NORTHERN STAR
RESOURCES LTD

RAMONE AND VAUSE GOURDIS MINING PROJECTS

Purpose Permit Application Supporting Document

Jundee Operations

April 2025

Document ID	Author		Reviewer		Approver	
NSR-JUN-NVCP-Ramone_VG-SD	DM	09/01/25	CB	12/03/25	KT	29/04/25

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TERMS USED

Acronym / Abbreviation	Definition
BC Act	*Biodiversity Conservation Act 2016*
DBCA	Department of Biodiversity, Conservation and Attractions
DEMIRS	Department of Energy, Mines, Industry Regulation and Safety
EGS	Environmental Group Site
EPA	Environmental Protection Authority
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
ha	hectare
IBRA	Interim Biogeographic Regionalisation for Australia
Northern Star	Northern Star Resources Ltd
PEC	Priority Ecological Community
ROM pad	Run-of-mine pad
RVGMP	Ramone and Vause Gourdis Mining Project
TEC	Threatened Ecological Community
WRL	Waste rock landform

1 Summary

This document has been prepared by Northern Star Resources Ltd (Northern Star) to support a purpose permit application for Northern Star's Ramone and Vause Gourdis Mining Project (the Project). Northern Star is developing the Project as a satellite operation to extract gold ore for processing at its nearby Jundee processing plant. Whilst geographically close, Ramone and Vause Gourdis are separate mines and at different operational stages as discussed further in this document.

This document includes an outline of the project description, tenure and environmental setting, an assessment of clearing against the native vegetation clearing principles and proposes environmental management measures to avoid and mitigate clearing impacts on the environment. Northern Star has determined that the proposed native vegetation clearing may be at variance with Clearing Principles **b**, **f** and **g**. Specific management measures to address these principles have been included.

A summary of the clearing application is detailed in Table 1-1 below.

Table 1-1: Project Summary

Category	Description
Permit Type	Purpose Permit
Proponent	Northern Star Resources Ltd
Project Name	Ramone and Vause Gourdis Mining Project
Clearing Purpose	Mineral extraction and associated activities
Clearing Method	Mechanical clearing
Project Location	Mining Tenements: M 53/155, M 53/156, M 53/182, M 53/197, M 53/221 M 53/228, M 53/229, M 53/247, M 53/248, M 53/347, M 53/441, M 53/589, M 53/611
Local Government Area	Shire of Wiluna
Clearing Area (ha)	940
Clearing Footprint (ha)	3,008

2 Project Description

The Project is located in the northern Goldfields region of Western Australia, approximately 50 km northeast of Wiluna, and 37km southeast of Jundee as shown in Figure 1. The Project and proposed clearing footprint lie within tenements owned wholly by Northern Star as detailed in Table 2-1 below.

Table 2-1: Tenements

Holder	Tenement	Area (ha)	Granted	Expiry
Northern Star Resources Ltd	M 53/155	732.85	17/08/1990	16/08/2032
	M 53/156	999.55	17/08/1990	16/08/2032
	M 53/182	767.20	09/08/1991	08/08/2033
	M 53/197	980.60	02/08/1991	01/08/2033
	M 53/221	957.20	02/04/1992	01/04/2034
	M 53/228	975.25	21/05/1992	20/05/2034
	M 53/229	715.10	21/05/1992	20/05/2034
	M 53/247	831.25	12/08/1992	11/08/2034
	M 53/248	750.45	12/08/1992	11/08/2034
	M 53/347	595.85	23/05/1994	22/05/2036
	M 53/441	464.80	31/08/1995	30/08/2037
	M 53/589	641.25	09/02/2001	08/02/2043
	M 53/611	39.72	10/07/2007	09/07/2028

2.1 Ramone Mining Area

Ramone is an active mining area comprised of one open pit, several waste rock landforms (WRL), run-of-mine (ROM) pad and other supporting mine infrastructure including offices, workshop, solar farm, haul road and utilities corridors. Ramone was first developed by Northern Star in 2019 and has operated continuously since. The Ramone project has approximately one year of mine life remaining, though the project is expected to remain operational relevant to the proximity of infrastructure to the Vause / Gourdis project and potential long-term expansion relevant to geological modelling.

Clearing at Ramone was conducted under purpose permit CPS 8176/1 which was approved in December 2018 and allowed for up to 186.3 ha of native vegetation clearing. Northern Star utilised this permit to conduct 145.14 ha of clearing within the approved footprint to support development of Ramone, with 41.16 ha of clearing unutilised.

Purpose permit 8176/1 expired on 28 December 2023. Prior to this date Northern Star submitted an application to amend the duration of the permit, however the permit expired before the assessment was completed. Minor amounts of clearing have been conducted under native vegetation clearing permit exemptions (Regulation 20 of the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*) since the permit expired.

Northern Star is seeking a new native vegetation clearing permit to replace the now expired clearing permit CPS 8176/1 and support native vegetation clearing requirements for mining operations. The proposed clearing footprint around Ramone is slightly larger than the area previously approved under CPS 8176/1, to provide operational flexibility consistent with mining proposals approved under the *Mining Act 1978*.

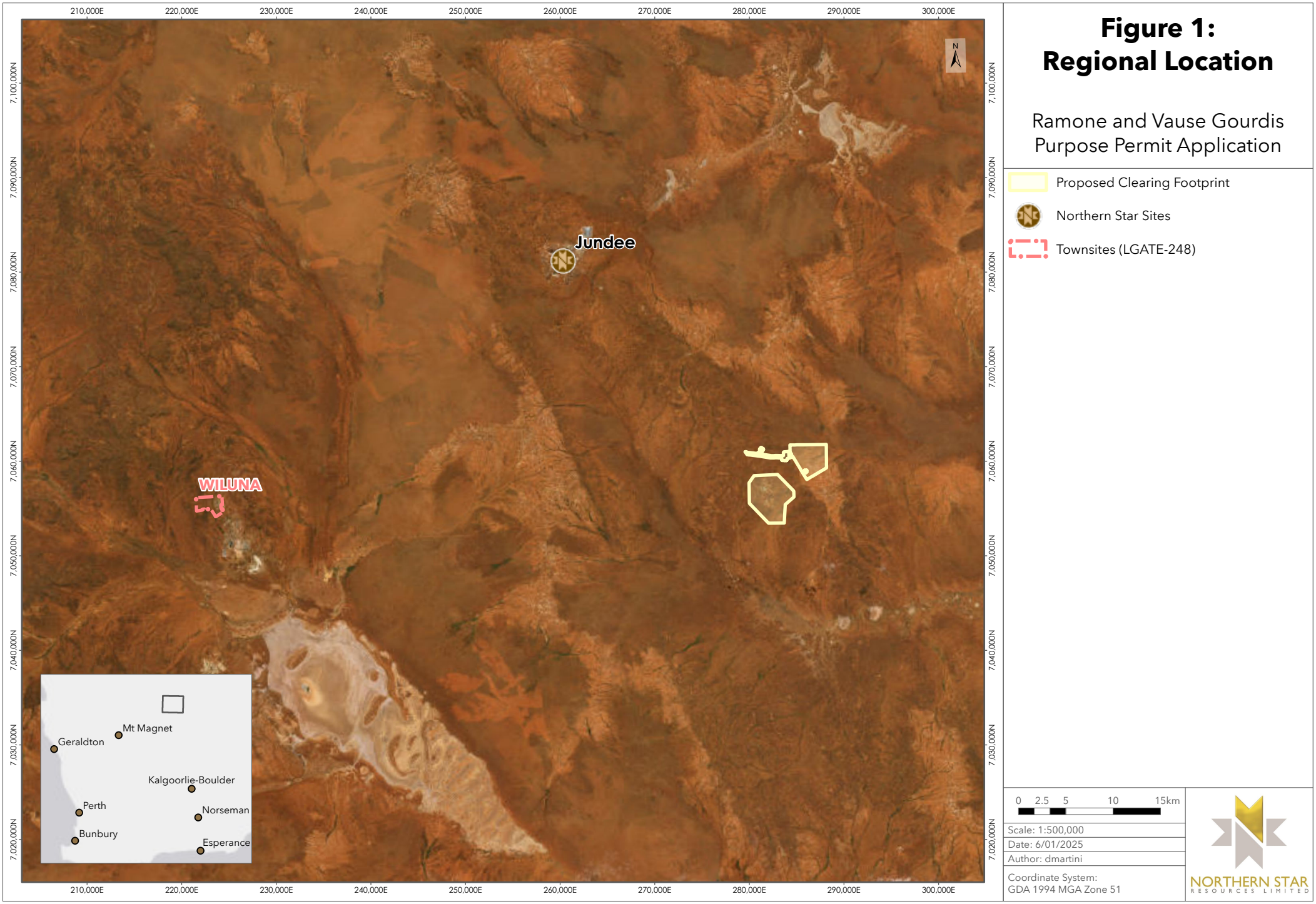

Figure 1: Regional Location

Ramone and Vause Gourdis Purpose Permit Application

- Proposed Clearing Footprint
- Northern Star Sites
- Townsites (LGATE-248)

0 2.5 5 10 15km

Scale: 1:500,000
Date: 6/01/2025
Author: dmartini

Coordinate System:
GDA 1994 MGA Zone 51

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2.2 Vause Gourdis Mining Area

Vause Gourdis is a predominantly inactive mining area comprised of several open pits, WRLs, ROM pads, and supporting mining infrastructure. Initial mining activities occurred in the early 1990s, with most recent activities occurring in the mid-2000s whilst under ownership of Newmont.

Clearing activities have been conducted under several clearing permits covering different areas of Vause Gourdis, all of which are now expired including:

- CPS 147/1 (expired 12/12/2006)
- CPS 276/2 (expired 09/03/2008)
- CPS 958/1 (expired 30/04/2011)

Northern Star is proposing to resume mining Vause Gourdis by expanding the existing open pit mines to create two new large open pits, and develop additional supporting infrastructure, including new WRLs, ROMs and laydowns. Previously disturbed land will be utilised as far as practicable, however native vegetation clearing will be required to support proposed mining activities. Some of this vegetation (up to approximately 108 ha) is land rehabilitated under previous operators.

The current design of Vause Gourdis is indicative and will be revised prior to submission of a Mining Proposal to the Department of Energy, Mines, Industry Regulation and Safety (DEMIRS). The proposed clearing footprint is based on a scoping level conceptual design and the clearing footprint will be refined further as detailed engineering studies progress. Mining of Vause Gourdis is currently planned to commence in 2026 pending securing of all regulatory approvals.

2.3 Proposed Clearing Footprint

Northern Star proposes to clear 940 ha of native vegetation within a 3,008 ha clearing footprint. The proposed clearing footprint is shown in Figure 2. Northern Star has opted to submit one application for a purpose permit covering both Ramone and Vause Gourdis mining areas. This is to align the clearing permit with Mining Act approvals for the Ramone Environmental Group Site approved under the Mining Act.

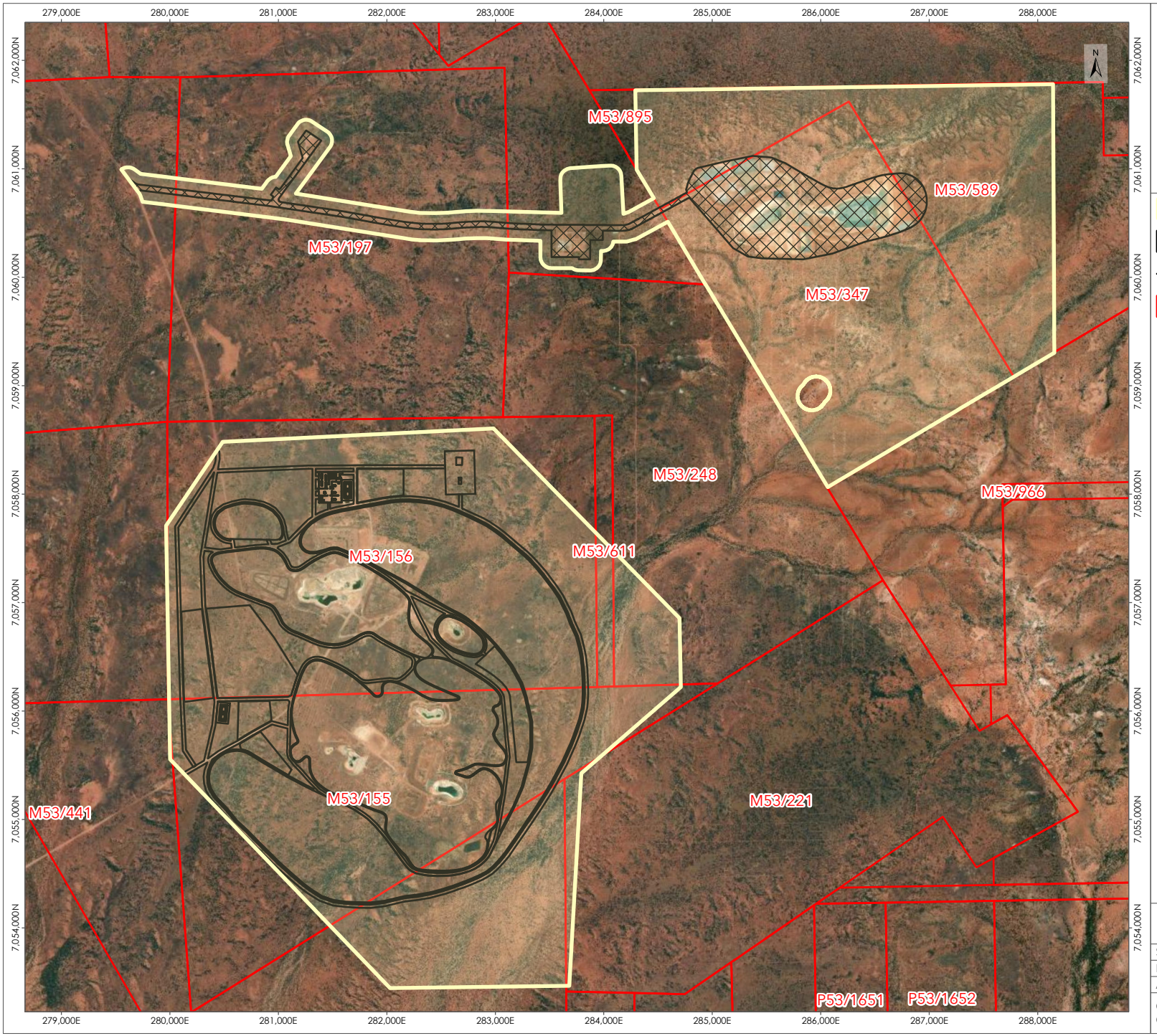

Figure 2: Proposed Clearing Footprint

Ramone and Vause Gourdis Purpose Permit Application

- Proposed Clearing Footprint
- CPS 8176/1 Boundary (Expired)
- Indicative Vause Gourdis Design
- Northern Star Tenements

0 0.25 0.5 1 1.5km

Scale: 1:50,000

Date: 6/01/2025

Author: dmartini

Coordinate System: GDA 1994 MGA Zone 51

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3 Environmental Setting

3.1 Landscape

3.1.1 Climate

The Shire of Wiluna is situated within a semi-arid to arid climatic zone of intermittent rainfall characterised by hot summers and cool winters. Data sourced from Wiluna weather station (BOM Site #13012) located approximately 55 km west shows a mean annual rainfall of 261 mm, however this is highly variable ranging from 49 mm to 712 mm from between 1898 to 2019 (BOM 2024). Mean annual evaporation is 2,409 mm which is approximately 10 times higher than mean annual rainfall, with evaporation exceeding rainfall every month of the year. Most rainfall occurs between the months of January – April and is associated with thunderstorms and ex-tropical cyclones.

3.1.2 Bioregion

The Interim Biogeographic Regionalisation of Australia (IBRA) divides Australia into 89 bioregions based on major biological, geographical and geological attributes. These bioregions are subdivided into 419 subregions as part of a refinement of the IBRA framework (Thackway & Cressdell 1995).

The Project occurs within the Eastern Murchison subregion of the Murchison bioregion which is characterised as Mulga low woodlands, often rich in ephemerals, on outcrop and fine-textured Quaternary alluvial and eluvial surfaces mantling granitic and greenstone strata of the northern part of the Yilgarn Craton (Thackway & Cressdell 1995). The dominant land uses in this region include pastoral leases, unallocated crown reserves, mining leases, conservation reserves and remote Aboriginal communities.

The Eastern Murchison subregion and proposed clearing footprint is located within the 'extensive land use zone' which is an expansive tract of native vegetation with low fragmentation.

3.1.3 Land Uses

There are no ecologically sensitive areas (ESAs) located within the proposed clearing footprint. The nearest ESA is associated with Wanjarri Nature Reserve which is located 70 km south of the Project. The nearest conservation reserve is Matuwa Kurrara Kurrara National Park, located approximately 37.5 km northeast. There is significant remnant vegetation surrounding these nature conservation reserves. The Project is located on the Lake Violet Pastoral Station (PL N050102) and surrounded by other pastoral stations. Surrounding land uses are shown in Figure 3.

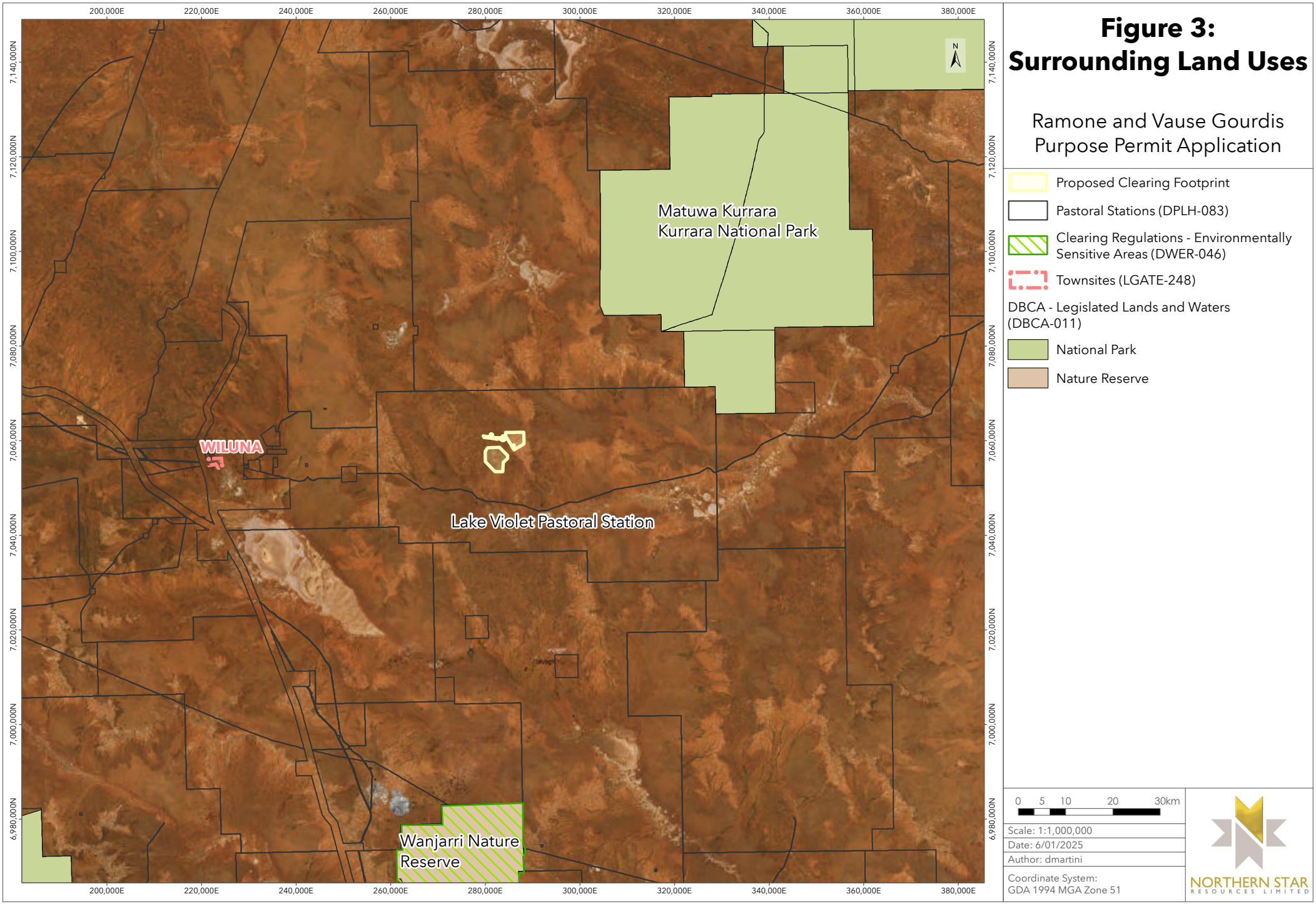

Figure 3: Surrounding Land Uses

Ramone and Vause Gourdis
Purpose Permit Application

- Proposed Clearing Footprint
- Pastoral Stations (DPLH-083)
- Clearing Regulations - Environmentally Sensitive Areas (DWER-046)
- Townsites (LGATE-248)

DBCA - Legislated Lands and Waters (DBCA-011)

- National Park
- Nature Reserve

0 5 10 20 30km

Scale: 1:1,000,000
Date: 6/01/2025
Author: dmartini

Coordinate System:
GDA 1994 MGA Zone 51

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3.2 Soils

Regional landscape mapping shows the Project predominantly occurs within the Violet and Sherwood systems with a small portion also intersecting the Yanganoo and Jundee systems. Regional land systems are shown in Figure 4 and described in Table 3-1 below.

Table 3-1: Regional Land Systems

Land System	Description
Jundee	Hardpan plains with variable gravelly mantles and minor sandy banks supporting weakly groved mulga shrublands.
Sherwood	Breakaways, kaolinised footslopes and extensive gently sloping plains on granite supporting mulga shrublands and minor halophytic shrublands.
Violet	Gently undulating gravelly plains on greenstone, laterite and hardpan, with low stony rises and minor saline plains; supporting groved mulga and bowgada shrublands and occasionally chenopod shrublands.
Yanganoo	Almost flat hardpan wash plains, with or without small wanderrie banks and weak groving; supporting mulga shrublands and wanderrie grasses on banks.

3.2.1 Soils Characterisation

Soils were characterised by Soilwater Consultants as part of the environmental approvals for mining of Ramone. Twenty three sampling locations were selected across the project area to adequately characterise the different potential soil profiles. Soil samples were collected at two depths and analysed for physiochemical properties and erosion potential, with the soil characterisation report provided as **Appendix A.**

Soils were characterised as relatively homogenous sandy loams to clay loams, shallow, and of low organic matter (Soilwater 2018). Surface soils were deemed as structurally unstable, sodic, dispersive and erosive and consequently disturbance of these soils is likely to increase erosion potential. Recommendations from this report will inform clearing, topsoil stripping and stockpiling activities to optimise topsoil recovery and minimise erosion risk.

Soils within Vause Gourdis were characterised by Botanica Consulting in 2023. Twelve test pits were excavated from across Vause Gourdis project area to accurately represent the different soil landscape systems present. Soil samples were taken to varying depths depending on profile depth (between 0 – 60 cm) and analysed for physiochemical properties affecting soil stability and suitability as growth media. The soil characterisation report is provided as **Appendix B**.

Soils were characterised as sandy loams, sandy clay loams and loamy sands, and were shallower in the north of the project area and deeper in the south (Botanica 2023a). Soils up to 150 mm depth can be treated as topsoils with hard setting below this depth varying across the project area. Nutrient levels were low for most macronutrients, which is typical for ancient, weathered landscapes. Soils were acidic with pH ranging between 3.7 to 7.2, and non-saline with EC ranging between 1 – 12 mS/m in all but two samples.

Surface soils in eight out of 12 locations had an Emerson Class of 1 or 2 a very high propensity for dispersion. These soils were distributed around all soil landscape systems and therefore it can be concluded that the majority of soils within Vause Gourdis project area should be treated as dispersive. Notwithstanding this, soils had a relatively high gravel content which will help stabilise soils and reduce erosion (Botanica 2023a).

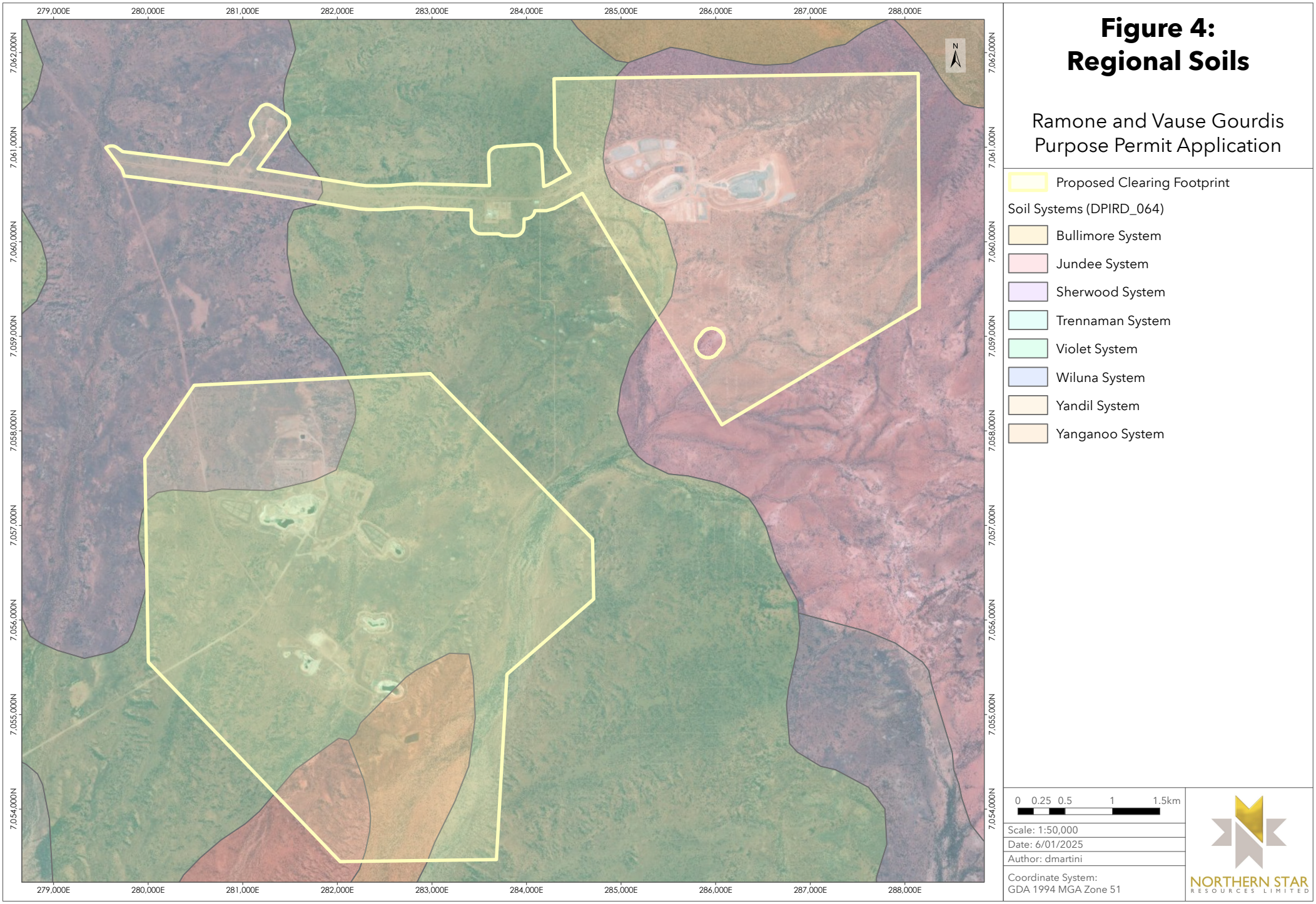

Figure 4: Regional Soils

Ramone and Vause Gourdis Purpose Permit Application

Proposed Clearing Footprint

Soil Systems (DPIRD_064)

- Bullimore System
- Jundee System
- Sherwood System
- Trennaman System
- Violet System
- Wiluna System
- Yandil System
- Yanganoo System

0 0.25 0.5 1 1.5km

Scale: 1:50,000

Date: 6/01/2025

Author: dmartini

Coordinate System:
GDA 1994 MGA Zone 51

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3.3 Biodiversity

3.3.1 Biological Surveys

Biological surveys have been undertaken over the Ramone and Vause Gourdis project areas with a summary of recent surveys detailed in Table 3-2 below. Surveys include both desktop and field assessments to determine biological values as well as the likelihood of significant vegetation, flora and fauna. Survey areas are shown in Figure 5, and recent biological surveys are provided as Appendices.

Table 3-2: Biological Surveys

Project Area	Survey Type	Survey Area	Fieldwork Date	Limitations Identified	Author / Appendix
Ramone	Detailed flora and vegetation assessment Level 1 (basic) vertebrate fauna assessment	1,815 ha	April – May 2018 March 2018	Nil	Stantec 2018 (**Appendix C**)
Vause Gourdis	Detailed flora and vegetation assessment Basic vertebrate fauna assessment	1,798 ha	March 2023	Survey undertaken within EPA recommended timing for surveys of the Eremaean Province however below average rainfall pre-survey.	Botanica 2023b (**Appendix D**)

3.3.2 Vegetation

Vegetation within the proposed clearing footprint is broadly mapped as Beard vegetation associations:

- Wiluna 18 – Low woodland; mulga (*Acacia aneura*)
- Wiluna 39 – Shrublands; mulga scrub

Areas retaining less than 30% of their pre-European vegetation extent show accelerated species loss, whilst areas with less than 10% are considered "endangered" (EPA, 2000). Clearing which would put the threat level into the 30% "threshold level" should be avoided (EPA 2000). Both mapped associations are largely intact with approximately 99% of pre-European vegetation remaining according to the 2018 Statewide Vegetation Statistics (DBCA 2019), and accordingly clearing is not inconsistent with the EPA position statement. Pre-European vegetation extent is summarised in Table 3-3 below and shown in Figure 6.

Table 3-3: Pre-European Vegetation

Association	Pre-European area (ha)	Current extent (ha)	Extent remaining (%)	DBCA managed (ha)	DBCA managed (%)
Eastern Murchison	21,135,083	21,065,967	99.67	1,737,906	8.25
Beard Vegetation Association – State					
Wiluna 18	4,308,335	4,290,594	99.59	409,513	9.54
Wiluna 39	426,536	421,470	98.81	83,869	10.76
Beard Vegetation Association – Shire of Wiluna					
Wiluna 18	1,083,181	1,073,708	99.13	41,923	3.90
Wiluna 39	153,842	153,216	99.59	1,303	0.85

Vegetation communities were identified and described using quadrats to take representative samples of different vegetation present. Ten vegetation communities were recorded within Ramone survey area (Stantec 2018), and five vegetation communities were identified within Vause Gourdis survey area (Botanica 2023b). These vegetation communities can broadly be described as open mulga shrublands which dominate the bioregion, with denser vegetation associated with drainage lines. A summary of mapped vegetation communities is provided in Table 3-4 below and shown in Figure 7.

Table 3-4: Vegetation Communities

Project Area	Vegetation Code	Description
Ramone	AaEcTm	*Acacia aneura* tall shrubland over *Eremophila citrina* open low heath over *Triodia melvillei* very open hummock grassland
	AaApEf	*Acacia aptaneura* and *Acacia pteraneura* open low woodland over *Eremophila fraseri* open shrubland
	AaApEs?b.Ee	*Acacia aneura* and *Acacia aptaneura* open tall shrubland over *Eremophila spectabilis subsp. ?brevis* open low shrubland over *Eragrostis eriopoda* open tussock grassland
	AaEffTb	*Acacia aneura* tall open shrubland over *Eremophila forrestii subsp. forrestii* low open shrubland over *Triodia basedowii* hummock grassland
	ApAiEcTm	*Acacia pruinocarpa* low open woodland over *Acacia incurvaneura* tall open shrubland over *Eremophila citrina* low shrubland over *Triodia melvillei* hummock grassland
	AaAtS?sEs?bSeEe	*Acacia aneura*, *Acacia tetragonophylla* and *Santalum ?spicatum* tall open shrubland over *Eremophila spectabilis subsp ?brevis* and *Sida ectogama* low open shrubland over *Eragrostis eriopoda* open tussock grassland
	AiEllAt	*Acacia incurvaneura* tall shrubland over *Eremophila latrobei subsp. latrobei* and *Acacia tetragonophylla* open low shrubland
	ApAaAcEllEfEfFd	*Acacia pteraneura* and *Acacia aneura* open scrub over *Acacia craspedocarpa* and *Eremophila latrobei subsp. latrobei* open shrubland over *Eriachne flaccida* and *Eragrostis falcata* closed tussock grassland over *Fimbristylis dichotoma* very open sedgeland.
	ElAcSeMsp.	*Eremophila linearis* and *Acacia craspedocarpa* tall shrubland over *Ptilotus obovatus* herbland over *Sclerolaena eriacantha* and *Maireana sp.* open chenopods
	SMSeSc	*Senna sp.* Meekatharra (E. Bailey 1-26) hybrid open low shrubland over *Sclerolaena eriacantha* and *Sclerolaena cuneata* (Maireana sp.) very open herbland.
Vause Gourdis	CLP-AFW1	Low woodland of *Acacia incurvaneura* over mid open shrubland of *Acacia tetragonophylla/ Psydrax latifolia* and low shrubland of *Eremophila margarethae* on clay-loam plain
	DD-AFW1	Low forest of *Acacia incurvaneura* over tall open shrubland of *Acacia aptaneura / A. tetragonophylla* and low open shrubland of *Eremophila forrestii subsp. forrestii / Eremophila margarethae* in drainage depression
	QRP-AFW1	Low forest of *Acacia incurvaneura* over mid open shrubland of *Eremophila fraseri / E. jucunda / E. margarethae* and low hummock grassland of *Triodia basedowii* on quartz-rocky plain
	RH-AFW1	Low forest of *Acacia incurvaneura* over mid open shrubland of *Eremophila jucunda / Eremophila linearis/ Senna sp.* Meekatharra (E. Bailey 1-26) and low open shrubland of *Ptilotus obovatus* on rocky hillslope
	SLP-AFW1	Low forest of *Acacia incurvaneura* over mid open shrubland of *Acacia balsamea/ Eremophila forrestii subsp. forrestii* and low hummock grassland of *Triodia basedowii/ T. melvillei* on sand-loam plain

3.3.2.1 Vegetation Condition

Vegetation condition ranged between cleared / degraded to excellent, as detailed in Table 3-5 below and shown in Figure 8. The majority of vegetation is in very good condition despite previous mining and exploration activities occurring within the Project area.

Table 3-5: Vegetation Condition

Project Area	Vegetation Condition	Survey Area (ha)	% of Survey Area
Ramone	Excellent	387	21
	Very Good	1285	71
	Good	98	5.5
	Degraded	44	2.5
	Total	**1,814**	**100**
Vause Gourdis	Very Good	930	52
	Good	542	30
	Cleared	326	18
	Total	**1,798**	**100**

3.3.2.2 Significant Vegetation

Based upon database searches, no threatened ecological communities (TEC) or priority ecological community (PEC) are known to occur within or near the Project area (Stantec 2018; Botanica 2023b). Field assessments found no evidence that any TEC, PEC, or otherwise conservation significant vegetation types were within the Project area (Stantec 2018; Botanica 2023b).

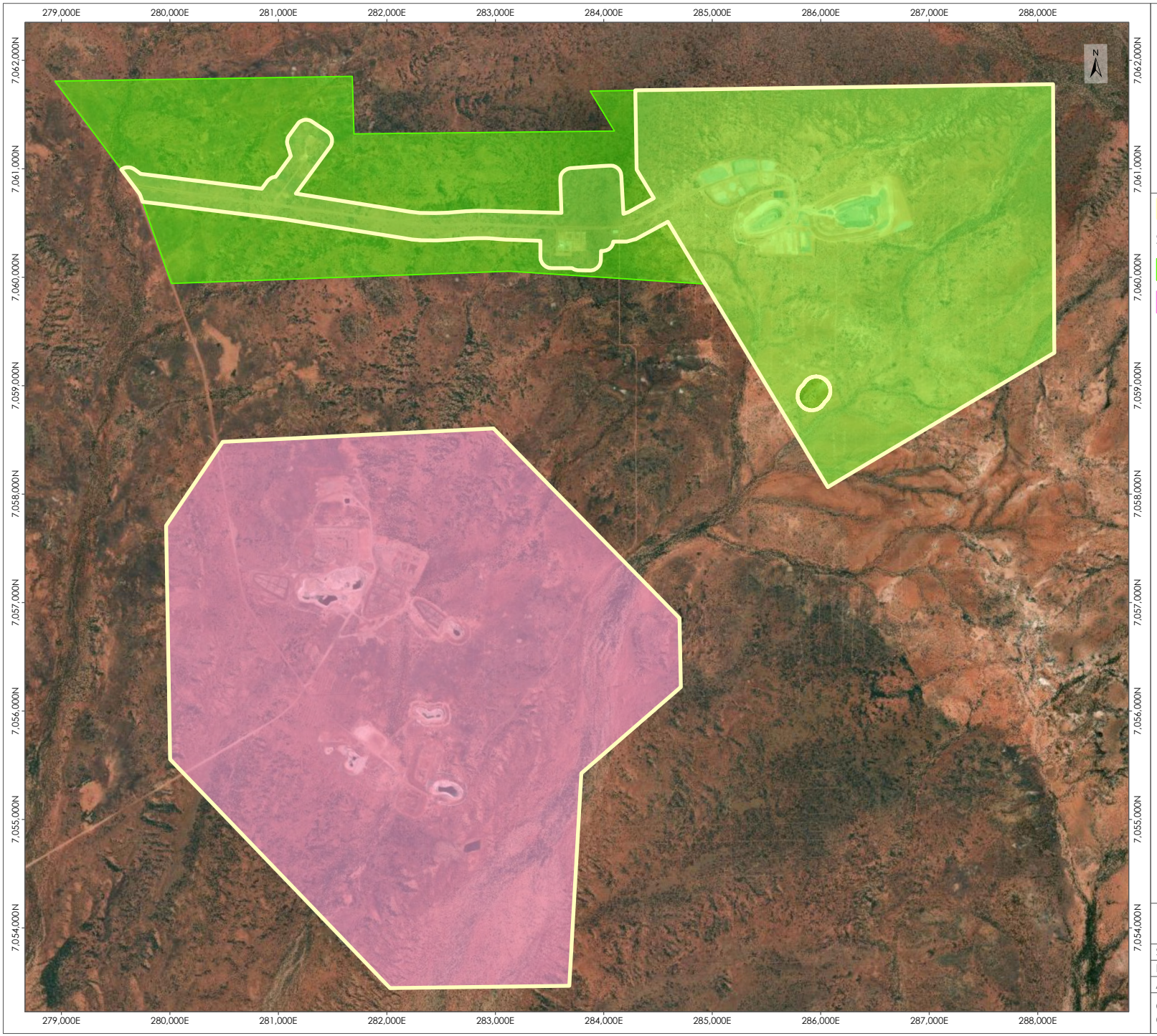

Figure 5: Biological Surveys

Ramone and Vause Gourdis Purpose Permit Application

Proposed Clearing Footprint

Survey Area

Ramone (Stantec 2018)

Vause Gourdis (Botanica 2023)

0 0.25 0.5 1 1.5km

Scale: 1:50,000

Date: 6/01/2025

Author: dmartini

Coordinate System: GDA 1994 MGA Zone 51

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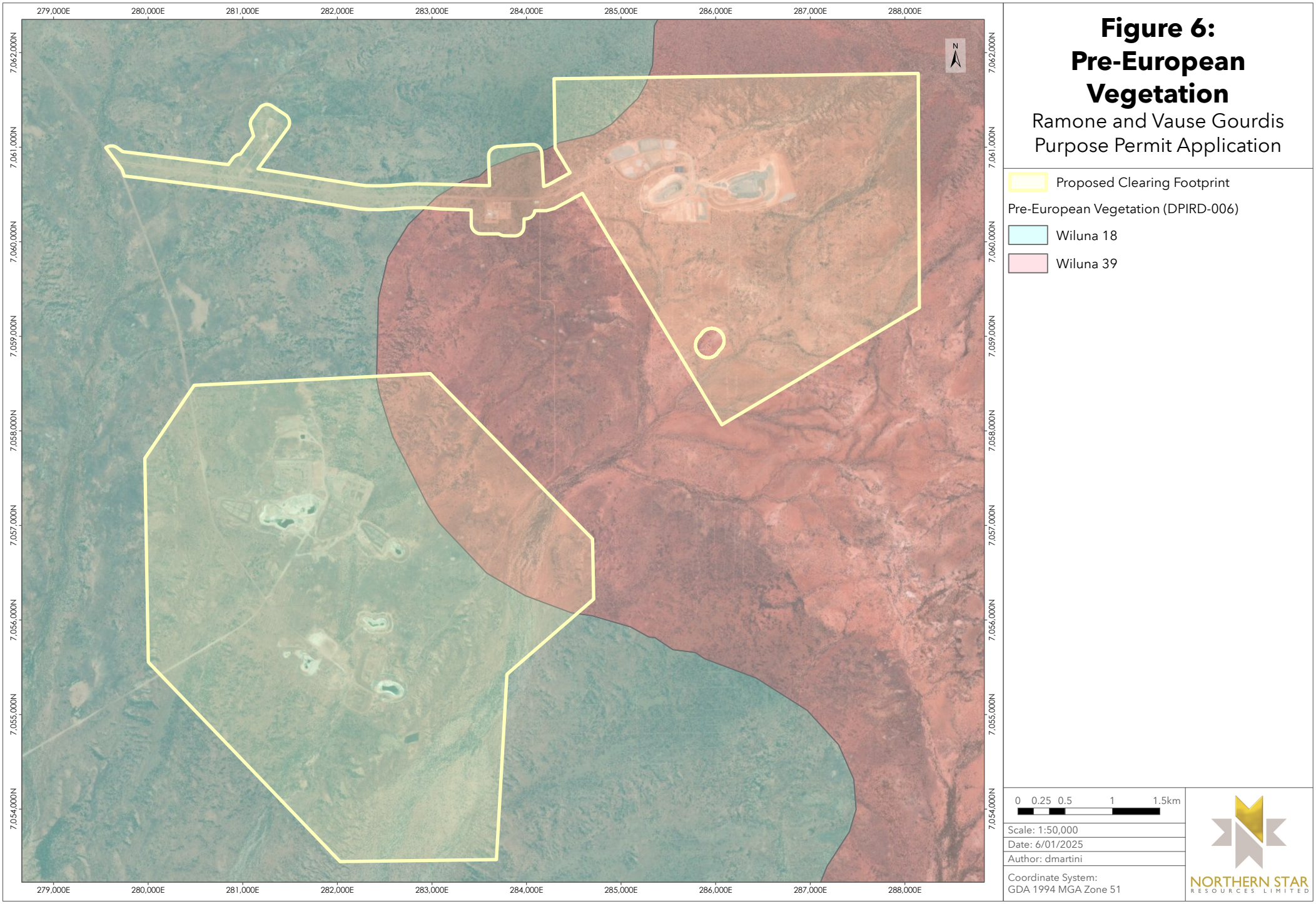

Figure 6: Pre-European Vegetation

Ramone and Vause Gourdis Purpose Permit Application

Proposed Clearing Footprint

Pre-European Vegetation (DPIRD-006)

Wiluna 18

Wiluna 39

0 0.25 0.5 1 1.5km

Scale: 1:50,000

Date: 6/01/2025

Author: dmartini

Coordinate System: GDA 1994 MGA Zone 51

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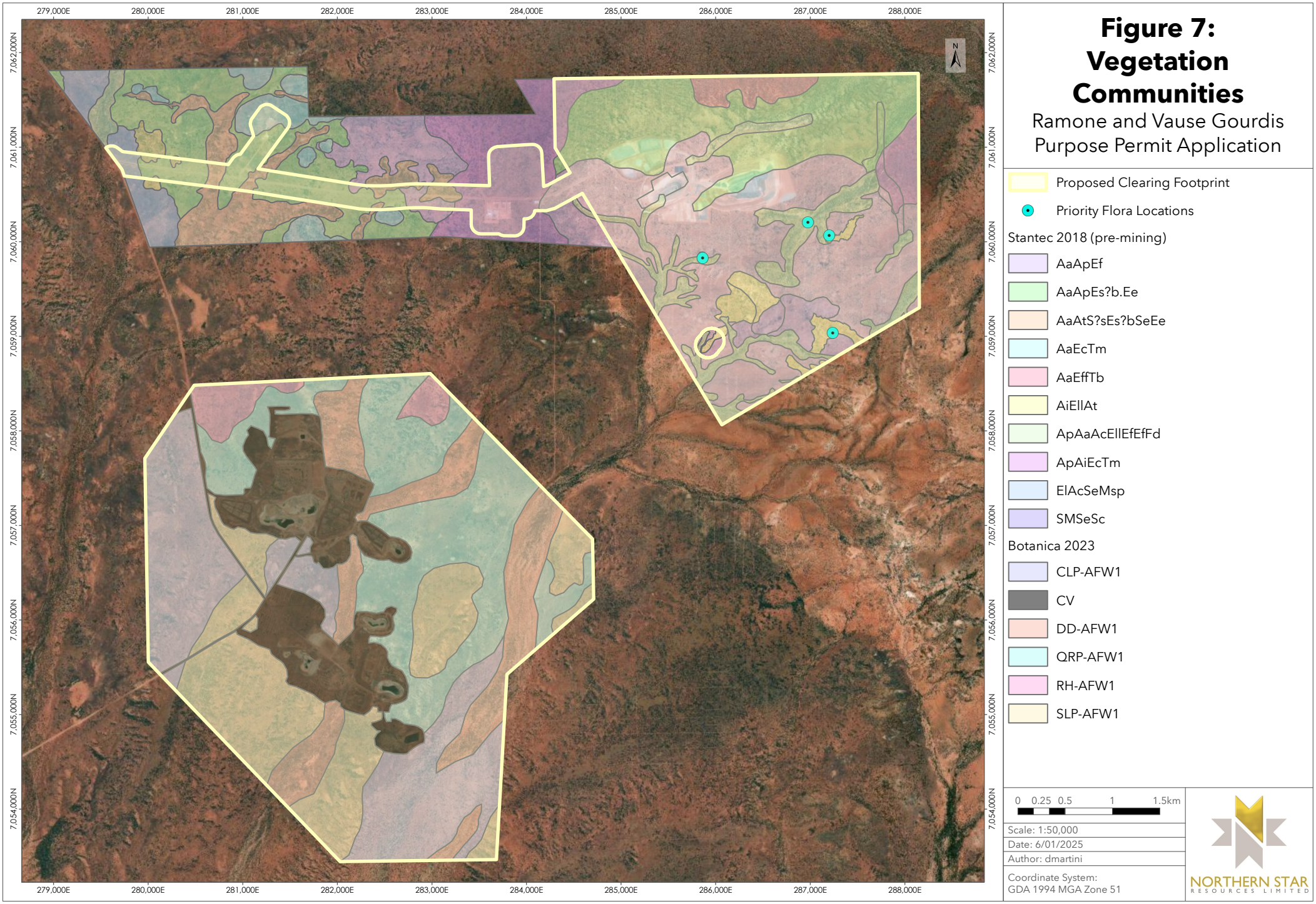

Figure 7: Vegetation Communities

Ramone and Vause Gourdis Purpose Permit Application

- Proposed Clearing Footprint
- Priority Flora Locations

Stantec 2018 (pre-mining)

- AaApEf
- AaApEs?b.Ee
- AaAtS?sEs?bSeEe
- AaEcTm
- AaEffTb
- AiEllAt
- ApAaAcEllEfEfFd
- ApAiEcTm
- ElAcSeMsp
- SMSeSc

Botanica 2023

- CLP-AFW1
- CV
- DD-AFW1
- QRP-AFW1
- RH-AFW1
- SLP-AFW1

0 0.25 0.5 1 1.5km

Scale: 1:50,000

Date: 6/01/2025

Author: dmartini

Coordinate System: GDA 1994 MGA Zone 51

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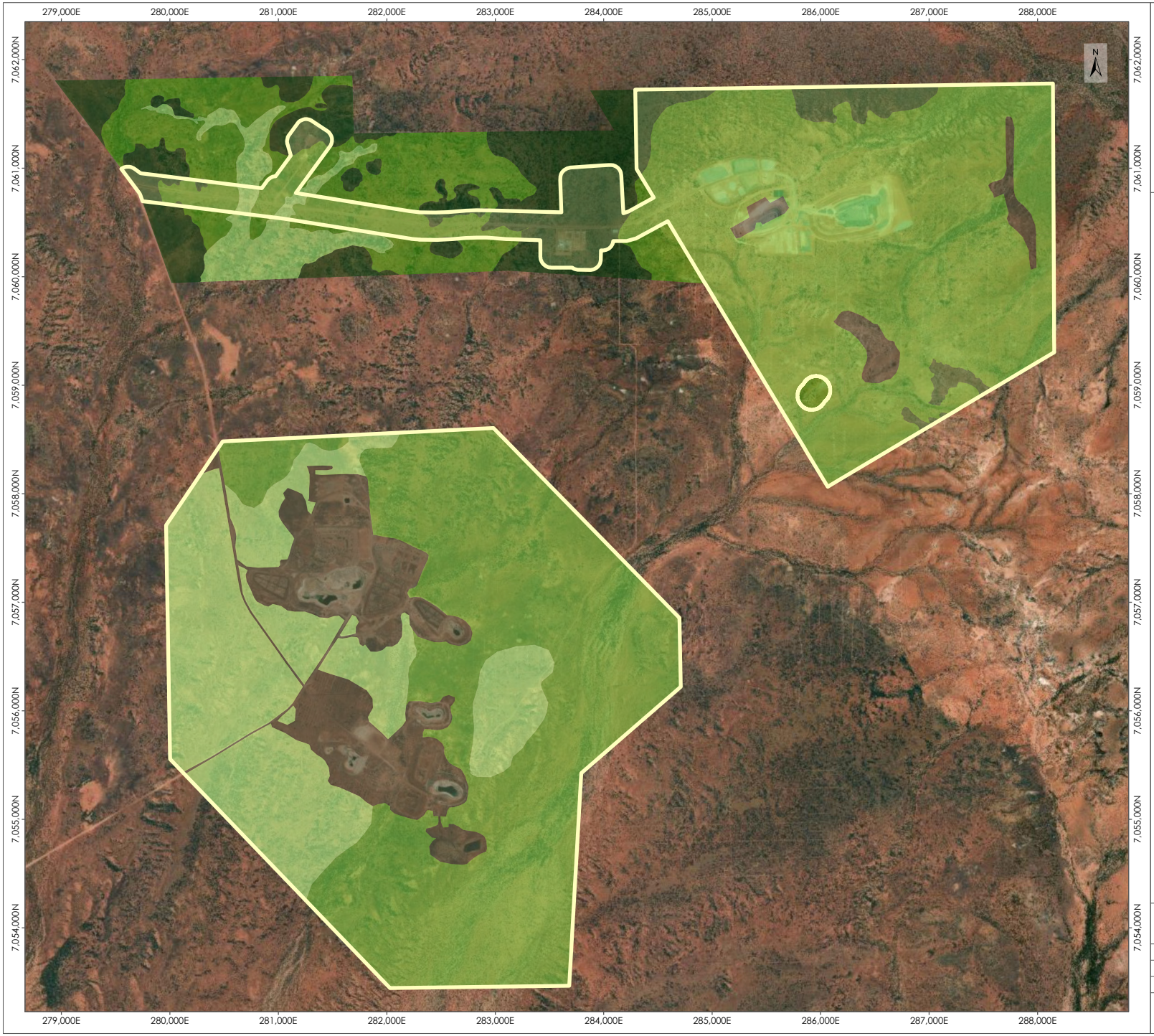
Figure 8: Vegetation Condition

Ramone and Vause Gourdis Purpose Permit Application



Proposed Clearing Footprint

Vegetation Condition

- Excellent
- Very Good
- Good
- Degraded / Cleared

0 0.25 0.5 1 1.5km

Scale: 1:50,000

Date: 6/01/2025

Author: dmartini

Coordinate System:
GDA 1994 MGA Zone 51

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3.3.3 Flora

There was 104 flora taxa recorded in the Ramone survey area, representing 21 families and 53 genera, the most common of which being Acacia (14) and Eremophila (14). Three introduced flora were recorded, of which none were listed as a Declared Plant Pest or Weed of National Significance (Stantec 2018).

