tr>
<tr><td>Vegetation condition:</td><td colspan="5">Excellent</td></tr>
<tr><td>Disturbances:</td><td colspan="5">None evident</td></tr>
<tr><td>Fire age:</td><td colspan="5">Old (> 5yrs)</td></tr>
<tr><td>Species:</td><td colspan="6">Acacia acradenia, Acacia adoxa var. adoxa, Acacia bivenosa, Acacia maitlandii, Acacia spondylophylla, Acacia tenuissima, Afrohybanthus aurantiacus, Eucalyptus leucophloia subsp. leucophloia, Indigofera monophylla, Senna glutinosa subsp. glutinosa, Triodia brizoides, Triodia epactia</td></tr>
</table>

<table>
<tr><th>Quadrat: SFQ06</th><th colspan="3">Described by: EK</th><th colspan="2">Date: 25/02/2023</th><th>Photograph</th></tr>
<tr><td>Location (GDA94):</td><td>MGA50</td><td>664404</td><td>mE</td><td>7557801</td><td>mN</td><td rowspan="8">  </td></tr>
<tr><td>Habitat:</td><td colspan="5">Hill (midslope)</td></tr>
<tr><td>Soil:</td><td colspan="5">Red-brown sandy-loam</td></tr>
<tr><td>Rocks:</td><td colspan="5">Basalt stones (85%)</td></tr>
<tr><td>Mapped as:</td><td colspan="5">THG (1)</td></tr>
<tr><td>Vegetation type:</td><td colspan="5">Closed Hummock Grassland of Triodia brizoides with Open Low Woodland of Eucalyptus leucophloia subsp. leucophloia and Sparse Low Shrubland of Senna glutinosa subsp. glutinosa</td></tr>
<tr><td>Vegetation condition:</td><td colspan="5">Excellent</td></tr>
<tr><td>Disturbances:</td><td colspan="5">None evident</td></tr>
<tr><td>Fire age:</td><td colspan="5">Old (> 5 years)</td></tr>
<tr><td>Species:</td><td colspan="6">Acacia bivenosa, Acacia maitlandii, Acacia tenuissima, Eucalyptus leucophloia subsp. leucophloia, Senna ? artemisioides, Senna glutinosa subsp. glutinosa, Senna glutinosa subsp. x luerssenii, Tribulus suberosus, Triodia brizoides, Triodia epactia</td></tr>
</table>

Quadrat: SFQ07	Described by: SH			Date: 25/02/2023		Photograph
Location (GDA94):	MGA50	664531	mE	7558017	mN	
Habitat:	Minor channel gentle south-east facing slope					
Soil:	Red-orange sandy-loam loose soil (5%)					
Rocks:	Basalt stones (50%), Ironstone stones (10%)					
Mapped as:	ASL (2)					
Vegetation type:	Tall Shrubland of *Acacia monticola* with Open Hummock Grassland of *Triodia epactia*					
Vegetation condition:	Very Good					
Disturbances:	None evident					
Fire age:	Old (> 5 years)					
Species:	*Acacia acradenia, Acacia adoxa* var. *adoxa, Acacia ancistrocarpa, Acacia atkinsiana, Acacia monticola, Acacia tumida* var. *pilbarensis, Afrohybanthus aurantiacus, Corchorus lasiocarpus* subsp. *parvus, Eriachne mucronata, Eucalyptus leucophloia* subsp. *leucophloia, Grevillea wickhamii, Hibiscus leptocladus, Indigofera monophylla, Paraneurachne muelleri, Triodia basedowii, Triodia epactia*					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