Seventy two flora taxa were recorded in the Vause Gourdis survey area, representing 19 families and 29 genera, the most common of which being Acacia (13) and Eremophila (10). No introduced flora were identified within the Vause Gourdis survey area (Botanica 2023b).

3.3.3.1 Significant Flora

Based on desktop searches within a 50 km radius, 39 flora taxa of conservation significance were identified in the vicinity of the Ramone survey area (Stantec 2018). Of the 39, one was listed as Threatened under the *Biodiversity Conservation Act* 2016 (BC Act), 11 were listed as Priority (P) 1, two were listed as P2, 21 were listed as P3 and four were listed as P4.

Of these species, two Priority flora species; *Aristida jerichoensis var. subspinulifera* (P3) and *Eremophila pungens* (P4) were identified during targeted searches during the field assessment (Stantec 2018). The field assessment did not include counts of individuals, however 'large numbers' of both species were encountered. Locations of Priority flora observations are shown in Figure 7.

Aristida jerichoensis var. subspinulifera is a compactly tufted perennial which grows in hardpan plains. In the survey area it was found within vegetation type ApAaAcEllEfEfFd, associated with mulga drainage areas. This species is primarily found in the Pilbara region around Newman but is also found in the Northern Territory, New South Wales, Victoria and Queensland, with Wiluna representing the southern area of the known distribution in Western Australia. The Western Australian distribution ranges approximately 1,200 km as shown in Plate 1.

Eremophila pungens is an erect slow growing shrub native to Western Australia. It is found growing in the Gascoyne, Great Victoria Desert and Murchison regions in plains, ridges and breakaways. Within the survey area it was found within vegetation type AiEllAt associated with low rocky hills with outcropping. The species has known populations within nearby Matuwa Kurrara Kurrara National Park and Wanjarri Nature Reserve, with the Western Australian distribution ranging approximately 350 km as shown in Plate 1.

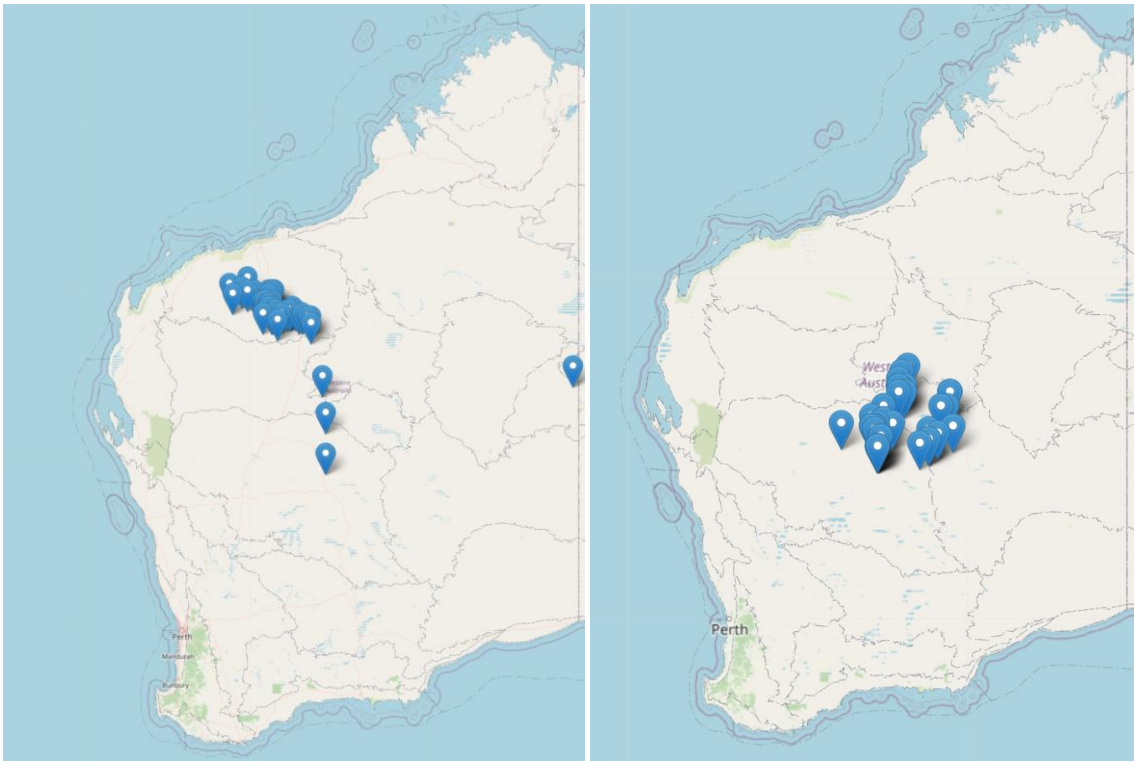

Plate 1: *Aristida jerichoensis var. subspinulifera* (left) and *Eremophila pungens* WA distributions (Florabase 2025)

Based on desktop searches within a 40 km radius, nine flora taxa of conservation significance were identified in the vicinity of the Vause Gourdis survey area (Botanica 2023b). Of the nine, none were listed as Threatened under the BC Act, two are listed as P1, five as P3 and two as P4. No Threatened flora species or Priority flora species were identified during targeted searches during the field assessment of the Vause Gourdis survey area (Botanica 2023b).

3.3.4 Fauna

Based on desktop searches of the Ramone survey area, 299 species of vertebrate fauna had the potential to occur of which 41 species were recorded during the field assessment (Stantec 2018). Nine of these species were mammals, 23 were birds and nine were reptiles. Four introduced fauna species were observed: dog, red fox, cat and camel.

Based on desktop searches of the Vause Gourdis survey area, 152 species of vertebrate fauna had potential to occur of which 11 species were recorded during the field assessment (Botanica 2023b). Two of these species were mammals, seven were birds, and two were reptiles. Two introduced fauna species were observed: European cattle and rabbit.

3.3.4.1 Significant Fauna

Based on desktop searches, 38 conservation significant fauna were identified as being previously identified within the vicinity of the Project (Stantec 2018; Botanica 2023b). Following field surveys, assessments provided by Stantec and Botanica identified four conservation significant fauna species as possible and one as confirmed (Brush-tailed Mulgara) in the combined survey areas. A further 17 species were deemed as unlikely to be found within the survey areas based upon the species known range, distance to nearest records and habitat suitability. A revised significant fauna assessment for the five confirmed and possible species was undertaken by Northern Star based upon the proposed clearing area as detailed in Table 3-6.

Brush-tailed Mulgara are found widely distributed across spinifex (hummock) grassland plains in the arid zones of Western Australia, the Northern Territory and northern sections of South Australia as shown in Plate 2. They were the eighth most commonly recorded mammal species and eighteen most overall recorded across all surveys conducted for the Arid Zone Monitoring project, being found in 4% of all surveys (NESP 2021).

Plate 2: Brush-tailed Mulgara Distribution (ALA 2025)

Table 3-6: Significant Fauna Assessment

P = Priority, VU = Vulnerable, MI = Migratory, OS = Other Species. Accurate as of November 2024

Species Name	Common Name	Conservation Status			Revised Assessment	Likelihood
		BC Act	EPBC Act	DBCA		
Dasycercus blythi	Brush-tailed Mulgara	-	-	P4	Recorded at three locations within the Spinifex Plain habitat type.	Confirmed within proposed clearing footprint.
Falco hypoleucos	Grey Falcon	VU	VU		Suitable foraging habitat may be present but is unlikely to represent breeding habitat for the species.	Possibly occurring in wider area.
Sminthopsis longicaudata	Long-tailed Dunnart	-	-	P4	Within species range and Low Rocky Hills with Outcropping identified as potential suitable habitat. Not observed during surveys.	Possibly occurring in proposed clearing footprint within specific habitat type.
Falco peregrinus	Peregrine Falcon	OS	-	-	Suitable foraging habitat may be present but is unlikely to represent breeding habitat for the species.	Possible occurring in wider area.
Apus pacificus	Fork-tailed Swift	MI	MI	-	May utilise the habitat as part of broader range however migratory shorebirds are typically associated with semi-permanent waterbodies (i.e. lakes and dams) which are not present within proposed clearing footprint.	Unlikely to occur within proposed clearing footprint.

3.3.4.2 Fauna Habitat

Eight fauna habitat types were mapped within the Ramone survey area, and four within the Vause Gourdis survey area as described in Table 3-7 below and shown in Figure 9 (Stantec 2018; Botanica 2023b). Broad habitat values observed included shelter, foraging and food sources, however the values varied across vegetation associations.

Of these total 12 habitat types, the two were determined to be potential habitat for conservation significant fauna species (both found within the Ramone survey area and none in Vause Gourdis survey area):

- Low rocky hills with outcropping – potential habitat for short range endemic (SRE) invertebrates and Long-tailed Dunnart (P4).
- Spinifex plain – confirmed habitat for Brush-tailed Mulgara (P4).

Table 3-7: Fauna Habitats

Project Area	Habitat Type	Habitat Description	Habitat Values	Example Image
Ramone (Stantec 2018)	Mulga shrubland over grasses (29%)	Plains with a sparse to moderate upper storey dominated by *Acacia aneura* interspersed with *Acacia pruinocarpa* over *Eremophila sp.*, *Senna sp.*, *Solanum sp.*, *Ptilotus schwartzii* and tussock grasses.	◤ Grasses provide cover and food sources for small. reptiles,mammals and birds. ◤ Minimal shelter in the form of woody debis. ◤ Impacted by introduced fauna (cattle, rabbit etc.) Widespread, limited significance and low SRE potential.	
	Mulga shrubland on stony plain (31%)	Rocky plains with a sparse to moderate upper storey dominated by *Acacia aneura* interspersed with *Acacia pruinocarpa* over a sparse understorey comprising isolated *Eremophila sp.*, *Senna sp.*, *Solanum sp.* and *Ptilotus schwartzii*, occasionally with isolated patches of tussock grasses.	◤ Abundant rocky substrate. ◤ Minimal cover for small mammals and reptiles. ◤ Limited woody debris shelter in upper storey. ◤ Impacted by introduced fauna (cattle, rabbit etc.). Widespread, limited significance and low SRE potential.	

Project Area	Habitat Type	Habitat Description	Habitat Values	Example Image
Ramone (Stantec 2018)	Mulga drainage (15%)	Drainage lines occurred in locations prone to flooding, and varied in vegetation composition and density. The habitat ranged from relatively open areas dominated by *Acacia aneura* and tussock grasses to densely vegetated areas with a thick understorey.	◤ Fallen trees and densse vegetation provides shelter for reptile, mammal and bird species. ◤ Variety of feeding and nesting prospects in dense upper storey. ◤ Suitable habitat for amphibians following inundation. Widespread, limited significance and low SRE potential.	
	Mulga over spinifex on low hill (3.5%)	Low hills with a sparse to moderate upper storey largely comprising *Acacia aneura* interspersed with *Acacia pruinocarpa* over *Eremophila sp.*, *Solanum sp.*, *Ptilotus schwartzii*, spinifex hummocks and patchy tussock grasses.	◤ Limited amount of woody debris and peeling bark. ◤ Spinifex grasses provide habitat cover for a variery of mammal, bird and reptile species. ◤ Impacted by introduced fauna (cattle, rabbit etc.). Widespread, limited significance and low SRE potential.	

Project Area	Habitat Type	Habitat Description	Habitat Values	Example Image
Ramone (Stantec 2018)	Eremophila shrubland (3%)	Plains with a sparse to moderate upper storey dominated by *Eremophila sp.* with isolated *Acacia aneura* over *Ptilotus sp.*, *Solanum sp.*, *Senna sp.* and isolated patches of tussock grasses.	◤ Minimal cover for small mammals and reptiles. ◤ Woody debris and peeling bark in upper storey provides some shelter. ◤ Impacted by introduced fauna (cattle, rabbit etc.). Widespread, limited significance and low SRE potential.	
	Low rocky hills with outcropping (3%)	Outcropping in the southeast contained isolated *Acacia pruinocarpa*, *Eremophila sp.*, including the P4 *Eremophila pungens*, *Senna sp.* and in some areas *Melaleuca sp.*, while the western understorey was sparse and comprised *Eremophila sp.*, *Ptilotus schwartzii* and isolated tussock and spinifex grasses. The western outcrop also occurred on a relatively high hill with steeper slopes. Both supported an upper storey of *Acacia aneura*, which was denser in the west.	◤ Rocky crevices provide shelter for ground dwelling mammals and reptiles and may provide suitable habitat for Long-tailed Dunnart (P4). ◤ Rocky outcrops have medium potential to support SRE invertebrates due to microhabitats available. Limited extent, moderate significance and SRE potential.	

Project Area	Habitat Type	Habitat Description	Habitat Values	Example Image
Ramone (Stantec 2018)	Spinifex plain (13%)	Plains with a sparse upper storey of *Acacia aneura* and *Acacia pruinocarpa* over low, long unburnt spinifex hummocks and sparse *Eremophila sp.* Spinifex plains contained some areas with a moderate upper storey associated with leaf litter, woody debris and peeling bark, also contained large open areas.	◤ Low cover various mammal and reptile species, and the substrate is suitable for foraging and burrowing (foraging evidence and two burrows were observed during the survey). ◤ Areas containing a sparse *Acacia* upper storey with woody debris provides additional shelter for birds, mammals and reptiles. ◤ Suitable for species such as the Brush-tailed Mulgara (P4) which was recorded within the habitat at three locations during the survey. Widespread, moderate significance and low SRE potential.	
	Senna shrubland on stony plain (2%)	Very open rocky plains with no upper storey and a sparse mid storey of *Senna sp.* Meekatharra (Bailey 1-26) hybrid over sparse *Sclerolaena eriacantha* and *Sclerolaena cuneata* (*Maireana sp.*). The substrate largely comprised bare soils and coarse rocky fragments, with minimal leaf litter and woody debris.	◤ Minimal shelter for birds, mammals and reptiles. ◤ Large rocks may provide some level of cover for small mammals and reptiles. Widespread, limited significance and low SRE potential.	

Project Area	Habitat Type	Habitat Description	Habitat Values	Example Image
Vause Gourdis (Botanica 2023b)	Clay-Loam Plain: Acacia Woodland (22%)	Clay-loam plain comprising of Mulga woodland over mixed low shrubs.	◤ Substrate moderately suited to a variety of burrowing small mammals and reptiles. ◤ Moderately diverse vegetation strata supporting diverse avifauna assemblage. ◤ Limited leaf litter and tree logs / hollows for fauna refuge. Widespread, limited significance and low SRE potential.	
	Drainage Depression: Acacia Woodland (14%)	Drainage depression comprising of Mulga woodland over mixed low shrubs and occasional tussock grassland.	◤ Substrate moderately suited to a variety of burrowing small mammals and reptiles. ◤ Diverse vegetation strata supporting diverse avifauna assemblage. ◤ Moderate leaf litter and tree logs / hollows for fauna refuge. ◤ Freshwater source during periods of high rainfall. Widespread, limited significance and low SRE potential.	

Project Area	Habitat Type	Habitat Description	Habitat Values	Example Image
Vause Gourdis (Botanica 2023b)	Sand-Loam Plain: Acacia Woodland (26%)	Sand-loam plain comprising of Mulga woodland over mixed low shrubs and spinifex grassland.	◤ Substrate very well suited to a variety of burrowing small mammals and reptiles. ◤ Less diverse vegetation strata supporting a less diverse avifauna assemblage. ◤ Limited leaf litter and tree logs/ hollows for fauna refuge. Widespread, limited significance and low SRE potential.	
	Rocky Plain / Hillslope: Acacia Woodland (20%)	Rocky plain/ hillslope comprising of Mulga woodland over mixed low shrubs.	◤ Substrate not well suited for burrowing. ◤ Moderately diverse vegetation strata supporting diverse avifauna assemblage. ◤ Limited leaf litter and tree logs/ hollows for fauna refuge. ◤ Rocky substrate providing shelter for small mammals and reptiles. Widespread, limited significance and low SRE potential.	

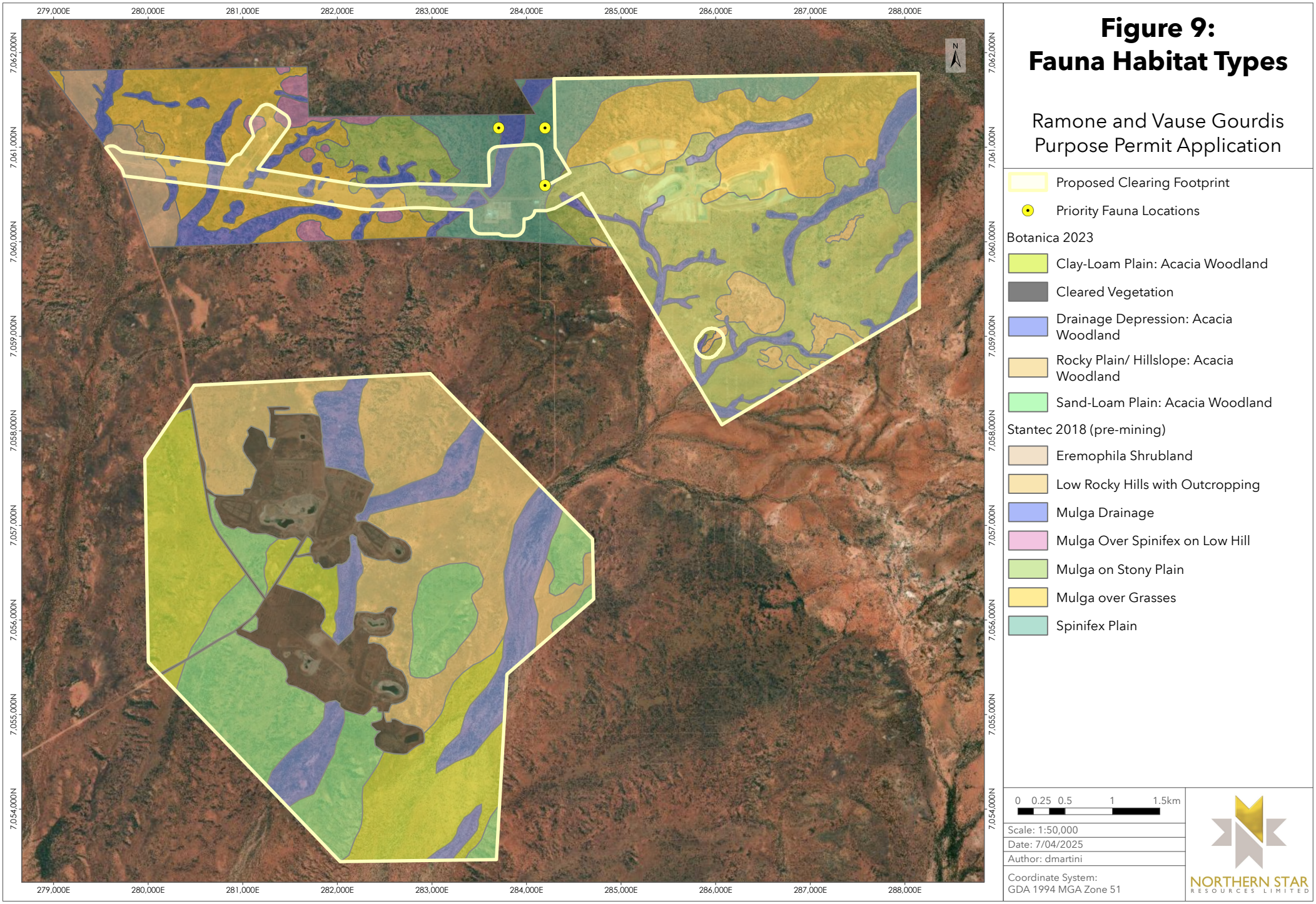

Figure 9: Fauna Habitat Types

Ramone and Vause Gourdis Purpose Permit Application

- Proposed Clearing Footprint
- Priority Fauna Locations

Botanica 2023

- Clay-Loam Plain: Acacia Woodland
- Cleared Vegetation
- Drainage Depression: Acacia Woodland
- Rocky Plain/ Hillslope: Acacia Woodland
- Sand-Loam Plain: Acacia Woodland

Stantec 2018 (pre-mining)

- Eremophila Shrubland
- Low Rocky Hills with Outcropping
- Mulga Drainage
- Mulga Over Spinifex on Low Hill
- Mulga on Stony Plain
- Mulga over Grasses
- Spinifex Plain

0 0.25 0.5 1 1.5km

Scale: 1:50,000

Date: 7/04/2025

Author: dmartini

Coordinate System: GDA 1994 MGA Zone 51

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3.4 Hydrology

3.4.1 Surface Water

Ramone and Vause Gourdis lie within the Lake Carnegie catchment area, defined by numerous shallow ephemeral drainage lines which discharge to salt lake systems following large rainfall events. Within the Project area drainage flows to the south with several ephemeral watercourses transecting the proposed clearing footprint as shown in Figure 10.

A surface water assessment was undertaken for Ramone by RPS to inform the preparation of a mining proposal. The surface water assessment found that the majority of the Ramone area is flat to undulating with the majority of runoff occurring as sheet flow. Minor watercourses support light vegetation but do not have well defined beds (RPS 2018).

A hydrogeological assessment was undertaken by KH Morgan to support the original development of Vause-Gourdis which included an estimation of stormwater runoff. The main drainage through Vause-Gourdis exists as a shallow flow path of approximately 0.5m to 1 m depth which spreads into a broad shallow outwash alluvial fan (KH Morgan 2002). An estimation of peak stormwater runoff for a 1 in 50-year rainfall event found that normal pit bunding to 2 m height was sufficient to prevent inundation risk (KH Morgan 2002).

Across both survey areas, vegetation communities ApAaAcEllEfEfFd, AaAtS?sEs?bSeEe and DD-AFW1 are associated with ephemeral watercourses. These represent approximately 15% of the Ramone and 14% of the Vause Gourdis survey areas (Botanica 2023b; Stantec 2018).

Clearing of vegetation associated with ephemeral watercourses will be minimised, however it is unlikely these vegetation types can be avoided altogether. Northern Star will maintain hydrological regimes, and where watercourses are impacted drainage diversion and erosion controls will be utilised to divert surface water drainage.

3.4.2 Groundwater

The Project is located within the Goldfields Groundwater Area pursuant to the *Rights in Water and Irrigation Act 1914*. The nearest public drinking water source area, Wiluna Water Reserve is located 49 km west of the proposed clearing footprint and will not be impacted by clearing activities.

Groundwater in the Goldfields region is characterised by fractured rock aquifers of low permeability and paleochannels of higher permeability (Johnson et al. 1999). Groundwater ranges from brackish to hypersaline, and the majority of groundwater resources are not utilised outside of the mining industry.

Local groundwater conditions were characterised by Rockwater (2020) as part of the Ramone mining proposal. Pre-mining groundwater levels ranged between 17 – 20 m deep, with low hydraulic conductivity on average 0.24 m / day associated with fractured rock (Rockwater 2020).

This indicates that groundwater is unlikely to be accessible by any vegetation and that groundwater recharge rates are low. As a result, there are no groundwater dependent ecosystems that are likely to be in the area or be impacted by clearing activities (Rockwater 2020).

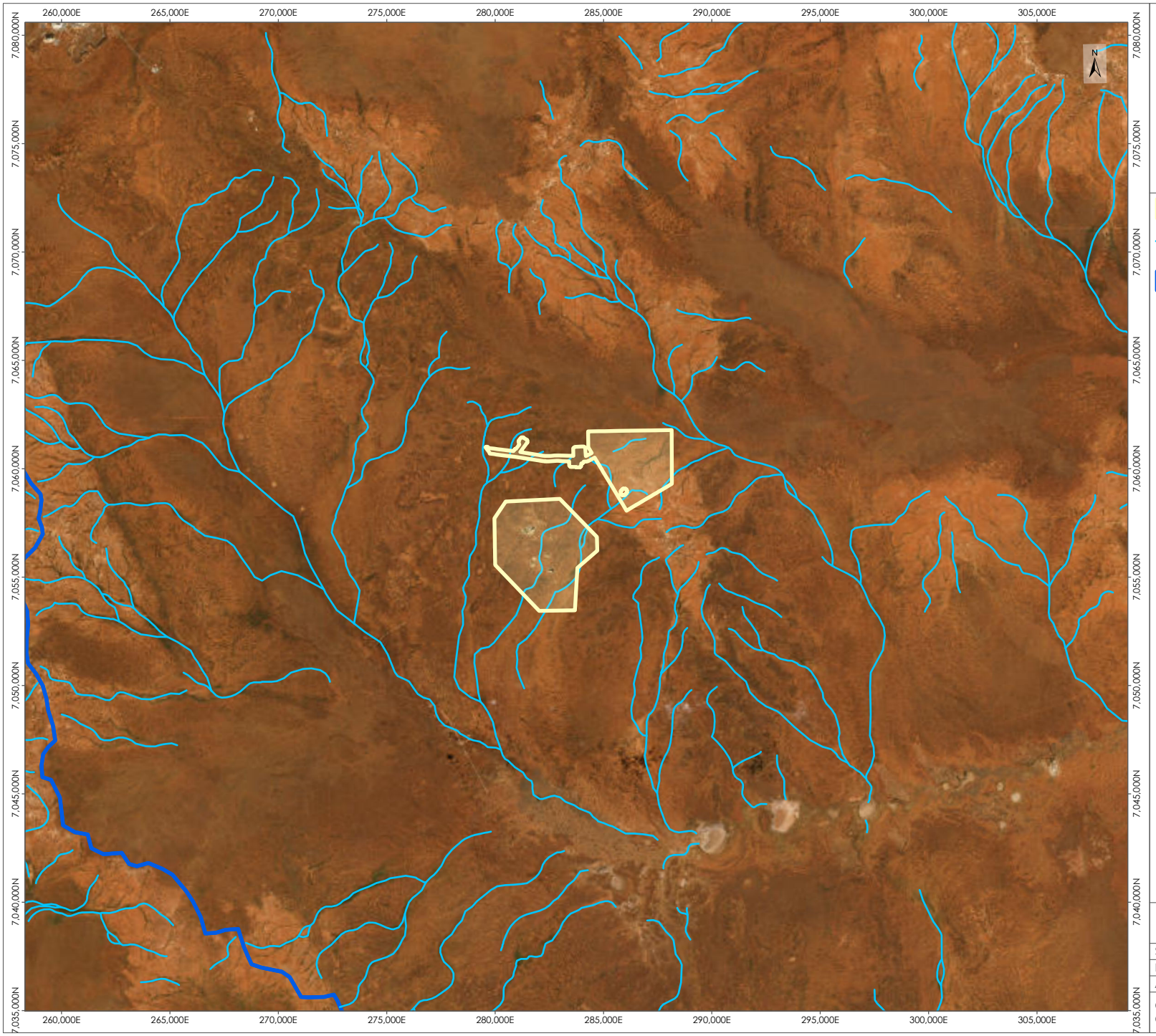

Figure 10: Surface Water Features

Ramone and Vause Gourdis Purpose Permit Application

- Proposed Clearing Footprint
- Watercourses (Geodata Topo 250K)
- Hydrographic Subcatchments (DWER-030)

0 1.25 2.5 5 7.5km

Scale: 1:250,000

Date: 6/01/2025

Author: dmartini

Coordinate System: GDA 1994 MGA Zone 51

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3.5 Heritage

The Project is located within the Wiluna Native Title Determination (WCD2013/004), which was determined on 29/07/2013. Tarlka Matuwa Piarku (Aboriginal Corporation) is the Registered Native Title Body Corporate (RNTBC). Northern Star maintain a Land Use Agreement with Tarlka Matuwa Piarku (Aboriginal Corporation) RNTBC for all tenements in this application.

A review of the Aboriginal Cultural Heritage Inquiry System (ACHIS) in December 2024 found that there are no registered Aboriginal Sites within the proposed clearing footprint. There are several registered sites in the vicinity of the Project, with the closest site known as "Jundee 10" located approximately 500 m west of Vause Gourdis mining area, as shown in Figure 11.

A lodged site known as Deep Well Site (#23112) has been excluded from the proposed clearing footprint (Ramone) with a 100 m buffer applied. Accordingly, no clearing activities will occur within the boundary of any registered or lodged Aboriginal Sites.

Northern Star undertake heritage surveys with relevant Traditional Owner groups over all areas planned to be cleared to ensure that any potential unregistered heritage sites are identified and protected with appropriate measures. Several locations within the proposed clearing footprint have been flagged as "Not Cleared" during heritage surveys, which are identified on internal databases and are treated as exclusion zones.

Northern Star utilise a disturbance permit form procedure to ensure that no clearing is conducted without first ensuring that the land is Heritage Cleared, and that all necessary government approvals have been obtained. As a result, including heritage "Not Cleared" areas in the proposed clearing footprint will not increase the risk of disturbance.

Northern Star understands its obligations under the *Aboriginal Heritage Act 1972* and will ensure that no Aboriginal Sites are impacted by proposed clearing activities.

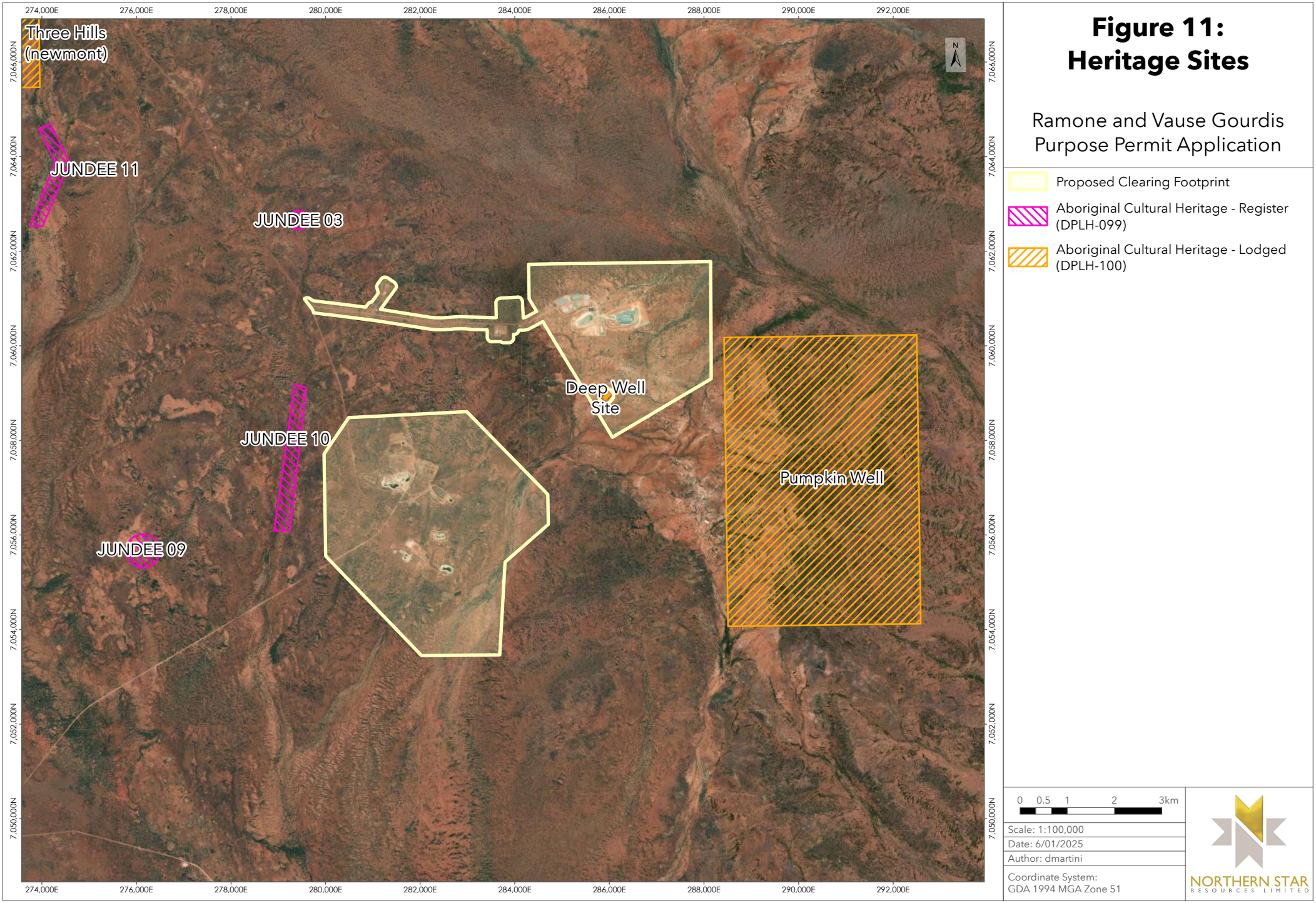

Figure 11: Heritage Sites

Ramone and Vause Gourdis Purpose Permit Application

- Proposed Clearing Footprint
- Aboriginal Cultural Heritage - Register (DPLH-099)
- Aboriginal Cultural Heritage - Lodged (DPLH-100)

0 0.5 1 2 3km

Scale: 1:100,000
Date: 6/01/2025
Author: dmartini

Coordinate System:
GDA 1994 MGA Zone 51

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4 Clearing Principles Assessment

Northern Star has undertaken an assessment of the proposed clearing using the ten native vegetation clearing principles (EP Act, Schedule 5). The assessment identified that native vegetation clearing may be at variance with Clearing Principles **b**, **f** and **g** with rationale outlined in Table 4-1 below.

Table 4-1: Clearing Principles Assessment

Assessment against the clearing principles	Variance Level	Further Consideration Required?
Environmental value: biological values		
Principle (a): "Native vegetation should not be cleared if it comprises a high level of biodiversity." Northern Star Assessment Native vegetation within the proposed clearing footprint does not display high levels of biodiversity, with several genera dominating the landscape. Widely represented taxa are found within the broader surrounding region. Whilst most vegetation is in good condition, the surrounding landscape is largely intact and undisturbed. No TECs or PECs are located within the proposed clearing footprint. Two Priority flora species, *Aristida jerichoensis var. subspinulifera* (P3) and *Eremophila pungens* (P4) were found within the Ramone survey area and are located within the proposed clearing footprint. These species are not restricted to the proposed clearing footprint or surrounds and are broadly distributed within Western Australia with ranges of approximately 1,200 km and 350 km respectively. Any impacts to local populations are unlikely to significantly impact either species. Data Sources Botanica (2023b); Stantec (2018).	Not likely to be at variance.	No.
Principle (b): "Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna." Northern Star Assessment Vegetation mapped as Spinifex plain provides habitat for Brush-tailed Mulgara (P4), and vegetation mapped as Low rocky hills with outcropping provides potential suitable habitat for Long-tailed Dunnart (P4) although the species was not recorded during surveys. Other mapped vegetation types are unlikely to provide habitat to any conservation significant fauna. Habitat is unfragmented on a landscape scale with approximately 99% intact and it is unlikely that any local habitat loss would be significant to Brush-tailed Mulgara which is widely distributed within spinifex plains across Australia and found commonly in the arid zone (eighth most common mammal as per NESP 2021). Controls implemented to minimise potential impacts on fauna habitat as outlined in Section 5 will mitigate potential impacts on the species at a local level and clearing will not have a significant impact on the species. Data Sources Botanica (2023b); Stantec (2018).	May be at variance.	Yes – proposed mitigation measures discussed in Section 5.

Assessment against the clearing principles	Variance Level	Further Consideration Required?
Principle (c): "Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora." Northern Star Assessment No Threatened flora species pursuant to the BC Act or EPBC Act were located within the proposed clearing footprint during field surveys. Data Sources Botanica (2023b); Stantec (2018).	Not at variance	No.
Principle (d): "Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a threatened ecological community." Northern Star Assessment There are no known TECs located within or in vicinity of the proposed clearing footprint. No vegetation representative of TECs were recorded in vegetation and flora surveys, and accordingly the clearing will not have any impact on TECs. Data Sources Stantec (2018); Botanica (2023b)	Not at variance.	No.
Environmental value: significant remnant vegetation and conservation areas		
Principle (e): "Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared." Northern Star Assessment The proposed clearing footprint includes pre-European vegetation associations Wiluna 18 and 39 which both have remaining extents of over 98% at both State and Local levels. Proposed clearing represents a minor proportion of these vegetation associations (<0.01%) in areas of low fragmentation and high vegetation connectivity, and remaining extents will continue to exceed 98% following clearing activities. Clearing is not inconsistent with the EPA's position statement of retaining 30% pre-European vegetation. Data Sources DBCA (2019); GIS databases: DPIRD-006.	Not at variance.	No.
Principle (h): "Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area." Northern Star Assessment The nearest conservation reserve Matuwa Kurrara Kurrara National Park is located approximately 37.5 km northeast of the proposed clearing footprint. Given the significant distance away the clearing will have no impacts on conservation areas. Data Sources GIS databases: DBCA-01, DWER-046.	Not at variance.	No.
Environmental value: land and water resources		

Assessment against the clearing principles	Variance Level	Further Consideration Required?
Principle (f): "Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland." Northern Star Assessment There are no permanent watercourses or wetlands within the proposed clearing footprint. Shrubland vegetation associations ApAaAcEllEfEfFd, AaAtS?sEs?bSeEe and DD-AFW1 are associated with ephemeral watercourses. Ephemeral watercourses are common in the broader landscape and support denser vegetation than surrounding areas. Clearing of ephemeral watercourses will be minimised and surface water drainage will be maintained. Data Sources Stantec (2018); Botanica (2023b).	May be at variance.	Yes – proposed mitigation measures discussed in Section 5.
Principle (g): "Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation." Northern Star Assessment The proposed clearing area contains mining and exploration disturbances, and proposed mining activities will result in further disturbance to soil resources. Proposed clearing activities include topsoil stripping and stockpiling for future rehabilitation of mining infrastructure as required under the *Mining Act 1978*. Soils in the proposed clearing footprint have been mapped as moderately to highly susceptible to erosion risk. On-site erosion generates coarse suspended sediment that can adversely affect downstream receptors. Controls to prevent land degradation as outlined in Section 5 will mitigate potential impacts of clearing on soil resources. Data Sources Soilwater (2018)	May be at variance.	Yes – proposed mitigation measures discussed in Section 5.
Principle (i): "Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water." Northern Star Assessment 0. There are no permanent watercourses or wetlands within the proposed clearing footprint. Ephemeral watercourses flow following large sporadic rainfall events and due to evaporation exceeding rainfall by a factor of 10 they remain dry most of the year. Local groundwater is 17 – 20 m deep, and recharge is slow due to poor hydraulic conductivity so clearing is unlikely to impact any groundwater resources. The nearest public drinking water source area, Wiluna Water Reserve is located 49 km west. Controls to prevent sedimentation of downstream receptors as outlined in Section 5 will mitigate potential impacts of clearing on surface and underground waters. Data Sources BoM (2024); Rockwater (2020); RPS (2018).	Not likely to be at variance.	No.

Assessment against the clearing principles	Variance Level	Further Consideration Required?
Principle (j): "Native vegetation should not be cleared if the clearing of the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding." Northern Star Assessment The climate is semi-arid to arid with an average annual rainfall under 300 mm. Surface water flows drain towards regional salt lake systems which are inundated following high rainfall events, but quickly evaporate. Drainage channels are typically shallow, under 1 m depth and are not well defined. Proposed clearing activities will not alter natural drainage pathways, with downstream hydrological regimes maintained. Drainage diversion infrastructure will be installed to ensure that flood risks are mitigated during mining operations whilst preserving natural surface water flows. Data Sources BoM (2024); RPS (2018).	Not likely to be at variance.	No.

5 Environmental Management

5.1 Clearing Mitigation

Northern Star utilises a hierarchy of avoid, minimise, rehabilitate and offset to reduce impacts of clearing activities. This hierarchy is achieved primarily through optimisation in design during mine planning and implementation of mitigation measures during operations. Measures to avoid, minimise, rehabilitate and offset clearing impacts are outlined below.

5.1.1 Avoid

Registered and lodged Aboriginal sites have been excluded from the proposed clearing footprint to avoid impacting heritage values. Prior to any clearing commencing, a disturbance permit form (NSR-ENV-001-FOR) will be authorised by Northern Star's environmental department to ensure that all proposed clearing occurs within approved boundaries, abides by relevant approval conditions, and avoids any impacts to protected sites / exclusion areas. Survey control for new disturbance (vegetated) areas including pegs and / or flagging tape must be in place prior to approval of a disturbance permit form to ensure that appropriate visual controls are implemented prior to clearing commencing.

5.1.2 Minimise

Design considerations to minimise clearing requirements are predominantly achieved by clearing only where necessary and reutilising existing disturbed land where practicable. This may include reutilising existing drill pads and access tracks for new exploration activities and placing new mining infrastructure over existing mining infrastructure (i.e. extending existing WRLs). Furthermore, vegetation associated with watercourses will be avoided as far as possible and mining infrastructure will avoid placement in areas prone to flooding and subsequent erosion.

Clearing is conducted as close as possible to construction activities to prevent over clearing areas not required and enabling optimisation in designs to occur. Furthermore this aids in preventing erosion and sedimentation by maintaining soil stability for as long as possible prior to clearing. The project will include the development of a diversion channel to redivert intercepted surface water drainage to existing flow paths, ensuring that surface water flows are maintained to downstream receptors and preventing erosion within cleared areas.

5.1.3 Rehabilitate

Cleared areas will be rehabilitated in accordance with mine closure obligations pursuant to the *Mining Act 1978*. Whilst some clearing such as that for mining voids will be permanent, most cleared areas will undergo progressive rehabilitation during the mining schedule in accordance with an approved Mine Closure Plan. During clearing activities vegetation will be stockpiled for possible reuse as erosion control, and topsoil will also be stripped and stockpiled for rehabilitation purposes. Following rehabilitation, monitoring will be conducted to ensure outcomes track towards approved performance criteria.

5.1.4 Offset

The proposed native vegetation clearing will not result in any significant residual impacts to the environment and therefore no environmental offsets should be required.

5.2 Environmental Management System

Clearing will be implemented in accordance with Northern Star's Environmental Management System (EMS). The EMS outlines plans, procedures and other strategies to managing environmental impacts from Northern Star's activities, as guided by Northern Star's Environmental Policy (NSR-COR-003-POL). Training is regularly conducted by Northern Star's environmental department to ensure workers are aware of the requirements of the EMS and adhere to expectations of management.

Applicable management measures from the EMS in relation to clearing of native vegetation are summarised below:

5.2.1 Air quality

Fugitive dust generated from clearing activities and topsoil stripping and handling can have detrimental impacts on surrounding flora and fauna. Excessive dust generation is minimised by implementing the following controls:

- Monitoring of weather conditions and restricting clearing activities during high winds.
- Provision of watercarts for wetting down soils as required.

5.2.2 Land and Soils

Land and soil resources may be negatively impacted during clearing including via spills of hydrocarbons from mobile plant and poor topsoil stripping and handling practises. Potential impacts to land and soil resources are managed by:

- Regular maintenance and daily pre-start inspections on all mobile plant used in clearing activities.
- Provision of spill response kits on service trucks and strategic locations around site (i.e. go-lines and laydowns).
- Minimising timeframes between clearing, topsoil stripping and handling, and construction of infrastructure to prevent erosion of topsoil resources.

5.2.3 Fauna

Fauna impacts (vehicle strike) during clearing activities may result in injury or death of native fauna or livestock. Whilst not all incidents are avoidable, impacts are minimised through:

- Maintaining speed limits on site and utilising existing cleared areas where possible.
- Reporting and investigating all incidents of fauna injury or death.
- Undertaking pre-clearance surveys for Brush-tailed Mulgara within habitat identified as Spinifex Plain.
- Undertaking pre-clearance surveys for Long-tailed Dunnart within habitat identified as Low rocky hills with outcropping.
- Limiting clearing activities within habitat identified as Low rocky hills with outcropping.

5.2.4 Surface Water

Surface water resources including ephemeral watercourses which intersect the proposed clearing footprint

- Minimising clearing within watercourses as far as practicable.
- Maintaining existing surface water flows and downstream hydrological regimes via drainage diversion and erosion control where any watercourses are impacted.

5.2.5 Weeds

Weeds can be introduced into areas following disturbance of vegetation and soils. Weed and seed hygiene protocols are utilised to prevent weeds from being transported into clearing areas by:

- Requiring mobile plant to be thoroughly cleaned prior to entering the Project.
- Undertaking inspections on mobile plant before entering the Project area.
- Restricting mobile plant access to proposed clearing areas and existing roads.

6 References

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7 Appendices

APPENDIX A – SOILWATER 2018

SOILWATER CONSULTANTS

RAMONE GOLD DEPOSIT - SOIL CHARACTERISATION STUDY	
Prepared for:	NORTHERN STAR RESOURCES LTD
Date of Issue:	8/10/2018
Project No.:	NST-18-001

Distribution:

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Revision Code[1]	Date Revised	Revision Comments	Signatures		
			Originator	Reviewer	Approved
A	15/05/2018	Draft report for internal review	IP	SC	-
B	06/06/2018	Issue of Draft Review to Client	IP	AP	AP
C	08/10/2018	Final Report issued to Client	SC	AP	AP

Revision Code[1]

A - Report issued for internal review

B - Draft report issued for client review

C - Final report issued to client

LIMITATIONS

The sole purpose of this report and the associated services performed by Soil Water Consultants (SWC) was to undertake a soil characterisation assessment at Northern Star Resources (Northern Star) Ramone Gold Deposit. This work was conducted in accordance with the Scope of Work presented to Northern Star ('the Client'). SWC performed the services in a manner consistent with the normal level of care and expertise exercised by members of the earth sciences profession. Subject to the Scope of Work, the soil characterisation was confined to the Ramone Gold Deposit site. No extrapolation of the results and recommendations reported in this study should be made to areas external to this project area. In preparing this study, SWC has relied on relevant published reports and guidelines, and information provided by the Client. All information is presumed accurate and SWC has not attempted to verify the accuracy or completeness of such information. While normal assessments of data reliability have been made, SWC assumes no responsibility or liability for errors in this information. All conclusions and recommendations are the professional opinions of SWC personnel. SWC is not engaged in reporting for the purpose of advertising, sales, promoting or endorsement of any client interests. No warranties, expressed or implied, are made with respect to the data reported or to the findings, observations and conclusions expressed in this report. All data, findings, observations and conclusions are based solely upon site conditions at the time of the investigation and information provided by the Client. This report has been prepared on behalf of and for the exclusive use of the Client, its representatives and advisors. SWC accepts no liability or responsibility for the use of this report by any third party.

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1 INTRODUCTION

Soil Water Consultants (SWC) was commissioned by Northern Star Resources Limited (Northern Star) to undertake a pre-mine soil characterisation for the proposed Ramone Gold Project (the 'Project Area'). The purpose of this assessment was to identify and characterise all surficial soil materials within the proposed disturbance area and suggest management strategies for their handling and utilisation. This information provides baseline data that can be used to assist in the mining of these materials, and in the construction and rehabilitation of any post-mine landforms. Implementation of the soil management recommendations suggested in this report will ensure that only optimal materials are used in the construction of the outer surface of the waste rock landform (WRL), thus facilitating stability and revegetation and ultimately closure and relinquishment.

1.1 OBJECTIVES OF WORK

The objectives of the Soil Characterisation were to:

- Define the distribution of soil materials in the Project Area;
- Characterise the physical and chemical properties of these materials;
- Identify materials that may be beneficial to the stabilisation of the WRL, and materials that may have an adverse impact on rehabilitation;
- Suggest management strategies for the handling and utilisation of the various surficial soils materials during mining and rehabilitation, and
- Identify the optimal design for the WRL to facilitate stability, sustainability and closure of the site.

1.2 SCOPE OF WORK

The scope of work (SoW) completed by SWC included:

- Desktop review of existing data, including flora and vegetation, regional soils, geology and hydrology of the area;
- Collection of soil materials from the proposed Project Area using trench excavations and surface soil sampling;
- Describe the surficial soil materials and their distribution throughout the Project Area;
- Conduct laboratory testing to quantitatively assess the soil properties;
- Undertake erosion modelling to establish the stability and erodibility of the various surface soils, and
- Preparation of this report.

2 SITE DESCRIPTION AND ENVIRONMENTAL SETTING

2.1 SITE LOCATION

The Ramone Gold Deposit is located within the Shire of Wiluna, approximately 30 km south-east of the existing Jundee Mining Operations, and 60 km east of Wiluna (Figure 2.1). Access to the site is via a local road linking both Wiluna Granite Peak and Wongawol Roads (Figure 2.2).

The main mining features (i.e. mine pit and WRL) for the Ramone Deposit occur on Mining Tenement M 53/347, whilst the remaining site infrastructure, including site access road, occurs across M 53/197, M 53/228, M53/247 and M 53/589 (Figure 2.3).

2.2 SITE LAYOUT

The disturbance area for the Ramone Deposit is shown in Figure 2.4 and covers an area of approximately 160 ha. The Project will consist of:

- 6 km site access road;
- 9.8ha open mine pit, covering an approximate area of 9.8 ha and extending to a depth of 100 – 130 m below ground level, and
- 38.4ha waste rock landform (WRL) consisting of three 10 m lifts (30 m total height).

2.3 CLIMATE

The bioclimate of the project area is described by Beard (1990) as mainly Eremaean (Tille, 2006), and is classified as a desert climate. Long term climate data for the Wiluna area (BOM Station 013012; data for period 1901 – 2017) shows that it receives an average annual rainfall of 258 mm, whilst the average annual maximum and minimum air temperatures are 29.2 and 14.3 °C, respectively. Monthly Class A Pan evaporation for the Wiluna region ranges from about 130 mm in June to about 600 mm in January, with an annual loss of about 5,400 mm (Luke *et al.,* 1987). This large deficit between annual rainfall and pan evaporation highlights that the Wiluna region exists in a water deficit environment, and that the native vegetation must have deep root systems in order to extract sufficient plant available water to meet their transpiration requirements.

2.4 GEOLOGY

2.4.1 REGIONAL GEOLOGY AND LANDFORMS

A detailed description of the regional geology of the Murchinson Province has been documented by Laws (1994) and Tille (2006). The Murchinson Province is the westernmost of three granite-greenstone terraces in the Archaen Yilgarn Craton. The underlying rocks are predominantly Archaean even-grained porphyritic granitic rocks. These are intruded by quartz veins and dolerite dykes (Tille, 2006). Areas of gneiss are associated with Archaean greenstone belts contain a mixture of metamorphosed mafic to ultra-mafic volcanic rocks (including basalt, amphibolite, dolerite and gabbro), felsic volcanic rocks, and metasedimentary rocks (including cherts and banded iron formations). This Archaean bedrock has been extensively weathered and laterised, and have been overlain by Tertiary and Quaternary alluvial, colluvial and aeolian deposits (Laws, 1994).

The Murchinson Province is comprised of an extensive plateau of low relief. Laterite or silicrete mesas often occur at the top of the landscape, and tend to be surrounded by gently undulating wash plains and sandplains (Tille, 2006). These

wash plains consist of gently inclined alluvial surfaces with an almost continuous underlying cemented red-brown hardpan. Other areas contain quartz-strewn plains and plains with stony and gravelly mantles associated with low rises containing outcrops of granite, gneiss and schists.

2.4.2 Local Geology and Landforms

The major geological units within the project area are comprised of mafic volcanic rocks with minor mafic and ultramafic intrusive rocks; minor felsic rocks (AYI(b)), granitoid rock being monzogranite dominant (AYI(g)) (Table 2.1). The proposed mine pit, waste rock dump and associated infrastructure are located within the geological unit AYI(g), while the proposed haul road and associated infrastructure is located within the geological unit AYI(b) (Figure 2.5).

Table 2.1: Geology of the Ramone Gold Project.

Code	Description	Rock Type	Tectonic Unit	Age
AYI(b)	Mafic volcanic rocks with minor mafic and ultramafic intrusive rocks; minor felsic rocks	Basalt	Yilgarn Craton	Archaean
AYI(g)	Granatoid rock; monzogranite dominant	Granite	Yilgarn Craton	Archaean

2.5 HYDROLOGY AND HYDROGEOLOGY

The report by Laws (1994) describes the surface water drainage and hydrogeology of the Murchinson Province. Much of the drainage is ephemeral, with >80% of the surface drainage flowing to the west into the Murchinson, Wooramel and Greenough River Catchments, and subsequently to the Indian Ocean. The remainder of the drainage flows to inland salt lake systems. Generally, the major drainage systems have broad flood plains (Laws, 1994).

Groundwater quality and quantity is variable within the Murchison Province, and is used for include pastoral and mining activities. Better quality groundwater is often sourced from colluvium, valley-fill alluvium, and calcrete and calcrete alluvium (Laws, 1994). The wash plains, often underlain by a hardpan, that flank the main drainage lines, provide a source of shallow, good quality groundwater of varying salinity.

Drilling logs within the project area record standing water levels in the range of 20 – 23 m below ground level. Given the dominance of evaporation over rainfall within the project area, rainfall infiltration and subsequent groundwater recharge is likely to be negligible, except following high intensity, prolonged rainfall events.

2.6 REGIONAL SOILS

2.6.1 Regional Soils and Associated Western Australia Soil Groups

The Murchison Province (Mapping Unit 27; Purdie *et al.*, 2004) is described as *extensive plains with residuals of laterite or Precambrian igneous rocks. Drainage lines have extensive saline or calcrete deposits. Soils with red-brown hardpan (duripan) are common*. The dominant geology comprises granitic rocks and greenstone of the Yilgarn Craton, and soils are red loamy and sandy earths, red shallow loams and red deep sands. The dominant vegetation is spinifex grasslands with wanyu scrub, eucalypt woodlands, and halophytic shrublands.

The Ramone Gold Deposit is located in the Salinaland Plains Zone (Map Unit 279) which is described as *sandplains (with hardpan wash plains and some mesas, stony plains and salt lakes) on granitic rocks of the Yilgarn Craton with Red sandy earths, Red deep sands, Red shallow loams (sometimes with hardpans) and Red loamy earths.* The dominant vegetation is mulga woodlands with spinifex grasslands (and some halophytic shrublands and eucalypt woodlands).

The major sub-units within the Salinaland Plains Zone occurring within the project area are presented in Table 2.2 and Figure 2.6. The proposed mine pit, WRL and associated infrastructure are located within the Sherwood Land System (279Sh), while the proposed haul road and associated infrastructure extend across the Violet (279Vi) and Wiluna (279Wi) Land Systems.

Table 2.2: Regional soil mapping units within the project area.

Mapping Unit	Mapping Unit Name	Mapping Unit General Description
279Sh	Sherwood Land System	Breakaways, kaolinised footslopes and extensive gently sloping plains on granite supporting mulga shrublands and minor halophytic shrublands.
279Vi	Violet Land System	Gently undulating gravelly plains on greenstone, laterite and hardpan, with low stony rises and minor saline plains; supporting groved mulga and bowgada shrublands and occasionally chenopod shrublands.
279Wi	Wiluna Land System	Low greenstone hills with occasional lateritic breakaways and broad stony slopes, lower saline stony plains and broad drainage tracts; supporting sparse mulga and other acacia shrublands with patches of halophytic shrubs.

The corresponding Soil Supergroup and associated Soil Groups based on the Western Australia classification for these soil mapping units are presented in Table 2.3 (Schoknecht and Pathan, 2013).

Table 2.3: Relationship between regional soil mapping unit and Western Australia Soil Groups.

Mapping Unit	Mapping Unit Name	Soil Super Group Description	Dominant WA Soil Group	WA Soil Group Description
279Sh	Sherwood Land System	Shallow loams supergroup	522 (40%)	Red shallow loam
		Sandy duplexes supergroup	406 (25%)	Red shallow sandy duplex
		Shallow sands supergroup	423 (25%)	Red shallow sand
279Vi	Violet Land System	Shallow loams supergroup	522 (45%)	Red shallow loam
			445 (20%)	Red deep sand
279Wi	Wiluna Land System	Shallow loams supergroup	522 (40%)	Red shallow loam
			406 (25%)	Red shallow sandy duplex
			423 (20%)	Red shallow sand

Soils within the Sherwood Land System are classed as “shallow loams”, “sandy duplex” or “shallow sands” and fall within the Western Australian Soil Groups *522 Red shallow* loam, *406 Red shallow sandy duplex* and *423 Red shallow sand* (Schoknecht and Pathan, 2013). Red shallow loam is the dominant soil type within this system and is found across 40% of the System, with lesser contributions from red shallow sandy duplex ((25%) and red shallow sand (25%).

Soils within the Violet Land System are classed as “shallow loams”, and fall within the Western Australian Soil Groups *522 Red shallow* loam, and *445 Red deep sand* (Schoknecht and Pathan, 2013). Red shallow loam is the dominant soil type within this system and is found across 45% of the System, with lesser contributions from red deep sand (20%).

Soils within the Wiluna Land System are classed as “shallow loams”, “sandy duplex” or “shallow sands” and fall within the Western Australian Soil Groups *522 Red shallow* loam, *406 Red shallow sandy duplex* and *423 Red shallow sand* (Schoknecht and Pathan, 2013). These are the same soil groups and relative contributions as for the Sherwood Land System, and as such soils within the Sherwood and Wiluna Land Systems may exhibit similar physical and chemical characteristics.

2.6.2 Characteristics of Soil Mapping Units and Groups in the Study Area

The dominant soil units and Western Australia Soil Groups occurring within the Ramone Gold Mine operation are (Table 2.2 and Table 2.3):

- Sherwood Land System - Red shallow loam (522), Red shallow sandy duplex (406) and Red shallow sand (423);
- Violet Land System – Red shallow loam (522) and Red deep sand (445);
- Wiluna Land System – Red shallow loam (522), Red shallow sandy duplex (406) and Red shallow sand (423).

Some general characteristics of these four groups (522, 406, 423 and 445) have been summarised by van Vreeswyk *et al.* (2004) and Schoknecht and Pathan (2013), and are as follows.

2.6.2.1 Soil Group 522 – Red shallow loam

Red shallow loams represent the dominant soil type within the proposed areas of disturbance at the Ramone Gold Mine (Figure 2.6). These soils are described as dark reddish brown (2.5YR 3/4) to dark red (2.5YR 3/6) occasionally yellowish red (5YR 4/6) loams (sandy loam to clay loam) less than 0.8 m deep (often <0.3 m deep) overlying rock, hardpan or other cemented layer. These soils commonly have a stony surface mantle with gravel sometimes present in the soil profile. Red shallow loam soil is often found overlying basalt, shale or schist, and has moderate inherent fertility, low organic carbon content, and moderate permeability. The soil pH varies from slightly acidic in the 0 – 0.1 m depth to neutral at 0.5 – 0.8 m. The shallow profile can restrict plant rooting depth and soil water storage capacity. This soil type is referred to as a *Red Kandosol* in the Australian Soil Classification.

2.6.2.2 Soil Group 406 – Red shallow sandy duplex

Red shallow sandy duplex soils represent about 25% of the soil type within the Sherwood and Wiluna Land Systems (Figure 2.6). These soils are described as dark reddish brown (2.5YR 3/4) to dark red (2.5YR 3/6) within the 0 - 0.3 m depth and the clay subsoil may be underlain by rock or hardpan. These soils commonly have a stony (ironstone) or gravelly surface mantle with little gravel present in the soil profile, except where a rock substrate exists. This soil type has moderate inherent fertility, low organic carbon content, and very slow to moderately slow permeability. The soil pH varies from slightly acidic in the 0 – 0.1 m depth to neutral / moderately alkaline at 0.5 – 0.8 m. Plant rooting depth can vary from moderately shallow to very deep depending on the depth to bedrock / hardpan. This depth to rock will also influence soil water storage capacity. This soil can be prone to surface compaction, crusting and hard-setting which can limit its land use. Red shallow sandy duplex soil type is referred to as a *Red Chromosol* or *Red* Sodosol in the Australian Soil Classification.

2.6.2.3 Red shallow sand (Soil Group 423)

Red shallow sands represent about 20 - 25% of the soil groups within the Sherwood and Wiluna Land Systems (Figure 2.6). These soils are described as dark reddish brown (2.5YR 3/4) to dark red (2.5YR 3/6) sand to a depth of about 0.8 m (often <0.3 m) underlain by rock or hardpan. The texture of this soil group varies depending on whether they are underlain by granite, basalt or calcrete (van Vreeswyk *et al.,* 2004). Soils overlying granite are described texturally as sand to clayey sand or sandy loam; soils underlain by basalt are described as clayey fine sand to fine sandy loam with abundant coarse rock fragments; and soils overlying calcrete exhibit uniform profiles of fine sandy loam or clayey sands grading to coastal loams. These soils commonly have a stony (ironstone) or gravelly surface mantle with little gravel present in the soil profile, except where a rock substrate exists. This soil type has low to very low inherent fertility, low organic carbon content, and rapid permeability in the 0 – 0.5 m depth interval. The soil pH is often slightly acidic in the 0 – 0.1 m and 0.5 – 0.8 m depths, but can be very strongly acid at 0.5 – 0.8 m. Plant rooting depth can vary from shallow to moderate depending on the depth to bedrock / hardpan, resulting in very low water storage capacity. The high permeability and low soil water storage capacity (due to sand texture) can pose restrictions to plant growth. Red shallow sand is referred to as a *Leptic Tenosol* or *Paralithic or Lithic Orthic Tenosol* in the Australian Soil Classification. Red shallow sands on basalt often occur with red shallow loams (van Vreeswyk *et al.,* 2004).

2.6.2.4 Red deep sand (Soil Group 445)

Red deep sands represent about 20% of the soil groups within the Violet Land System (Figure 2.6). These soils are described as dark red (2.5YR 3/6, 10R 3/6) to yellowish red (5YR 4/6) sand to depths >1 m. These soils often occur on sandplains, sand sheets and sand banks, a loamy sand topsoil between 0.1 and 0.3 m thick) underlain by >0.6 m of clayey sand or sandy loam subsoil. The subsoil can contain gravel and/or ironstone. This soil type has low inherent fertility, moderate to high organic carbon in the topsoil, and rapid permeability in the 0 – 0.5 m depth interval. The soil pH can be moderately to strongly acid in the 0 – 0.1 m, but can be very strongly acid to neutral at a depth of 0.5 – 0.8 m. Plant rooting depth is deep to very deep but due to the sand texture this soil type has low to very low water storage capacity. The high permeability and low soil water storage capacity can pose restrictions to plant growth. Also, the relatively high organic carbon content in the topsoil could produce water repellence, a property not observed in the other soil groups in the Land Systems. Red deep sand is referred to as a *Red Orthic Tenosol* in the Australian Soil Classification.

2.7 RELATIONSHIP BETWEEN LOCAL GEOLOGY AND SOILS

The relationship between soils and geology within the Ramone Gold Mine Operation is provided in Table 2.4.

Table 2.4: Relationship between soils and geology in the Mine Operation

Mapping Unit Name	Mapping Unit General Geology	Rock Type	WA Soil Group
Sherwood Land System (279Sh)	Granitoid rock; monzogranite dominant.	Granite	Red shallow loam (522) Red shallow sandy duplex (406) Red shallow sand (423)
Violet Land System (279Vi)	Mafic volcanic rocks with minor mafic and ultramafic intrusive rocks; minor felsic rocks.	Basalt	Red shallow loam (522) Red deep sand (445)

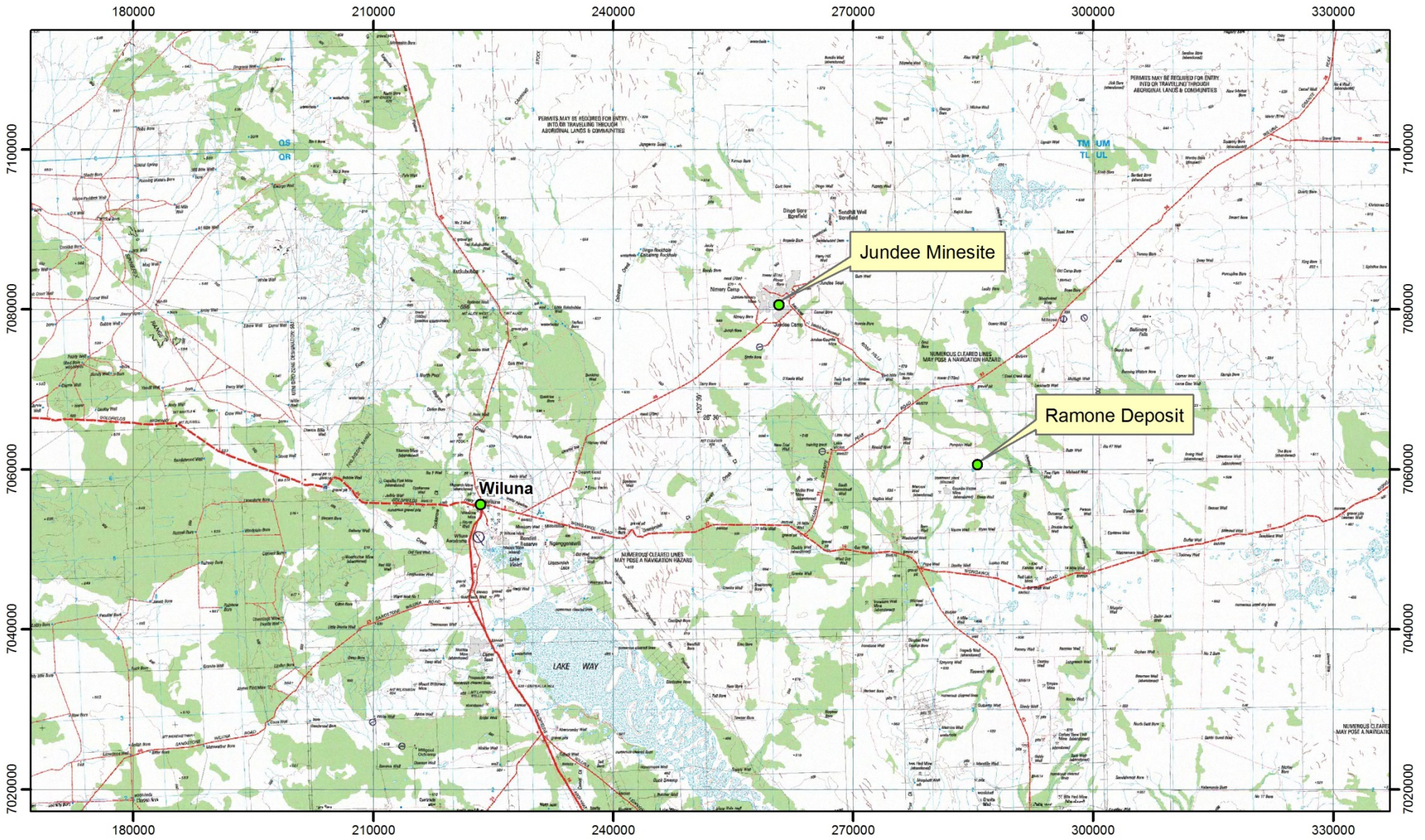
Mapping Unit Name	Mapping Unit General Geology	Rock Type	WA Soil Group
Wiluna Land System (279Wi)	Mafic volcanic rocks with minor mafic and ultramafic intrusive rocks; minor felsic rocks.	Basalt	Red shallow loam (522) Red shallow sandy duplex (406) Red shallow sand (423)

The Red shallow loam, Red shallow sandy duplex and Red shallow sand soil groups of the Sherwood Land System are predominantly associated with granite geology, the Violet and Wiluna Land Systems are associated with basalt geology. The difference between rock geology occurring within the Ramone Gold Mine Operation can influence key physical (hydraulic conductivity, texture and soil water retention) and chemical (soil nutrition, pH and salinity) characteristics of the soil groups and consequently their suitability for use in future rehabilitation activities. Understanding the potential variability in soil physical and chemical properties will form a primary focus of the field sampling program.

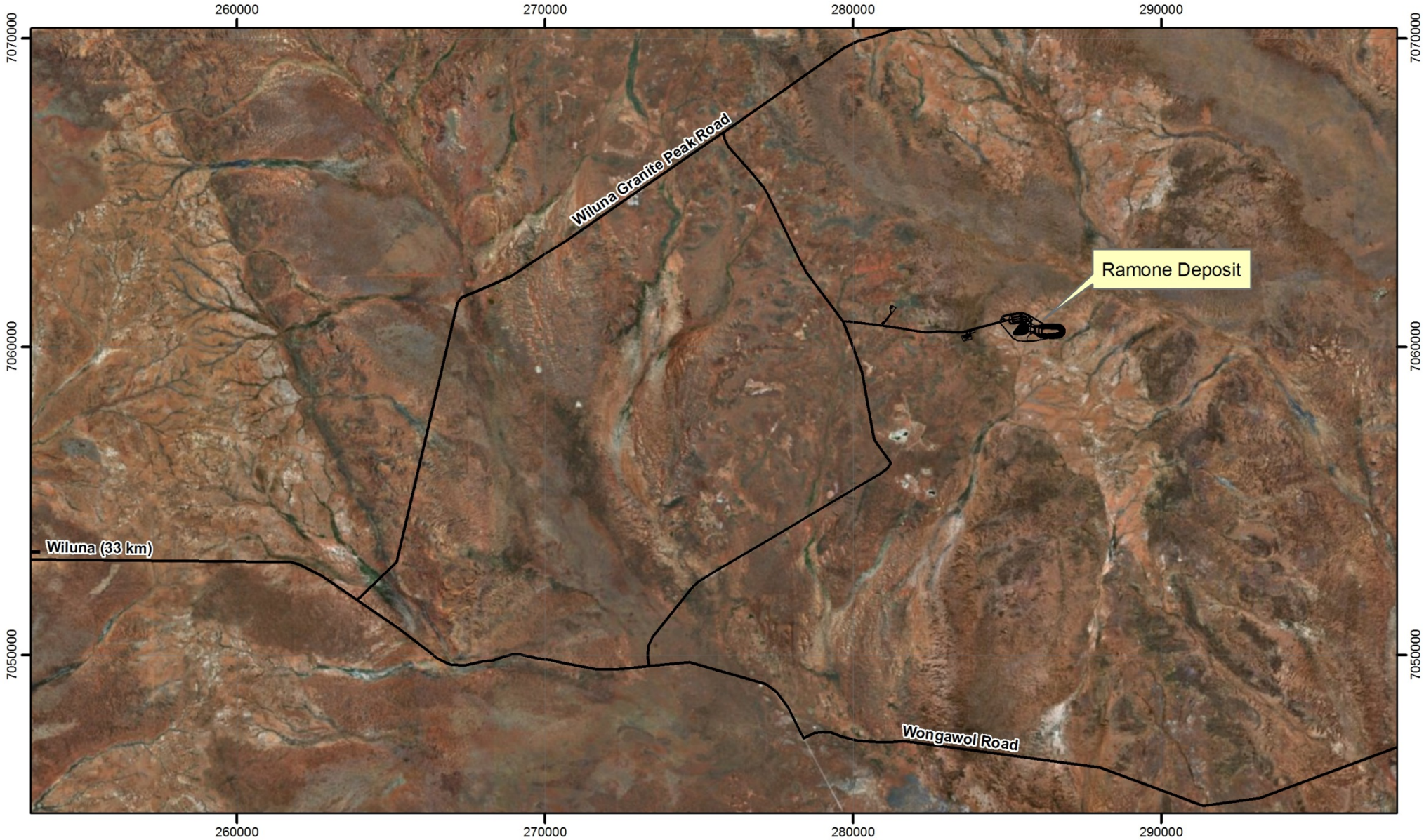
2.8 VEGETATION

Vegetation within the Murchinson Province is described as woodlands with spinifex grasslands (and some wanyu scrub, eucalypt woodlands and halophytic shrublands). A more comprehensive description of the vegetation found in the Murchinson Province is provided by Beard (1990) and Tille (2004). Generally, mulga (*Acacia aneura*) shrublands and woodlands (*A. pruinocarpa*, *A. tetragonophylla*, *A. linophylla*, *A. ramulosa*, *A. acuminata*, *A. grasbyi*), Senna *spp*. and Eremophila *spp*. dominate the hardpan wash plains, while the sandplains in the east support grasslands of hard spinifex (*Triodia basedowii*). These grasslands occur with an open tree and shrub steppe of mulga, marble gum (*Eucalyptus gongylocarpa*), mallees (*E. kingsmillii*, *E. trichopoda*, *E. brachycorys* and *E. youngiana*), bowgada (*A. ramulosa*) and spinifex wattle (*A. coolgardiensis*). The stony plains support shrublands of mulga, gidgee (*A. pruinocarpa*), granite wattle (*Acacia quadrimarginea*), and Eremophila *spp*. The valley floors support shrublands of samphire (Halosarcia *spp.*), saltbush (Atriplex *spp.*), sage (*Cratystylis subspinescens*) and Frankenia *spp*. surrounding salt lakes. Floodplains along the Murchison and its tributaries have shrublands of bluebush (Maireana *spp.*), saltbush and Frankenia *spp.*, as well as mulga, prickly wattle and Acacia distans.

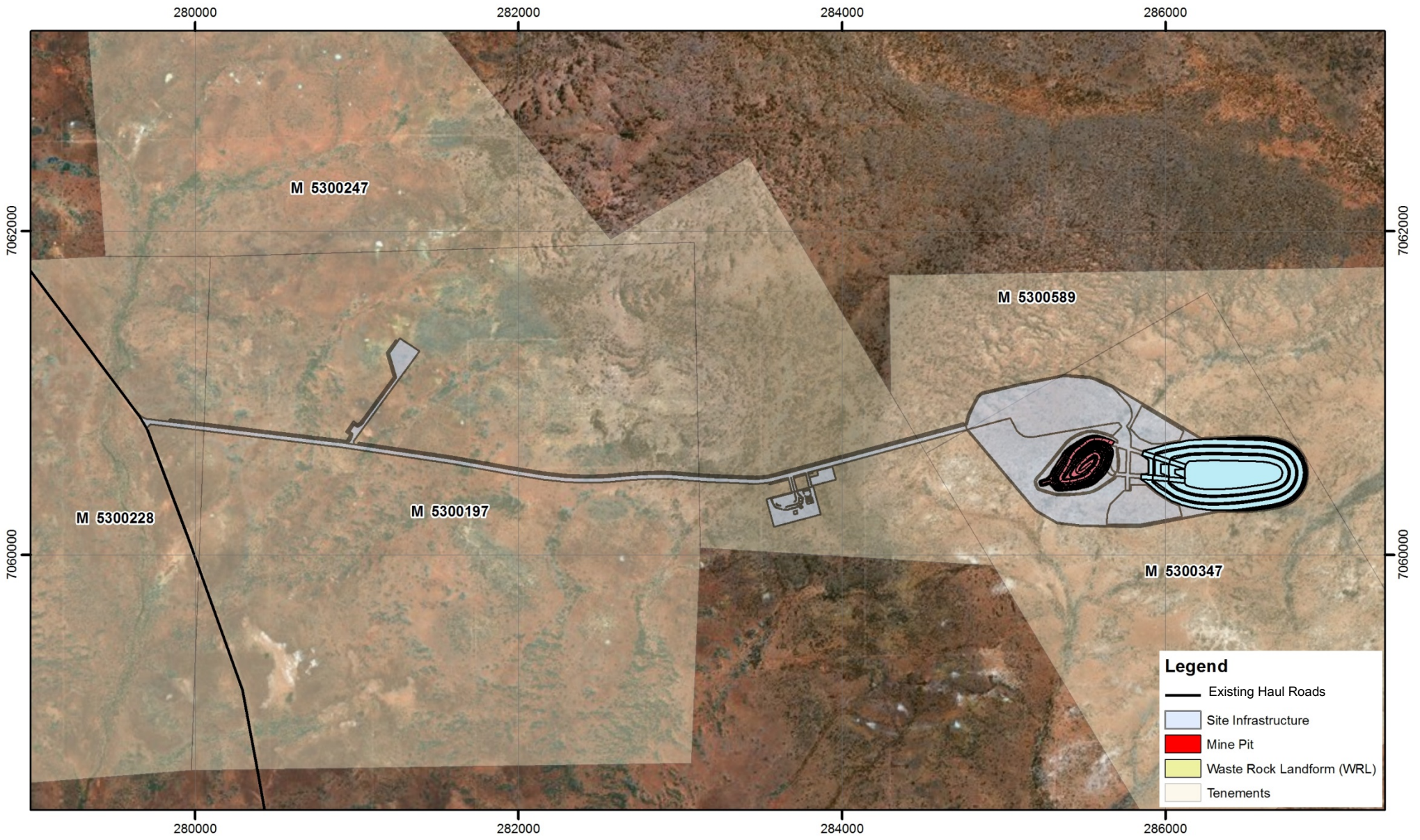
The Salinaland Plains Zone (279) supports predominantly mulga shrubland with spinifex grasslands (Tille, 2004).



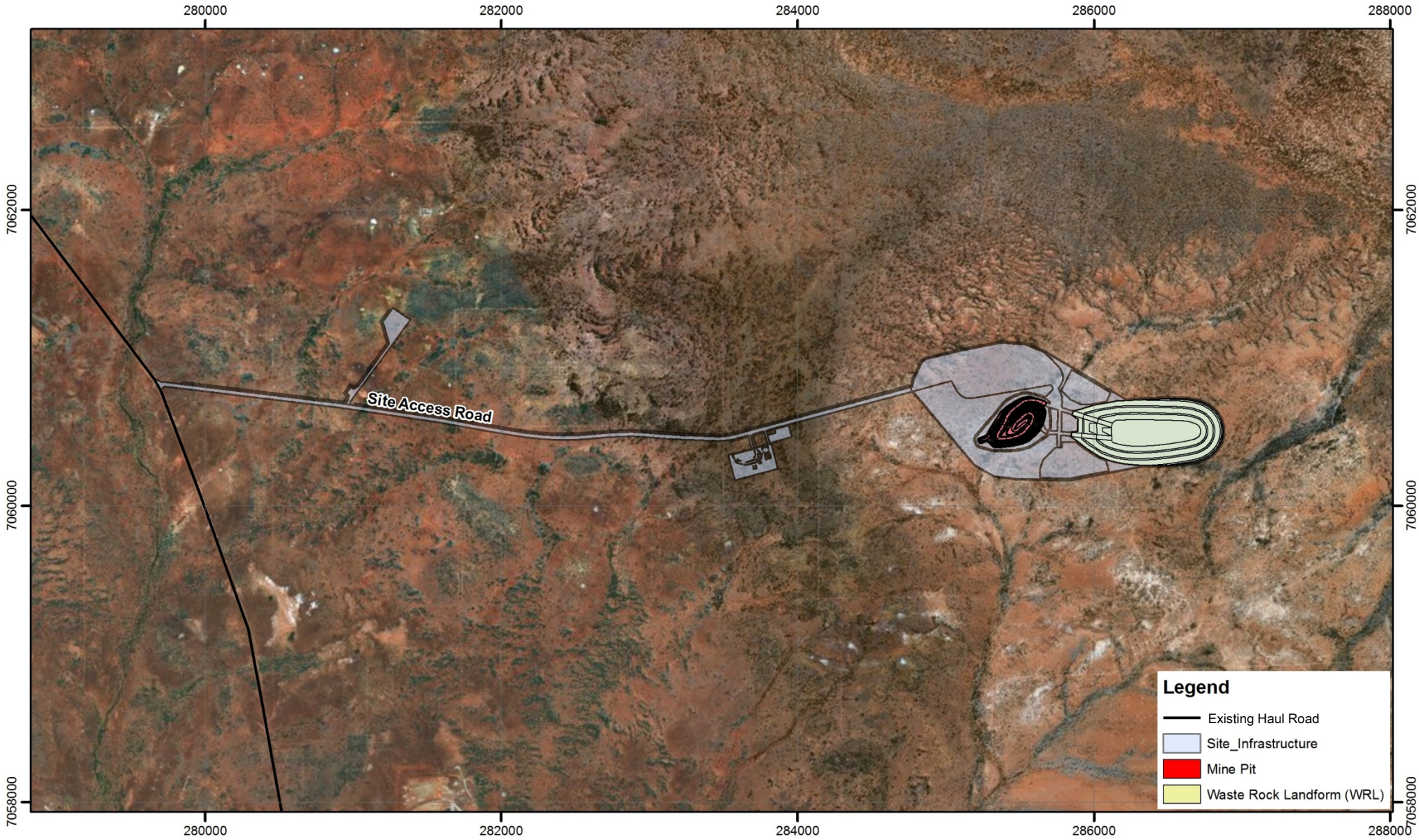
NORTHERN STAR RESOURCES LTD	Figure 2.1: Regional location of the Ramone Gold Deposit	soilwater GROUP
RAMONE GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		



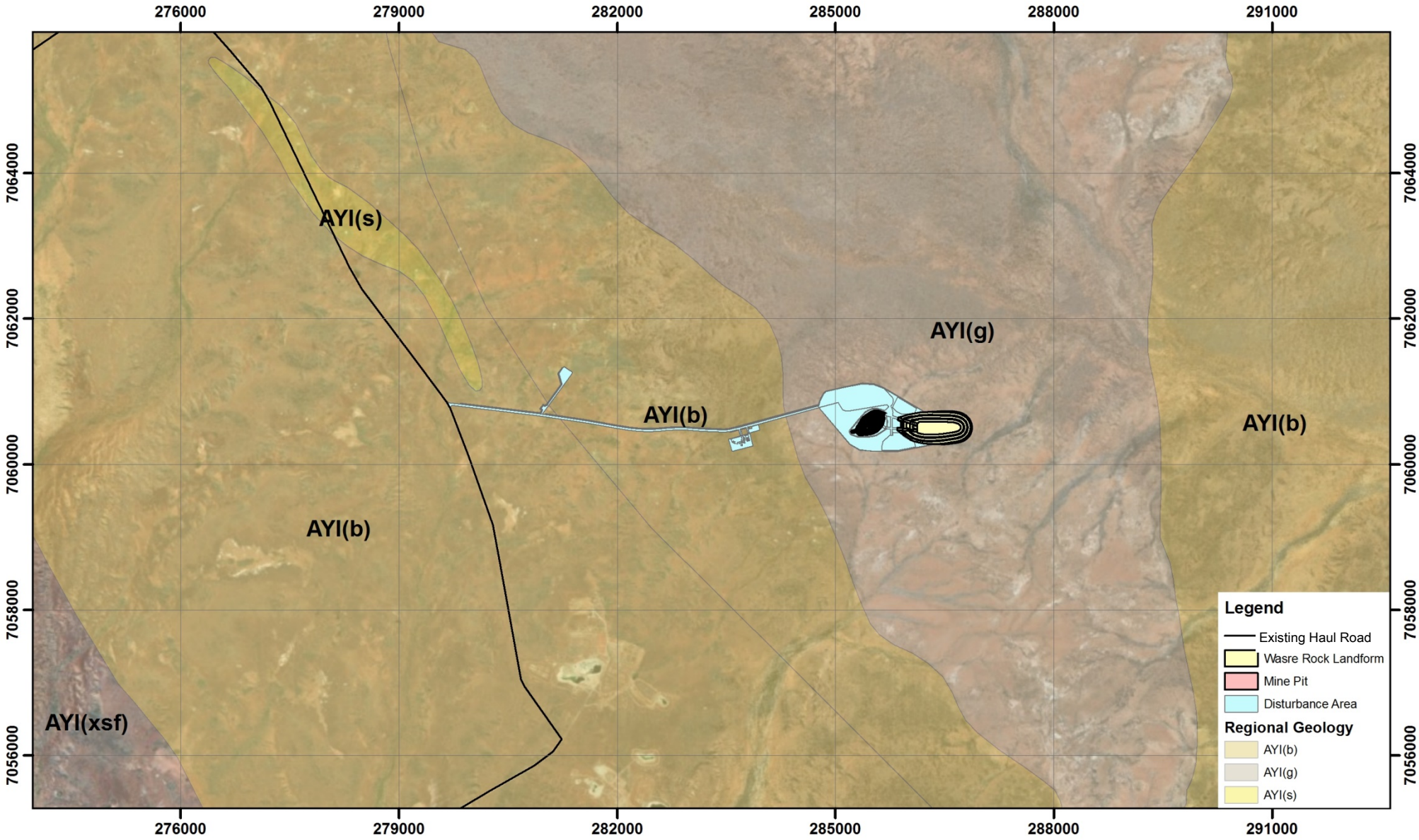
NORTHERN STAR RESOURCES LTD	Figure 2.2: Local location of the Ramone Deposit	soilwater GROUP
RAMONE GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		



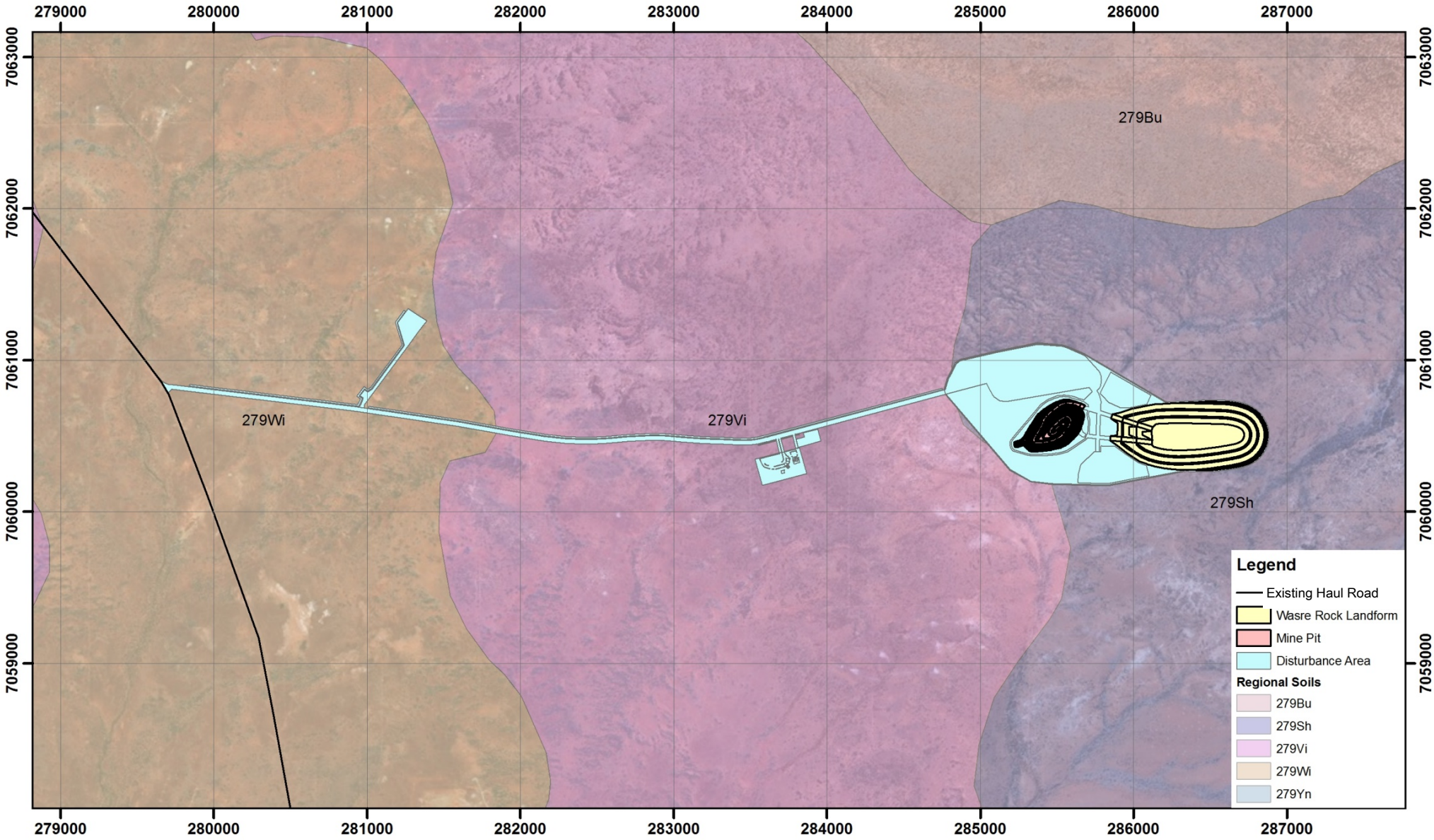
NORTHERN STAR RESOURCES LTD	Figure 2.3: Tenement Map	soilwater GROUP
RAMONE GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		



NORTHERN STAR RESOURCES LTD RAMONE GOLD DEPOSIT - SOIL CHARACTERISATION STUDY	Figure 2.4: Site Layout	soilwater GROUP



NORTHERN STAR RESOURCES LTD	Figure 2.5: Regional geology within the project area.	soilwater GROUP
RAMONE GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		



NORTHERN STAR RESOURCES LTD	Figure 2.6: Regional soil within the project area.	soilwater GROUP
RAMONE GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		

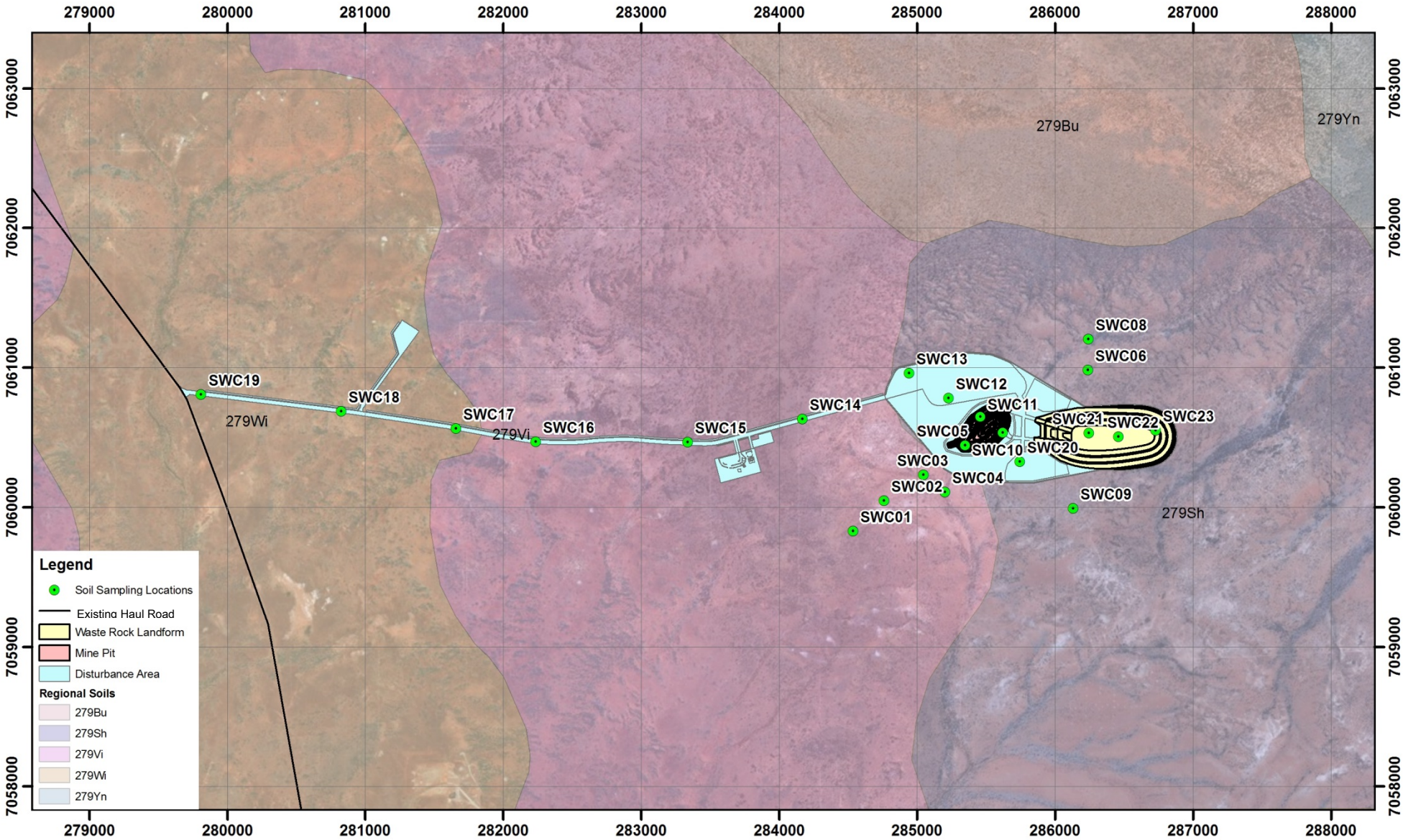
3 STUDY METHODOLOGY

3.1 SELECTION OF SAMPLING LOCATIONS

Soil sampling locations within Ramone Gold Mine Operation were selected based on expected variability due to geology, soil type and properties (physical and chemical), and on landscape geomorphology and pedogenic processes. Sampling locations targeted the upper, mid and lower slopes of the landscape as processes such as erosion; transportation and sedimentation are expected to play an important role in soil development and depth within the project area. Sites also targeted expected disturbance areas during the mining process such as the mine pit, haul road and associated infrastructure and waste rock dumps because soil removed from these areas could provide a valuable resource during future mine management, mine closure and rehabilitation activities. The location of each sampling point was confirmed following consultation with relevant Northern Star Resources site personnel to ensure no sampling was undertaken in non-approved areas. Final agreed locations were recorded in GIS and on field hand-held GPS units. The location of each sampling point within the Mine operations area is provided in Figure 3.1 and Table 3.1.

Table 3.1: Location and depth of excavation for each sampling location.

Sample ID	Coordinates (GDA 94, Zone 51)		Depth of Trench (m)	Sample Location
	Easting	Northing		
SWC01	284539	7059828	1.5	Outside mine disturbance area
SWC02	284764	7060046	1.3	Outside mine disturbance area
SWC03	285048	7060233	1.2	Outside mine disturbance area
SWC04	285206	7060110	1.7	Outside mine disturbance area
SWC05	285351	7060445	1.7	Inside proposed mine pit area
SWC06	286241	7060984	1.3	Outside mine disturbance area
SWC07	285726	7060743	1.5	Inside proposed mine pit area
SWC08	286245	7061203	1.3	Outside mine disturbance area
SWC09	286133	7059992	1.4	Outside mine disturbance area
SWC10	285625	7060534	1.2	Inside proposed mine pit area
SWC11	285462	7060647	1.4	Inside proposed mine pit area
SWC12	285232	7060783	1.4	Proposed infrastructure area
SWC13	284945	7060959	1.5	Outside mine disturbance area
SWC14	284137	7060704	0.3	Proposed haul road
SWC15	283302	7060932	0.2	Proposed infrastructure area
SWC16	282245	7060785	0.3	Proposed haul road
SWC17	281677	7061148	0.3	Proposed infrastructure area
SWC18	280823	7060847	0.15	Proposed haul road
SWC19	279810	7060936	0.2	Proposed haul road
SWC20	285748	7060328	0.3	Proposed infrastructure area
SWC21	286249	7060530	0.25	Proposed waste rock dump area
SWC22	286462	7060504	0.3	Proposed waste rock dump area
SWC23	286731	7060551	0.1	Proposed waste rock dump area



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RAMONE GOLD DEPOSIT - SOIL CHARACTERISATION STUDY

Figure 3.1: Soil sampling locations within the Ramone Gold Deposit

3.2 SOIL SAMPLING

Sampling trenches (SWC01 to SWC13) were dug using a 30 t excavator. Grab samples (SWC14 to SWC23) were obtained by manual excavation (i.e. shovel) to a depth where the underlying rock was encountered along the proposed haul road and infrastructure areas.

The sampling protocol at each location involved:

- Recording the location in a hand-held GPS.
- Recording surface features such as topography, vegetation and soil surface condition using field recording sheets and a digital camera.
- Describing the soil profile morphology in terms of colour, texture, structure and horizonation / layering. All field information was recorded using recording sheets and by digital camera. Field texture analysis was performed to estimate soil type (McDonald and Isbell, 2009) and subsequent identification of soil management units (SMUs).
- Discrete samples were collected down the exposed soil profile for subsequent laboratory analyses.
- Estimated root density was recorded using the semi-quantitative method of McDonald and Isbell (2009) (Table 3.2).

A total of 46 soil samples from 23 locations were collected from within the Project Area. Some examples of the soil surface conditions across the study area are provided in Plate 3.1

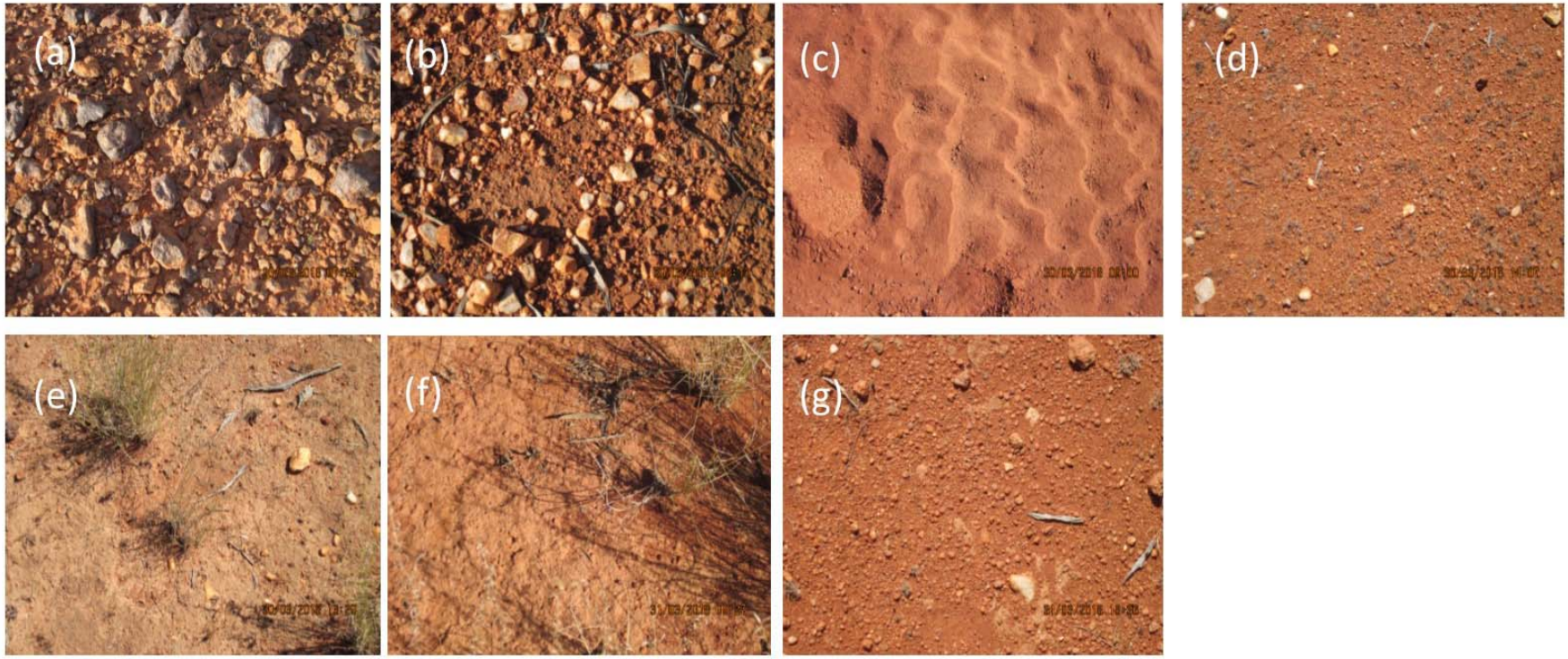
Table 3.2: Semi-quantitative assessment of plant roots used in this investigation.

Rating	Number of roots per 0.01 m2 (10 cm × 10 cm)	
	Very fine - fine roots (< 2 mm diameter)	Medium - coarse roots (> 2 mm diameter)
0 No roots	0	0
1 FSWC roots	1 - 10	1 - 2
2 Common roots	10 - 25	2 - 5
3 Many roots	25 - 200	> 5
4 Abundant roots	> 200	> 5

In addition to the above soil sampling, approximately 300 kg of soil was collected from four distinct locations for erosion testing. Samples were collected from locations from the major areas of disturbance and / or exhibiting contrasting visual and physical characteristics. This selection of samples was based on observations made during the field sampling program. Samples were collected from the following locations:

- Proposed mine pit area (composite of materials from SWC5, SWC7, SWC10 and SWC11);
- Drainage line intersecting the site containing deep sand and minor clay (SWC4);
- Proposed infrastructure area adjacent to the pit (SWC12); and
- Area which may be disturbed in the future (SWC08).

A sample of the underlying rock materials was also collected at each location for comparing erosion rates for rock-armoured and non-armoured surfaces.



Photos of the various soil surface conditions observed within the study area (a) ironstone rock (gibber plain; Trench 1), (b) quartz rock (Trench 2), (c) bare sandy creek bed (Trench 3), (d) coarse sandy surface (Trench 6), (e) poor surface structure (Trench 8), poor surface structure (Trench 12), and exposed hardpan/granite outcrop (WRL1).

Plate 3.1: Photos of various soil profiles and surface conditions observed within the Project Area.

3.3 LABORATORY ANALYSIS

3.3.1 PHYSICAL AND CHEMICAL ANALYSES

The physical and chemical properties of the soil materials were assessed at Soilwater Analysis and CSBP Laboratories in Perth. All samples collected in the field were analysed for pH, EC, field (gravimetric) moisture content and gravel content, to initially screen samples for more detailed analyses and to establish key properties that may distinguish important soil characteristics (e.g. salinity limitations, texture, surface charge chemistry etc.). The remaining properties (Table 3.3) were assessed on a select number of samples that will reflect the physical and chemical properties of soil materials within each of the major soil mapping units.

Samples for detailed laboratory testing were selected based on (1) varying soil types, (2) different positions in the landscape, and (3) from areas underlain by different geology. The full suite of analyses and analytical results are presented in Appendix A.

Table 3.3: Physical and chemical properties of the soils measured in the laboratory.

Parameter	Method	Standard Reference
Soil Physical Properties		
Particle size distribution	Pipette sedimentation	McKenzie *et al.* (2002)
Gravel content	Sieve analysis (> 2 mm soil fraction)	
Bulk density	Constant volume	
Aggregate stability	Emerson dispersion	
Hardsetting Potential		Harper and Gilkes (1994)
Soil Hydraulic Properties		
Saturated hydraulic conductivity	Constant head permeameter	McKenzie *et al.* (2002)
Water retention characteristics	Pressure plate equipment	
Soil Chemical Properties		
pH	1:5 soil/water extraction	Rayment and Lyons (2010)
Electrical conductivity (EC; salinity))	1:5 soil/water extraction	
Macro-nutrients		
- Total Nitrogen (N)	Leco	
- Colwell Phosphorus (P)	$NaHCO_3$ extraction	
- Colwell Potassium (K)	$NaHCO_3$ extraction	
- Available Sulfur (S)	KCl extractable S/ICP	
Organic Carbon	Walkley Black Method	Rayment and Lyons (2010)
Exchangeable cations – Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K)	NH_4Cl extraction	Rayment and Lyons (2010)
Effective Cation Exchange Capacity (ECEC)	Sum of exchangeable cations	-
Exchangeable Sodium Percentage (ESP; sodicity)	ESP = (Ex. Na/CEC)×100	-

3.3.2 EROSION TESTING

The laboratory-scale rainfall simulator (Plate 3.2) was used to measure the interrill (raindrop impact) erodibility of each material. The rainfall simulator was designed to apply water at an intensity of approximately 80 mm/hr, with a raindrop

size and spatial distribution closely resembling natural rainfall. An intensity of 80 mm/hr corresponds to a 1:10, 1:20 and 1:100 year ARI storm event of approximately 6, 10, and 20 min duration, respectively (BOM, 2018).

Prior to testing, each of the materials described above was placed into a 0.75 x 0.75 x 0.20 m container and lightly compacted to approximate the expected field conditions. The base of the container was free draining to avoid saturated conditions and air entrapment within the samples. Each material was pre-treated by sequentially wetting and drying the surface to allow natural organisation and settling of the soil particles.

The container was set at a slope angle of 18° to simulate likely batter conditions at the site. The materials were then subjected to a simulated rainfall of approximately 80 mm/hr, and 10 samples of the resulting surface runoff were collected over a 4 hour period. Runoff volume and sediment loss in each sample were determined gravimetrically. Measurements from the rainfall simulator were used to calculate soil erodibility parameters required for the WEPP erosion model. The methods used for calculating these parameters are discussed further in Section 3.5.

Plate 3.2: Laboratory scale rainfall simulator

3.4 EROSION MODELLING

The Watershed Erosion Prediction Project (WEPP; Flanagan & Livingston, 1995) model was used to predict the long-term (100 year duration) erosion rates from the surface of the proposed waste rock landform at the Ramone Deposit. The WEPP model used a series of input files describing the soils, climate, slope geometry, and land management regime for the site. Model input values and assumptions are discussed in the following sections.

3.4.1 SOIL PARAMETERS

The soil parameters required by WEPP were derived from the laboratory testing undertaken at SWA Laboratories. These parameters include the effective hydraulic conductivity (K_{eff}), interrill erodibility (K_i), rill erodibility (K_r), and soil critical shear stress (τ_C), and are summarised in TTT

Keff was estimated by fitting the Green-Ampt equation (Green & Ampt, 1911) to the measured infiltration rates using Equation 1:

$$F = K_{eff}(1 + Ns / F) \qquad \text{Equation 1}$$

where: f = infiltration rate (mm/h)

K_{eff} = effective saturated hydraulic conductivity (mm/h)

N_s = effective matric potential at the wetting front (m), and

F = cumulative infiltration (m).

K_i was calculated from the inter-rill erosion rate measured in the rainfall simulator, according to Elliot *et al.* (1989) using Equation 2:

$$D_i = K_i \ I^2 \ S_f \qquad \text{Equation 2}$$

Where: D_i = interrill erosion rate (kg/(m^2 s)

K_i = interrill erodibility (kg s)/m^4

I = rainfall intensity (m/s), and

S_f = dimensionless slope factor (1.05 - 0.85 $^{-0.85\ \sin(\alpha)}$)

K_r and τ_C were determined from the shear stress (τ) and rill erosion rate (D_c) measurements collected in the laboratory. This was done by a linear regression analysis according to the method described by Foster (1982) and Elliott *et al.*, (1989). The rill erodibility parameters are related to the measured parameters τ and D_c by Equation 3:

$$D_c = K_r (\tau - \tau_C) \qquad \text{Equation 3}$$

where: D_c = measured erosion rate (kg/m2 s)

K_r = rill erodibility (s/m)

τ = measured shear stress (Pa), and

τ_C = critical shear stress (Pa).

D_c was plotted against τ for each of the rainfall simulator measurements. The slope of the linear regression line was K_r, and the intercept with the horizontal axis was τ_C.

Table 3.4: Key soil parameters used in the WEPP model.

Material ID	Sand (%)	Clay (%)	OM (%)	CEC [meq/100g]	K_{eff} (mm/hr)	$K_i \times 10^5$ (Kg s / m^4)	$K_r \times 10^3$ (s / m)	τ_C (Pa)
Mine pit material	81	17	52	1.42	20.6	1.48	0.23	9.3

Material ID	Sand (%)	Clay (%)	OM (%)	CEC [meq/100g]	K_{eff} (mm/hr)	$K_i \times 10^5$ (Kg s / m^4)	$K_r \times 10^3$ (s / m)	τ_C (Pa)
Mine pit material + rock mulch					7.65	0.87	0.18	16.6
Drainage line material	77	17	45	2.77	78.0	0.04	0.10	10.8
Trench 12	86	12	23	1.86	10.5	14.5	0.72	5.6
Trench 8	74	22	45	2.11	11.6	6.14	0.51	11.0
Trench 8 + rock mulch					8.09	2.38	0.48	13.9

3.4.2 CLIMATE DATA

A 100-year synthetic climate file was generated using the CLIGEN stochastic weather generator (Yu, 2003), using 30 years of observational data gathered at weather stations located at Wiluna and Millrose, (BOM stations #13012 and #13006, respectively). Figure 3.2 a and Figure 3.2 b demonstrate that the CLIGEN file is generally consistent with the 30 years of measured data from which it was generated. Figure 3.2a compares the frequency of 24-hour rainfall totals, indicating that larger 24-hour storms occurred slightly more frequently in the calculated ARI data than in the CIGEN file and measured rainfall data. Figure 3.2b compares average monthly rainfall totals, and shows that the CLIGEN file captures a similar degree of seasonal variability as was observed at the regional climate stations. Figure 3.3 compares the 30 years of measured daily rainfall totals at Wiluna and Milrose to representative 30-year section of the CLIGEN model, showing a similar degree of variability.

3.4.3 SLOPE PROPERTIES

The slopes with WEPP were modelled under the assumption of slope angles between 15° and 18°, with a lift height of 10 and 20 m to simulate likely conditions on post-mine landforms.

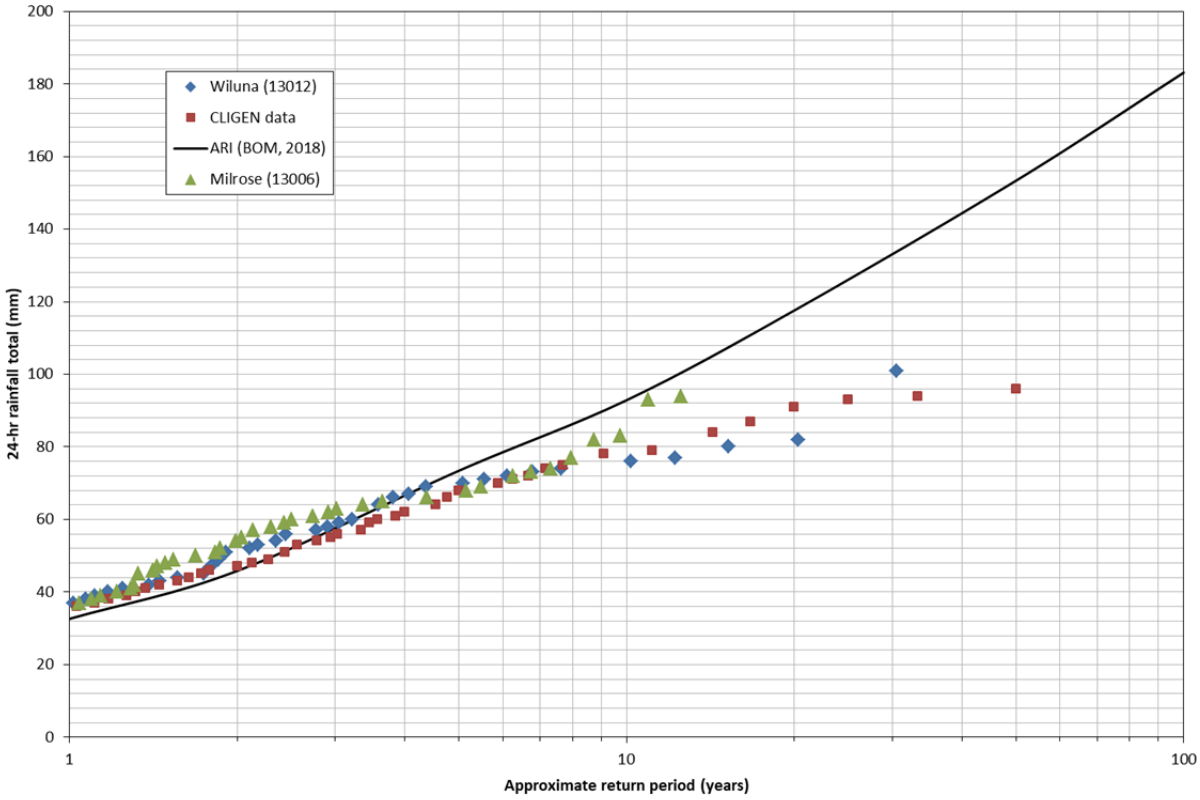
3.4.4 MANAGEMENT ASSUMPTIONS

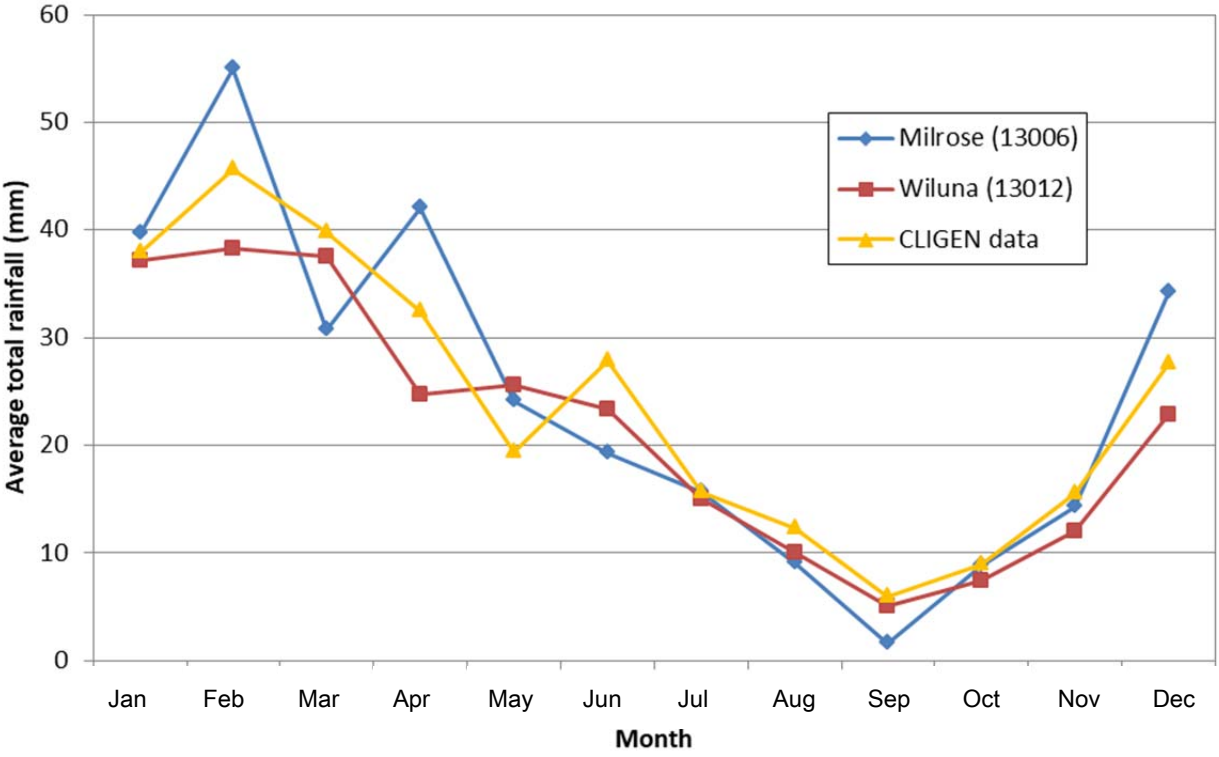
The land management input file used in the WEPP model was designed to describe the expected conditions on the remediated waste rock landform at the Ramone Deposit. The key features of the input management file include:

- A pre-consolidated soil surface. This means that no further settling is simulated within the model, and that the measured infiltration rates and runoff characteristics apply for the duration of the model (i.e., no further changes in these properties with time). This is reasonable because the laboratory measurements (from which the input parameters were derived) were conducted on pre-consolidated soil samples.
- No vegetation. This assumption will result in conservative (i.e. “worst-case”) erosion results, and will apply to the landform during the period prior to re-vegetation establishment. Subsequent vegetation growth will act to enhance the stability of the landform by dissipating rainfall impact energy, producing leaf litter as a ground cover, and stabilising the sub-surface and improving infiltration with root growth. The degree of stabilisation will depend on the types of vegetation used, and their rates of establishment.
- Zero initial surface cover (i.e. no woody debris or plant litter). This means that no additional surface cover was expected to be added to the soil surface to reduce erosion rates. This assumption does not have any impact on the

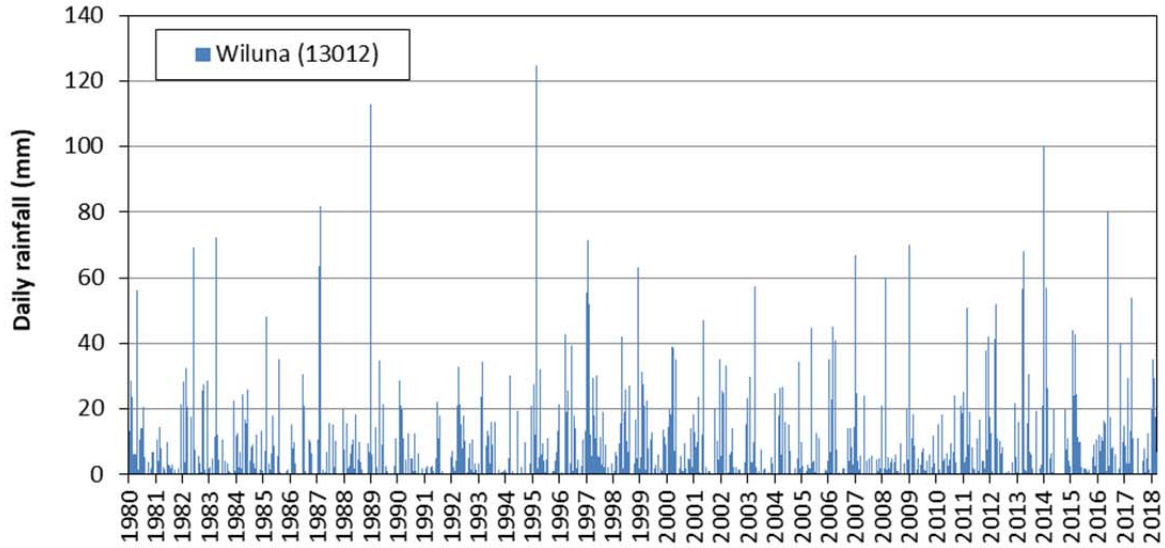
armouring effect of the rock and gravel fraction in the soil, which was already accounted for within the measured soil parameters shown in Table 3.4.

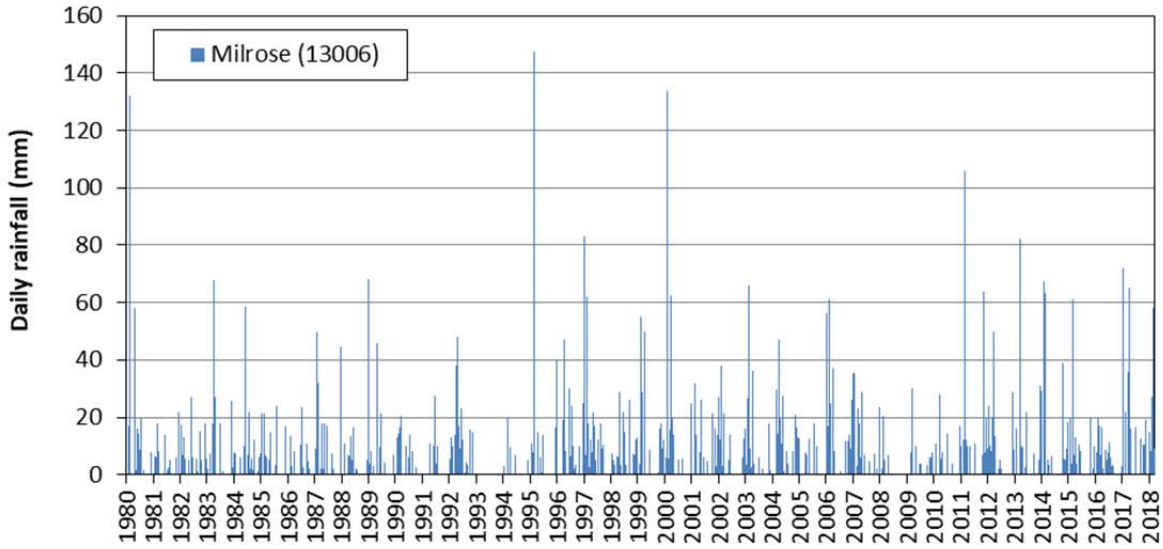
- Rill geometry is adjusted internally within the model based on the input soil parameters and on the size of erosion events encountered within the modelled timeframe.

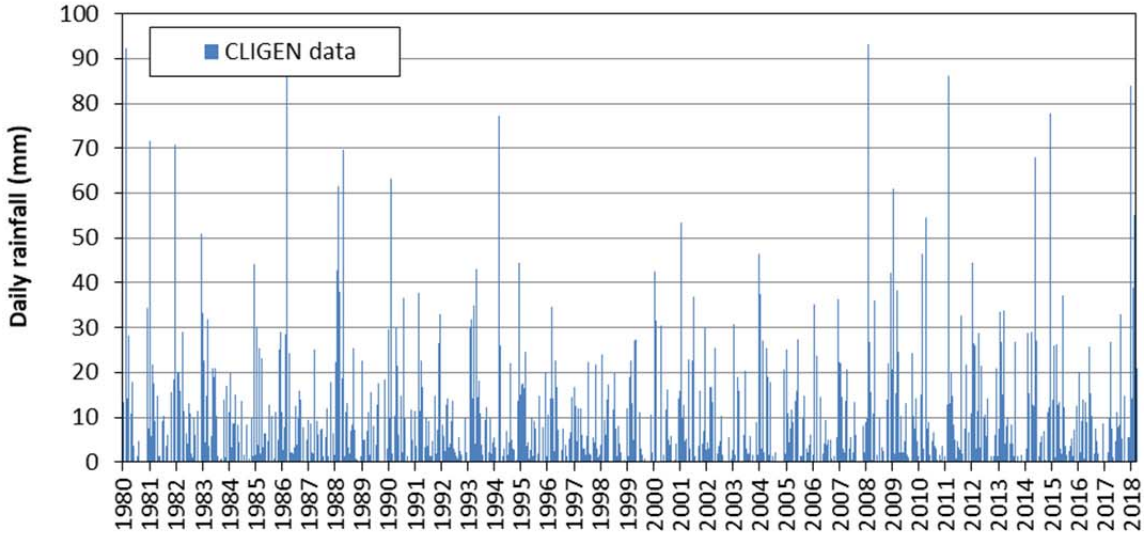




NORTHERN STAR RESOURCES LTD RAMONE GOLD DEPOSIT - SOIL CHARACTERISATION STUDY	Figure 3.2: a) 24 hour and b) mean monthly rainfall data	soilwater GROUP







NORTHERN STAR RESOURCES LTD	Figure 3.3: Annual rainfall data comparison	soilwater GROUP
RAMONE GOLD DEPOSIT - SOIL CHARACTERISATION STUDY		

4 SOIL CHARACTERISATION

4.1 RELATIONSHIP BETWEEN SOIL MAPPING UNIT, WA SOIL GROUP AND GEOLOGY

Soil sampling locations generally occurred within either the Sherwood Land System (Soil Mapping Unit 279Sh), or the Violet Land System (Soil Mapping Unit 279Vi) (Table 4.1). The corresponding WA Soil Group for the Sherwood Land System was Red shallow loam, Red shallow sandy duplex and Red shallow sand (Group 522, 406 and 423), and these soil types were primarily associated with the granitic geology. The main disturbance areas of the Ramone Gold Mine (i.e. pit, waste rock landform and infrastructure) are located within the Sherwood Land System.

The corresponding WA Soil Group for the Violet Land System was Red shallow loam and Red deep sands (Group 522 and 445), and these soil types were primarily associated with basaltic geology (Table 4.1). The proposed haul road largely passes through the Violet Land System with a small section passing through the Wiluna Land System (Group 522, 406 and 423), and is primarily associated with the basaltic geology.

4.2 SOIL CHARACTERISATION

4.2.1 SHERWOOD LAND SYSTEM (SOIL MAPPING UNIT 279SH)

4.2.1.1 Morphological Properties

Soil sampling within the Sherwood Land System was conducted at the following locations: SWC5, SWC6, SWC7, SWC8, SWC9, SWC10, SWC11, SWC12, SWC13, SWC20, SWC21, SWC22 and SWC23 (Figure 3.1). Soils at these locations are generally associated with relatively flat to low slope topographic positions, and consist of a relatively homogeneous shallow (<0.5 m) surface soil overlying weathered bedrock (equivalent to saprock or transition zone). Fresh bedrock occurs at 1-1.5 m below the surface (Plate 4.1 and Plate 4.2).

The weathered bedrock or transition zone, has experienced considerable soil illuviation and bioturbation processes and thus the residual rock fragments are interspersed with surficial soil, providing a growth medium. The vegetation within the Sherwood System is generally sparse, with isolated stands of *Acacia aneura* (mulga), and little understorey or ground cover (Plate 4.3).

Table 4.1: Relationship between soil mapping unit, WA Soil Group, and geology for each sampling location.

SWC Code	Regional Soil Mapping Unit	WA Soil Group	Rock Type
SWC01	Violet Land System	Red shallow loam / Red deep sand	Basalt
SWC02	Violet Land System	Red shallow loam / Red deep sand	Basalt
SWC03	Violet Land System	Red shallow loam / Red deep sand	Basalt
SWC04	Violet Land System	Red shallow loam / Red deep sand	Basalt
SWC05	Sherwood Land System	Red shallow loam / Red shallow sandy duplex / Red shallow sand	Granite
SWC06	Sherwood Land System	Red shallow loam / Red shallow sandy duplex / Red shallow sand	Granite
SWC07	Sherwood Land System	Red shallow loam / Red shallow sandy duplex / Red shallow sand	Granite
SWC08	Sherwood Land System	Red shallow loam / Red shallow sandy duplex / Red shallow sand	Granite
SWC09	Sherwood Land System	Red shallow loam / Red shallow sandy duplex / Red shallow sand	Granite
SWC10	Sherwood Land System	Red shallow loam / Red shallow sandy duplex / Red shallow sand	Granite
SWC11	Sherwood Land System	Red shallow loam / Red shallow sandy duplex / Red shallow sand	Granite
SWC12	Sherwood Land System	Red shallow loam / Red shallow sandy duplex / Red shallow sand	Granite
SWC13	Sherwood Land System	Red shallow loam / Red shallow sandy duplex / Red shallow sand	Granite
SWC14	Violet Land System	Red shallow loam / Red deep sand	Basalt
SWC15	Violet Land System	Red shallow loam / Red deep sand	Basalt
SWC16	Violet Land System	Red shallow loam / Red deep sand	Basalt
SWC17	Violet Land System	Red shallow loam / Red deep sand	Basalt
SWC18	Wiluna Land System	Red shallow loam / Red shallow sandy duplex / Red shallow sand	Basalt
SWC19	Wiluna Land System	Red shallow loam / Red shallow sandy duplex / Red shallow sand	Basalt
SWC20	Sherwood Land System	Red shallow loam / Red shallow sandy duplex / Red shallow sand	Granite
SWC21	Sherwood Land System	Red shallow loam / Red shallow sandy duplex / Red shallow sand	Granite
SWC22	Sherwood Land System	Red shallow loam / Red shallow sandy duplex / Red shallow sand	Granite
SWC23	Sherwood Land System	Red shallow loam / Red shallow sandy duplex / Red shallow sand	Granite

Plate 4.1: Surficial soil profile within the Sherwood Soil System (SWC05, located in the proposed mine pit)

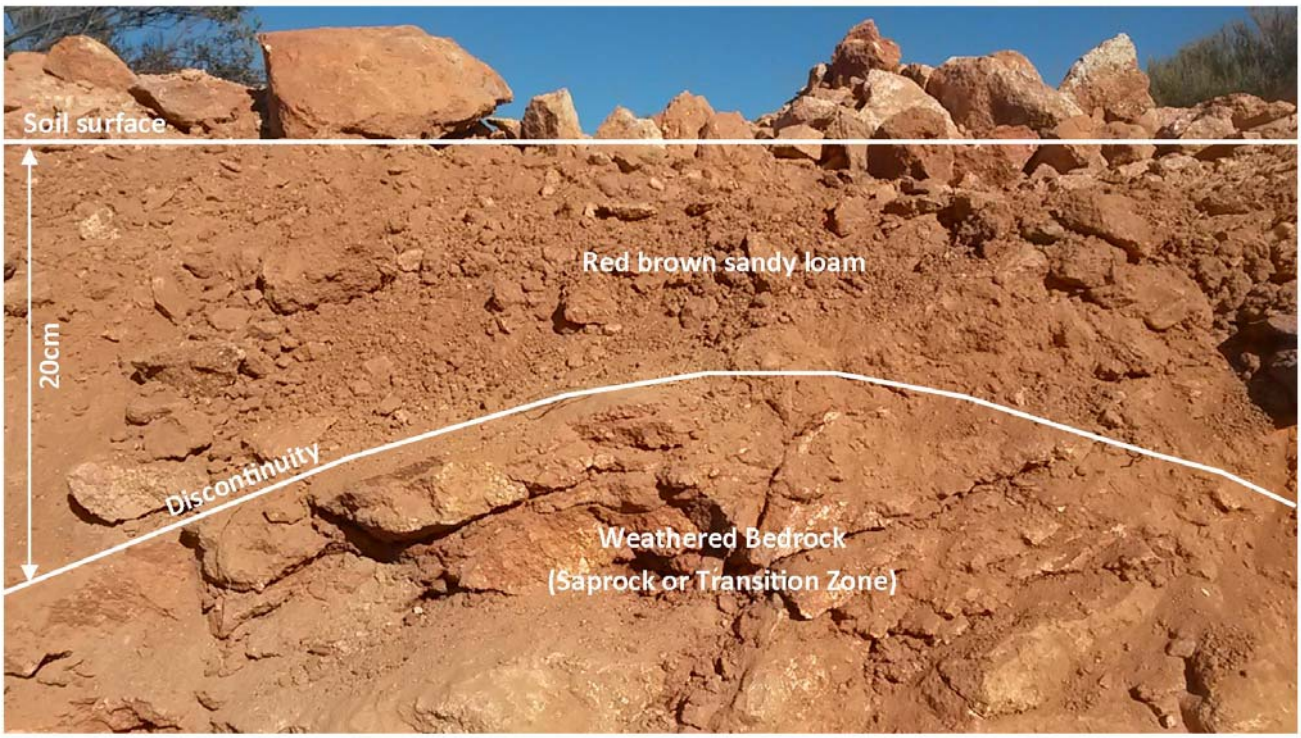
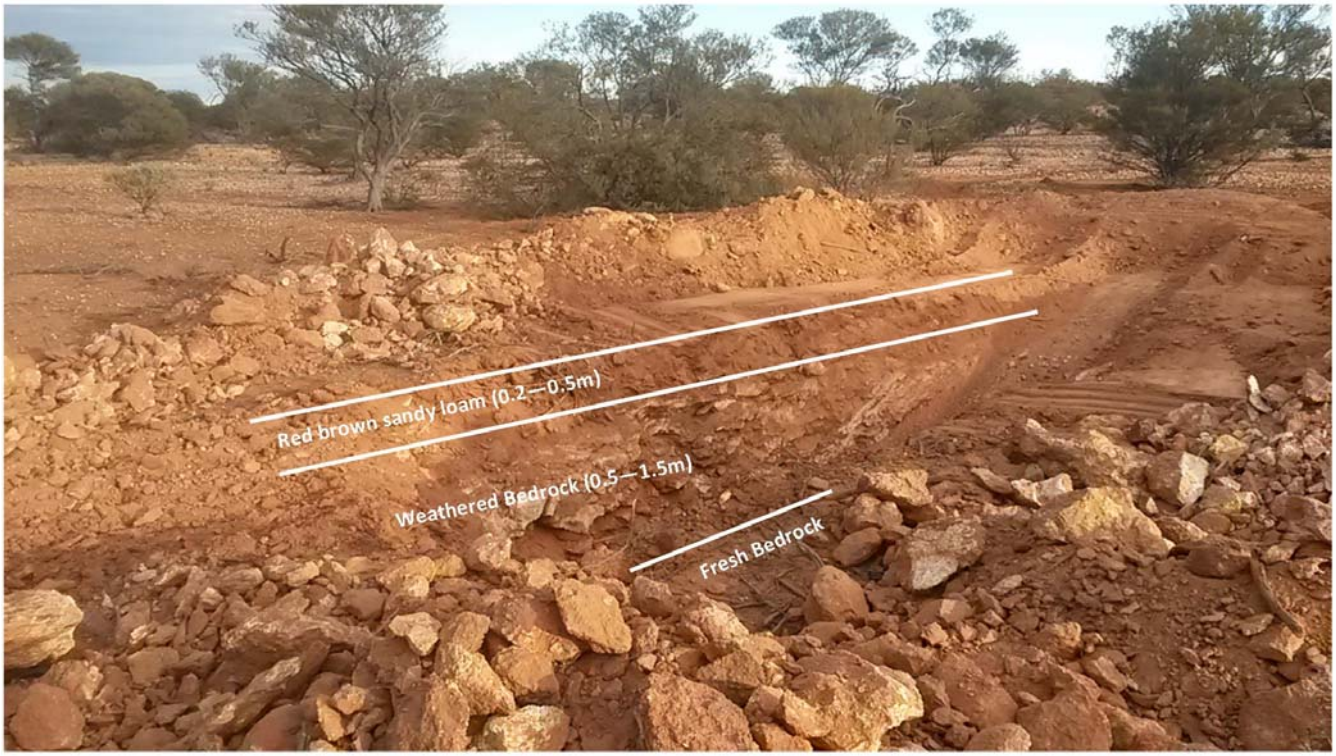


Plate 4.2: Deeper soil profile within the Sherwood Soil System (SWC11; locate on the boundary of the proposed mine pit)



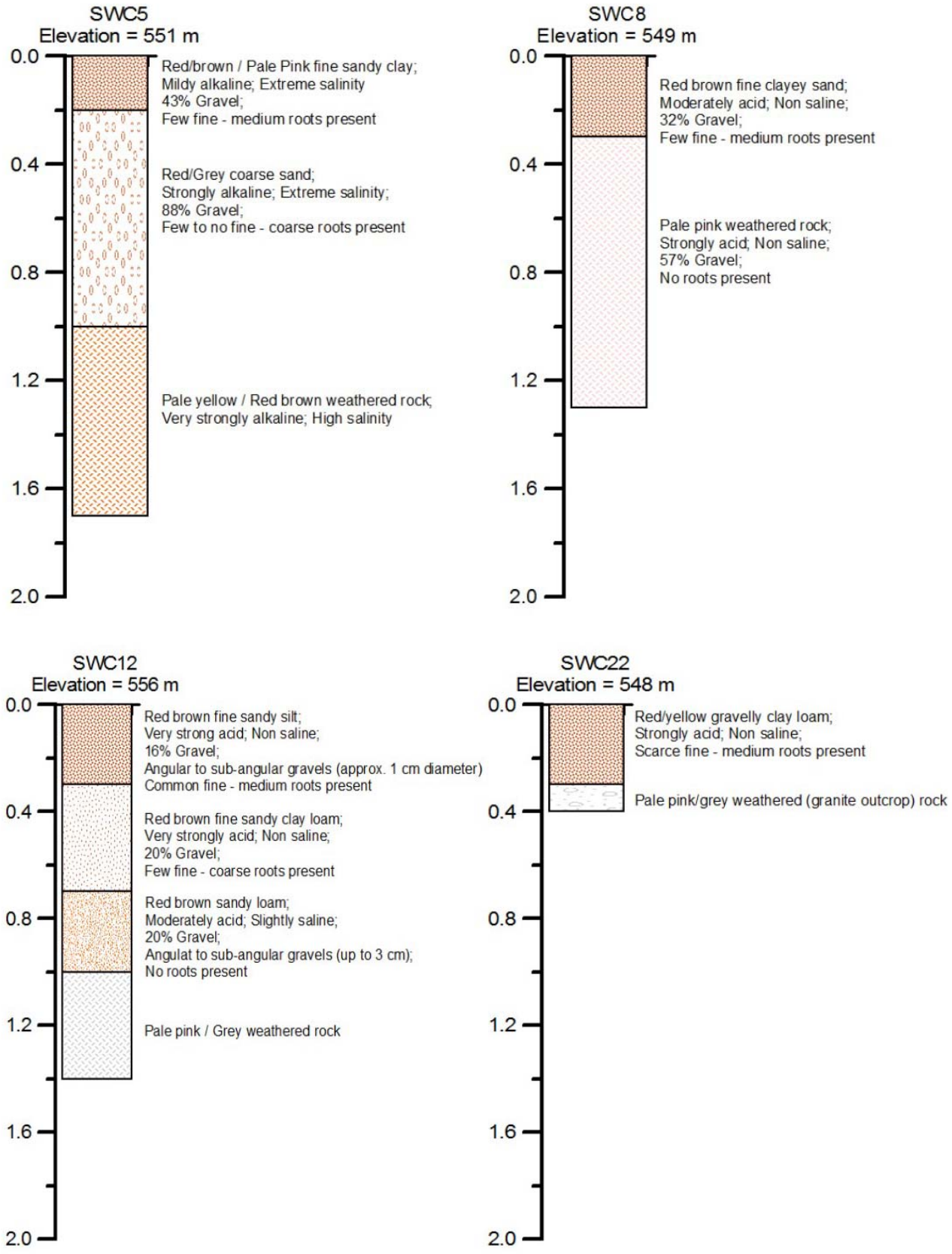


Figure 4.1: Characteristic soil profiles within the Sherwood Land System (SWC5, SWC8, SWC12 and SWC22).

Plate 4.3: Characteristic vegetation within the Sherwood Land System

4.2.1.2 Physical Properties

The physical properties of the soils within the Sherwood Land System are provided in Table 4.2. The surface soils generally have around 40% gravel, with the fine fraction composed primarily of sand (82 %) reflecting its granitic parent rock. It has up to 18 % silt + clay, and thus it has a reasonable high water holding capacity (25 % at field capacity) and plant available water (PAW) content (6.3 %).

The weathered rock material contains up to 66 % gravel (residual / fracture parent rock), with a fines matrix dominated by sand (86 %); again, reflecting its granitic origin. Although the fine fraction does contain a relatively high silt + clay fraction (13.8 %), the abundance of residual rock fragments, limits its water holding capacity to around 11 % at field capacity and only 3 % PAW.

Both the surface soil and fine fraction of the weathered rock material exhibit poor macro (i.e. slaking) and micro (dispersion) stability.

Table 4.2: Typical physical properties of the soils in the Sherwood Land System

Parameter	Material	
	Surficial Soil (0-0.2 m)	Weathered Rock (0.2 – 1 m)
Gravel Content (%)	40	66
Particle Size Distribution		
- % Sand	82.1	86.2
- % Silt	3.4	3.3
-% Clat	14.5	10.5
- Texture	Sandy Loam	Sandy Loam
Emerson Class	Class 1	Class 2

Parameter	Material	
	Surficial Soil (0-0.2 m)	Weathered Rock (0.2 – 1 m)
Bulk Density (g/m3)	1.65	1.81
Ksat (m/d)	0.69	0.23
Water Retention Characteristics (%)		
- 0 kPa	45.7	17.7
- 10 kPa	25.1	11.0
- 33 kPa	15.8	5.8
- 100 kPa	13.2	4.6
- 1,500 kPa	9.5	2.8
- PAW	6.3	3.0

4.2.1.3 Chemical Properties

The chemical of the soils within the Sherwood Land System are provided in Table 4.3. The surface soils have a pH around 5.5, whilst the underlying weathered rock material has a neutral pH. All materials are classified as non-saline (EC < 40 mS/m), which combined with the elevated silt + clay fraction is likely to exacerbate the observed poor structural stability of these soils.

All materials have very low nutrients levels and organic carbon contents, relatively their infertile nature. The surface soils have a CEC of 1.4 %, indicating a dominance of kaolinite in the clay mineral fraction, and are classified as non-sodic, with an ESP of only 2.6 %. Although these soils are classified as non-sodic, they are still structurally unstable and dispersive – this is likely to be a function of their very low salinity.

The underlying weathered material has a CEC of 14.3 %, indicating the presence of illite and minor smectite in the clay mineral fraction. This is expected as these soils are less weathered than the overlying surface soils. The combination of minor smectite, high sodicity (13.3 %) and low salinity makes the fines fraction of this material structurally unstable and dispersive; however, the high gravel / rock fraction (up to 66 %) will protect these soils from erosion.

Table 4.3: Typical chemical properties of the soils in the Sherwood Land System

Parameter	Material	
	Surficial Soil (0-0.2 m)	Weathered Rock (0.2 – 1 m)
pH	5.5	7.0
EC (mS/m)	13.8	28.1
NH4-N (mg/kg)	<1	<1
NO3-N (mg/kg)	2	7
Colwell P (mg/kg)	3	<2
Colwell K (mg/kg)	113	470
Ext. S (mg/kg)	5.2	161
Org C (%)	0.3	0.3
Exchangeable Cations (meq/100g)		
- Ca	0.72	5.53
- Mg	0.33	2.27
- Na	0.04	2.21
- K	0.32	4.29

Parameter	Material	
	Surficial Soil (0-0.2 m)	Weathered Rock (0.2 – 1 m)
- Al	0.41	0.13
Cation Exchange Capacity (CEC; meq/100g)	1.35	14.30
Exchangeable Sodium Percentage (Sodicity; %)	2.6	13.3

4.2.2 VIOLET LAND SYSTEM (SOIL MAPPING UNIT 279VI)

4.2.2.1 Morphological Properties

The Violet Land System represents a more residual land surface, which was sampled at sites SWC01, SWC02, SWC03, SWC04, SWC14, SWC15, and SWC16 (Table 4.1). This land system underlies most of the proposed Site Access Road (Figure 2.6) and consists of a gravelly shallow (typically < 0.5 m) surface soil overlying an often calcareous lateritic hardpan, likely to be equivalent to the regionally extensive Wiluna Hardpan (Plate 4.4).

The gravel fraction within the Violet Land System is derived from the weathering of the lateritic hardpan, and thus it consists predominately of sub-rounded pisolithic gravels (Plate 4.5). The surface of this land system contains a thin layer of residual pisolithic gravel, which has formed by the elluviation or erosion of the fine soil fraction, leaving the coarse gravel fraction, which now effectively 'rock amours' the land surface and protects it from erosion (i.e. sheet wash).

Plate 4.4: Typical soil profile within the Violet Land System

Plate 4.5: Sub-rounded pisolithic gravel characteristic of the Violet Land System

The vegetation within the Violet Land System contains more abundant grass lands, with an overstorey of Mulga (Plate 4.6). It is likely that the more abundant vegetation within this land system is supported by a deeper soil profile, and that the roots of the larger shrubs and trees are accessing fractures in the lateritic hardpan, and accessing the stored soil moisture below this layer.

Plate 4.6: Typical vegetation within the Violet Land System

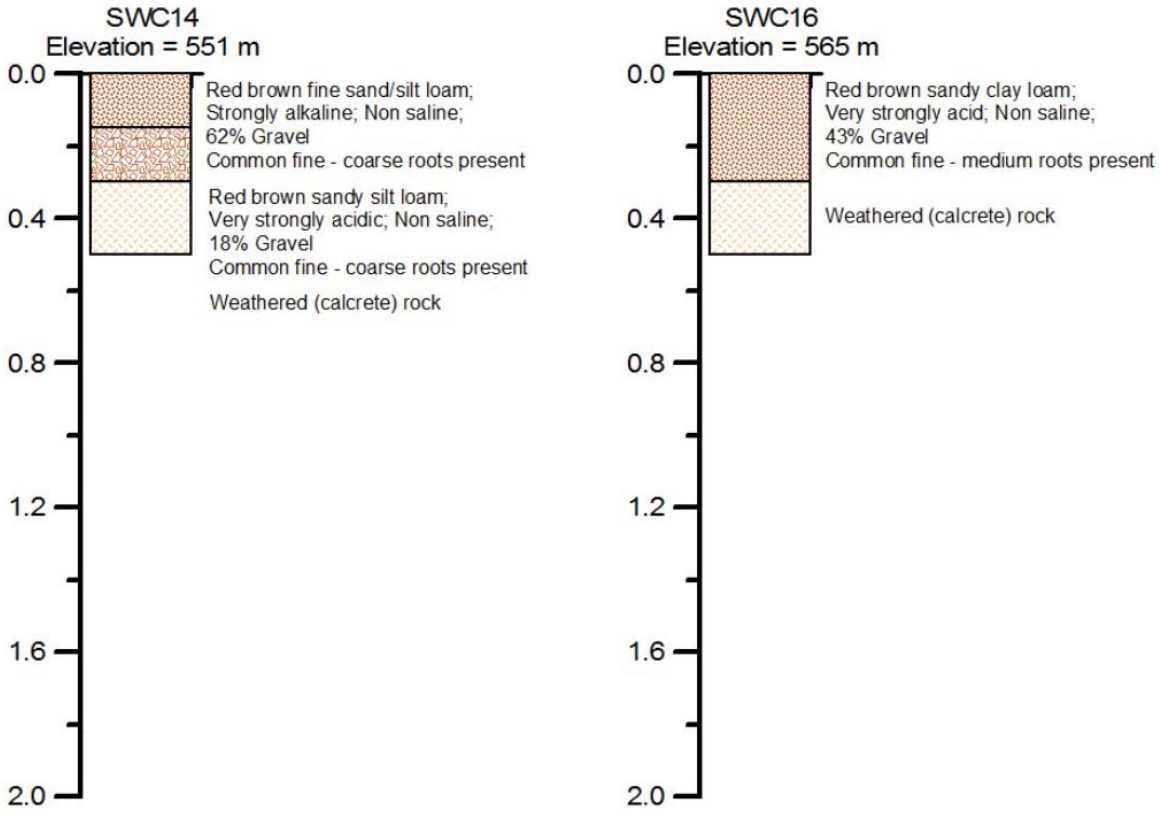


Figure 4.2: Soil profiles for soils within the Violet Land System (SWC14 and SWC16)

4.2.2.2 Physical Properties

The physical properties of the soils within the Violet Land System are presented in Table 4.4. The surficial soil within this land system contains around 40% gravel (>2.36 mm fraction), with the majority of the pisolithic gravel <20 mm in diameter. The fine fraction is dominated by sand (> 20 µm fraction), with up to 17 % silt + clay, and thus the surface soils are classified as a Sandy Loam.

The underlying lateritic hardpan contains around 70 % consolidated gravel, with the fines fraction composed predominately of sand (86 %), with 14.4 % silt + clay. The similarity in particle size distribution between the surficial soil and the fines fraction in the hardpan, suggests that the surficial soils are in situ and not transported.

The fines fraction of both the surficial soil and lateritic hard are structurally unstable; however, the cemented nature of the hardpan and the dominance of gravel, means that this material is relatively stable on the whole.

Table 4.4: Typical physical properties of the soils in the Violet Land System

Parameter	Material	
	Surficial Soil (0-0.3 m)	Lateritic Hardpan (>0.3 m)
Gravel Content (%)	41.2	70.4
Particle Size Distribution		
- % Sand	83.2	85.7
- % Silt	3.9	6.0
-% Clay	12.8	8.4

- Texture	Sandy Loam	Loamy Sand
Emerson Class	Class 2	Class 5
Bulk Density (g/m3)	1.74	1.74
Ksat (m/d)	0.48	0.06
Water Retention Characteristics (%)		
- 0 kPa	46.1	14.3
- 10 kPa	28.6	9.5
- 33 kPa	17.9	6.3
- 100 kPa	15.6	5.6
- 1,500 kPa	10.6	4.2
- PAW	7.4	2.1

4.2.2.3 Chemical Properties

The chemical of the soils within the Violet Land System are provided in Table 4.5. The surface soils have a pH around 6.4, whilst the underlying lateritic hardpan has an alkaline pH, reflecting its calcareous nature. All materials are have low salinity (EC < 60 mS/m), which combined with the elevated silt + clay fraction is likely to exacerbate the observed poor structural stability of these soils.

All materials have very low nutrients levels and organic carbon contents, highlighting their infertile nature. The surface soils have a CEC of 2.4 %, indicating a dominance of kaolinite in the clay mineral fraction, and are classified as non-sodic, with an ESP of only 2.6 %. Although these soils are classified as non-sodic, they are still structurally unstable and dispersive – this is likely to be a function of their very low salinity.

The underlying lateritic hardpan has a CEC of 8.5 %, indicating the presence of illite and minor smectite in the clay mineral fraction. This is expected as these soils are less weathered than the overlying surface soils. Although the fines fraction of the lateritic hardpan is considered non-sodic (ESP < 6), the combination of minor smectite and low salinity makes the fines fraction of this material structurally unstable and dispersive; however, the high gravel / rock fraction (up to 70 %) will protect these soils from erosion.

Table 4.5: Typical chemical properties of the soils in the Violet Land System

Parameter	Material	
	Surficial Soil (0-0.2 m)	Weathered Rock (0.2 – 1 m)
pH	6.4	8.6
EC (mS/m)	10.1	58.1
NH4-N (mg/kg)	<1	>1
NO3-N (mg/kg)	<1	4
Colwell P (mg/kg)	2	<2
Colwell K (mg/kg)	115	618
Ext. S (mg/kg)	8.0	6.3
Org C (%)	0.2	0.14
Exchangeable Cations (meq/100g)		
- Ca	1.18	4.83
- Mg	0.33	1.18
- Na	0.25	0.46

- K - Al	0.72 0.35	2.05 0.33
Cation Exchange Capacity (CEC; meq/100g)	2.43	8.52
Exchangeable Sodium Percentage (Sodicity; %)	2.6	5.40

4.2.3 WILUNA LAND SYSTEM (SOIL MAPPING UNIT 279WI)

4.2.3.1 Morphological Properties

The Wiluna Land System is contiguous with the Violet Land System and consists of a surficial (<0.3m) pisolithic gravelly clay loam soil overlying a calcareous lateritic hardpan (equivalent to the regionally extensive Wiluna Hardpan). A typical soil profile is provided in Figure 4.3. The primary difference between the Wiluna and Violet Land System soils is the surficial soils in the Wiluna are appreciably more clayey, with a higher gravel fraction (Plate 4.7).

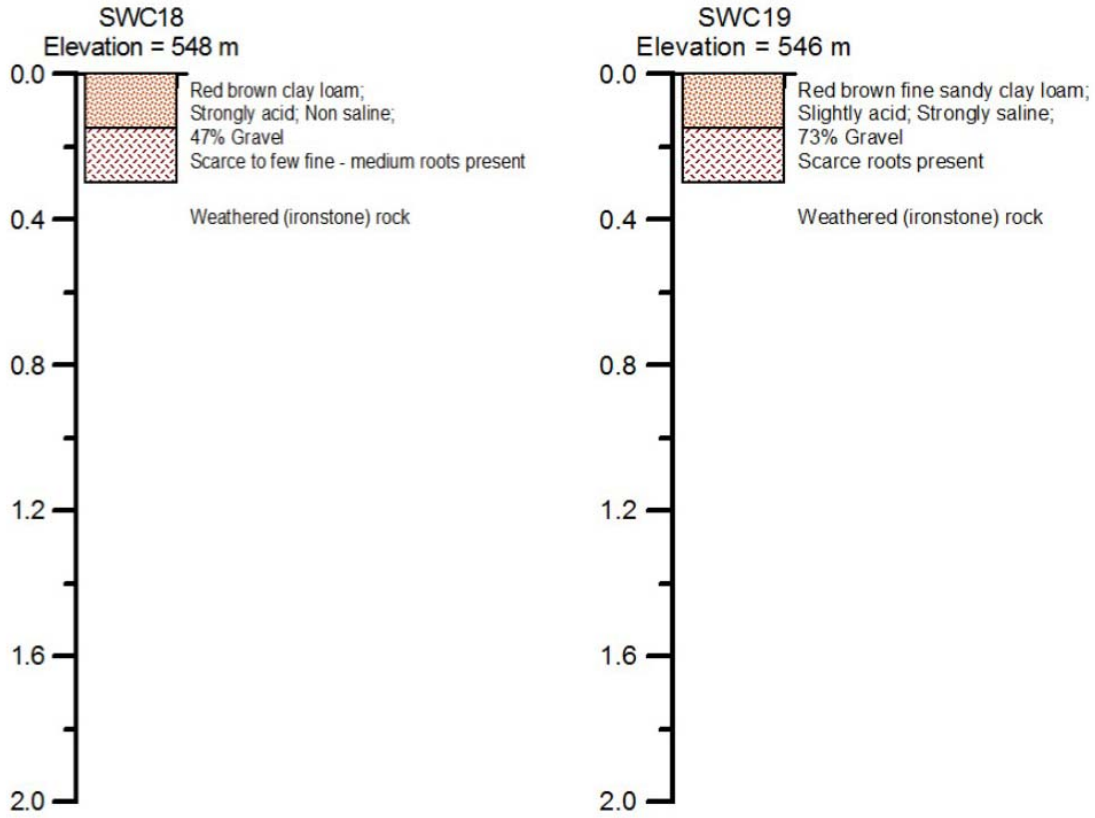


Figure 4.3: Soil profiles for soils within the Wiluna Land System (SWC18 and SWC19).

Plate 4.7: Typical soil profile in the Wiluna Land System

4.2.3.2 Physical Properties

The physical properties of the soils within the Wiluna Land System are presented in Table 4.6Table 4.4. The surface soils consist of around 47% gravel (>2.36 mm fraction), which is set in a relatively clayey soil matrix. The majority of the pisolithic gravel <20 mm in diameter, and the fine fraction contains approximately 50 % silt + clay (resulting in a gravelly clay loam texture).

The underlying lateritic hardpan is equivalent to that sampled in the Violet Land System and contains around 70 % consolidated gravel. The primary difference between the two lateritic hardpans is the parent material, with the hardpan developed in the Wiluna Hardpan derived from basalt with less influence of granites; hence the fine fraction of the hardpan in the Wiluna Land System contains up to 40 % silt + clay, compared to only 14 % for the Violet Land System, As for the Violet Land System, the similarity in particle size distribution between the surficial soil and the fines fraction in the hardpan, suggests that the surficial soils are in situ and not transported.

Table 4.6: Typical physical properties of the soils in the Wiluna Land System

Parameter	Material	
	Surficial Soil (0-0.3 m)	Lateritic Hardpan (>0.3 m)
Gravel Content (%)	47	73.4
Particle Size Distribution - % Sand	51	42.6

- % Silt	11.8	9.8
-% Clat	37.2	47.6
- Texture	Clay Loam	Clay
Emerson Class	Class 2	Class 5
Bulk Density (g/m3)	1.45	1.89
Ksat (m/d)	0.23	0.01
Water Retention Characteristics (%)		
- 0 kPa	48.9	19.3
- 10 kPa	32.8	12.4
- 33 kPa	25.9	11.3
- 100 kPa	21.8	9.6
- 1,500 kPa	16.1	5.2
- PAW	9.8	6.1

The fines fraction of both the surficial soil and lateritic hard are structurally unstable; however, the cemented nature of the hardpan and the dominance of gravel, means that this material is relatively stable on the whole.

4.2.3.3 Chemical Properties

The chemical of the soils within the Wiluna Land System are provided in Table 4.7. The surface soils have a pH around 5.4, whilst the underlying lateritic hardpan has a pH of 6.5. All surface soils are non-saline (EC < 40 mS/m), which combined with the elevated silt + clay fraction is likely to exacerbate the observed poor structural stability of these soils. The underlying lateritic hardpan contains elevated salts (indicating it is less weathered) and is classified as highly saline (> 100 mS/m).

All materials have very low nutrients levels and organic carbon contents, highlighting their infertile nature. Both the surface and underlying lateritic hardpan have elevated CEC (> 5 meq/100g) indicating the presence of illite and minor smectite in the clay mineral fraction, and both are classified as sodic with ESP > 6. The high sodicity (ESP < 6), in combination with minor smectite, makes the fines fraction of this material structurally unstable and dispersive; however, the high gravel / rock fraction (up to 70 %) will protect these soils from erosion.

Table 4.7: Typical chemical properties of the soils in the Wiluna Land System

Parameter	Material	
	Surficial Soil (0-0.2 m)	Weathered Rock (0.2 – 1 m)
pH	5.43	6.49
EC (mS/m)	2.8	206.1
NH4-N (mg/kg)	<1	>1
NO3-N (mg/kg)	6	4
Colwell P (mg/kg)	2	<2
Colwell K (mg/kg)	379	618
Ext. S (mg/kg)	813.2	6.3
Org C (%)	0.11	0.09
Exchangeable Cations (meq/100g)		
- Ca	0.38	0.62
- Mg	0.71	0.85

- Na - K - Al	0.39 4.83 -	0.86 3.56 -
Cation Exchange Capacity (CEC; meq/100g)	6.31	5.89
Exchangeable Sodium Percentage (Sodicity; %)	6.2	14.6

4.3 EROSION MODELLING RESULTS

Table 4.8 summarises the average runoff and sediment yield values predicted by the WEPP erosion model, given the input parameters previously summarised in Section **Error! Reference source not found.**. Variability around these averages does occur however they are within normal limits based on WEPP calibration parameters.

Table 4.8: Summary of WEPP erosion modelling results.

Material ID	Lift height (m)	Slope angle	Average annual runoff (mm/yr)	Average erosion rate (mm/yr)	Average erosion rate (t/ha/yr)
Surficial soils in the mine pit are	10	15°	17	0.9	5.8
		18°	19	1.1	7.0
Surficial soils in the mine pit area + rock mulch	10	15°	27	0.3	1.9
		18°	28	0.3	2.0
	20	15°	45	0.9	6.2
		18°	51	1.3	8.4
Drainage line material	10	15°	3	< 0.1	< 1.0
		18°	3	< 0.1	< 1.0
Surficial soils in the Infrastructure area	10	15°	24	5.1	34
		18°	26	5.9	39
Surficial soils in the WRL area	10	15°	20	2.1	14
		18°	21	2.4	16
Surficial soils in the WRL area + rock mulch	10	15°	26	1.2	7.9
		18°	29	1.5	9.7

The WEPP model indicated average sediment yields ranging from ≤ 1 t/ha/yr (≤ 0.1 mm soil loss per year) for the drainage line material to almost 40 t/ha/yr for surficial soils in the infrastructure area. In general slopes with lower angles and heights performed better than higher angles and materials which had a surface armouring effect from rock mulch performed much better than the same material without the rock mulch. Interestingly the rock mulch samples had higher run-off rates, suggesting that the majority of the reduction in erosion rates was from lower inter-rill erosion (caused by rainfall impact).

It should be noted that more than the average amount of sediment (e.g. the average t/ha/yr) are likely to be generated in years with greater than average rainfall, and from extreme individual storm events. Runoff and erosion depend largely on the size and intensity of each rainfall event and the infiltration characteristics of each material – Not all rainfall events generate runoff, and not all runoff events generate erosion. It is reasonable to expect that more than one year's worth of sediment loss (when considered as an average annual loss) will occasionally occur in response to a single large or intense storm event.

5 SOIL MANAGEMENT

Based on the results presented in Section 4 (Soil Characterisation), the following soil management strategies are recommended for the proposed Ramone Deposit:

5.1 SURFACE SOILS

The surface soils throughout the Ramone Deposit are relatively homogeneous, irrespective of parent material, and are typically characterised as sandy loams to clay loams, with variable gravel contents, overlying either a weathered transition zone and subcropping basement or a calcareous lateritic hardpan (Section 0). The surface soils are relatively shallow, with depths typically < 50cm, and often < 20cm, particularly within the proposed pit area. Based on this shallow depth, the volume of soil that can be captured for use in rehabilitation is limited, as outlined in Table 5.1.

There is no defined 'Topsoil' within the proposed Ramone Deposit, with little organic matter or nutrient accumulation (Table 4.3, Table 4.5 and Table 4.7) occurring in the surface 10 cm of the soil profile. Subsequently, all surface soils can be treated as one Soil Material Management Unit (SMMU) and can be excavated and stockpiled together, with no need to segregate. Although 'bulking-out' the surface soils as one SMMU will dilute this seed store (which only occurs in the top 5 cm of the soil profile), it is considered restricting the stockpiling height of this material to 1.8 m will maintain the viability of the native seed, which will likely be supplemented by hand seeding in rehabilitation.

Table 5.1: Soil resources available for use in rehabilitation

Feature	Area (ha)	Striping Depth (cm)	Volume Available (m^3)
Mine Pit	9.8	0.3*	29,400
Waste Rock Landform (WRL)	38.4	0.3*	115,200
Access Road	15	0.1	15,000
Infrastructure Areas	68	0.1	68,000

*This is an average depth and stripping to the underlying weathered rock or lateritic hardpan should occur to capture as much material as possible for later use in rehabilitation.

As shown in Section 4.2, all surface soils are structurally unstable, and are considered sodic, dispersive and highly erodible (erosion rates typically > 10 t/ha/y; Table 4.8). It is therefore considered that these materials should preferentially be placed on the berms and top of the WRL to reduce the risk of erosion. Based on the current WRL design (i.e. total area of 38.4ha, three 10 m lifts, with 10 m wide berms), the total berm area is approximately 49,280 m^2, whilst the top of the WRL has an area of 91,224 m^2. Based on these surface areas, and the available surface soils from the mine pit and WRL footprints (144,600 m^3), there is sufficient volume to restore a 1 m thick profile on the berms and top of the WRL. With this thickness of soil cover, and its optimal water retention characteristics and lack of limiting properties, a sustainable, diverse revegetation should be achievable on these areas. If however this material was to be uniformly spread over the entire WRL surface, then a depth of only 40 cm will be achieved, which is not sufficient to support the growth requirements of most revegetation species. In addition, to stabilise this material on the batter slopes, considerable fresh rock would be needed to be ripped through to stabilise the surface soils and prevent excessive erosion; hence, preferentially utilising this material only on the berms and top of the WRL will achieve the best rehabilitation outcome.

5.2 WEATHERED ROCK AND LATERITIC HARDPAN

Within the proposed mine pit area, a 1 m thick weathered bedrock or transition material occurs, which has optimal soil physical and stability properties. Given the area of the Mine Pit (Table 5.1), and the characteristics of this material, approximately 29,400 m^3 of this material will likely be excavated, which should preferentially be placed on the berms of the WRL for stability. The surface area of the berms is around 243,500 m^2, and thus the captured transition material, is sufficient to restore a 0.12 m soil profile, which will consist predominately of unweathering rock fragments interspersed with a friable soil material.

Although the weathered rock or transition material is physical stable and will provide long-term protection of the WRL batter slopes, its limited thickness and fine soil fraction (i.e. < 2.36 mm) will restrict the revegetation species that can be supported. It is therefore recommended that only small (<0.3 m high), shallow-rooted and low transpiring revegetation species should be used on the batter slopes to ensure the sustainability of the rehabilitation.

It is recommended that contour ripping of the batter slopes only occurs to 30 cm to prevent loss of the available soil fraction in the transition material. This material is already physically stable and thus there is no requirement to rip underlying rock through, hence the aim of the contour ripping is just to provide a surface undulation to assist in the capture of surface water, applied seed and leaf material as the rehabilitation develops.

There is no restriction on the stockpiling height of this material, as it contains negligible biological viability.

Within the proposed Mine Pit and WRL areas, the subcropping bedrock has prevented the formation of the lateritic (Wiluna) hardpan. The lateritic hardpan has been shown to provide a suitable growth medium for revegetation species, however at the Ramone Deposit negligible quantities will be excavated in the current mine plan, and thus it cannot be relied on to increase the rehabilitation resources.

5.3 FRESH ROCK

Underlying the weathered rock or transition zone, within the Mine Pit and WRL areas, the fresh bedrock occurs at approximately 1.5 m below the land surface. This material is competent and will provide optimal armouring for the batter slopes. Provided the fresh rock is Non-Acid Forming (NAF), there is no restriction on its use below the surface soils and transition material in rehabilitation.

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APPENDIX

APPENDIX A – ANALYTICAL RESULTS: BULK DENSITY AND KSAT

Table A.1: Bulk density and saturated hydraulic conductivity for selected samples.

Trench Number	Depth	Elevation	Soil MU	Geology	ρ_b (g/cm^3)	K_{sat} (m/d)
						(m/d)
SWC07	0 - 10	505	285Ne	P_-Hab-cib	2.31	N
SWC07	20 - 30	505	285Ne	P_-Hab-cib	2.36	N
SWC07	50 - 60	505	285Ne	P_-Hab-cib	2.70	N
SWC09	0 - 10	505	285Ne	A-HAd-kd	2.03	N
SWC09	20 - 30	505	285Ne	A-HAd-kd	1.86	N
SWC10	0 - 10	532	285Ne	A-Had-kd	1.19	N
SWC10	20 - 30	532	285Ne	A-Had-kd	1.39	N
SWC10	50 - 60	532	285Ne	A-Had-kd	2.06	N
SWC11	0 - 10	546	285Bg	A-Had-kd	2.19	N
SWC12	0 - 10	554	285Bg	A-Had-kd	1.57	N
SWC12	20 - 30	554	285Bg	A-Had-kd	1.98	N
SWC17	10 - 20	567	285Bg	A-Had-kd	1.38	N
SWC17	30 - 50	567	285Bg	A-Had-kd	1.54	N
SWC18	0 - 10	605	285Bg	A-HAS-xsi-ci	2.12	N
SWC17 (2% Gravel : 98% Fines)	10 - 20	567	285Bg	A-Had-kd	1.33	0.54
100% Fines : 0% Gravel						0.12
30% Gravel : 70% Fines						0.17
70 % Gravel : 30% Fines						0.29
100% Gravel : 0% Fines						50.35

N = not measured

APPENDIX A – ANALYTICAL RESULTS: PHYSICAL DATA

Table A.2: Particle size analysis and texture for selected samples.

Trench Number	Depth	Elevation	Soil MU	Geology	Sieve Analysis		PSD				
					Percent >2.36 mm	Percent <2.36 mm	% Gravel	% Sand	%Silt	% Clay	Texture
SWC02A	0 - 5	597	285Ne	A-Ham-cib	63	37	63	86.2	9.7	4.2	Loamy Sand
SWC02A	5 - 10	597	285Ne	A-Ham-cib	78	22	78	78.8	10.9	10.3	Sandy Loam
SWC03A	0 - 5	531	285Ro	A-Ham-cib	78	22	78	86.5	10.7	2.8	Loamy Sand
SWC03A	5 - 10	531	285Ro	A-Ham-cib	63	37	63	83.8	7.9	8.3	Loamy Sand
SWC03A	10 - 20	531	285Ro	A-Ham-cib	72	28	72	83.5	7.1	9.4	Loamy Sand
SWC04	0 - 5	495	285Rk	A-FO-od	34	66	34	91.9	4.9	3.2	Sand
SWC04	5 - 10	495	285Rk	A-FO-od	57	43	57	85.7	6.6	7.7	Loamy Sand
SWC04	10 - 20	495	285Rk	A-FO-od	42	58	42	82.0	7.4	10.5	Sandy Loam
SWC31	0 - 10	638	285Ne	A-HAS-xsi-ci	84	16	84	72.2	10.9	16.9	Loam
SWC31	10 - 20	638	285Ne	A-HAS-xsi-ci	79	21	79	63.6	11.3	25.1	Clay Loam
SWC31	20 - 30	638	285Ne	A-HAS-xsi-ci	75	23	75	63.3	10.4	26.3	Clay Loam
SWC14	0 - 5	621	285Ne	A-Ham-cib	67	33	67	81.1	12.3	6.6	Loamy Sand
SWC12	0 - 10	554	285Bg	A-Had-kd	12	88	12	94.1	3.8	2.2	Sand
SWC12	10 - 30	554	285Bg	A-Had-kd	31	69	31	85.2	6.2	8.6	Loamy Sand
SWC12	30 - 50	554	285Bg	A-Had-kd	54	46	54	78.7	5.9	15.4	Sandy Loam
SWC12	50 - 70	554	285Bg	A-Had-kd	50	50	50	76.5	6.8	16.7	Sandy Loam
SWC15	0 - 10	587	285Pl	A-HAd-kd	75	25	75	82.6	10.0	7.4	Loamy Sand
SWC15	10 - 30	587	285Pl	A-Had-kd	91	9	91	81.9	6.1	12.0	Sandy Loam
SWC15	30 - 50	587	285Pl	A-Had-kd	84	16	84	76.9	7.7	15.4	Sandy Loam
SWC15	50 - 70	587	285Pl	A-Had-kd	87	13	87	74.9	8.8	16.3	Sandy Loam
SWC15	70 - 90	587	285Pl	A-Had-kd	80	20	80	70.9	10.6	18.6	Loam
SWC15	90 - 110	587	285Pl	A-Had-kd	73	27	73	69.7	10.2	20.0	Loam

Trench Number	Depth	Elevation	Soil MU	Geology	Sieve Analysis		PSD				
					Percent >2.36 mm	Percent <2.36 mm	% Gravel	% Sand	%Silt	% Clay	Texture
SWC15	110 - 130	587	285PI	A-Had-kd	80	20	80	69.9	10.8	19.4	Loam
SWC15A	0 - 10	582	285PI	A-Had-kd	47	53	47	87.9	6.5	5.5	Loamy Sand
SWC15A	10 - 30	582	285PI	A-Had-kd	69	31	69	85.4	5.4	9.2	Sandy Loam
SWC15A	30 - 50	582	285PI	A-Had-kd	60	40	60	81.9	5.1	13.0	Sandy Loam
SWC15A	50 - 70	582	285PI	A-Had-kd	77	23	77	81.5	6.4	12.0	Sandy Loam
SWC15A	70 - 90	582	285PI	A-Had-kd	80	20	80	78.5	7.7	13.9	Sandy Loam
SWC15A	90 - 110	582	285PI	A-Had-kd	78	22	78	80.3	6.6	13.1	Sandy Loam
SWC15A	110 - 130	582	285PI	A-Had-kd	58	42	58	79.4	8.6	12.1	Sandy Loam
SWC17	0 - 10	567	285Bg	A-Had-kd	1	99	1	73.2	17.9	8.9	Loamy Sand
SWC17	10 - 30	567	285Bg	A-Had-kd	1	99	1	76.6	12.5	10.8	Sandy Loam
SWC17	30 - 50	567	285Bg	A-Had-kd	59	41	59	88.5	6.7	4.9	Loamy Sand
SWC17	50 - 70	567	285Bg	A-Had-kd	63	37	63	94.0	2.9	3.1	Sand
SWC17	70 - 90	567	285Bg	A-Had-kd	67	33	67	95.4	2.2	2.4	Sand
SWC17	90 - 110	567	285Bg	A-Had-kd	77	23	77	98.0	0.4	1.6	Sand
SWC17	110 - 130	567	285Bg	A-Had-kd	77	23	77	98.0	0.8	1.2	Sand
SWC22	0 - 5	546	285PI	A-Had-kd	75	24	75	88.1	7.1	4.8	Loamy Sand
SWC22	5 - 10	546	285PI	A-Had-kd	80	20	80	83.9	8.7	7.5	Loamy Sand
SWC22	10 - 20	546	285PI	A-Had-kd	78	21	78	76.2	11.1	12.7	Sandy Loam
SWC22A	0 - 5	535	285PI	A-Had-kd	36	64	36	79.2	9.1	11.7	Sandy Loam
SWC22A	5 - 10	535	285PI	A-Had-kd	44	56	44	89.5	7.4	3.2	Loamy Sand
SWC22A	10 - 20	535	285PI	A-Had-kd	35	65	35	92.0	5.2	2.8	Sand
SWC21	0 - 5	572	285Ne	A-Ham-cib	64	36	64	91.6	6.0	2.4	Sand
SWC26	0 - 5	575	285PI	A-HAd-kd	11	88	11	79.2	10.4	10.4	Sandy Loam
SWC26	5 - 10	575	285PI	A-HAd-kd	19	81	19	100.0	0.0	0.0	Sand
SWC26	10 - 20	575	285PI	A-HAd-kd	35	64	35	78.7	10.4	11.0	Sandy Loam

Trench Number	Depth	Elevation	Soil MU	Geology	Sieve Analysis		PSD				
					Percent >2.36 mm	Percent <2.36 mm	% Gravel	% Sand	%Silt	% Clay	Texture
SWC27	0 - 5	591	285PI	A-Ham-cib	70	30	70	81.3	11.7	7.0	Loamy Sand
SWC27	5 - 10	591	285PI	A-Ham-cib	53	47	53	78.9	9.8	11.4	Sandy Loam
SWC27	10 - 20	591	285PI	A-Ham-cib	62	37	62	77.1	10.4	12.4	Sandy Loam
SWC28	0 - 5	614	285Ne	A-Ham-cib	72	28	72	78.1	12.4	9.5	Loamy Sand

Table A.3: Flocculation rating, water repellence, soil water retention and plant available water for selected samples.

Trench Number	Depth	Elevation	Soil SMU	Geology	Flocculation Rating	Water Repellence	Water Retention (kPa)					PAW
							0	10	33	100	1,500	(%)
SWC02A	0 - 5	597	285Ne	A-Ham-cib	Category 4 - Complete Dispersion	No Significant Repellence	0.514	0.369	0.286	0.216	0.159	12.7%
SWC02A	5 - 10	597	285Ne	A-Ham-cib	Category 4 - Complete Dispersion	No Significant Repellence	0.501	0.372	0.286	0.212	0.134	15.2%
SWC03A	0 - 5	531	285Ro	A-Ham-cib	Category 4 - Complete Dispersion	No Significant Repellence	0.513	0.409	0.297	0.227	0.121	17.6%
SWC03A	5 - 10	531	285Ro	A-Ham-cib	Category 4 - Complete Dispersion	No Significant Repellence	0.533	0.371	0.286	0.234	0.156	13.0%
SWC03A	10 - 20	531	285Ro	A-Ham-cib	Category 4 - Complete Dispersion	No Significant Repellence	0.513	0.349	0.274	0.225	0.146	12.8%
SWC04	0 - 5	495	285Rk	A-FO-od	Category 4 - Complete Dispersion	No Significant Repellence	0.490	0.329	0.246	0.180	0.098	14.7%
SWC04	5 - 10	495	285Rk	A-FO-od	Category 4 - Complete Dispersion	No Significant Repellence	0.564	0.342	0.266	0.212	0.138	12.8%
SWC04	10 - 20	495	285Rk	A-FO-od	Category 4 - Complete Dispersion	No Significant Repellence	0.495	0.351	0.264	0.208	0.147	11.6%
SWC31	0 - 10	638	285Ne	A-HAS-xsi-ci	Category 4 - Complete Dispersion	No Significant Repellence	N	N	N	N	N	N
SWC31	10 - 20	638	285Ne	A-HAS-xsi-ci	Category 4 - Complete Dispersion	No Significant Repellence	0.586	0.400	0.288	0.186	0.111	17.8%
SWC31	20 - 30	638	285Ne	A-HAS-xsi-ci	Category 4 - Complete Dispersion	N	0.585	0.402	0.305	0.260	0.135	17.0%
SWC14	0 - 5	621	285Ne	A-Ham-cib	Category 4 - Complete Dispersion	No Significant Repellence	0.484	0.265	0.241	0.174	0.112	12.9%
SWC12	0 - 10	554	285Bg	A-Had-kd	Category 4 - Complete Dispersion	No Significant Repellence	0.419	0.240	0.172	0.136	0.096	7.6%
SWC12	10 - 30	554	285Bg	A-Had-kd	Category 4 - Complete Dispersion	N	0.464	0.304	0.218	0.164	0.121	9.7%
SWC12	30 - 50	554	285Bg	A-Had-kd	Category 4 - Complete Dispersion	No Significant Repellence	0.444	0.287	0.215	0.166	0.119	9.6%

Trench Number	Depth	Elevation	Soil SMU	Geology	Flocculation Rating	Water Repellence	Water Retention (kPa)					PAW
							0	10	33	100	1,500	(%)
SWC12	50 - 70	554	285Bg	A-Had-kd	Category 4 - Complete Dispersion	N	0.462	0.307	0.226	0.174	0.126	10.0%
SWC15	0 - 10	587	285PI	A-HAd-kd	Category 4 - Complete Dispersion	No Significant Repellence	0.437	0.301	0.256	0.182	0.108	14.8%
SWC15	10 - 30	587	285PI	A-Had-kd	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC15	30 - 50	587	285PI	A-Had-kd	Category 4 - Complete Dispersion	N	0.447	0.289	0.182	0.163	0.134	4.8%
SWC15	50 - 70	587	285PI	A-Had-kd	Category 4 - Complete Dispersion	N	0.487	0.332	0.214	0.189	0.144	7.0%
SWC15	70 - 90	587	285PI	A-Had-kd	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC15	90 - 110	587	285PI	A-Had-kd	Category 4 - Complete Dispersion	N	0.461	0.347	0.205	0.188	0.140	6.6%
SWC15	110 - 130	587	285PI	A-Had-kd	Category 4 - Complete Dispersion	N	0.511	0.371	0.251	0.212	0.140	11.2%
SWC15A	0 - 10	582	285PI	A-Had-kd	Category 4 - Complete Dispersion	No Significant Repellence	0.482	0.372	0.236	0.198	0.160	7.6%
SWC15A	10 - 30	582	285PI	A-Had-kd	Category 4 - Complete Dispersion	N	0.440	0.321	0.182	0.173	0.126	5.6%
SWC15A	30 - 50	582	285PI	A-Had-kd	Category 4 - Complete Dispersion	No Significant Repellence	0.482	0.344	0.228	0.212	0.141	8.7%
SWC15A	50 - 70	582	285PI	A-Had-kd	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC15A	70 - 90	582	285PI	A-Had-kd	Category 4 - Complete Dispersion	N	0.461	0.310	0.221	0.183	0.129	9.2%
SWC15A	90 - 110	582	285PI	A-Had-kd	Category 4 - Complete Dispersion	No Significant Repellence	N	N	N	N	N	N
SWC15A	110 - 130	582	285PI	A-Had-kd	Category 4 - Complete Dispersion	N	0.468	0.321	0.217	0.189	0.140	7.7%
SWC17	0 - 10	567	285Bg	A-Had-kd	Category 4 - Complete Dispersion	No Significant Repellence	0.558	0.444	0.317	0.241	0.174	14.2%
SWC17	10 - 30	567	285Bg	A-Had-kd	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC17	30 - 50	567	285Bg	A-Had-kd	Category 4 - Complete Dispersion	No Significant Repellence	0.487	0.286	0.204	0.159	0.125	7.9%
SWC17	50 - 70	567	285Bg	A-Had-kd	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC17	70 - 90	567	285Bg	A-Had-kd	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC17	90 - 110	567	285Bg	A-Had-kd	Category 4 - Complete Dispersion	No Significant Repellence	0.444	0.152	0.139	0.132	0.108	3.1%
SWC17	110 - 130	567	285Bg	A-Had-kd	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC22	0 - 5	546	285PI	A-Had-kd	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC22	5 - 10	546	285PI	A-Had-kd	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC22	10 - 20	546	285PI	A-Had-kd	Category 2 - Moderate dispersion	N	N	N	N	N	N	N
SWC22A	0 - 5	535	285PI	A-Had-kd	Category 4 - Complete Dispersion	N	N	N	N	N	N	N

Trench Number	Depth	Elevation	Soil SMU	Geology	Flocculation Rating	Water Repellence	Water Retention (kPa)					PAW
							0	10	33	100	1,500	(%)
SWC22A	5 - 10	535	285PI	A-Had-kd	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC22A	10 - 20	535	285PI	A-Had-kd	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC21	0 - 5	572	285Ne	A-Ham-cib	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC26	0 - 5	575	285PI	A-HAd-kd	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC26	5 - 10	575	285PI	A-HAd-kd	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC26	10 - 20	575	285PI	A-HAd-kd	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC27	0 - 5	591	285PI	A-Ham-cib	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC27	5 - 10	591	285PI	A-Ham-cib	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC27	10 - 20	591	285PI	A-Ham-cib	Category 4 - Complete Dispersion	N	N	N	N	N	N	N
SWC28	0 - 5	614	285Ne	A-Ham-cib	Category 4 - Complete Dispersion	N	N	N	N	N	N	N

APPENDIX A – ANALYTICAL RESULTS: CHEMICAL DATA

Table A.4: pH, EC, organic carbon and nutrient concentrations for selected samples.

Trench Number	Depth	Elevation	Soil SMU	Geology	pH1:5	EC1:5 (µS/cm)	Organic Carbon (%)	Total Nitrogen (%)	Available Phosphorus (mg/kg)	Available Potassium (mg/kg)	Available Sulfur (mg/kg)
SWC02A	0 - 5	597	285Ne	A-Ham-cib	5.62	15.98	1.23	0.10	11	203	2.8
SWC02A	5 - 10	597	285Ne	A-Ham-cib	5.89	14.57	0.95	0.09	4	216	2.4
SWC03A	0 - 5	531	285Ro	A-Ham-cib	6.56	24.59	1.17	0.10	8	278	1.4
SWC03A	5 - 10	531	285Ro	A-Ham-cib	6.69	15.11	0.91	0.09	3	215	1.3
SWC03A	10 - 20	531	285Ro	A-Ham-cib	6.74	13.44	0.69	0.08	2	214	1.3
SWC04	0 - 5	495	285Rk	A-FO-od	6.88	18.53	1.01	0.08	9	420	0.8
SWC04	5 - 10	495	285Rk	A-FO-od	7.23	41.70	0.85	0.09	3	363	1.2
SWC04	10 - 20	495	285Rk	A-FO-od	7.22	22.01	0.87	0.09	3	190	0.7
SWC31	0 - 10	638	285Ne	A-HAS-xsi-ci	6.48	20.65	1.35	0.09	5	167	3.1
SWC31	10 - 20	638	285Ne	A-HAS-xsi-ci	6.39	42.90	1.19	0.11	5	169	6.3
SWC31	20 - 30	638	285Ne	A-HAS-xsi-ci	6.52	68.40	1.10	0.11	5	161	9.9
SWC14	0 - 5	621	285Ne	A-Ham-cib	5.81	20.21	0.33	0.04	9	143	2.2
SWC12	0 - 10	554	285Bg	A-Had-kd	6.40	9.65	0.46	0.04	8	98	0.6
SWC12	10 - 30	554	285Bg	A-Had-kd	6.64	6.37	0.36	0.03	2	164	0.6
SWC12	30 - 50	554	285Bg	A-Had-kd	6.89	6.31	0.27	0.04	< 2	176	0.7
SWC12	50 - 70	554	285Bg	A-Had-kd	7.13	7.49	0.21	0.05	< 2	167	0.9
SWC15	0 - 10	587	285Pl	A-HAd-kd	6.10	9.28	0.70	0.07	5	130	1.4
SWC15	10 - 30	587	285Pl	A-Had-kd	6.45	10.75	0.63	0.08	2	127	1.9
SWC15	30 - 50	587	285Pl	A-Had-kd	6.82	9.12	0.44	0.06	< 2	104	2.1
SWC15	50 - 70	587	285Pl	A-Had-kd	6.81	9.73	0.42	0.06	< 2	93	2.7
SWC15	70 - 90	587	285Pl	A-Had-kd	6.78	11.53	0.34	0.05	< 2	76	5.1
SWC15	90 - 110	587	285Pl	A-Had-kd	6.82	11.62	0.27	0.05	< 2	63	5.4
SWC15	110 - 130	587	285Pl	A-Had-kd	6.97	12.56	0.30	0.05	< 2	62	4.8

Trench Number	Depth	Elevation	Soil SMU	Geology	pH1:5	EC1:5 (µS/cm)	Organic Carbon (%)	Total Nitrogen (%)	Available Phosphorus (mg/kg)	Available Potassium (mg/kg)	Available Sulfur (mg/kg)
SWC15A	0 - 10	582	285Pl	A-Had-kd	6.27	15.38	0.31	0.04	13	145	1.9
SWC15A	10 - 30	582	285Pl	A-Had-kd	6.58	9.74	0.27	0.05	3	143	2.1
SWC15A	30 - 50	582	285Pl	A-Had-kd	6.54	16.87	0.29	0.04	< 2	160	4.3
SWC15A	50 - 70	582	285Pl	A-Had-kd	6.73	25.04	0.26	0.06	2	144	2.1
SWC15A	70 - 90	582	285Pl	A-Had-kd	6.99	23.27	0.28	0.03	< 2	109	1.9
SWC15A	90 - 110	582	285Pl	A-Had-kd	7.21	22.96	0.23	0.05	< 2	72	2.1
SWC15A	110 - 130	582	285Pl	A-Had-kd	7.29	22.76	0.21	0.04	< 2	59	1.7
SWC17	0 - 10	567	285Bg	A-Had-kd	6.57	21.54	2.40	0.17	4	461	1.6
SWC17	10 - 30	567	285Bg	A-Had-kd	6.83	9.38	1.01	0.06	4	225	< 0.5
SWC17	30 - 50	567	285Bg	A-Had-kd	6.86	5.95	0.59	0.05	5	167	< 0.5
SWC17	50 - 70	567	285Bg	A-Had-kd	6.95	4.53	0.34	0.02	4	97	< 0.5
SWC17	70 - 90	567	285Bg	A-Had-kd	6.89	3.89	0.18	0.04	5	66	< 0.5
SWC17	90 - 110	567	285Bg	A-Had-kd	6.77	3.81	0.14	0.02	4	61	< 0.5
SWC17	110 - 130	567	285Bg	A-Had-kd	6.76	4.74	0.05	0.03	4	71	< 0.5
SWC22	0 - 5	546	285Pl	A-Had-kd	5.51	23.36	0.64	0.06	6	90	12.8
SWC22	5 - 10	546	285Pl	A-Had-kd	5.56	37.20	0.47	0.07	6	117	4.1
SWC22	10 - 20	546	285Pl	A-Had-kd	5.40	38.00	0.40	0.07	3	136	8.6
SWC22A	0 - 5	535	285Pl	A-Had-kd	7.16	45.90	0.42	0.06	2	152	9.0
SWC22A	5 - 10	535	285Pl	A-Had-kd	7.26	26.92	0.95	0.08	12	208	1.0
SWC22A	10 - 20	535	285Pl	A-Had-kd	7.26	22.75	0.65	0.07	7	172	0.8
SWC21	0 - 5	572	285Ne	A-Ham-cib	5.97	30.30	0.60	0.05	8	177	0.6
SWC26	0 - 5	575	285Pl	A-HAd-kd	5.90	50.30	1.48	0.13	5	258	3.1
SWC26	5 - 10	575	285Pl	A-HAd-kd	6.23	24.82	1.11	0.09	4	258	1.7
SWC26	10 - 20	575	285Pl	A-HAd-kd	6.20	19.56	1.25	0.10	3	247	2.3
SWC27	0 - 5	591	285Pl	A-Ham-cib	5.41	16.53	0.46	0.07	9	124	5.1
SWC27	5 - 10	591	285Pl	A-Ham-cib	5.13	15.05	0.54	0.06	4	86	9.4

Trench Number	Depth	Elevation	Soil SMU	Geology	pH1:5	EC1:5 (µS/cm)	Organic Carbon (%)	Total Nitrogen (%)	Available Phosphorus (mg/kg)	Available Potassium (mg/kg)	Available Sulfur (mg/kg)
SWC27	10 - 20	591	285PI	A-Ham-cib	5.19	15.44	0.52	0.07	4	74	6.0
SWC28	0 - 5	614	285Ne	A-Ham-cib	6.23	11.03	0.86	0.08	7	142	1.1

Table A.5: Exchangeable cations and Trace Elements

Trench Number	Depth	Elevation	Soil SMU	Geology	Exchangeable Cations (meq/100g)					Potentially Hazardous Elements (µg/kg)						
					Ca	Mg	K	Na	Al	Arsenic	Cadmium	Chromium	Cobalt	Lead	Molybdenum	Selenium
SWC02A	0 - 5	597	285Ne	A-Ham-cib	3.23	0.82	0.38	0.02	0.21	11,492	57	96,148	8,863	14,431	900	1,296
SWC02A	5 - 10	597	285Ne	A-Ham-cib	4.76	1.01	0.45	0.02	0.08	12,664	43	98,595	10,826	15,595	1,085	1,688
SWC03A	0 - 5	531	285Ro	A-Ham-cib	7.09	1.36	0.60	0.02	0.02	11,601	62	107,317	8,271	15,383	1,030	1,195
SWC03A	5 - 10	531	285Ro	A-Ham-cib	5.48	1.06	0.46	0.01	0.05	14,133	46	123,671	8,096	16,561	1,259	1,924
SWC03A	10 - 20	531	285Ro	A-Ham-cib	4.74	0.99	0.48	0.01	0.10	14,468	53	112,161	7,116	15,866	1,252	1,715
SWC04	0 - 5	495	285Rk	A-FO-od	12.66	3.47	0.50	0.02	0.04	3,026	159	119,951	43,836	5,692	257	646
SWC04	5 - 10	495	285Rk	A-FO-od	15.86	4.27	0.50	0.02	0.04	3,322	175	126,584	43,701	5,928	246	1,096
SWC04	10 - 20	495	285Rk	A-FO-od	17.18	6.57	0.30	0.04	0.06	5,127	180	140,771	42,138	7,162	384	1,441
SWC31	0 - 10	638	285Ne	A-HAS-xsi-ci	6.36	1.51	0.36	0.03	0.07	16,044	73	82,872	14,408	14,884	1,032	2,275
SWC31	10 - 20	638	285Ne	A-HAS-xsi-ci	7.13	1.85	0.36	0.07	0.10	17,137	48	77,033	12,705	13,952	1,025	2,664
SWC31	20 - 30	638	285Ne	A-HAS-xsi-ci	6.69	1.87	0.38	0.13	0.08	15,796	54	69,801	11,751	13,079	839	2,270
SWC14	0 - 5	621	285Ne	A-Ham-cib	2.99	0.73	0.20	0.03	0.09	10,850	59	86,233	10,711	15,157	911	955
SWC12	0 - 10	554	285Bg	A-Had-kd	2.35	0.45	0.16	< 0.01	0.08	16,623	83	123,884	4,606	15,991	1,374	1,683
SWC12	10 - 30	554	285Bg	A-Had-kd	2.63	0.75	0.29	0.01	0.11	15,830	75	128,745	8,888	16,414	1,268	1,484
SWC12	30 - 50	554	285Bg	A-Had-kd	3.84	1.04	0.38	0.01	0.12	15,419	68	117,979	9,343	15,664	1,253	1,261
SWC12	50 - 70	554	285Bg	A-Had-kd	4.39	1.03	0.34	0.01	0.11	14,994	71	117,530	10,115	16,465	1,051	1,337
SWC15	0 - 10	587	285PI	A-HAd-kd	2.03	0.79	0.27	0.01	0.12	13,685	50	113,155	10,545	16,040	1,137	1,161

Trench Number	Depth	Elevation	Soil SMU	Geology	Exchangeable Cations (meq/100g)					Potentially Hazardous Elements (µg/kg)						
					Ca	Mg	K	Na	Al	Arsenic	Cadmium	Chromium	Cobalt	Lead	Molybdenum	Selenium
SWC15	10 - 30	587	285Pl	A-Had-kd	2.52	0.90	0.28	0.02	0.08	13,947	37	111,906	9,417	15,299	1,105	1,760
SWC15	30 - 50	587	285Pl	A-Had-kd	2.16	1.13	0.21	0.04	0.12	18,229	27	129,031	9,406	18,560	1,432	2,081
SWC15	50 - 70	587	285Pl	A-Had-kd	1.99	1.26	0.23	0.05	0.16	15,788	32	117,910	9,501	18,015	1,175	1,867
SWC15	70 - 90	587	285Pl	A-Had-kd	2.10	1.62	0.18	0.05	0.15	14,328	29	109,332	7,912	17,145	1,034	1,647
SWC15	90 - 110	587	285Pl	A-Had-kd	2.18	1.81	0.15	0.06	0.12	14,521	21	100,721	7,749	16,258	949	1,226
SWC15	110 - 130	587	285Pl	A-Had-kd	2.26	2.11	0.14	0.09	0.12	14,603	34	100,720	7,742	16,429	944	1,122
SWC15A	0 - 10	582	285Pl	A-Had-kd	2.30	0.56	0.24	0.01	0.10	14,104	55	73,104	5,148	13,265	1,223	532
SWC15A	10 - 30	582	285Pl	A-Had-kd	2.05	0.63	0.30	0.01	0.14	19,612	52	76,119	6,307	13,815	1,479	3,067
SWC15A	30 - 50	582	285Pl	A-Had-kd	2.08	0.97	0.34	0.02	0.11	14,914	44	74,902	6,940	16,044	1,118	2,482
SWC15A	50 - 70	582	285Pl	A-Had-kd	2.31	1.09	0.30	0.04	0.07	16,227	30	69,288	6,495	13,690	1,572	2,324
SWC15A	70 - 90	582	285Pl	A-Had-kd	2.90	1.33	0.27	0.06	0.07	12,747	33	68,684	7,052	13,093	1,099	1,987
SWC15A	90 - 110	582	285Pl	A-Had-kd	2.75	1.28	0.16	0.07	0.11	13,737	29	68,526	6,260	14,857	1,081	2,365
SWC15A	110 - 130	582	285Pl	A-Had-kd	2.94	1.40	0.13	0.08	0.16	15,975	43	76,056	7,458	14,378	1,206	2,289
SWC17	0 - 10	567	285Bg	A-Had-kd	10.83	1.86	1.13	0.01	0.05	10,507	64	91,947	11,069	14,791	957	1,398
SWC17	10 - 30	567	285Bg	A-Had-kd	7.59	1.36	0.41	0.01	0.05	12,177	60	106,528	11,075	15,788	986	2,322
SWC17	30 - 50	567	285Bg	A-Had-kd	4.03	0.76	0.30	0.01	0.04	15,654	51	144,549	8,205	20,577	1,223	2,216
SWC17	50 - 70	567	285Bg	A-Had-kd	2.21	0.48	0.18	0.01	0.07	18,754	52	132,978	5,558	17,652	1,584	1,985
SWC17	70 - 90	567	285Bg	A-Had-kd	2.05	0.45	0.12	< 0.01	0.06	20,368	68	142,461	6,084	38,551	1,593	1,838
SWC17	90 - 110	567	285Bg	A-Had-kd	1.03	0.27	0.10	0.01	0.07	18,219	58	146,342	3,958	18,488	1,400	1,407
SWC17	110 - 130	567	285Bg	A-Had-kd	1.10	0.28	0.12	< 0.01	0.05	23,256	59	131,226	3,572	20,776	1,607	1,700
SWC22	0 - 5	546	285Pl	A-Had-kd	2.30	0.36	0.16	0.01	0.02	11,044	51	76,775	6,282	7,408	1,070	3,425
SWC22	5 - 10	546	285Pl	A-Had-kd	1.99	0.77	0.25	0.01	0.19	11,572	57	126,816	6,988	15,781	1,303	1,083
SWC22	10 - 20	546	285Pl	A-Had-kd	1.82	0.90	0.34	0.03	0.17	12,371	47	140,354	13,140	17,274	1,377	1,809
SWC22A	0 - 5	535	285Pl	A-Had-kd	1.63	0.83	0.32	0.03	0.10	10,329	28	106,866	12,692	17,216	1,192	1,116

Trench Number	Depth	Elevation	Soil SMU	Geology	Exchangeable Cations (meq/100g)					Potentially Hazardous Elements (µg/kg)						
					Ca	Mg	K	Na	Al	Arsenic	Cadmium	Chromium	Cobalt	Lead	Molybdenum	Selenium
SWC22A	5 - 10	535	285PI	A-Had-kd	8.52	0.94	0.46	0.01	0.04	17,862	119	157,876	7,925	20,680	1,460	1,604
SWC22A	10 - 20	535	285PI	A-Had-kd	7.02	0.94	0.35	< 0.01	0.07	17,717	114	174,613	7,533	21,234	1,466	1,545
SWC21	0 - 5	572	285Ne	A-Ham-cib	6.79	0.92	0.36	< 0.01	0.06	17,092	102	161,487	7,147	20,250	1,375	1,258
SWC26	0 - 5	575	285PI	A-HAd-kd	5.92	1.37	0.58	0.01	0.05	16,389	78	201,017	10,277	19,390	1,511	1,828
SWC26	5 - 10	575	285PI	A-HAd-kd	5.98	1.06	0.56	0.01	0.04	13,782	85	178,202	11,752	19,531	1,346	1,568
SWC26	10 - 20	575	285PI	A-HAd-kd	5.21	0.78	0.52	0.01	0.07	16,558	84	209,119	11,570	20,421	1,587	1,857
SWC27	0 - 5	591	285PI	A-Ham-cib	1.60	0.68	0.23	0.03	0.21	12,243	47	185,817	8,314	17,039	1,119	1,222
SWC27	5 - 10	591	285PI	A-Ham-cib	1.70	0.71	0.14	0.03	0.34	12,015	30	175,071	7,402	17,716	1,268	1,713
SWC27	10 - 20	591	285PI	A-Ham-cib	1.84	0.82	0.13	0.04	0.28	12,856	32	190,917	7,179	17,652	1,339	1,825
SWC28	0 - 5	614	285Ne	A-Ham-cib	4.53	1.53	0.24	0.05	0.06	11,118	78	100,353	9,659	14,984	916	1,278

APPENDIX B – BOTANICA 2023A

Vause Gourdis Project

SOIL CHARACTERISATION REPORT 2023

Prepared for Northern Star Resources NL

November 2023

Prepared by

BOTANICA CONSULTING

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Disclaimer

Quality Assurance

An internal quality review process has been implemented to each project task undertaken by BC. Each document and its contents is carefully reviewed by core members of the Consultancy team and signed off at Director Level prior to issue to the client. Draft documents are submitted to the client for comment and acceptance prior to final production.

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1 INTRODUCTION

1.1 Project Background

The Vause - Gourdis Project is approximately 30km to the south of Jundee. It was mined by NSR from 2003, via several small open pits and ore trucked to Jundee until September 2007. Historically the area has produced 273koz at 1.9g/t. A location map is shown in Figure 1-1. NSR is proposing to develop further resources located in this area. An indicative map of the proposed development areas is shown in Figure 1-1. Botanica was engaged to provide information on soil resources both within the proposed activity footprint and within the project area as a whole (see black area below).

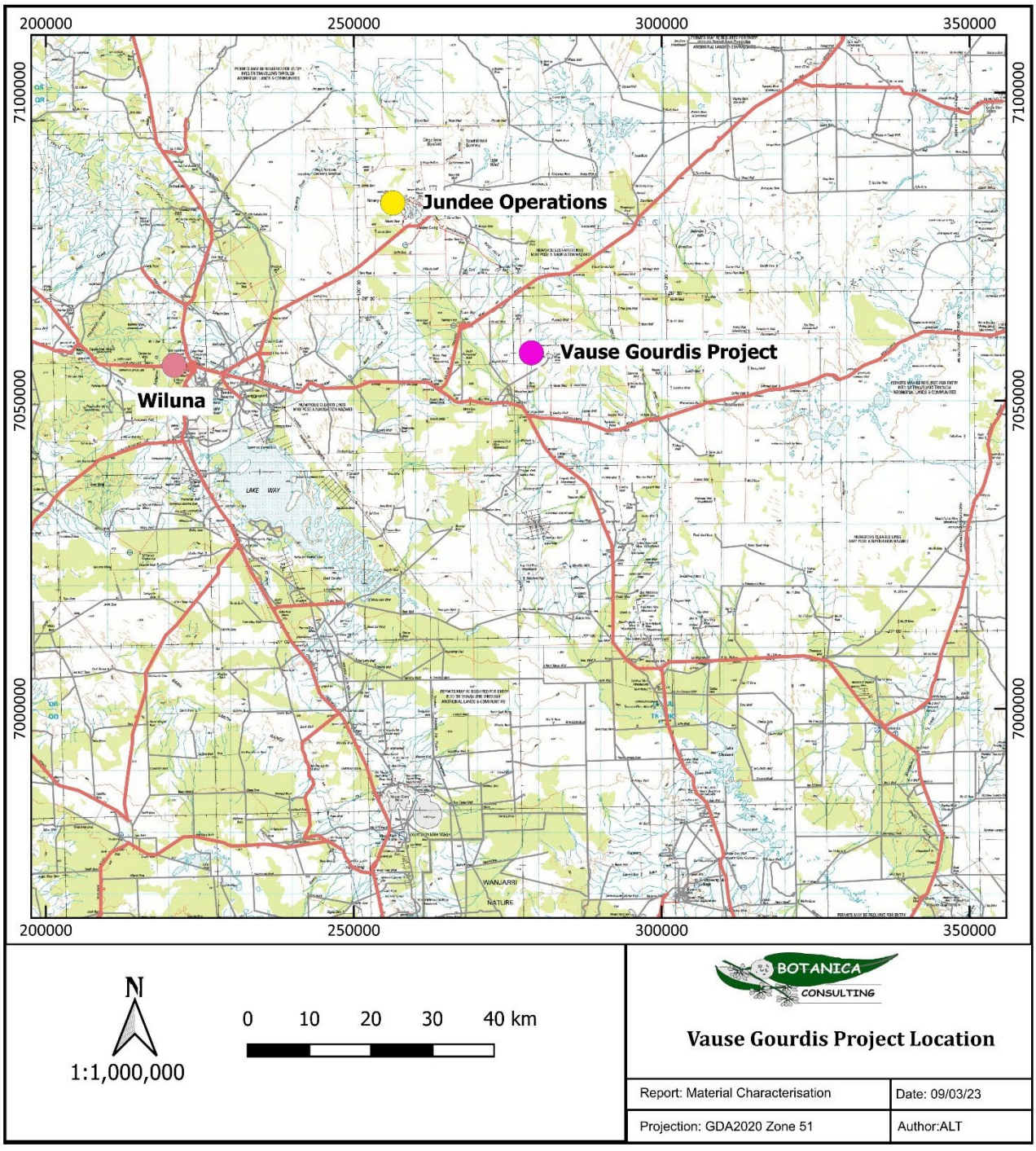

Figure 1-1: Project Location

1.2 Landscape

The project area is located on a flat plain that slopes south at 1-2 degrees, with some gentle hills to the trending northwest 2km to the east. Drainage is to the southwest, following the fall in elevation. The survey area located within the IBRA bioregion “Murchison” and the Eastern Murchison subregion (MUR02). The Eastern Murchison comprises the northern parts of the craton’s Southern Cross and Eastern Goldfields Terrains and is characterised by internal drainage and extensive areas of elevated red desert sandplains with minimal dune development. Salt Lake systems are associated with the occluded paleodrainage system. Broad plains of red-brown soils and breakaways complexes as well as red sandplains are widespread. Vegetation is dominated by Mulga woodlands and is often rich in ephemerals, hummock grasslands, saltbush shrublands and *Tecticornia* shrublands (Cowan, 2001). Locally the Project area has been mapped as *Acacia* forests and woodlands, with *Eremophila*, cottonbush and spinifex understory (Botanica 2023).

1.3 Climate

The climate of the Eastern Murchison subregion is characterised as an arid climate with mainly winter rainfall and annual rainfall of approximately 200 mm (Beard, 1990; Cowan, 2001). Rainfall monthly distribution data for the Yeelirrie weather station (#012090) located approximately 105 km southwest of the survey area is shown in Figure 1-2 (BoM, 2023a).

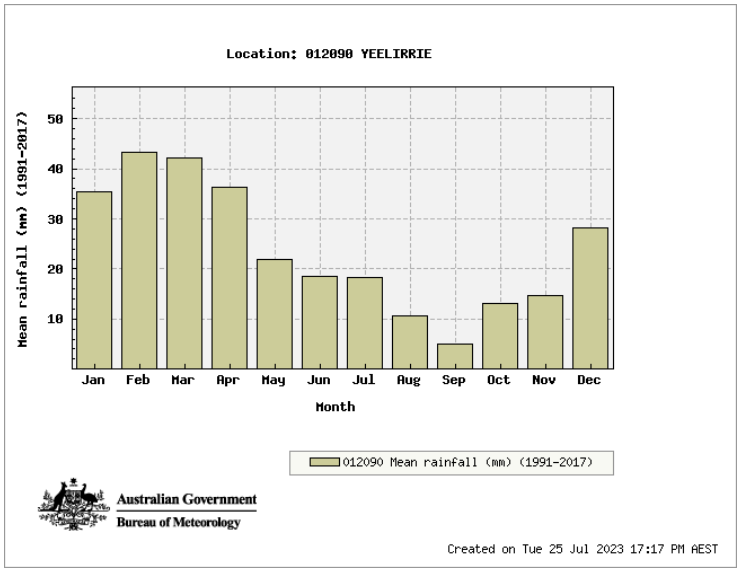

Figure 1-2: Historic Annual Rainfall Distribution (Yeelirie #0129098)

1.4 Geology and Regolith

The Vause and Gourdis deposits are surficial and hosted by laterite and lateritic ferruginous materials. This includes pisolitic and nodular duricrust, lateritic gravels, and hardpanised colluvium and alluvium. The deposits are located adjacent to palaeovalleys that do not reflect the current topography. Although the deposits overlie the Yandal Belt greenstone geology, the bedrock is overlain by some 7m of variably reworked lateritic products and remnants. A mottled zone derived from bedrock lies at the base of these units, followed by up to 15m of clays (after basalt or quartz feldspar porphyry), although there is considerable variation in units and depths through the area. Typically, a collapsed mottled zone nodular duricrust tops the saprolite which terminates in an erosional surface (unconformity), above which there is a basal layer of magnetic ferruginous nodules,

several meters of ferruginous gravels, and approximately 1m of hardpanised colluvium or alluvium (Paine and Foo 2003).

The Project area regolith (GSWA 2018) has been mapped as ferruginous duricrust, massive to rubbly; includes iron-cemented reworked products on upland areas; and adjacent colluvial ferruginous gravel and reworked ferruginous duricrust. Flatland areas clay, silt, and sand in extensive fans; local ferruginous gravel in between. Around major drainages regolith was mapped as clay, silt, sand, and gravel in channels and on floodplains. See Figure 1-3. (GSWA 2018).

Based on geographic information provided by DPIRD (2019), the survey area is located within the South-eastern Zone of Ancient Drainage (250) of the Murchison Province. The soil landscape mapping showed similar units to those described in the regolith mapping, with soil landscape systems within the soil landscape systems of the survey area described in Table 1-1.

Table 1-1: Soil Landscape Units

Landscape System/ Mapping Unit	Description
Jundee System	Hardpan plains with variable gravelly mantles and minor sandy banks supporting weakly groved mulga shrublands.
Violet System	Gently undulating gravelly plains on greenstone, laterite and hardpan, with low stony rises and minor saline plains; supporting groved mulga and bowgada shrublands and occasionally chenopod shrublands.
Wiluna System	Low greenstone hills with occasional lateritic breakaways and broad stony slopes, lower saline stony plains and broad drainage tracts; supporting sparse mulga and other acacia shrublands with patches of halophytic shrubs.
Yanganoo System	Almost flat hardpan wash plains, with or without small wanderrie banks and weak groving; supporting mulga shrublands and wanderrie grasses on banks.

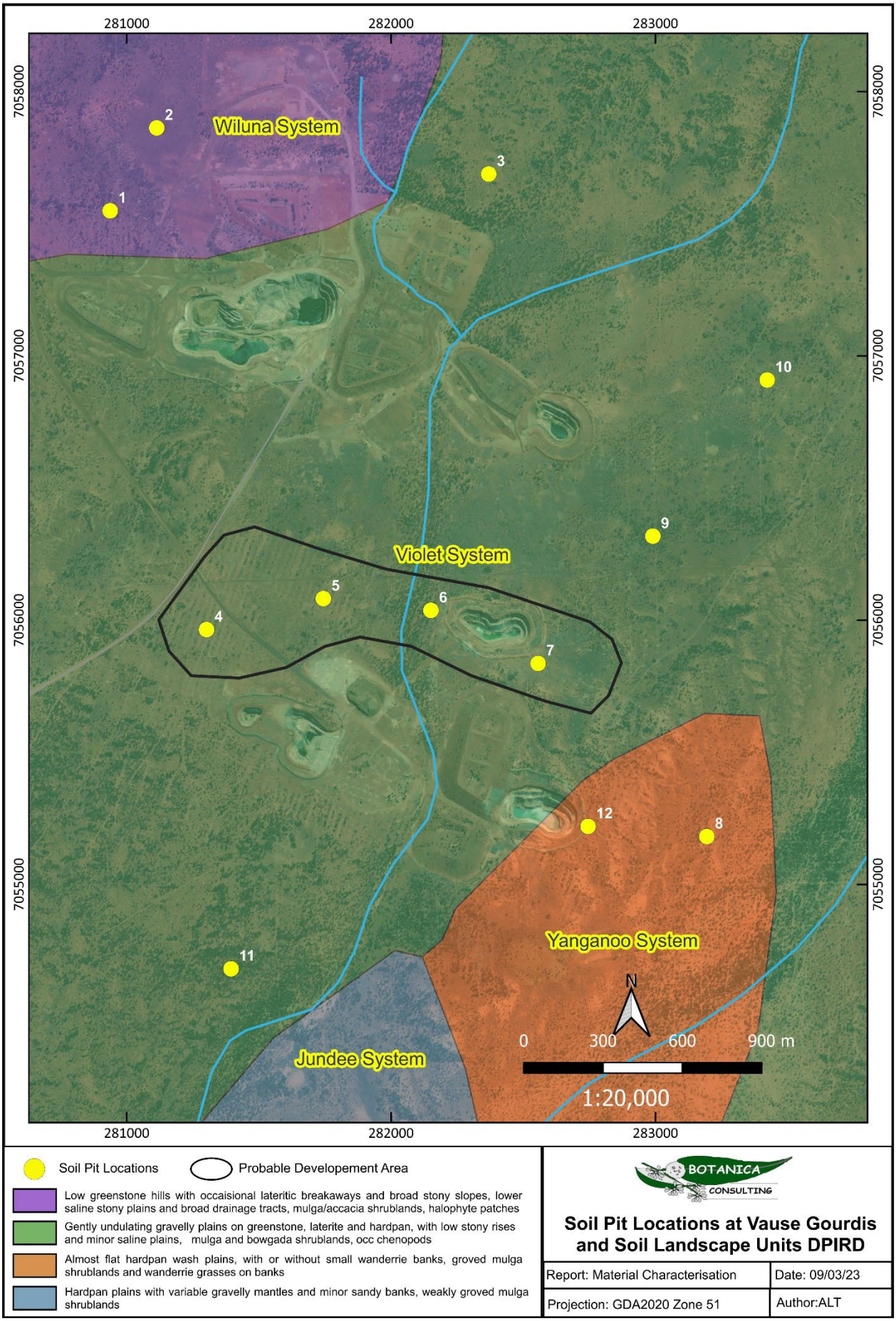

Figure 1-3: Soil Pit Locations and Soil Landscape Mapping

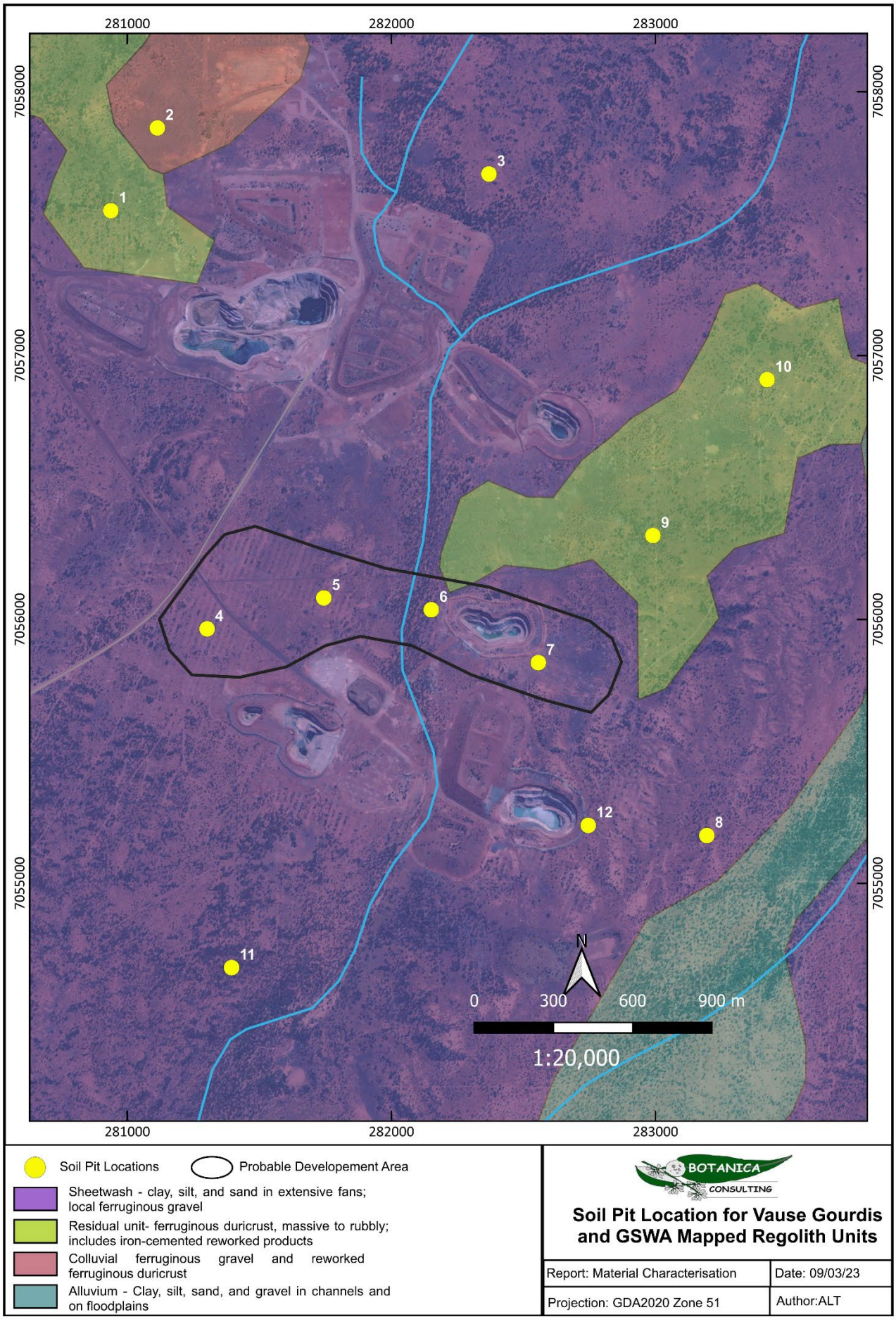

Figure 1-4: GSWA Mapped Regolith Units

2 METHODOLOGY

2.1 Sampling

Twenty two (22) soil samples were taken from the Vause and Gourdis Project area to be assessed for baseline soil conditions, use as a rehabilitation growth medium and soil handling, and to provide an overall picture of soils and regolith materials within the Project area. The soil samples were selected using the available soil and regolith mapping (GSWA 2018), and soil landscape and vegetation units (Botanica 2023), together with satellite imagery. Samples were taken and described by BC staff with the assistance of NSR. Samples were taken from pits dug by hand or from cleaned edges of excavated drill sump pits. Hand dug pits did not allow as clear identification of subsoil materials.

Data interpretation of laboratory results was undertaken by Botanica Environmental Consultants. Following are the qualifications of the personnel undertaking the materials characterisation assessment:

- Anna Timmins - Environmental and Geosciences Consultant, Botanica Consulting Pty Ltd. B.Sc., M.Sc.

2.2 Analysis

Soils were analysed by the ChemCentre for a variety of physical and chemical characteristics affecting soil physical stability and suitability for use as a growth medium, including:

- Soil particle sizes
- Bulk density and moisture
- Emerson class
- pH and EC
- Exchangeable cations (Ca, Mg, K, and exchangeable sodium percentage (ESP))
- Plant available nutrients (organic C, total N Mehlich 3 tests for B, Ca, Cu, Fe, K, Mg, Mn, P, S, Zn)
- Baseline metals by acid digest (As, Cd, Co, Cr, Cu, Mn, Mo, Pb, Zn).

Details on the laboratory analysis method for each parameter is specified in the laboratory report provided in Appendix

2.3 Interpretation of Analysis

Soils tests aim to assess soil for use as a mine landform cover material, from the perspectives of stability to erosion and use as a plant growth medium. Soils in WA due to the age of the landscape, have specific qualities and issues with respect to these uses (to which some WA plants are adapted to), and therefore the results are interpreted with reference to WA and Australian specific texts and databases including:

- Moore (2004) Soil Guide – A handbook for Understanding and managing Agricultural Soils. Bulletin 4343. Department of Agriculture, Western Australia,

- McArthur (2004) - Reference Soils of Southwestern Australia. Department of Agriculture, Western Australia.

- Hazelton and Murphy (2007). What do all the numbers mean?. CSIRO Publishing.

3 RESULTS

3.1 Soil Types and Distribution

Fine sandy loams, sandy clay loams and loamy sands with variable proportions of lateritic, weathered rock and quartz gravel predominate in the Project area. Generally, total soil profile thickness increases from north to south of the Project area. A low rise in the north around pit 1 overlies lateritic rubble and cemented pisolites. Pits 2,3, and 4 appear to overlie hard saprolitic clays whilst the southern half of the area overlies Wiluna hardpan (identifiable in excavated pits 5 to 8). The hardpan consists of a cemented colluvium or alluvium layer from 1 to 7m thick formed through silicification and illuviation). Pits 9 and 10 had shallow stony soils with abundant ironstones similar to Pit 1.Pits 11 and 12, in the southern area have deep soil profiles, with well-structured more clay rich soil, and abundant vegetation and roots and are located adjacent to wide sheet flow drainages. Pit 12 ended in hardpan identifiable in the excavated pit and was rich in very small pisolites. The soils in all areas are highly acidic to neutral (3.6-6.4), with acidity increasing in the subsoil, and are predominantly non-saline (2-56mS/m).

In summary soils could be grouped as

- 15-30cm gravelly and stony sand loams and sandy clay loams (37-64% >2mm) overlying rubbly stony cemented lateritic material with an abundance of surficial ironstone, with moderate to abundant roots and strongly acidic pH (3.6 to 3.9) (pits 1,9 and 10). Colluvial derived .

- 20-30cm sandy and sandy clay loams over hard clays (pits 2, 3 and 4). or Wiluna hardpan (pits 6,7 and 8) with 15-24%>2mm, and variable pH (3.9 to 6.4) with low to moderate root abundance. Derived from sheet wash and ungraded alluvium.

- 50-60cm of deep sandy or gravelly sandy clay loam overlying hardpan with moderate to abundant roots, and acidic pH (4.2 to 4.6), and variable fine pisolite content. Occurring in pits 5 and 12. Derived from sheet wash and ungraded alluvium.

3.2 Nutrients

The soils overall fine sandy loam texture and compositional characteristics reflect their origin as reworked lateritic and saprolitic product, and have led to overall low macro and micronutrient contents. Carbon levels are low (<0.5%) except for the subsoil in pit 1 which contained charcoal fragments, as are nitrogen levels (<0.05%), reflecting the hot arid climate, with low rainfall and subsequent low vegetative productivity associated with it. Cation exchange capacities are predominantly low (<05 cmol(+)/kg) with only pits 10, 8 and 11 in the medium range (7-13 cmol(+)/kg), which will reduce nutrient holding capacity. All samples have low molybdenum, (<0.01mg/kg), with 4 pits low in boron (<0.1mg/kg), and 3 pits low in magnesium (<20mg/kg), and low phosphorous in 4 pits (<0.1mg/kg). Local plants are adapted to this soil, as evidenced by abundant roots developed in the thicker soils. Additionally, nutrients will be less plant available due to the high acidities.

3.3 Baseline Metals and Metalloids

Baseline levels of a small suite of elements of environmental concern show all soils are mostly below the environmental investigation levels (EIL) for soils for most elements tested except for one sample in arsenic (pit

6 23mg/kg compared to the EIL of 20mg/kg). Pit 6 is the nearest sample to a pit so this sample is probable reflecting the probable presence of a supergene halo (caused by post saprolitic and pedogenic water table fluctuations) from the nearby gold mineralisation and associated alterations. Chromium levels exceeding the EIL are found in pits 2 and 5, although an immobile element this could reflect underlying ultramafic geology, and subsequent lateritic enrichment. Nickel, cobalt manganese and chromium can all be residually enriched in laterites derived from the weathering of ultramafic rocks. High manganese in pits 8, 9 and 10 is more likely to cause plant toxicity issues due to the high acidity in these soils.

3.4 Resistance to Erosion and Chemistry

A number of factors (and the interactions between them) affect soil stability including potential for dispersion of aggregates (as tested using Emerson tests), salinity, exchangeable cation sodium (ESP) and Ca:Mg ratios, soil carbon, and soil texture including clay and gravel contents. A high ESP (>6%) can cause propensity to disperse in the absence of complimentary high salinity.

Clay dispersion is the complete breakdown of aggregates into primary particles of sand, silt and clay in saturated soils and is tested using the Emerson Aggregate Test. About half the samples (8 out of 16) have Emerson scores of 1 or 2, indicating a very high or high propensity for spontaneous dispersion. These soils are also prone to structural collapse (aggregate disintegration) which causes hard setting. Soils and materials where clay content is between 15 and 30%, and silt and fine sand >50% will be most susceptible to dispersion where Emerson score results are 1 or 2. The soils have however a relatively low clay content (10 to 18%) (and 5 samples, but a relatively high fine sand content (approximately 50%). There is a coarse fragments (>2mm) content of >30% (36-68%) which will increase resistance to dispersion and erosion resistance to surface flow. The samples have low exchangeable sodium percentages a (<6%) in 13 samples, however three are sodic to highly sodic (ESPs – 11.5 to 25). In samples VG0013 and VG011 the high ESP is offset by higher salinity, and this has led to Emerson scores of 5 in both cases. The third high ESP sample (VG022) has low salinity (2mS/m) and consequently a low Emerson score of 1. This sample, however, also has a coarse fraction of 68 percent which will increase overall stability and resistance to erosion.

The hardpan samples will be resistant to erosion. The hardpan would make useful rehabilitation material to add stability to the soil. One sample had a high ESP whilst the other was extremely low, and it is possible the high ESP in sample 18 was due to drilling activity derived water previously in the pit.

4 SUMMARY AND RECOMMENDATIONS

The following key characteristics define the survey area soils:

- Strongly acidic non saline soils with a site-specific low nutrient profile
- Shallower in the north of the project area, with deeper soils in the southwest
- 15-30cm of soil overlies the Wiluna hardpan throughout the Project development area.

Recommendations for use in rehabilitation are as follows:

- Although the soils are variably dispersive, the high gravel content will assist in stabilizing these soils on WRL slopes, when applied with suitable slope stability measures such as contoured ripping and armoring with competent material.
- In the absence of suitably competent waste material, the underlying Wiluna hardpan in the development area will be a suitable slope stabilizing rock armour.
- Soils are suitable for rehabilitation using locally sourced appropriate native seed to fit the site specific nutrient and pH profile.

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6 APPENDIX – ANALYSIS RESULTS

6.1 Analysis Results Summaries

Table 7-1: Vouse Gourdis Texture and Stability Factors Analysis Results

ChemCentre ID	Client ID	Pit	Depth	Soil Type	Clay	Sand	Silt	Stones Seived	EC (1:5)	pH (CaCl2)	OrgC (W/B)	Emerson Class	ESP
					%				mS/m		%		%
22S4414/008	VG_015	1	0-20	Sandy loam	13	82	5	38.9	3	3.9	0.32	2	<0.1
22S4414/014	VG_016	1	20-30	Sandy clay loam				54.7	3	3.6	1.36	5	<0.1
22S4414/007	VG_013	2	0-20	Sandy loam	14	78	8	21.7	56	6.2	0.08	5	11.5
22S4414/005	VG_009	3	0-20	Sandy clay loam				19	3	3.9	0.06	2	<0.1
22S4414/004	VG_007	4	0-30	Sandy clay loam	18	76	6	15.2	7	4.5	0.06	5	1.9
22S4414/003	VG_005	5	0-20	Sandy clay loam				20.6	4	4	0.33	2	<0.1
22S4414/009	VG_017	6	0-15	Sandy clay loam				19	6	5.4	0.07	2	1.3
22S4414/010	VG_018	6	15-	Cemented hardpan					12	7.2	<0.05		80.2
22S4414/011	VG_019	7	0-15	Loamy sand (ends in hardpan)	10	82	8	22.5	2	6.4	<0.05	1	<0.1
22S4414/012	VG_020	8	0-20	Loam				24.2	2	4.1	0.16	2	<0.1
22S4414/002	VG_003	9	20-40	Sandy loam	11	85	4	36.4	2	3.9	0.14	2	<0.1
22S4414/016	VG_004	9	20-40	Gravelly loam (ends in hardpan)				61.4	3	3.8	0.16	5	<0.1
22S4414/001	VG_001	10	0-20	Sandy clay loam hardpan at base)				37.3	2	3.8	0.32	2	<0.1
22S4414/006	VG_011	11	0-30	Deep sandy clay loam				16	37	4.6	0.14	5	24.9
22S4414/013	VG_022	12	0-40	Sandy gravelly loam				68.3	2	4.2	0.09	1	13.9
22S4414/015	VG_021	12	40-60	Cemented hardpan				31.1	2	3.8	<0.05	5	<0.1
Limit of Reporting					*0.5*	*0.5*	*0.5*	*0.1*	*1*	*0.1*	*0.05*	*0*	*0.1*
*Desired range**									*<70*		*0.5-1.5*	*>3*	*<6*

Below Desired Range

Above desired range

* *Reference values from: McArthur (2004), Hazelton and Murphy (2007), and Moore (2004).*

Table 7-2: Vause Gourdis Soil Nutrient Analysis Results

ChemCentre ID	Client ID	Pit	Depth	Soil Type	N	CEC	Ca (exch)	K (exch)	Mg (exch)	Na (exch)	B	Ca	Cu	Fe	K	Mg	Mn	Mo	P	S	Zn
					%		cmol(+)/kg				plant available mg/kg										
22S4414/008	VG_015	1	0-20	Sandy loam	0.034	4	0.92	0.22	0.33	<0.02	<0.1	150	0.8	38	74	35	13	<0.01	3	11	0.5
22S4414/014	VG_016	1	20-30		0.02	4	0.96	0.13	1	<0.02	<0.1	180	0.8	36	52	110	8.9	<0.01	3	16	0.2
22S4414/007	VG_013	2	0-20	Sandy loam	0.043	4	1.3	0.37	0.27	<0.02	0.2	240	0.6	46	120	30	8.2	<0.01	11	11	0.5
22S4414/005	VG_009	3			0.018	3	0.83	0.32	0.85	0.07	0.3	150	0.6	18	100	94	49	<0.01	<1	35	0.3
22S4414/003	VG_005	5	0-20		0.022	3	0.54	0.33	0.28	<0.02	0.2	97	1	23	110	32	9.5	<0.01	2	25	0.5
22S4414/004	VG_007	4	0-30	Sandy clay loam	0.027	3	1.1	0.4	0.7	0.91	1.2	190	0.7	24	140	80	9.1	<0.01	<1	160	0.9
22S4414/009	VG_017	6	0-15		0.017	4	0.99	0.49	2.2	0.41	2.6	200	1	23	170	260	47	<0.01	5	160	2
22S4414/010	VG_018	6	15-	Cemented hardpan	0.025	4	0.19	0.13	0.09	<0.02	<0.1	37	0.9	24	46	13	3.9	<0.01	3	22	0.2
22S4414/011	VG_019	7	0-15	Loamy sand	0.021	5	1.7	0.42	1.4	0.18	0.3	310	1.6	39	130	160	180	<0.01	1	11	3
22S4414/012	VG_020	8	0-20		0.013	13	5.7	1.3	5.5	2.9	1.3	970	0.7	56	410	630	140	<0.01	2	16	3.6
22S4414/002	VG_003	9	0-20	Sandy loam	0.015	4	1.6	0.37	0.75	<0.02	0.2	290	0.9	31	120	110	170	<0.01	6	2	2.3
22S4414/016	VG_004	9	20-40	Gravelly loam	0.027	4	0.73	0.48	0.57	<0.02	0.2	130	0.8	30	150	66	18	<0.01	5	12	0.8
22S4414/001	VG_001	10	0-20		0.022	7	1.9	0.45	1.5	0.39	0.2	310	0.7	50	130	150	210	<0.01	<1	19	0.8
22S4414/006	VG_011	11	0-		0.036	6	0.35	0.15	0.09	<0.02	<0.1	60	1.4	79	56	11	9.4	<0.01	2	17	0.6
22S4414/013	VG_022	12	0-40	Gravelly loam	0.018	3	0.17	0.15	0.1	<0.02	<0.1	38	0.6	22	56	16	44	<0.01	<1	37	0.2
22S4414/015	VG_021	12	40-60	Cemented hardpan	0.023	3	0.2	0.11	0.13	<0.02	<0.1	43	0.8	27	42	19	6.2	<0.01	1	23	<0.1
Limit of Reporting					*0.005*	*1*	*0.02*	*0.02*	*0.02*	*0.02*	*0.1*	*10*	*0.1*	*1*	*1*	*10*	*0.05*	*0.01*	*1*	*1*	*0.1*
Desired Level					*0.05-0.3*	*5-15*	*5-10*	*0.5-2.0*	*1-5*	*0.3-1.0*	*0.1-2.0*	*50-50000*	*0.1-5.0*	*10-200*	*10-300*	*20-2000*	*5-100*	*0.01-0.05*	*2-10*	*5-200*	*0.2-5.0*

Below Desired Range

Above desired range

* *Reference values from : McArthur (2004), Hazelton and Murphy (2007), and Moore (2004).*

Table 7-3: Vause Gourdis Baseline Soil Metals and Metalloid Results

ChemCentre ID	Client ID	Pit	As	Cd	Co	Cr	Cu	Ni	Pb	Sb	Se
			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
22S4414/001	VG_001	1	11	<0.05	4.9	160	29	10	7.4	0.25	1
22S4414/002	VG_003	1	17	<0.05	5.7	260	25	17	6.9	0.36	0.74
22S4414/003	VG_005	2	15	<0.05	5.8	410	26	16	11	0.53	1.1
22S4414/004	VG_007	3	11	<0.05	6.9	280	21	9.6	14	0.49	1.2
22S4414/005	VG_009	4	9.6	<0.05	7.3	490	45	30	11	0.17	1.1
22S4414/006	VG_011	5	8.3	<0.05	4.7	200	23	11	13	0.24	1
22S4414/007	VG_013	6	23	<0.05	7.7	180	35	11	9.7	0.43	0.93
22S4414/008	VG_015	6	14	<0.05	2.7	290	19	8.2	9.2	0.43	0.94
22S4414/009	VG_017	7	13	0.05	17	250	36	27	11	0.27	0.91
22S4414/010	VG_018	8	16	0.1	8.6	210	32	17	8.3	0.75	0.62
22S4414/011	VG_019	9	19	0.08	7.8	230	28	15	8.1	0.95	0.59
22S4414/012	VG_020	9	11	<0.05	4	320	24	11	10	0.45	0.71
22S4414/013	VG_022	10	13	<0.05	31	200	30	29	12	0.47	0.87
22S4414/014	VG_016	11	14	<0.05	4	280	19	9	15	0.33	0.98
22S4414/015	VG_021	12	11	<0.05	5.7	230	21	8.4	7.4	0.48	0.74
22S4414/016	VG_004	12	13	<0.05	4.5	210	22	12	8.5	0.09	0.87
Limit of Reporting			*0.2*	*0.05*	*0.5*	*0.05*	*0.5*	*0.1*	*0.5*	*0.05*	*0.05*
Soil Ecological Investigation Levels[1]			*20*	*3*	*50*	*400*	*100*	*60*	*600*	*NA*	*NA*
Soil Health Investigation Levels for Parks and Recreation[2]			*200*	*40*	*200*	*24000*	*2000*	*600*	*600*	*NA*	*NA*
Soil Median Value (SMV)[3]			*6*	*0.35*	*8*	*70*	*30*	*50*	*35*	*5*	*0.4*

[1] Ecological investigation levels - Department of Environment and Conservation 2010. *Contaminated Sites Management Series*, Assessment levels for Soil.

[2] Health investigation levels (for parks and recreation) - Department of Environment and Conservation 2010. Contaminated Sites Management Series, Assessment levels for Soil.

[3] Median Soil Value (GARD Guide).

6.2 Pit and Site Photos

6.2.1 Pit 1

6.2.2 Pit 2

6.2.3 Pit 3

6.2.4 Pit 4

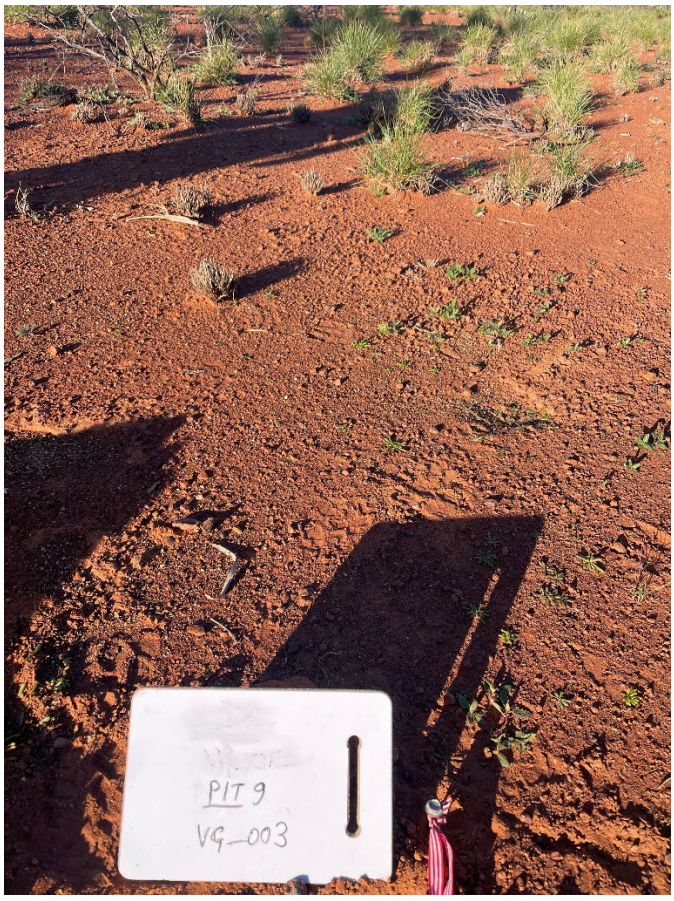
6.2.5 Pit 5

6.2.6 Pit 6

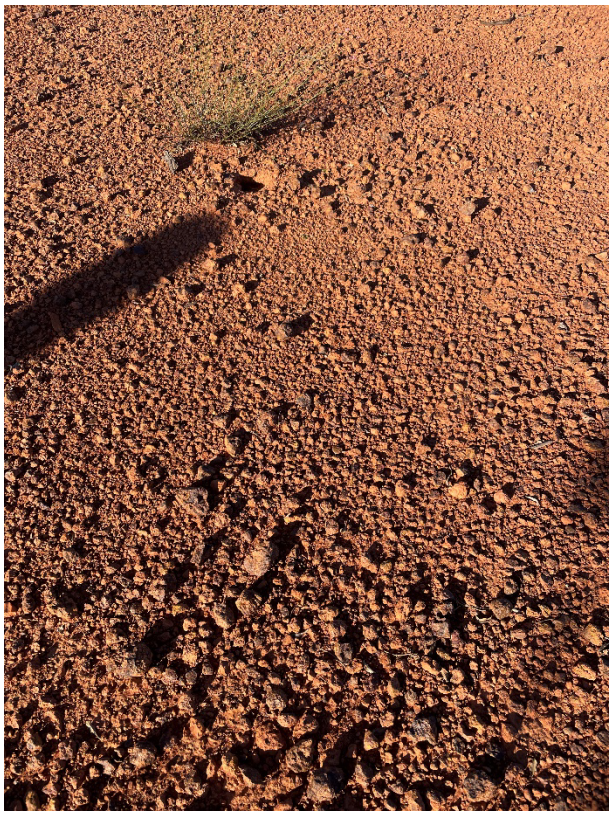
6.2.7 Pit 7

6.2.8 Pit 8

6.2.9 Pit 9



6.2.10 Pit 10



6.2.11 Pit 11

6.2.12 Pit 12

6.3 Field Data Tables

Table 7-4: Field Pit Mapping Notes

Pit Number	Sample No.	Location		Depth from - to (cm)	Layer Description			Surface Float	Vegetation	Landform/scape
		Easting (m) GDA2020	Northing (m) GDA2020		Substrate - Texture, colour	Mansell colour	Coarse fragments- lithology, roundness			
Pit 1	VG015	As design		0-30	Sandy Loamy with 40% rounded ironstone to pisolitic pebbles, red bn darkening at base. Base Lat Rubble. Abundant roots.	Dk red	Ironstone pebbles 100%	Surface ironstone pebbles 100%	Acaia,sparse trees w.understory eremophilas.	Low plateau slightly uphill from the pit. Flat. Sl rise from point 013.
	VG016			30-40	Loamy with clay. Dk red, brown, moist, charcoal. Lots of roots to base. Ends in saprolitic clay at 40cm	Dk red	40-50% laterite pebbles, rest oxidised rock.			
Pit 2	VG013	As design		0-5	Sandy loam with 50% tiny pisolites, ironstones. Few roots.	Red to dk red	Ironstones and quartz mixed. Ironstones, 3-5mm to 30-40mm.	Ironstone pebbles and scattered quartz.	Sparse accacia bushes, low succulents, herbs, previously cleared.	Flat plain.
				5-20	Sandy clay loam red to dk red, grading to mottled clay, lighter red brown.	Red to dk red				
Pit 3	VG009	As design		0-20	Red to redbwn sandy clay rich loam. Well structured aggregates. Fine roots common.	Light orange red brown	10-20% ironstone and quartz fragments, fine, 2-10mm.	Clay surface with mixed ironstone and scattered quartz.	Lots of tall shrubs to 5m trees (accacia). Abundant herbs and portulaccas.	Flat plain.
Pit 4	VG007			0-30	Sheetwash covering mottled clay. Sandy clay loam grades to soft clay, red.	Light orange red brown	10-20% ironstone and quartz fragments, fine, 2-10mm.	As above.	Previously partly cleared, but nearby as above.	Flat plain.
Pit 5	VG005	As design		0-20	Red fine sandy clay loam, structured with peds and aggregates. Fine roots throughout. HP at base.	Light orange red brown	20-30% rock fragments.	Fine ironstone, with scattered quartz fragments.	Previously cleared, scattered accacia shrubs and trees, eremophilas.	Flat clay loam plain.
Pit 6	VG017	As design		0-15	Red fine sandy clay loam with fine gritty pebbles. Fine roots. HP at base.	Red brown	As above	As above	As above	Near drainage
	VG018			15-60	Hardpan	Dk red brown				
Pit 7	VG019	As design		0-15	As above, red fine sandy clay loam. HP at base. HP extends from Pit 6 as visible in multiple drill sums	Dk red brown	As above		Acaia,sparse trees w.understory eremophilas.	Clay loam plain with sheetwash.
Pit 8	VG020	As design		0-20	Red clay loam. Fine roots moderate. Structured aggregates.	Medium sl red brown	Angular oxidised rock fragments, and minor pisolites	Minor fine gravel of oxidised rock	Abundant vegeation as above and areas of spinifex.	Clay loam plain, very flat. Nearer drainage, slightly lower than pit area.
				20 -30	Dk red ferruginous HP crust at base.	Dr red brown				
Pit 9	VG003	As design		0-20	Silty and fine sandy loam with gravel (50%).	Or red brown	rounded rock fragments and 10% medium pisolites	Oxidised rounded rock frags to 30mm (80%), ironstone frags 20%.	Well vegetated with trees, abundant shrubs and spinifex.	Flat with very flat low rise.
	VG004	As design		20-40	Very gravelly (60%), sandy silty loam. Ends in HP.	Red brown	rounded rock fragments with 10% pisolites			
Pit 10	VG001	As design		0-20	Sandy loam clay aggregates, 60% gravel. Few fine roots. HP at base.	Or red brown		Abundant coarse ironstone and pisolites	Sparse accacia , little understory.	Flat, gravelly, but on a low rise
Pit 11	VG011	As design		0-40	Soft sandy clay loam. Mod abundant roots, fine and large, Clay peds, moist. Very deep soil.	Dk red	Very few scattered tiny ironstones and pisolites	Minor v small ironstones and ox rock	Thick tall shrubs and abundant understory of eremophilas.	V. flat clay loam plain.
Pit 12	VG021	282745	7055220	0-40	Gravelly fine sandy clay loam.	Dk red brown	minor scattered ironstone and quartz.	Minor v small ironstones and ox rock	Scattered eremophila bushes and spinifex	Clay loam plain, very flat. Nearer drainage, slightly lower than pit area.
	VG022			40-60	Ferruginous HP (cemented ferruginous silty/sandy	Red brown				

6.4 Analyses Reports

APPENDIX C – STANTEC 2018

RAMONE FLORA, FAUNA AND VEGETATION SURVEY

PREPARED FOR **NORTHERN STAR RESOURCES LIMITED**

14 August 2018

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Rev No.	Date	Description	Signature or Typed Name (documentation on file)			
			Prepared by	Checked by	Reviewed by	Approved by
v.1.0.	14-05-2018	Draft report for client comment	SL, CH, LT	AB	PB	PB
V2.0	13-08-2018	Final report	SL	SL	PB	PB

Executive Summary

This report presents the background, methodology and results of a Detailed flora and vegetation (formerly Level 2) and Level 1 Vertebrate fauna assessment undertaken by Stantec Australia for Northern Star Resources Limited at the Ramone mine site. The Study Area is located approximately 55 km east of Wiluna, Western Australia and comprises approximately 1814.7 ha.

The fauna field survey took place from 20 to 23 March 2018 and the flora and vegetation field survey took place from 26 April to 01 May 2018. Flora and vegetation was sampled by way of opportunistic collections, vegetation mapping and data collected from 33 quadrats. For fauna, fourteen broad habitat assessments were undertaken within the Study Area and six motion-sensor cameras were deployed. In addition, the Study Area was traversed on foot with searches undertaken for fauna taxa of conservation significance and to develop a fauna species list.

The vegetation condition ranged from 'Degraded' to 'Excellent', with the majority of the vegetation considered to be 'Very Good'. Historical impacts to the Study Area include drilling, the establishment of multiple vehicle tracks, and trampling and grazing by feral fauna including camel, cattle and rabbit. Three introduced flora were confirmed, **Bidens bipinnata*, **Malvastrum americanum* and **Portulaca pilosa*. An additional Curcurbitaceae species was recorded, that is likely to be a weed, although could not be identified to species level. None of the introduced taxa recorded represent a declared pest or Weed of National Significance

Ten vegetation types were recorded within the Study Area, broadly described as mixed mulga shrublands, of mostly *Acacia incurvaneura* and *Acacia pteraneura*, over a mixed mid shrubland layer comprised largely of the following shrubs: *Acacia tetragonophylla*, *Eremophila fraseri*, *Eremophila forrestii* subsp. *forrestii*, *Eremophila latrobei* subsp. *latrobei, Eremophila spectabilis* and *Sida ectogama*. The vegetation types identified within the Study Area were not analogous to any Threatened or Priority Ecological Communities, and none are considered regionally or locally significant.

A total of 104 flora taxa were recorded from the Study Area from 21 families and 53 genera, including three introduced taxa. The field survey confirmed the presence of two Priority-listed flora in the Study Area: *Aristida jerichoensis* var. *subspinulifera* (P3) and *Eremophila pungens* (P4). *Eremophila pungens* was found in a low open shrubland on low rocky outcrops. *Aristida jerichoensis* var. *subspinulifera* was dominant in the tussock grassland layer in temporary drainage areas that lacked an incised channel.

Eight fauna habitats were identified within the Study Area; Mulga shrubland over grasses, Mulga shrubland on stony plain, mulga drainage, mulga over spinifex on low hill, Eremophila shrubland, low rocky hills with outcropping, spinifex plain and Senna shrubland on stony plain. Of these, all habitats were considered to have low SRE potential with the exception of low rocky hills with outcropping. This was considered to have moderate SRE potential owing to its limited and isolated extent. Spinifex plains and low rocky hills with outcropping were considered to have the highest potential significance to fauna. This is owing to the limited extent of the complex and unique habitat provided by rocky outcrops, which may support the Long-tailed Dunnart (*Sminthopsis longicaudata*) (P4). Old, unburnt spinifex provides habitat to the Brush-tailed Mulgara (*Dasycercus blythi*) (P4), which was confirmed within this habitat in the Study Area.

A total of 41 species of vertebrate fauna were recorded during the field survey, of which one was of conservation significance; the Brush-tailed Mulgara (P4). This species was recorded at all three motion cameras deployed within spinifex plain habitat, equating to 18 nights. Four species of conservation significance were considered to possibly occur based on habitat suitability, species range and previous records; the Long-tailed Dunnart (P4), Fork-tailed Swift (*Apus pacificus*) (Mi S5), Peregrine Falcon (*Falco peregrinus*) (S7) and the Grey falcon (*Falco hypoleucos*) (S3).

The flora, vegetation and fauna diversity was found to be consistent with the results of similar assessments completed in the general vicinity of the Study Area and to the habitats expected in the Murchison region.

Northern Star Resources Limited

Ramone Flora, Fauna and Vegetation Survey

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APPENDICES

1. Introduction

1.1 Project Background and Location

Stantec Australia Pty Ltd (Stantec) was appointed by Northern Star Resources Limited (Northern Star) to complete a flora, vegetation and fauna survey of the proposed Ramone Project (the Project). The Study Area comprises approximately 1,814.7 hectares (ha) and is located approximately 55 kilometres (km) east of the town of Wiluna, Western Australia (WA) (**Figure 1-1** and **Figure 1-2**).

1.2 Report Scope and Objectives

The principal objectives of the Detailed (former Level 2) flora and vegetation survey and Level 1 fauna surveys were to define the environmental values of the Study Area and to describe their conservation significance in relation to the Project. The scope requirements to meet these objectives are listed below:

- complete a desktop review (database searches and literature review), to develop a list of flora and fauna species and vegetation communities that have been previously recorded in the vicinity of the Study Area including species and communities with the potential to be of conservation significance;
- conduct a field survey to identify, describe and map fauna habitats and vegetation communities and their condition within the Study Area;
- conduct targeted searches for flora, fauna and vegetation communities of conservation significance, including species and communities of local and regional significance that may not be listed on government databases;
- develop a list of flora and fauna species recorded as occurring within the Study Area, including introduced fauna and weed species; and
- assess the survey findings in a local and regional context by comparing them with available data from other localities within the bioregion.

The objectives and methods adopted for these surveys are aligned with the following relevant regulatory guidelines:

- EPA Factor Guideline (EPA 2016f), Environmental Factor Guideline: Flora and Vegetation;
- EPA Technical Guide (EPA 2016g), Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment;
- EPA Factor Guideline (EPA 2016a), Environmental Factor Guideline: Terrestrial Fauna;
- EPA Factor Guideline (EPA 2016c), Sampling Methods for Terrestrial Vertebrate Fauna and
- EPA Technical Guide (EPA 2016d), Technical Guidance – Terrestrial Fauna Surveys.

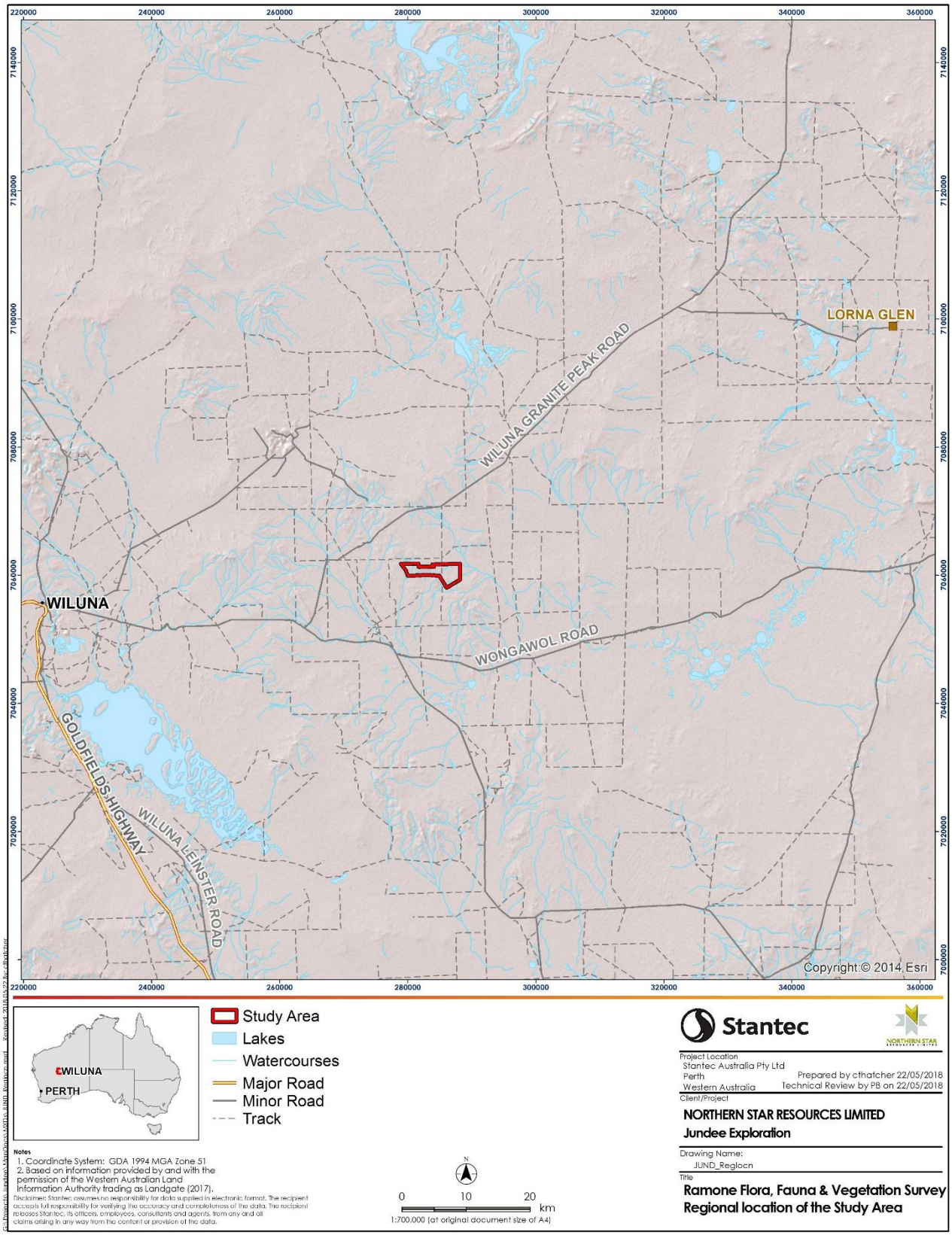


Figure 1-1: Regional location of the Study Area

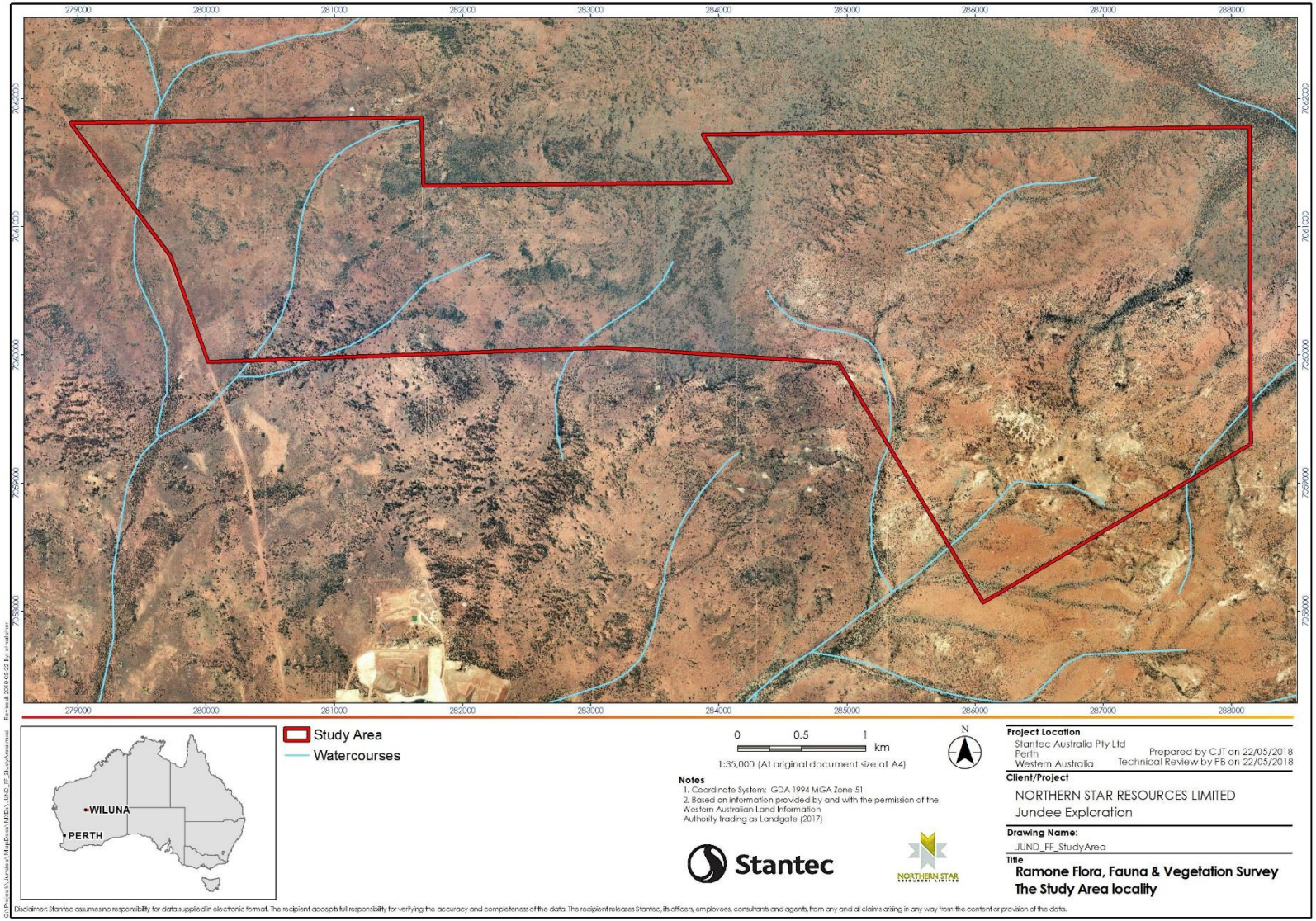


Figure 1-2: The Study Area locality

2. Existing Environment

2.1 Physical Environment

2.1.1 Climate

The Study Area is located within the Goldfields region of WA, which is classed as being arid to semi-arid, and is considered to be within the bioclimatic category of 'desert; summer and winter rainfall', where the months of the year are not reliably wet, zero rainfall can be recorded within any month and rainfall is typically erratic (Pringle et al. 1994).

The nearest operating Bureau of Meteorology (BOM) weather stations for the Study Area, with relevant long-term and recent climatic data, are located at Millrose weather station (station number 13006) and Wiluna weather station (station number 013012). Millrose station provided long term rainfall trends and is located approximately 20 km north east of the Study Area, while Wiluna station provided long term temperature data and is located approximately 60 km west of the Study Area. The long-term (1929 to 2018) annual rainfall recorded at Millrose is 241.5 millimetres (mm) per annum with the majority falling during the warmer months of December to March. The hottest three months occur between January and March with daily maximum temperatures regularly exceeding 30°C (1901 to 2018). The coolest three months occur between June and August with minimum temperatures regularly falling below 10°C(**Figure 2-1**) (BoM 2018).

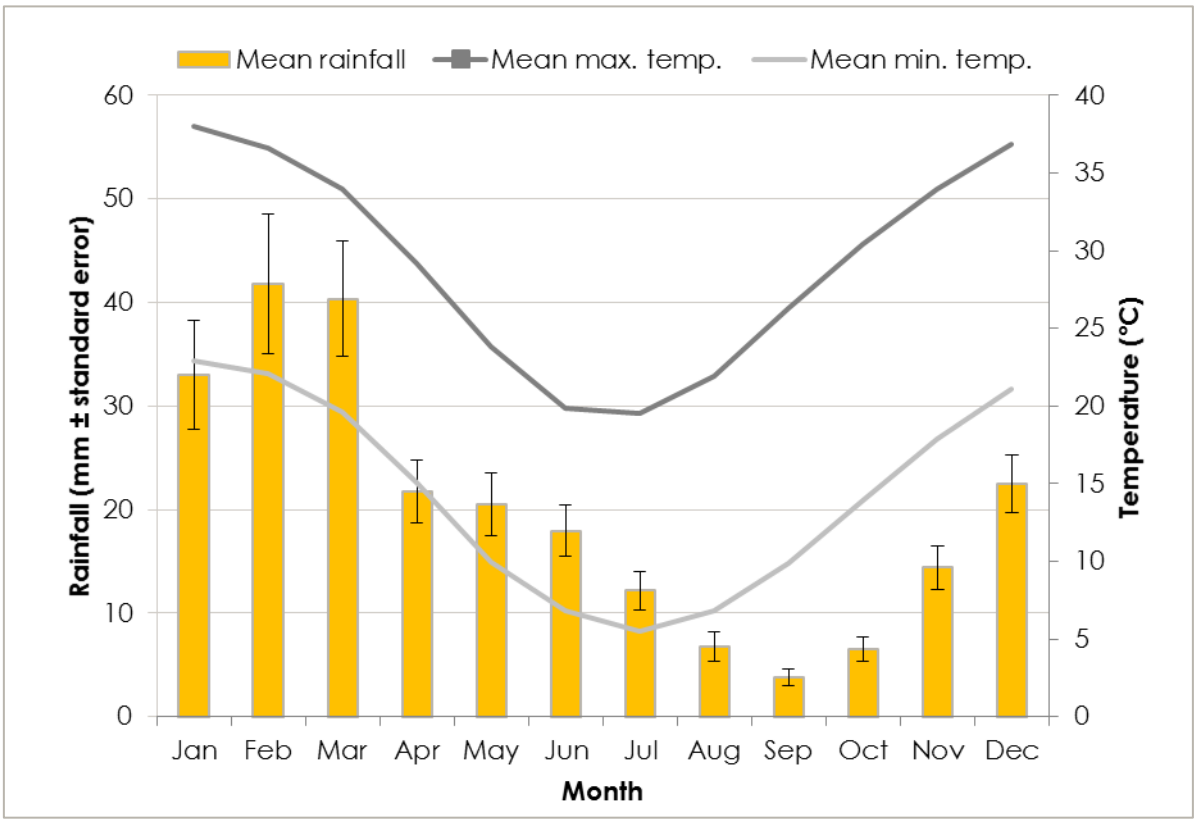


Figure 2-1: Long-term mean rainfall recorded at Millrose station (13006, 1929 – 2018) and mean maximum temperature recorded at Wiluna station (013012, 1901 – 2018)

2.1.2 Landforms, Geology and Soils

The geology of the Murchison region mainly consists of granite greenstone terrain of the Archean Yilgarn Craton, and is characterised by hill ranges separated by large flat colluvial and alluvial plains (Curry *et al.*

1994). Granitic rocks contain quartz veins and dolerite dykes (Tille 2006). The greenstone belts have a north-west orientation, become more common in the east Murchison, and tend to be associated with areas of gneiss (Tille 2006). Soils are typically shallow, sandy and infertile and lie over red-brown siliceous hardpan in lower areas of the Murchison (Curry *et al.* 1994). Tille (2006) describes soils according to:

- **Wash Plains:** red loamy earths and red-brown hardpan shallow loams with some red shallow loams. Red sandy earths and red deep sands occur on sandy banks.
- **Sandplains:** red sandy earths and red deep sands, with some red loamy earths and calcareous loamy earths occurring in low lying areas. Yellow deep sands occur in the south-west.
- **Mesas:** dominated by red shallow loam, red shallow sandy duplexes and red shallow sands with some stony soils and red/brown non-cracking clay.
- **Hilly terrain:** dominated by red shallow loams, stony soils and red shallow sands with some bare rock and red shallow sandy duplexes. Stony Plains are dominated by red shallow loams with red shallow sandy duplexes with red shallow sand on plains over granite. Red-brown hardpan shallow loams, calcareous loamy earths and red loamy earths are also present.
- **Valley floors:** mainly salt lake soils with some deep red sand with some red deep sandy duplexes, red/brown non-cracking clays, red shallow sandy duplexes and red-brown hardpan shallow loams mainly occurring on north-west floodplains. Calcareous shallow loams occur on calcrete platforms.

2.1.3 Land Use

The majority of land within the East Murchison is used for grazing (85.47%), with smaller areas comprising Unallocated Crown Land (UCL)), Crown Reserves and mining (Cowan *et al.* 2001). Mining activity within the region is considerable and dominated by nickel and gold mining (Cowan *et al.* 2001, Water and Rivers Commission 1999). Most mining leases adhere to the pastoral land act, and are required to support stock (Cowan *et al.* 2001). The Study Area is located on the Lake Violet Pastoral Station. Only a small fraction of the Eastern Murchison is protected within the conservation reserve system (<2%) (Cowan *et al.* 2001).

2.1.4 Reserves and Environmentally Sensitive Areas

The Study Area does not overlap with reserves or environmentally sensitive areas (ESA). The closest reserve is the Lorna Glen Conservation Nature Reserve (**Figure 1-1**), which lies approximately 30 km south-west of the Study Area and covers approximately 244,000 ha (DoEE 2008). Lorna Glen reserve served as pastoral land before being purchased by the Department of Biodiversity, Conservation and Attractions (DBCA) in 2000 to establish a conservation reserve (DoEE 2008). The reserve supports a wide array of native vertebrate fauna, which were surveyed in a 2002 – 2010 monitoring program (DPaW 2015). The following conservation significant mammals have been re-introduced in the reserve; Bilby (*Macrotis lagotis*), Brushtail Possum (*Trichosurus vulpecula*) and Golden Bandicoot (*Isoodon auratus*), Burrowing Bettong (*Bettongia lesueur*), Rufous Hare-Wallaby (*Lagorchestes hirsutus*) and Shark Bay Mouse (*Pseudomys fieldi*) (DPaW 2015). All of these, with the exception of the Bilby and Brushtail Possum, were introduced into predator-proof enclosures (DPaW 2015). A fire regime and non-native species (cats, cattle, camels and foxes) control measures have been implemented (DPaW 2015).

2.2 Biophysical Environment

2.2.1 Biogeographic Region

The Interim Biogeographic Regionalisation for Australia (IBRA) is a bioregional framework that divides Australia into 89 biogeographic regions and 419 subregions on the basis of climate, geology, landforms, vegetation and fauna (Thackway and Cresswell 1995). It was developed through collaboration between state and territory conservation agencies with coordination by the Commonwealth Department of the Environment, Water, Heritage and the Arts (now the Commonwealth Department of the Environment and Energy, DoEE).

The Study Area is located within the Eastern Murchison subregion (MUR1) of the Murchison bioregion. This subregion comprises 7,847,996 ha, encompassing an internal drainage system and areas of extensive elevated red desert sand plains with reduced dune development (Cowan *et al.* 2001). Vegetation tends to be low mulga woodland over ephemeral species including hummock grasses and saltbush and samphire shrublands (Cowan *et al.* 2001).

2.2.2 Land Systems

An assessment of land systems provides an indication of the occurrence and distribution of fauna habitats and vegetation within and surrounding the Study Area (Curry *et al.* 1994). Land systems across the Murchison have been mapped by the Natural Resources Assessment Group of the former Department of Agriculture (now Department of Primary Industries and Regional Development, DPIRD) and provide a comprehensive description of biophysical resources within the area (Curry *et al.* 1994). The Study Area lies within relatively similar portions of the Wiluna, Violet, and Sherwood Systems (**Table 2-1** and **Figure 2-2**).

Table 2-1: Land systems and their extent within the Study Area

Land System	Description	Total Area of Land System in WA (ha)	Extent within Study Area	
			Hectare (ha)	Percentage (%)
Wiluna system	Mainly low greenstone hills, with some lateritic breakways and stony slopes, low saline stony plains and broad drainage areas. Supports sparse mulga shrublands and patchy halophytic shrublands.	10324.39	374.34	21
Violet system	Undulating gravelly plains, low stony rises and minimal saline plains, dominated by mulga and bowgada shrubland with patchy halophyte shrublands.	10999.58	533.15	29
Sherwood system	Gently sloping stony and sandy plains over outcrops of weathered rock and saline footslopes of laterised breakaways. Supports mulga shrublands over other non-halophytic and halophytic shrubs.	2630.57	907.21	50
Total	**-**	**-**	**1814.7**	**100**

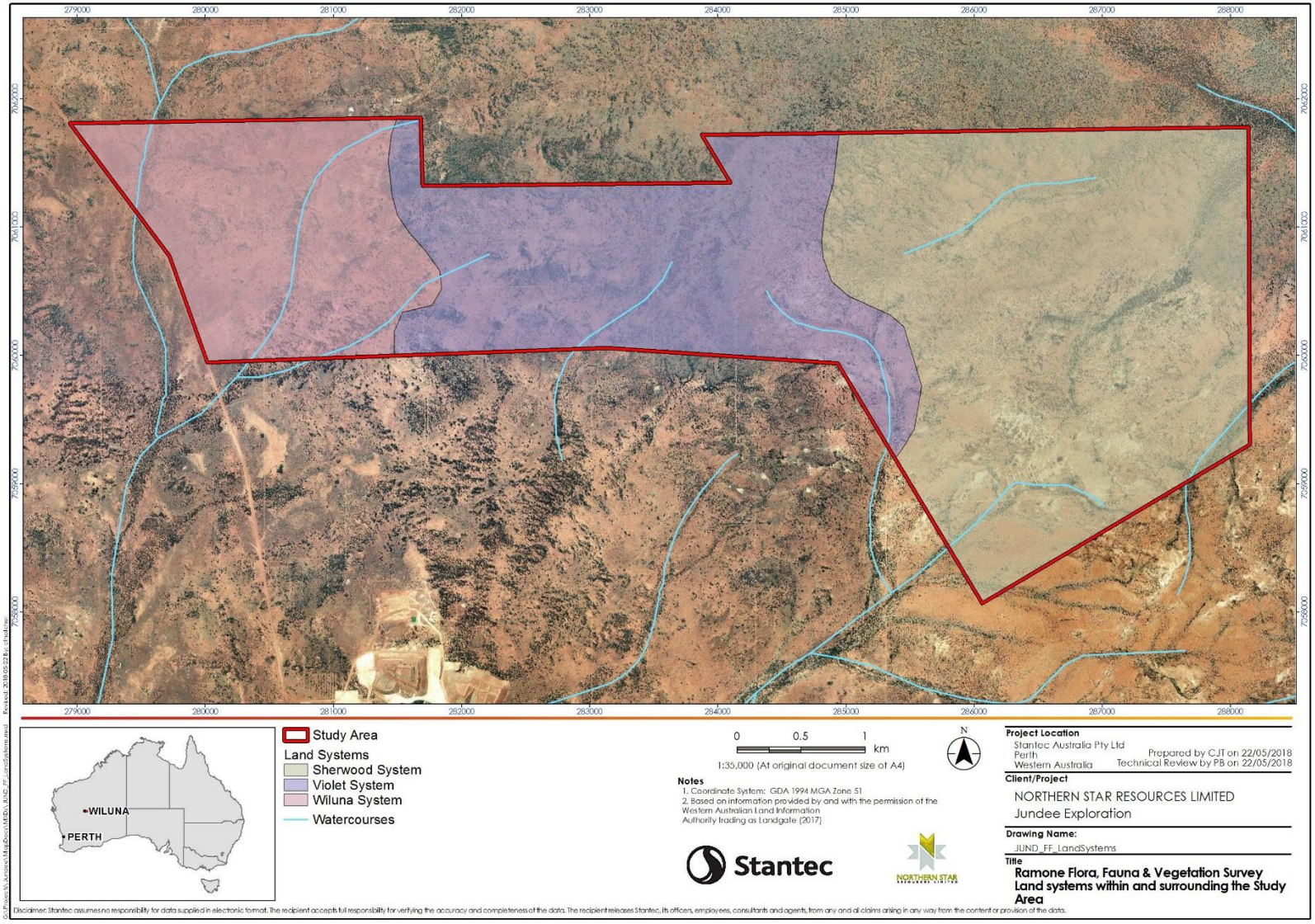


Figure 2-2: Land systems withinthe Study Area

2.2.3 Pre-European Vegetation

Vegetation mapping of Western Australia was completed on a broad scale (1:1,000,000 and 1:250,000) by (Beard 1975), who classified vegetation into broad vegetation associations. These vegetation associations were re-assessed by Shepherd *et al.* (2002) to account for clearing in the intensive land use zone, and to divide some larger vegetation units into smaller units. Shepherd *et al.* (2002) developed a series of systems to assist in the removal of mosaics; however, some mosaics still occur. Vegetation system associations described by Shepherd *et al.* (2002) correspond with that of Beard (1975). The Study Area is located in the Wiluna system (**Table 2-2**) as represented in **Figure 2-3**.

Table 2-2: Vegetation system associations within the Study Area

System	System Code	Description	Extent in Study Area (ha)
Wiluna	18	Low woodland; mulga (*Acacia aneura*)	694.51
	39	Shrublands; mulga scrub	1120.20

The current extent of the remaining vegetation system associations is over 98% across all regional scales (State, bioregion, subregion and Local Government Authority (LGA)) (**Table 2-3**). The current extent is above the recommended threshold of 30% of remaining extent (EPA 2000).

Table 2-3: Extent of Vegetation system association remaining across four scales (State, Bioregion, Subregion and Local Government Area)

System	Scale	Pre-European Extent	Current Extent	% Remaining	Current extent within IUCN Class I-IV Reserves (ha)	% of current extent protected within IUCN Class I-IV Reserves
Wiluna 18	Statewide	4,308,336	4,290,594	99.59	45,238	1.05
	Bioregional (IBRA)	4,307,946	4,290,204	99.59	45,030	1.05
	Bioregional (IBRA sub-region)	4,273,510	4,256,038	99.59	45,030	1.05
	LGA	1,083,182	1,073,708	99.13	4,920	0.45
Wiluna 39	Statewide	426,536	421, 470	98.81	0	0
	Bioregional (IBRA)	426,436	421,370	98.81	0	0
	Bioregional (IBRA sub-region)	411,278	406,212	98.77	0	0
	LGA	153,843	153,217	99.59	0	0

NB: Hectares have been rounded to the nearest whole number

Source: (Government of Western Australia 2017)

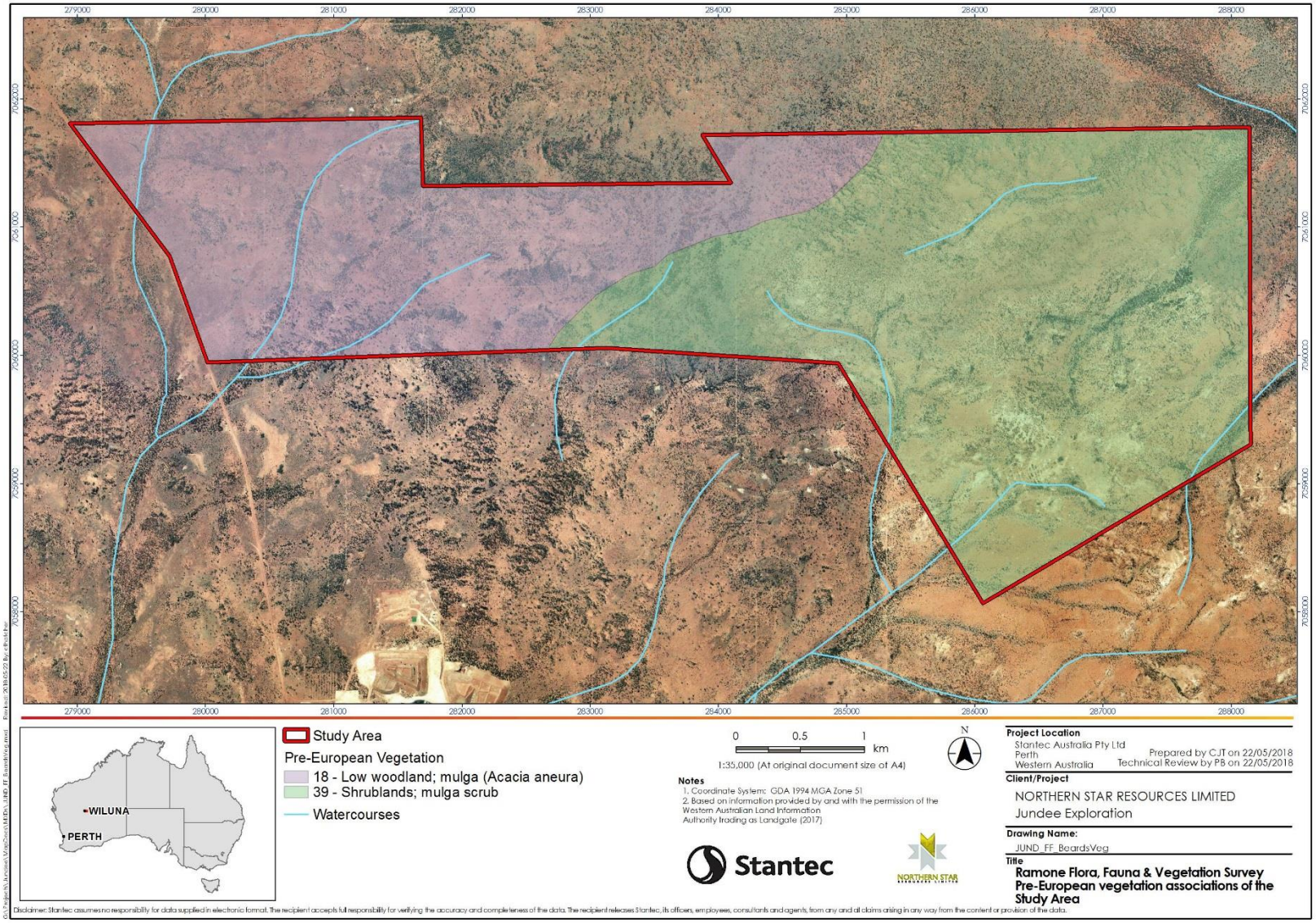


Figure 2-3: Pre-European vegetation associations of the Study Area

3. Desktop Assessment

A desktop assessment, comprising database searches and a literature review, was undertaken prior to the field survey to gather contextual information on the Study Area. The purpose of the desktop assessment was to identify flora, vegetation and terrestrial fauna potentially occurring in the Study Area, in particular species of conservation significance. Conservation significance and conservation rankings used under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and Biodiversity Conservation Act 2016 (BC Act), as well as the DBCA Priority list, are defined in **Appendix A**.

3.1 Database Searches

Database searches were completed to generate a list of vascular flora, vegetation communities and vertebrate fauna previously recorded within, and in the vicinity of the Study Area, with an emphasis on species and communities of conservation significance and introduced species. Six database searches were conducted from a central coordinate (51 J, 284230.64 m E, 7060598.83 m S) with appropriate search buffers selected for each database based on their technical capabilities as well as ecological features of the Study Area (**Table 3-1**).

Table 3-1: Database searches conducted for the desktop assessment

Custodian	Database	Ecological Group	Reference	Buffer (km)
DoEE	Protected Matters Search Tool (PMST)	MNES Flora and Fauna	(DoEE 2018a)	50
DBCA	NatureMap	Flora and Fauna	(DBCA 2018a)	50
DBCA	Threatened and Priority Ecological Communities	Vegetation communities	(DBCA 2018b)	50
DBCA	Threatened and Priority Flora (TPFL, TP, WAHerb)and Fauna	Flora and Fauna	(DBCA 2018c) (DBCA 2018d)	50
Birdlife Australia	Birdlife Bird data	Fauna	(Birdlife Australia 2018)	50

Introduced flora species were compared to the Western Australian Organisms List (WAOL) (Department of Agriculture and Food WA (DAFWA)) to determine if any have been listed as declared pests or Weeds of National Significance (WoNS) list. Categories of introduced flora are defined in **Appendix A**.

3.2 Literature Review

Background information on the Study Area and surrounds was compiled prior to the field survey. Historic vegetation mapping by Shepherd *et al.* (2002), soil and landform mapping and characteristics (Curry *et al.* 1994) and IBRA classification system information (Cowan *et al.* 2001) were reviewed to identify broad contextual information. A more detailed literature review considered twelve previously completed surveys of relevance to the Study Area, comprising six flora and vegetation surveys (**Table 3-2**) and seven terrestrial fauna surveys (**Table 3-3**). Surveys considered were those that were publically available, recently conducted, and in close proximity to the Study Area.

Table 3-2: Key findings of flora and vegetation studies conducted within the vicinity of the Study Area

Reference	Study Details	Proximity to Study Area	Vegetation Types	Flora Recorded	Vegetation Condition	Species and communities of conservation significance
Botanica Consulting (2007)	Location: Jundee Gold Mine Study Type: Flora and vegetation survey of the Deep Well Tenement (M53/347) Survey Date: 27-30th May 2005	Coincident with Study Area	Four vegetation communities: • Mulga low woodland – dominant species was *Acacia aneura*, with understorey of *Acacia tetragonophylla, Eremophila forrestii, E. fraseri, E. compacta* ssp *compacta, E. spectabilis, Psydrax attenuata, Santalum lanceolatum* and *Ptilotus obovatus.* • Mulga creek line - dominant species was *Acacia aneura*, with understorey of *Acacia tetragonophylla, Eremophila forrestii, E. fraseri, Psydrax attenuata, Santalum lanceolatum* and *Ptilotus obovatus*. • Hummock grassland - dominant species was *Triodia basedowii* and *Triodia melvillei*. Rocky outcrop - dominant species was *Acacia aneura*, with understorey of *Eremophila pungens* (P4), *Hysterobaeckea* occlusa), *E. linearis*, *Acacia tetragonophylla, Ptilotus schwartzii* and *Senna artemisioides* ssp *sturtii*.	• 40 taxa • 19 genera • 11 families	Very Good	*Eremophila pungens* (P4)
Outback Ecology (2007)	Location: Lake Way (E53/1132 and E53/1168) and Centipede (M53/224) project areas Study Type: Baseline Detailed flora and vegetation survey Survey Date: 15-22nd October 2007	44 km south-west	Twenty two vegetation communities identified: • Playa Vegetation • Fringing Vegetation • Dune and Plains Vegetation • Calcrete Vegetation Clay-Pan Vegetation	• 132 taxa • 10 genera • 32 families	Pristine to Good	None
GHD (2005)	Location: Wiluna to Magellan section of the Goldfields Highway Study Type: Biological survey Survey Date: 8-9th & 29th August 2005	~60 km west	Thirteen vegetation associations: • Mulga Woodland, dominated by *Acacia aneura* over *Eremophila* species and Spinifex *(Triodia basedowii*). • Mulga woodland over *Eremophila* species (dominated by *E. forrestii, E. spectabilis* and *E. pterocarpa*) and Spinifex (*Triodia basedowii*). • Mulga woodland, dominated by *Acacia aneura*, and *Acacia pruinocarpa* over *Eremophila* species and Spinifex (*Triodia basedowii*). • Mulga woodland, dominated by an understorey of Spinifex (*Triodia basedowii* and *T. mellvillei*). • Mixed Acacia shrubland dominated by mulga, *Acacia pruinocarpa*, *Acacia tetragonophylla* over *Grevillea striata* (Beefwood), *Eremophila* species and Spinifex (*Triodia basedowii*). • Mixed Acacia woodland dominated by *Acacia aneura* (mulga), *Acacia victoriae* and *Acacia tetragonophylla* over *Eremophila* species and *Senna artemisioides* subsp. x *coriacea.* • Mulga over *Acacia victoriae, Senna artemisioides* subsp. x *coriacea*, *Grevillea berryana*, *Eremophila* species understorey of *Solanum lasiophyllum* and *Ptilotus obovatus*. • Mulga woodland with understorey of *Senna artemisioides* subsp. x *coriacea, Eremophila maculata* and *Grevillea berryana,* and no herbaceous species. • Mixed Acacia shrubland, with a dominance of mulga, *Acacia victoriae* and *Acacia tetragonophylla* over *Grevillea berryana, Eremophila* species and *Senna artemisioides* subsp. x *coriacea.* • Very open mulga woodland dominated by *Acacia aneura* over *Eremophila* species (predominantly *E. linearis* and *E. maculata*) and *Solanum lasiophyllum*. • Mulga woodland, dominated by Mulga, *Acacia burkittii*, *Acacia tetragonophylla* over *Senna artemisioides* subsp. x *coriacea,* mixed	• 110 taxa • 36 families	Excellent to Good	None

Reference	Study Details	Proximity to Study Area	Vegetation Types	Flora Recorded	Vegetation Condition	Species and communities of conservation significance
			Eremophila species, *Scaevola spinescens.* Understorey and ground layer was dominated by *Solanum lasiophyllum*, *Goodenia* species, *Brachyscome ciliocarpa* and *Ptilotus obovatus*. • Mulga woodland, dominated by mulga, with *Acacia tetragonophylla* over *Senna* species, mixed *Eremophila* species, and scattered *Scaevola spinescens.* The understorey and ground layer was dominated by *Solanum lasiophyllum, Ptilotus obovatus,* and various chenopod shrubs. Mulga (*Acacia aneura*) is almost co-dominant with *Acacia rhodophloia,* with scattered emergent *Acacia pruinocarpa*. Understorey dominated by *Eremophila* and *Senna* species, with scattered herbs.			
Outback Ecology (2009)	Location: Lake Maitland Study Type: Baseline Detailed flora and vegetation survey Survey Date: May 2007, November 2007 and May 2009	67 km south	Four vegetation associations identified: • Salt Lake (playa); • Kopi Ridge; • Calcrete and • Plains.	• 244 taxa • 78 genera • 36 families	Excellent to Degraded	*Maireana prosthecochaeta* (possible - insufficient flowering material to confirm identification) (P3)
SRK Consulting (2015)	Location: Paroo Station Study Type: Detailed flora survey Survey Date: 2011, 2014	85 km west	Eight vegetation types recorded (not specified)	• 178 taxa • 93 genera • 39 families	N/A	None
Western Botanical (2011)	Location: Yeelirrie Pastoral Station Study Type: Detailed flora and vegetation survey Survey Date: December 2008 – December 2010 (numerous site visits)	~105 km south-west	Fifty two communities within the following broad habitats: • Granite Breakaway System; • Sand Plain System; • Playa System • Central Calcrete System (Calcrete System); • Hardpan and Drainage System and • Saline Playa System.	• 143 taxa • 70 genera • 29 families	Largely Excellent with some Degraded areas.	• *Atriplex yeelirrie* K.A.Sheph. & K.R.Thiele (formerly: *Atriplex* sp. Yeelirrie Station (P1)) (DRF-Extant); • *Baeckea* sp. Sandstone (P3) • *Bossiaea eremaea* (P3); • *Comesperma viscidulum* (P4); • *Eremophila arachnoides* subsp. *arachnoides* (P3); • *Euryomyrtus inflata* (P3); • *Olearia arida* (P4); • *Rhagodia* sp. Yeelirrie Station (P1)

Table 3-3: Key findings of fauna studies conducted within the vicinity of the Study Area

Reference	Study details	Proximity to Study Area	Fauna habitats	Fauna assemblages recorded	Species of conservation significance
DPaW (2015)	Location: Lorna Glen Reserve Study Type: Vertebrate fauna trapping survey Survey Date: January 2013	~30km northeast of Study Area	• Bare areas and salt lakes • Hummock grassland • Low mulga woodland • Shrubland, mulga scrubland • Succulent steppe, samphire	103 taxa including; • 56 genera	• Long-tailed Dunnart (P4) • Barrow Island Golden Bandicoot (Vu, S3) • Barrow Island Burrowing Bettong (Vu, S6) • Rufous Hare-wallaby (En, S2) • Shark Bay Mouse (Vu, S3) • Bilby (Vu, S3)
Cowan (2004)	Location: Lorna Glen Reserve Study Type: Vertebrate fauna trapping survey Survey Date: June, July 2003	~30km northeast of Study Area	• Dune and adjacent spinifex sandplain • Mulga over spinifex • Marble Gum over spinifex	53 taxa including; 31 genera	• Long-tailed Dunnart (P4)
Outback Ecology (2011)	Location: Wiluna Uranium Project Study Type: Level 2 fauna survey Survey Date: March 2010	~55km west of Study Area	• Melaleuca stands • Open mulga woodland over spinifex • Eucalypt woodland • Mulga woodland over chenopod shrubland • Mallee/Mulga complex over spinifex • Mulga over calcrete • Minor drainage line • Red sand dune • Chenopod floodplain • Creek line with River Red Gum • Open mulga woodland over spinifex on hardpan • Major drainage line	101 taxa including; • 76 genera	• Sharp-tailed Sandpiper (Mi, S5)
Outback Ecology (2012)	Location: Wiluna Uranium Project Study Type: Level 1 fauna survey Survey Date: May 2011	~51km southwest of Study Area	• Mallee/Mulga complex over spinifex • Melaleuca stands • Mixed samphire • Open mulga over calcrete • Eucalypt woodland • Salt lake • Open Mulga woodland over spinifex • Mulga over stony plain	18 taxa including; • 17 genera	-
Ecologia (2015)	Location: Lake Maitland to Millipede haul road Study Type: Level 2 fauna survey and two Level 1 fauna surveys Survey Date: October 2014, June 2014, March 2015 respectively	~56km southwest of Study Area	• Mulga over spinifex sandplain • Mulga over stony tussock grassland • Mallee/Mulga over spinifex sandplain • Melaleuca woodland over calcrete flats • Stony hills and footslopes • Low halophytic shrubland	119 taxa including; 85 genera	Brush-tailed Mulgara (P4)
GHD (2005)	Location: Goldfields Highway: Wiluna – Magellan Study Type: Level 1 fauna survey Survey Date: August 2005	~61km west of Study Area	• Acacia shrubland over hummock grassland • Open mulga shrubland • Acacia shrubland • Acacia over sparse over grazed understorey • Open mulga woodland	29 taxa including; • 26 genera	-

Reference	Study details	Proximity to Study Area	Fauna habitats	Fauna assemblages recorded	Species of conservation significance
Engenium (2015)	Location: Lake Maitland Study Type: Phase 1, 2 and 3 Level 2 fauna survey (Engenium completed Phase 3, reporting results of Outback Ecology Phase 1&2) Survey Date: March 2015 (Phase 3), December 2007 (Phase 2) and May 2007 (Phase 1)	~69km south of Study Area	• Low halophytic shrubland • *Triodia plurinervata* on lake edge • Open calcrete plain • Mallee/Mulga over spinifex sandplain • Woodland on calcrete plain • Mulga woodland • Open spinifex sandplain • Kopi dune	174 taxa including; • 124 genera	• Brush-tailed Mulgara (P4) • Peregrine Falcon (S7)

3.3 Likelihood of Occurrence of Conservation Significant Flora and Fauna

Prior to conducting the field survey, the likelihood of occurrence of each species of conservation significant flora and vertebrate fauna that were identified from the database searches was assessed for potential occurrence in the Study Area. The rankings were assigned using the following definitions:

Confirmed – the presence of the species in the Study Area has been recorded unambiguously during the last ten years (i.e. during recent surveys of the Study Area or from reliable records obtained via database searches);

Very Likely – the Study Area lies within the known distribution of the species and is likely to contain suitable habitat(s) and has been recorded nearby within the last 20 years;

Likely – the Study Area lies within the known distribution of the species and the species has been recorded nearby within the last 20 years; however, either:

- the Study Area is likely to contain only a small area of suitable habitat, or habitat that is only marginally suitable; or
- the species is generally rare and patchily distributed in suitable habitat;

Possible – there is an outside chance of occurrence, because:

- the Study Area is just outside the known distribution of the species, but is likely to contain suitable and sufficient habitat (the species may be common, rare, or patchily distributed); or
- the Study Area lies within the known distribution of the species, but the species is very rare and/or patchily distributed; or
- the Study Area lies on the edge of, or within, the known distribution and is likely to contain suitable habitat, but the species has not been recorded in the area for over 20 years;

Unlikely – the Study Area lies outside the known distribution of the species, the Study Area is unlikely to contain suitable habitat, and the species has not been recorded in the area for over 20 years.

4. Survey Methodology

4.1 Survey Timing

The optimal timing for surveying flora and fauna in the Eremaean Province (where the Study Area is located) is 6 to 8 weeks following the season which normally contributes the most rainfall (EPA 2016b, e). For the Murchison bioregion, the season of highest rainfall is summer.

The fauna field survey was undertaken on 20 to 23 March 2018, and the flora and vegetation field survey was undertaken on 26 April to 01 May 2018. Mean monthly rainfall for the four months preceding the fauna survey and five months preceding the flora survey is represented in **Figure 4-1**. The first significant rainfall event of the season took place on 29 December 2017, where 20 mm was recorded (BoM 2018). A total of 81.4mm and 77.9mm was recorded for the months of January and February 2018 respectively, which is 33.4mm and 36.1mm above the long-term average rainfall of 33.0mm and 41.8mm for the same time period (1929 to 2018). Below average rainfall (7.5mm) was received for March 2018, one month prior to the flora and vegetation survey (DBCA 2018b).

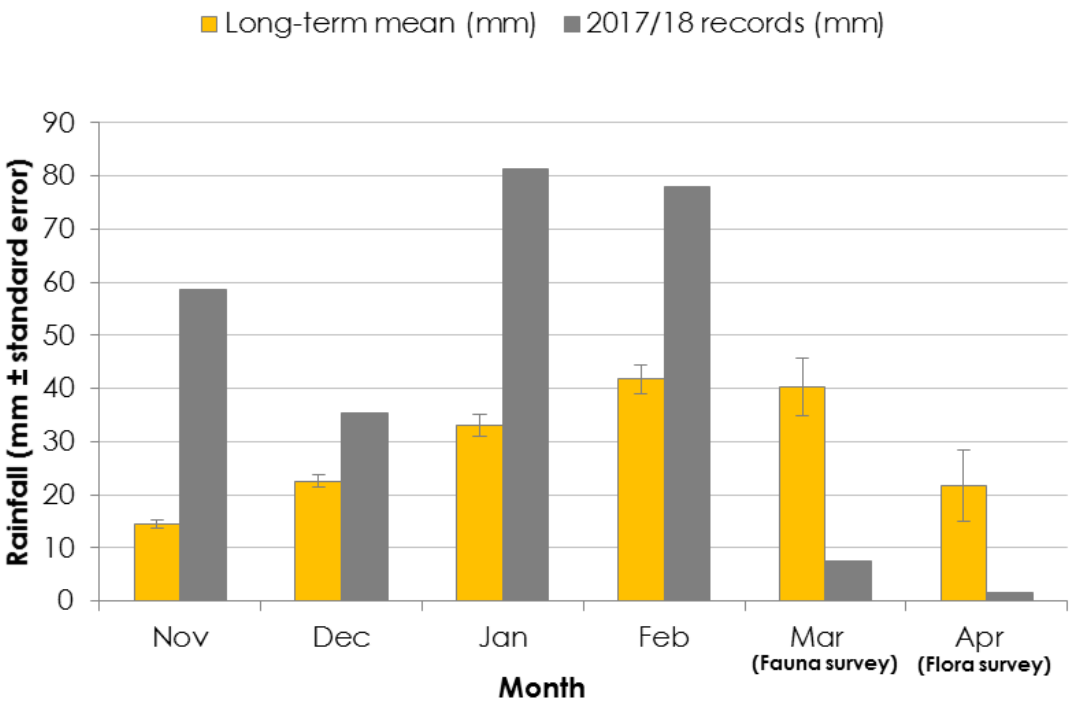


Figure 4-1: Long-term mean monthly rainfall (1929 to 2018) at Millrose weather station (13006), commencing four months preceding the fauna survey and five months preceding the flora and vegetation survey

4.2 Survey Team and Licensing

The flora field survey was undertaken by Alice Bott (senior botanist) and Crystal Heydenrych (botanist). Alice is an experienced arid-zone botanist, with extensive experience spanning over eight years conducting vegetation and flora surveys in WA, and was the technical lead for the flora field survey. All plant collections were made under flora collecting permits SL012176 pursuant to the WC Act Section 23C and Section 23F. The fauna field survey was undertaken by Paul Bolton (senior zoologist) and Samantha Lostrom (zoologist). Paul is an experienced zoologist with more than eleven years' experience with vertebrate and invertebrate zoological surveys, and was the technical lead for the fauna field survey.

4.3 Flora and Vegetation Assessment

Prior to the field survey, broad vegetation habitats were mapped on aerial imagery based on vegetation signatures and landscape features. Propososed quadrat locations were identified prior to the field survey and according to the estimated number of vegetation types within the Study. These habitats were assessed in the field and a detailed flora and vegetation survey, consistent with EPA (2016b), was employed to sample the flora and vegetation within the Study Area. Thirty three permanent quadrats[1], of 20 m x 20 m in dimension, were sampled to complile a representative species list and to characterise the vegetation types identified (**Figure 4-2**, **Appendix F**). Quadrats were established by measuring a square of 20 m x 20 m and permanently marked with a galvanised steel fence dropper in the north-western corner. In some instances, to account for landform features and drainage lines, dimensions of the quadrats were adjusted to represent 400 m². In addition, four detailed mapping notes were taken. The remainder of the Study Area was traversed on foot and via vehicle to map vegetation types and to sample flora opportunistically.

The following information was recorded at each quadrat:

[1] Fence droppers were left *in situ* at the north-western corner of each of the quadrats. However, fence droppers were not installed where the substrate was too rocky.

- Quadrat number;
- Survey date;
- Personnel;
- GPS coordinates at north-west corner (GDA 94);
- Site photograph – taken from the north-west corner, facing south-east;
- Soil characteristics (texture and colour);
- Geology (type, size and nature of any rocks, stones, gravel, or outcropping);
- Topography (landform type and aspect);
- Vegetation condition (based on (Trudgen 1988); **Appendix D**);
- Vegetation structure description (based on ESCAVI 2003) (**Appendix E**);
- Details of disturbance (if present); and
- Approximate time since last fire.

The height and percentage foliar cover (PFC) was recorded for all vascular flora recorded from quadrats and opportunistically while traversing the Study Area.

4.3.1 Targeted Survey

Targeted searches were conducted for conservation significant flora identified from the desktop assessment (**Section 5.2.1**). Field personnel familiarised themselves with photographs, reference samples and descriptions of these taxa before the survey and actively searched for them in and around quadrats, while traversing on foot within the Study Area and in known locations or preferred habitat encountered in the field. Given that populations of the Priority 4-listed species, *Eremophila pungens*, had previously been identified in the Study Area, habitat suitable to support this taxon was specifically targeted. Where flora of conservation significance were identified, the boundaries of their populations were walked and recorded with a GPS to map their extent.

The following information was collected for each population of conservation significant flora identified in the field:

- Location;
- Population size;
- Density; and
- Reproductive status.

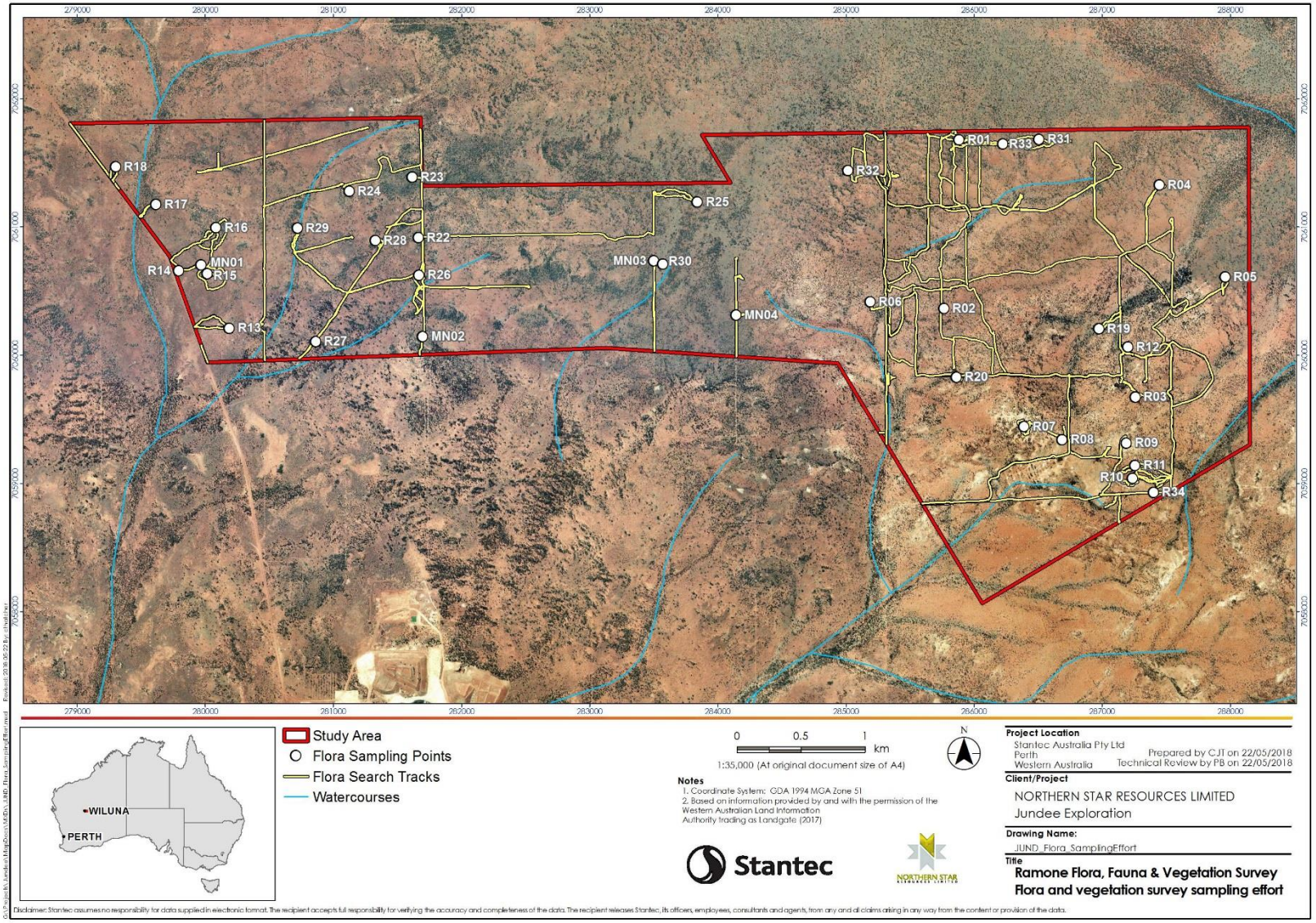


Figure 4-2: Flora and vegetation survey sampling effort

4.4 Specimen Identification

The flora taxa that were not identified in the field were collected and taken to the Western Australian Herbarium (WAH) for identification by senior taxonomist Sharnya Thomson. Species nomenclature was assigned according to the current listing of scientific names recognised by the WAH. Where specimens were lacking in diagnostic characteristic or in poor condition, they were assigned the 'sp.' epithet, indicating that identification could only be confirmed to genus level.

Flora taxa that belong to the Western Australia Mulga Flora Group (*Acacia aneura* F.Muell. ex Benth. and its close relatives) (Maslin and Reid 2012) are variable due to hybridisation and show superficial similarities within the group. All specimens from this group were collected at each quadrat to account for this.

Specimens of each priority flora species were collected for verification and lodgement at the WAH as per flora licensing requirements.

4.5 Vegetation Type and Condition Mapping

Vegetation types were delineated and described from aerial imagery utilising the flora quadrat and mapping note sampling data. The broad mapping that was done on desktop level was changed on aerial maps in the field where necessary as a result of ground-truthing. The vegetation types have been described to Level V (Vegetation Association) in the NVIS hierarchical structure (ESCAVI 2003) (**Appendix E**). Vegetation condition was defined using the six categories described by (Trudgen 1988) **Appendix D**.

4.6 Terrestrial Fauna Assessment

Fourteen broad fauna habitat assessments were undertaken within the Study Area (**Figure 4-3**). At each location, the following key habitat parameters were recorded:

- description of broad vegetation community;
- hollow bearing trees and dead stag trees (average size and abundance);
- presence of fauna refuges such as burrows;
- substrate (description of composition, presence of algal crust and percentage cover of leaf litter); and
- wetland habitats and water courses including drainage lines, sumplands, floodplains, etc.

The Study Area was traversed on foot with searches undertaken for fauna taxa of conservation significance and to develop a fauna species list for the Study Area.

4.6.1 Motion Sensor Camera

Six Reconyx HC600 motion-sensor cameras were deployed to record fauna species unlikely to be sighted opportunistically during the field survey (**Table 4-1**, **Figure 4-3**). Cameras were placed in areas likely to support fauna of conservation significance and in areas displaying fauna activity e.g. burrows, foraging evidence. Cameras were spaced to ensure adequate coverage of available habitats and also to achieve appropriate geographical coverage of the Survey Area.

Table 4-1: Motion camera locations within the Study Area

Camera	Habitat Type	Location notes	Coordinates (51J)		Recording nights
			Easting	Northing	
REC 08	Spinifex plain	Large burrow entrance	283707mE	7061203mS	29
REC 19	Mulga drainage	Foraging evidence	283134mE	7060525mS	30
REC 24	Spinifex plain	Fallen tree	284197mE	7060593mS	32
REC 27	Low rocky hills with outcropping	On outcropping hill	279934mE	7061092mS	30
REC 28	Mulga drainage	Fallen tree	287457mE	706049pmS	28

Camera	Habitat Type	Location notes	Coordinates (51J)		Recording nights
			Easting	Northing	
REC 44	Spinifex plain	Foraging evidence	284196mE	7061202mS	29

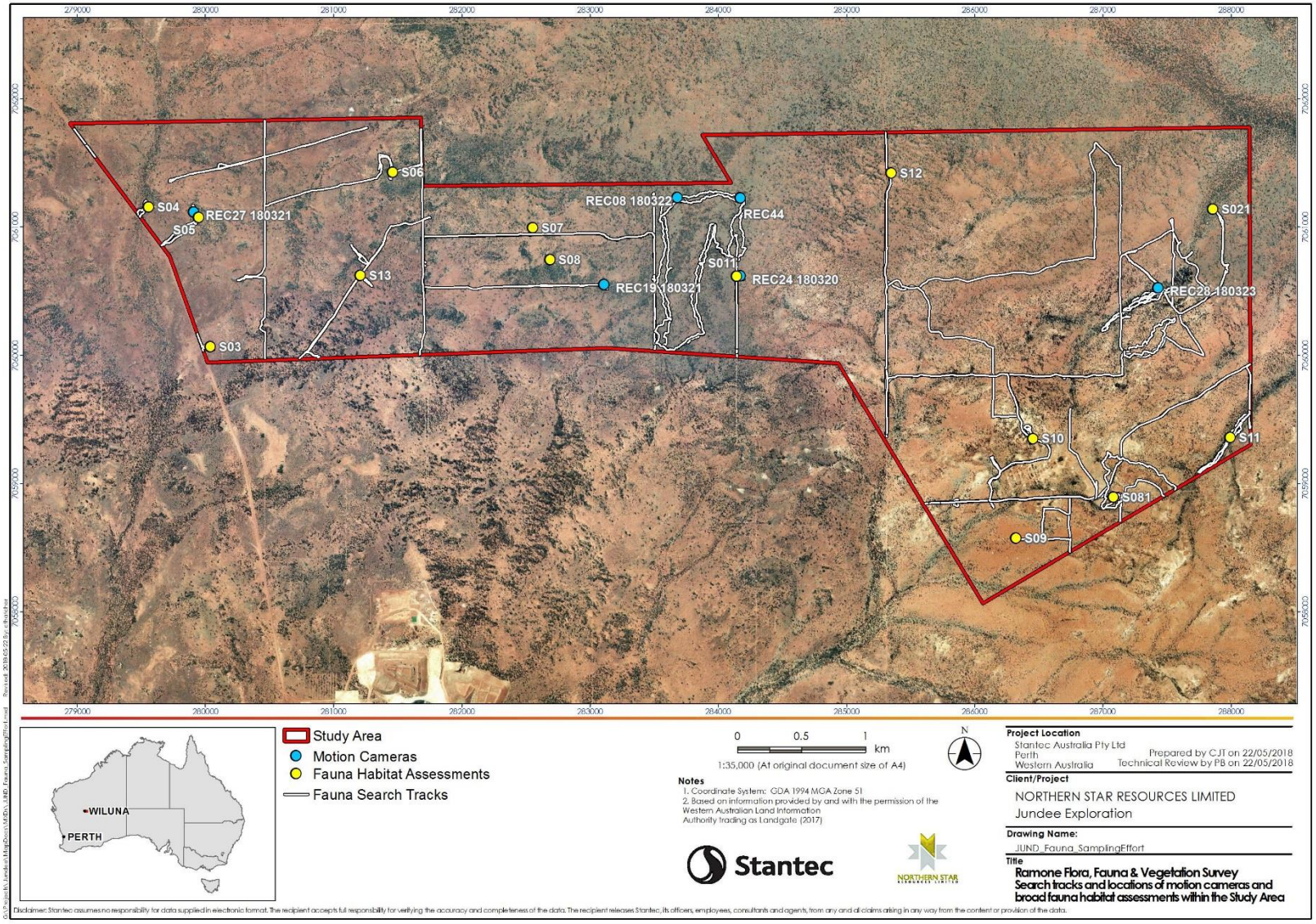


Figure 4-3: Search tracks and locations of motion cameras and broad fauna habitat assessments within the Study Area

5. Results

5.1 Survey Limitations and Constraints

There are a number of possible limitations and constraints that can impinge on the adequacy of flora, vegetation and fauna surveys (EPA 2016b, d) These are summarised in **Table 5-1**, with respect to the survey of the Study Area.

Table 5-1: Potential limitations and constraints of the field survey

Factor	Constraint	Comments
Competency and experience of consultants	No	The field personnel, Paul Bolton, Samantha Lostrom, Alice Bott and Crystal Heydenrych have appropriate qualifications and experience undertaking flora, vegetation and fauna surveys of this nature within the Murchison region. The specimen identifications were undertaken by senior taxonomist Sharnya Thomson, who has extensive Murchison experience.
Scope	No	The scope was well-defined. Flora, vegetation, fauna and their habitats were surveyed using standardised and well-established techniques. Relevant databases and previous studies surrounding the Study Area were reviewed.
Proportion of species identified	No	Survey sampling, timing, and intensity was considered adequate for the identification of most perennial species. Due to seasonal conditions, however, many of the annual species and grasses had senesced. Of the specimens collected from the Study Area, eight could only be identified to family level and six could only be identified to genus level. Further to this, five taxa were identified to species level and two taxa were identified to infraspecies level at a low confidence due to a lack of flowering and fruiting material. The floristic richness is considered to be in the lower range for the region in comparison to other surveys undertaken in the vicinity of the Study Area. It is considered this is largely due to the timing of the survey, following a month of below average rainfall (Section 4.1). All flora of conservation significance identified during the desktop assessment that were considered 'likely' to occur were perennials and could be identified at the time of the survey if present. The timing of the field survey was adequate for the Level 1 fauna survey.

Factor	Constraint	Comments
Information sources (e.g. historic or recent)	No	Stantec has completed numerous assessments in the Murchison region. Further to this, six flora and vegetation surveys and seven fauna surveys within proximity to the Study Area were available for review to obtain information about expected habitat and taxa present within the Study Area. Regional contextual information was also obtained from IBRA (Thackway and Cresswell 1995), land system data (Curry *et al.* 1994) and vegetation mapping of Western Australia Shepherd *et al.* (2002).
Completeness and Intensity	No	A total of 33 quadrats and four mapping notes were established and sampled across the Study Area. This was sufficient to adequately sample all broad vegetation types and flora within the Study Area.
Timing / weather / season / cycle	No	Seasonal conditions were considered adequate. Below average rainfall was received in the month prior to the flora and vegetation field survey, and as such some species could not be confidently identified due to lack of flowering and/or fruiting material. The field survey took place during the optimal time of year according to the guidelines for flora and vegetation surveys (EPA 2016f).
Disturbances	No	Owing to the presence of numerous tracks, parts of the Study Area were in a disturbed ecological state. Further to this, historical and present grazing and trampling by feral fauna including camels, cattle and rabbits had contributed to the alteration of vegetation from its natural state. None of these disturbances limited the outcomes of this report.
Resources	No	Resources were adequate to carry out the survey and the survey participants were competent in identification of species present. WAH herbarium specimens, taxonomic guides, DBCA database searches and the FloraBase database were all used to prepare for the survey and used for the confirmation of any flora species where identification was uncertain.
Remoteness / access problems	No	All survey sites were easily accessible by vehicle and on foot.

5.2 Desktop Assessment Results

5.2.1 Flora

Thirty nine flora taxa of conservation significance were identified from the database searches (**Appendix B**). Of the 39 taxa recorded, one taxon was listed as Threatened under the BC Act 2016, 11 taxa were listed as Priority1, two taxa were listed as Priority 2, 21 taxa were listed as Priority 3 and four taxa were listed as Priority 4.

One taxon, *Eremophila pungens* (P4), was listed as 'very likely' to occur and has been confirmed in the Study Area in the previous assessment conducted by Western Botanical (2011). In addition, the pre-survey assessment identified four additional taxa as 'Very Likely' to occur based on habitat requirements and previous recorded locations: *Aristida jerichoensis* var. *subspinulifera, Sida picklesiana*, *Tribulus adelcanthus* and *Xanthoparmelia nash*i (all listed as P3) (**Appendix B**).

5.2.2 Vegetation

No Threatened Ecological Communities (TEC's) were identified from the DBCA database search or the Department of the Environment and Energy's (DoEE) Protected Matters Database Search (DoEE 2018a) as occurring within or near to the Study Area. In addition, no terrestrial PECs were recorded within or in close proximity to the Study Area.

5.2.3 Terrestrial Vertebrate Fauna

The desktop study identified a total of 299 species of vertebrate fauna, which have been recorded and/or have the potential to occur within the Study Area (**Appendix C**). This total comprises 36 native mammal, 10 introduced mammal, 151 native bird, one introduced bird, 94 native reptile, and seven amphibian species. Many of these species are unlikely to occur in the Study Area because, as leading practice, these records have been collected from a large area encompassing a wide range of habitats, many of which do not occur within the Study Area. Furthermore, some small, common, ground-dwelling reptile and mammal species tend to be patchily distributed even where appropriate habitats are present, and many species of bird can occur as regular migrants, occasional visitors or vagrants.

Of the 229 species of vertebrate fauna identified during the desktop, 38 species are listed as being of conservation significance, comprising 12 mammals, 25 birds and one reptile (**Table 5-2**).

Table 5-2: Fauna of conservation significance identified during the desktop assessment

Species Name	Common Name	EPBC	WA
Dasycercus blythi	Brush-tailed Mulgara		P4
Dasycercus cristicauda	Crest-tailed Mulgara	Vu	P4
Sminthopsis longicaudata	Long-tailed Dunnart		P4
Isoodon auratus barrowensis	Barrow Island Golden Bandicoot	Vu	S3
Macrotis lagotis	Bilby	Vu	S3
Bettongia lesueur lesueur	Shark Bay Burrowing Bettong	Vu	S6
Bettongia lesueur 'Barrow Island form'	Barrow Island Burrowing Bettong	Vu	S6
Petrogale lateralis lateralis	Black-footed Rock-wallaby	En	S2
Lagorchestes hirsutus ssp. (NTM U2430)	Rufous Hare-wallaby (Point Peron)	En	S2
Leporillus apicalis	Lesser Stick-nest Rat	Ex	S4
Pseudomys fieldi	Shark Bay Mouse	Vu	S3
Macroderma gigas	Ghost Bat	Vu	S3
Leipoa ocellata	Malleefowl	Vu	S3
Plegadis falcinellus	Glossy Ibis	Mi	S5
Charadrius veredus	Oriental Plover	Mi	S5
Pluvialis fulva	Pacific Golden Plover	Mi	S5
Calidris acuminata	Sharp-tailed Sandpiper	Mi	S5
Calidris alba	Sanderling	Mi	S5
Calidris ferruginea	Curlew Sandpiper	Cr; Mi	S3; S5
Calidris melanotos	Pectoral Sandpiper	Mi	S5
Calidris ruficollis	Red-necked Stint	Mi	S5
Calidris subminuta	Long-toed Stint	Mi	S5
Tringa glareola	Wood Sandpiper	Mi	S5
Tringa hypoleucos	Common Sandpiper	Mi	S5
Tringa nebularia	Common Greenshank	Mi	S5

Species Name	Common Name	EPBC	WA
Glareola maldivarum	Oriental Pratincole	Mi	S5
Sterna nilotica	Gull-billed Tern	Mi	S5
Tyto novaehollandiae novaehollandiae	Masked Owl (SW ssp.)		P3
Apus pacificus	Fork-tailed Swift	Mi	S5
Falco hypoleucos	Grey Falcon		S3
Falco peregrinus	Peregrine Falcon		S7
Pezoporus occidentalis	Night Parrot	En	S1
Polytelis alexandrae	Princess Parrot	Vu	P4
Amytornis striatus striatus	Striated Grasswren		P4
Amytornis textilis textilis	Thick-billed Grass-wren (western ssp.)		P4
Motacilla cinerea	Grey Wagtail	Mi	S5
Motacilla flava	Yellow Wagtail	Mi	S5
Liopholis kintorei	Great Desert Skink	Vu	S3

1 – See **Appendix A** for terms and descriptions for conservation codes.

5.3 Flora

5.3.1 Flora Composition

A total of 104 flora taxa (including subspecies, varities and forms) were recorded from the Study Area, representing 21 families and 53 genera and including three introduced taxa (**Appendix G**). An additional four samples were unable to be identified beyond genus level and a further eight species were unable to be identified to species level. The most represented plant families were Poaceae (21), Fabaceae (20), Scrophulariaceae (13) and Chenopodiaceae (9); collectively comprising over 60% of the recorded taxa from the Study Area (**Figure 5-1**). The most represented plant genera were *Acacia* (14) and *Eremophila* (14); making up over 25% of the recorded taxa. The floral diversity recorded from the Study Area is within the lower range of the expected diversity in the Murchison compared to similar assessments of this nature in the general vicinity of the Project (**Table 3-2**). It is expected that the presence of annual plants would increase the total flora taxa count following a good wet season.

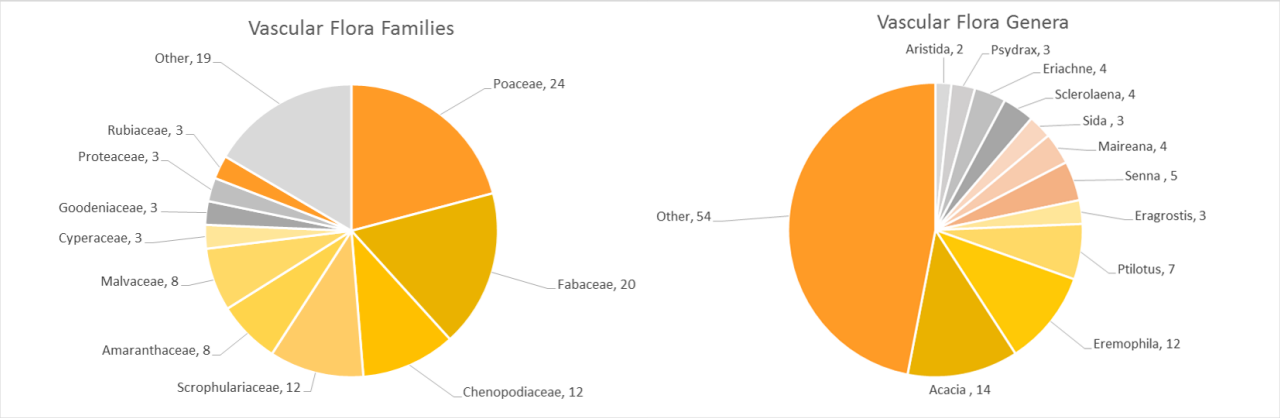


Figure 5-1: Flora composition of plant families and genera from the Study Area

5.3.2 Flora of Conservation Significance

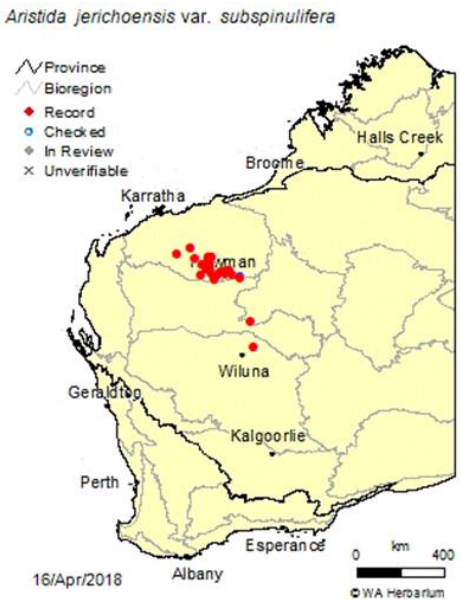
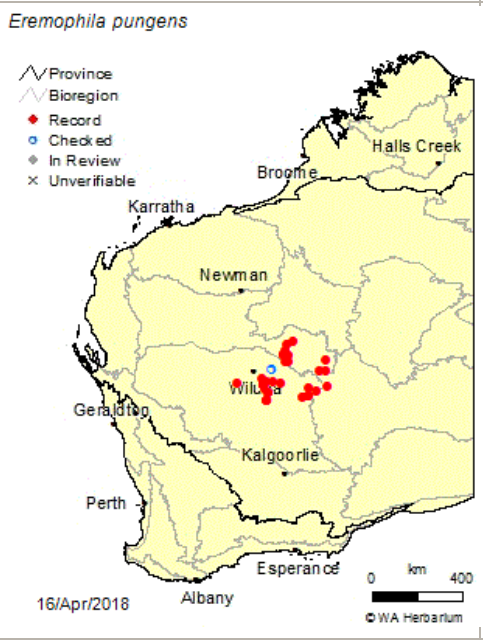
The field survey confirmed the presence of two priority-listed taxa: *Aristida jerichoensis* var. *subspinulifera* (P3) and *Eremophila pungens* (P4) (**Table 5-3**). The targeted survey did not involve species counts, due to the large numbers encountered, however, the supporting vegetation habitats for each of the identified conservation significant flora was mapped with a high level of confidence in the field.

A. jerichoensis var. *subspinulifera* is a compactly tufted perennial grass with a narrow inflorescence and grows 0.3-0.8m tall (DBCA 2018c). *A. jerichoensis* var. *subspinulifera* was identified in the ApAaAcEllEfEfFd vegetation type represented in **Table 5-4**, in un-channelled temporary drainage areas. This taxon is typically found in hardpan plains (WAH 2018) in a vegetation assemblage characterised by grasslands of *Cymbopogon obtectus*, *Digitaria ammophila*, *Eragrostis eriopoda, Neurachne minor, Thyridolepis multiculmis* with scattered *Acacia incurvaneura* and *Acacia pruinocarpa* trees (DBCA 2018c). In the Study Area, it was dominant in the tussock grassland layer with *Enneapogon polyphyllus*, *Eragrostis eriopoda* and *Eragrostis falcata*. Most specimens were senescent, however, some individuals were in seed. This taxon was identified from two locations in the eastern portion of the Study Area (**Figure 5-2**; **Appendix F**).

E. pungens is an erect, viscid shrub, 0.5-1.5m tall, and is restricted to stony slopes of hills and breakaways east of Wiluna to the edge of the Great Victoria Desert and south to Bandya Station (Chinnock 2007). It is distinguished from similar species due to its distinct rigid, erect, leaves that terminate in well-developed spines. *E. pungens* was identified from vegetative collections from the Study Area and was not in flower at the time that the flora field survey was completed, however, one individual had immature fruit. This taxon is typically found on plains, ridges and breakaways on sandy loam and clayey sand soils, associated with

Acacia pruinocarpa, Acacia aneura and *Acacia tetragonophylla* (DBCA 2018c). In the Study Area, it was identified from the AiEllAt vegetation type (**Table 5-3**) on skeletal soils and clayey sand. It was found in association with *Acacia tetragonophylla* and *Eremophila latrobei* subsp. *latrobei* in a low open shrubland. An estimated 700 plants of *E. pungens* were previously recorded on rocky outcrops within the Study Area (Botanica Consulting 2007).

Table 5-3: Flora of conservation concern identified in the Study Area

Taxon	Distribution in WA	Photograph
Aristida jerichoensis var. *subspinulifera* (P3)		
Eremophila pungens (P4) Flowering time: Jun-Oct.		

References: Distribution maps obtained from Western Australian Herbarium, Department of Biodiversity, Conservation and Attractions (https://florabase.dpaw.wa.gov.au/help/copyright); *Aristida jerichoensis* var. *subspinulifera* Photograph by Don Wood (2017)

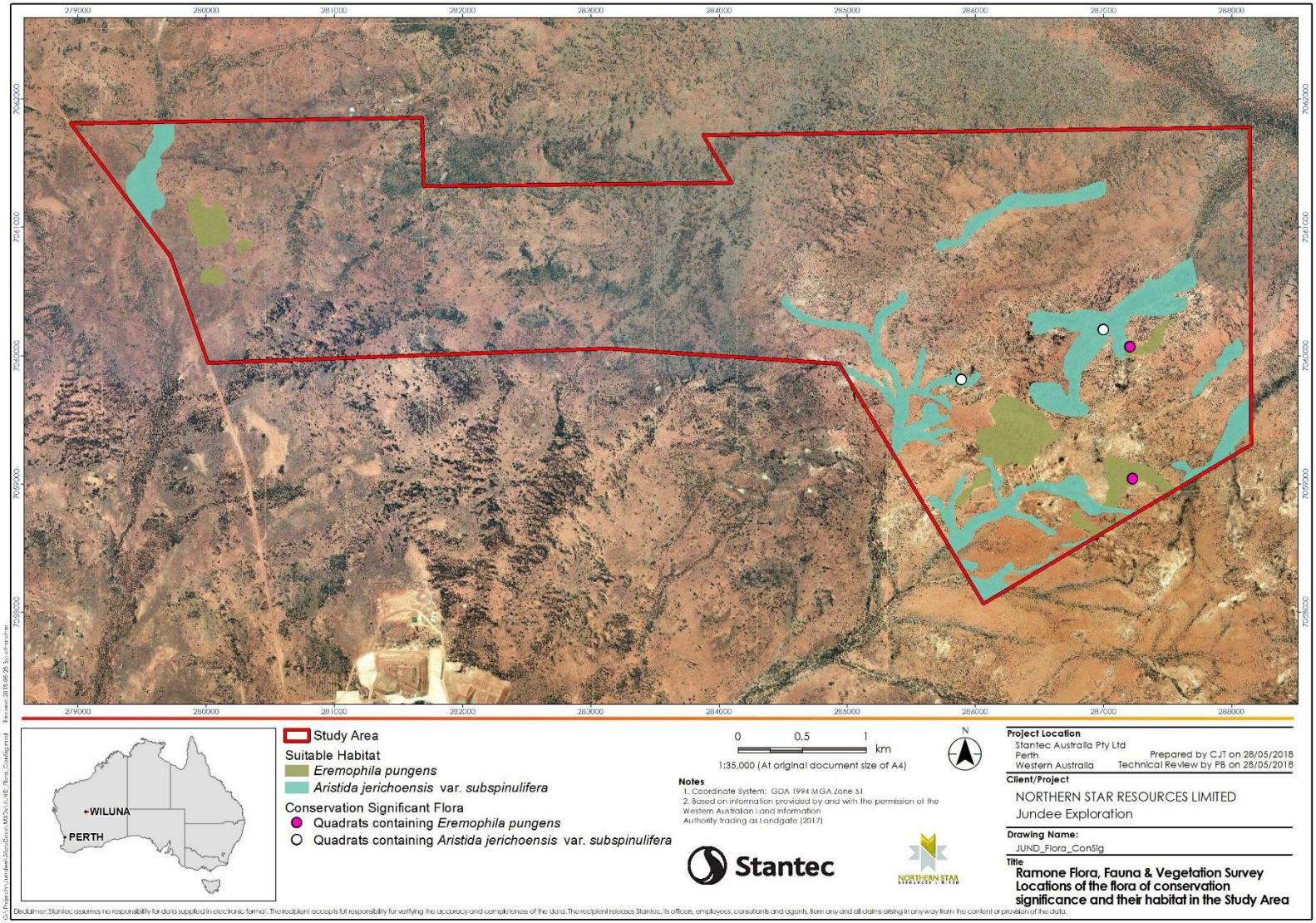


Figure 5-2: Locations of flora of conservation significance and their habitat in the Study Area

5.3.2.1 Post-survey Likelihood of Occurrence of Conservation Significant Flora

Following the field survey, with a greater understanding of the habitat types that occur within the Study Area, three Priorty 3 species, *Sida picklesiana, Tribulus adelacanthus* and *Xanthopermelia nashi* are considered to be 'likely' to occur within the Study Area but were not recorded during the field survey. All three species have previously been recorded within 30 km of the Study Area and suitable habitat for these species was identified within the Study Area. *Xanthoparmelia nashi* belongs to the foliose group of lichens which if present in the Study Area, may not have been recorded due to relatively dry conditions at the time of the field survey. *Sida picklesiana* and *Tribulus adelacanthus* are both herbs and/or shrubs, which if present in the Study Area, may have gone unnoticed due to their small habit, deciduous nature (*S. picklesiana*) and the likely absence of flowers and fruit at the time of the field survey. If present, none of these species would be restricted to the Study Area, as indicated by the vouchers records listed with the WAH.

5.3.3 Flora of Other Significance

The(EPA 2016b) advises that flora species, subspecies, varieties, hybrids and ecotypes may be considered significant for reasons other than listing as a Threatened or Priority Flora taxa, and may include the following:

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

Based on these parameters, none of the 100 native vascular flora taxa recorded from the Study Area are of "other" significance. The native vascular flora taxa recorded from the Study Area are represented in the local and regional area and no unique or unusual taxa were recorded.

5.3.4 Introduced Flora

Three introduced flora taxa were recorded within the Study Area (**Plate 5-1**), none of which are considered to be Declared Plant Pests listed under Section 22 of the *Biosecurity and Agriculture Management Act 2007* (BAM Act) or to be a Weed of National Significance (WoNS) identified by the Commonwealth Government:

- **Bidens bipinnata* (Bipinnate Beggartick);
- **Malvastrum americanum* (Spiked Malvastrum); and
- **Portulaca* pilosa (Djanggara).

Bidens bipinnata* was present in the AaAtS?sEs?bSeEe and ApAaAcEllEfEfFd vegetation types (Table 5-4**, **Figure 5-3**). In addition, one taxa from the Cucurbitaceae family is highly likely to be a weed species but was not identifiable to species level due to the absence of reproductive material.

Plate 5-1: *Bidens bipinnata*, *Malvastrum americanum* and *Portulacca pilosa*

Photography by G. Byrne, J. Dodd & Anonymous, J.F. Smith & E. Wajon and C. P. Campbell. Image used with the permission of the Western Australian Herbarium, Department of Biodiversity, Conservation and Attractions (https://florabase.dpaw.wa.gov.au/help/copyright).

5.4 Vegetation

5.4.1 Vegetation Types

Ten broad vegetation types were recorded within the Study Area. **Table 5-4** provides a summary of each of the vegetation types identified and **Figure 5-3** represents their distribution within the Study Area. The raw quadrat and mapping note data is presented in **Appendix F**. The vegetation can broadly be described as mixed mulga shrublands, of mostly *Acacia incurvaneura* and *Acacia pteraneura*, over a mixed mid shrubland layer comprised largely of the following shrubs: *Acacia tetragonophylla*, *Eremophila fraseri*, *Eremophila forrestii* subsp. *forrestii*, *Eremophila latrobei* subsp. *latrobei, Eremophila spectabilis* and *Sida ectogama*. The general topography showed little variation, with exception to low hills comprised of mulga shrubland over *Eremophila* spp. (AaEcTm) and low, sparsely vegetated outcrops (AiEllAt). The most widespread vegetation type was type AaApEf, occupying just over 30% and was found on plains in the central and eastern portions of the Study Area.

Ephemeral and temporary drainage areas were characterised by a denser upper canopy layer of trees and shrubs, as well as a higher density of grasses than the surrounding vegetation associated with plains. Ephemeral drainage areas were characterised by a distinct channel and supported the ApAaAcEllEfEfFd vegetation type, whereas temporary drainage areas lacked a definable channel and supported the AaAtS?sEs?bSeEe vegetation type. Owing to seasonal conditions, the grass layer in most vegetation types was significantly reduced, leaving much of the substrate exposed. It is expected that grasses will occupy a larger proportion of the area following sufficient rains.

Table 5-4: Vegetation types recorded within the Study Area

Code	Description	Quadrats & Mapping Notes	Area		Photograph
			ha	%	
AaEcTm	*Acacia aneura* tall shrubland over *Eremophila citrina* open low heath over *Triodia melvillei* very open hummock grassland	R22 R23 R24 Mn02	63.78	3.51	
AaApEf	*Acacia aptaneura* and *Acacia pteraneura* open low woodland over *Eremophila fraseri* open shrubland	R02 R03 R06	562.25	30.98	

Code	Description	Quadrats & Mapping Notes	Area		Photograph
			ha	%	
AaApEs?b.Ee	*Acacia aneura* and *Acacia aptaneura* open tall shrubland over *Eremophila spectabilis* subsp. *?brevis* open low shrubland over *Eragrostis eriopoda* open tussock grassland	R04 R26 R32 Mn01	519.80	28.66	
AaEffTb	*Acacia aneura* tall open shrubland over *Eremophila forrestii* subsp. *forrestii* low open shrubland over *Triodia basedowii* hummock grassland	R01 R31 R33	32.84	1.81	

Code	Description	Quadrats & Mapping Notes	Area		Photograph
			ha	%	
ApAiEcTm	*Acacia pruinocarpa* low open woodland over *Acacia incurvaneura* tall open shrubland over *Eremophila citrina* low shrubland over *Triodia melvillei* hummock grassland	R05 R25 R30 Mn03 Mn04	209.12	11.53	
AaAtS?sEs?bSeEe	*Acacia aneura, Acacia tetragonophylla* and *Santalum ?spicatum* tall open shrubland over *Eremophila spectabilis subsp ?brevis* and *Sida ectogama* low open shrubland over *Eragrostis eriopoda* open tussock grassland	R27 R28 R29	125.92	6.94	

Code	Description	Quadrats & Mapping Notes	Area		Photograph
			ha	%	
AiEllAt	*Acacia incurvaneura* tall shrubland over *Eremophila latrobei* subsp. *latrobei* and *Acacia tetragonophylla* open low shrubland	R07 R10 R11 R12 R15 R16	55.16	3.04	
ApAaAcEllEfEfFd	*Acacia pteraneura* and *Acacia aneura* open scrub over *Acacia craspedocarpa* and *Eremophila latrobei* subsp. *latrobei* open shrubland over *Eriachne flaccida* and *Eragrostis falcata* closed tussock grassland over *Fimbristylis dichotoma* very open sedgeland.	R17 R19 R20	152.37	8.39	

Code	Description	Quadrats & Mapping Notes	Area		Photograph
			ha	%	
ElAcSeMsp.	*Eremophila linearis* and*Acacia craspedocarpa* tall shrubland over *Ptilotus obovatus* herbland over *Sclerolaena eriacantha* and?*Maireana* sp. open chenopods	R13 R14 R18	56.41	3.10	
SMSeSc	Senna sp. Meekatharra (E. Bailey 1-26) hybrid open low shrubland over *Sclerolaena eriacantha* and *Sclerolaena cuneata* (*Maireana* sp.) very open herbland.	R08 R09 R34	37.04	2.04	
Total			1814.7	100	

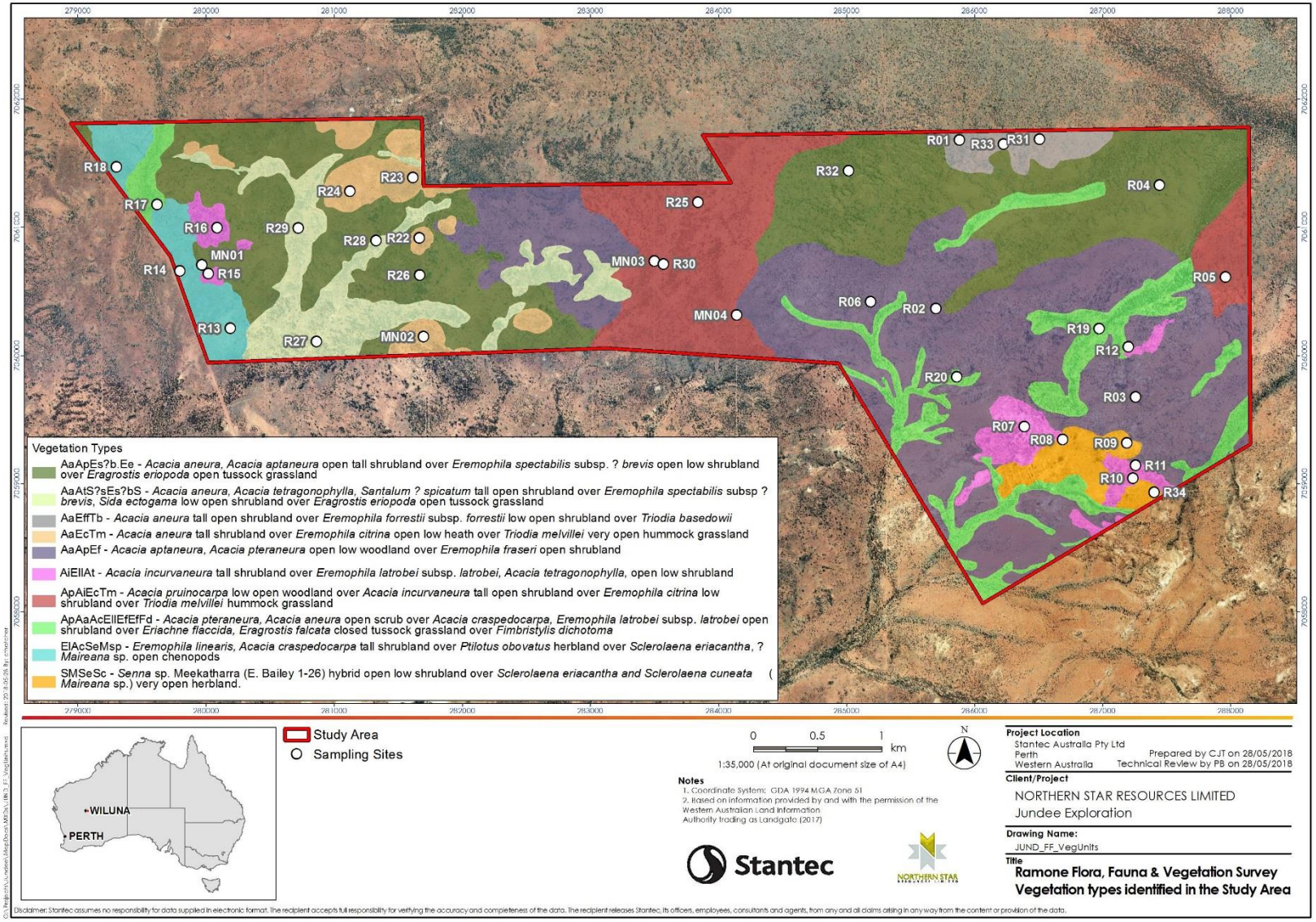


Figure 5-3: Vegetation types identified in the Study Area

5.4.2 Vegetation Condition

The vegetation in the Study Area ranged from 'Degraded' to 'Excellent' condition (Trudgen 1988) (**Table 5-5**; **Figure 5-3**), with the majority of the vegetation in a 'Very Good' condition. The primary impacts to vegetation condition were related to drilling activity and associated tracks, as well as trampling and grazing by feral fauna including camel, cattle and rabbit. Due to the presence of multiple tracks and drill lines, some areas had been severely impacted and are in a 'Degraded' condition. Together, this 'Degraded' vegetation accounts for 44.19 ha (2.43%) of the Study Area. Three introduced flora taxa were recorded within the AaAtS?sEs?bSeEe and ApAaAcEllEfEfFd vegetation types associated with a temporary and ephemeral un-channelled drainage networks (**section 5.3.2.1**).

Table 5-5: Vegetation condition extents across the Study Area

Condition rating	Area	
	ha	%
Excellent	387.46	21.35
Very Good	1284.77	70.80
Good	98.27	5.42
Degraded	44.19	2.44
Total	**1814.7**	**100**

Note: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.

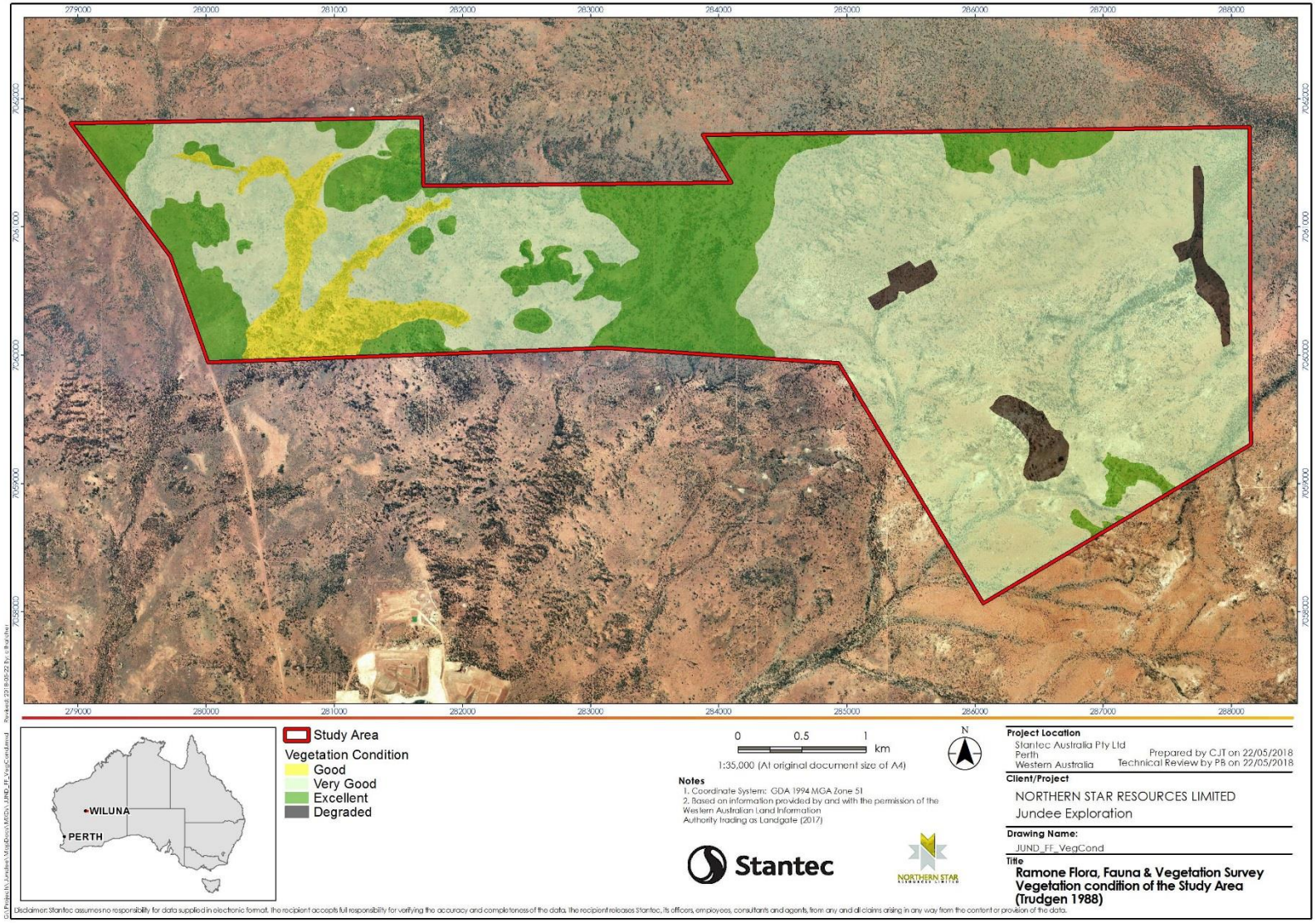


Figure 5-4: Vegetation condition of the Study Area (Trudgen 1988)

5.4.3 Vegetation of Conservation Significance

The EPA (EPA 2016b) advises that vegetation may be considered to be of significance for a range of reasons, other than a listing as a TEC or a PEC, including:

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

The desktop assessment did not identify any known TECs within the Study Area and the immediate surrounds. None of the vegetation types within the Study Area are analogous to any TECs under the EPBC Act, or listed by Parks and Wildlife, which qualify for special protection and there were no PECs directly related to terrestrial vegetation recorded within the Study Area. Further to this, the vegetation units described from the Study Area are not considered to represent any PECs known to occur in the Murchison bioregion.

Although two of the identified vegetation types were found to support priority taxa, *Aristida jerichoensis* var. *subspinulifera* (P3) and *Eremophila pungens* (P4) in the ApAaAcEllEfEfFd and AiEllAt vegetation types respectively; these vegetation types are well-represented throughout the Murchison region. In addition, *Aristida jerichoensis* var. *subspinulifera* is distributed throughout the Gascoyne and Greater Victoria Desert regions and *Eremophila pungens* is distributed throughout the Gascoyne and Pilbara regions. Based on the survey results, none of the vegetation types within the Study Area were considered to be of conservation significance on a local or regional scale.

5.5 Terrestrial Fauna

5.5.1 Fauna Habitat

Eight broad fauna habitats were identified and delineated from fauna habitat assessments conducted across the Study Area (**Table 5-7**, **Figure 5-5**). These comprised;

- Mulga shrubland over grasses;
- Mulga shrubland on stony plain;
- Mulga drainage;
- Mulga over spinifex on low hill;
- Eremophila shrubland;
- Low rocky hills with outcropping;
- Spinifex plain; and
- Senna shrubland on stony plain.

These habitats differed primarily in the composition of their vegetation and structure, in particular the density of grasses and taller Acacia sp., and the presence of large rocky outcrops. The habitat types in the Study Area were assessed on their extents and levels of significance according to the following criteria:

- Distribution: those habitats widespread and common within the surrounding regions were categorised as widespread; otherwise they were categorised as being of limited extent. The Low Rocky Hills with Outcropping were considered Limited Extent.
- Significance: those habitats considered important to species of conservation significance or distinct fauna assemblages are deemed significant; otherwise they were categorised as being of limited significance. Low rocky hills with outcropping and spinifex plain habitats were considered significant.
- SRE potential: habitats were categorised on the potential to support SRE invertebrate fauna based on the presence of microhabitats, whether the habitat was restricted or widespread in the landscape, and whether the habitat formed isolates or was well connected in the landscape. All habitats within the Study Area were considered to have low potential to support SRE species, with the exception of low rocky hills with outcropping which was considered to have a moderate potential to support SREs.

Table 5-6: Fauna habitats recorded within the Study Area

Habitat type	Proportion of Study Area		Veg. Types	Condition	Value to fauna	Reference Photographs
	ha	%				
Mulga shrubland over grasses • Widespread • Limited significance • Low SRE potential	519.80	28.64	AaApEs?b.Ee	'Degraded' to 'Very Good'	Plains with a sparse to moderate upper storey dominated by *Acacia aneura* interspersed with *Acacia pruinocarpa* over *Eremophila sp.*, *Senna sp.*, *Solanum sp.*, *Ptilotus schwartzii* and tussock grasses. These areas were impacted by tracks/ clearing associated with exploration, cattle/ camels and rabbit. Grasses would provide low cover and/or a food source for small reptiles, mammals and birds. The habitat contained minimal shelter in the form of woody debris and peeling bark.	 
Mulga shrubland on stony plain • Widespread • Limited significance • Low SRE potential	562.25	30.98	AaApEf	'Degraded' to 'Very Good'	Rocky plains with a sparse to moderate upper storey dominated by *Acacia aneura* interspersed with *Acacia pruinocarpa* over a sparse understorey comprising isolated *Eremophila sp.*, *Senna sp.*, *Solanum sp.* and *Ptilotus schwartzii*, occasionally with isolated patches of tussock grasses. The soil was covered by an abundant rocky substrate, with coarse fragments typically reaching ~6-20cm in diameter. Some areas contained lower levels of rocky substrate and vegetation cover (pictured left). This habitat was impacted by tracks/ clearing associated with exploration, cattle/ camels and rabbit. The sparse lower storey provided minimal cover for small mammals and reptiles, and the habitat did not contain a substantial amount of alternative shelters aside from the upper storey (woody debris, peeling bark etc.).	 
Mulga drainage • Widespread • Limited significance • Low SRE potential	278.30	15.34	AaAtS?sEs?bSeEe; ApAaAcEllEfEfFd	'Good' to 'Excellent'	Drainage lines occurred in locations prone to flooding (one contained water at the time of the survey), and varied in vegetation composition and density. The habitat ranged from relatively open areas dominated by *Acacia aneura* and tussock grasses (pictured lower right and left), to densely vegetated areas with a thick understorey (pictured top right and left). Densely vegetated drainage lines contained an upper storey of *Acacia aneura*, in some areas including *Eucalyptus sp* (including mallee) and *Grevillea striata*, over *Eremophila sp, Solanum, sp.* and tussock grasses. Drainage lines tended to be complex habitats, containing woody debris, leaf litter and peeling bark. The habitat occurred on sandy/clay soil and was impacted by tracks, clearing and cattle.	 

Habitat type	Proportion of Study Area		Veg. Types	Condition	Value to fauna	Reference Photographs
	ha	%				
					The complex nature of the drainage line habitat (e.g. fallen trees, dense vegetation) would provide shelter for reptile, mammal and bird species, and the relatively dense upper storey and diverse vegetation would provide a variety of feeding and nesting prospects. Higher levels of bird activity and large amounts of foraging evidence, particularly in areas with a dense understorey, were observed during the survey. Upon flooding, drainage lines would provide water sources and serve as suitable habitat for amphibians. One drainage line contained water at the time of the survey, which supported amphibians at various life stages.	 
Mulga over spinifex on low hill • Widespread • Limited significance • Low SRE potential	63.78	3.51	AaEffTb; ApAiEcTm	'Excellent'	Low hills with a sparse to moderate upper storey largely comprising *Acacia aneura* interspersed with *Acacia pruinocarpa* over *Eremophila sp., Solanum sp., Ptilotus schwartzii,* spinifex hummocks and patchy tussock grasses. Spinifex was long unburnt however was low and patchy, in some areas only comprising isolated hummocks (pictured right). Habitat occurred on low hills with rocky substrates on compact soil, and contained a limited degree of woody debris and peeling bark. These areas were impacted by tracks/ clearing associated with exploration, cattle and rabbits. The moderate upper storey occasionally associated with woody debris and peeling bark, combined with cover provided by spinifex and grasses, would serve as suitable habitat to a variety of bird, mammal and reptile species.	 
Eremophila shrubland • Widespread • Limited significance • Low SRE potential	56.41	3.11	ElAcSeMsp	'Excellent'	Plains with a sparse to moderate upper storey dominated by *Eremophila sp.* with isolated *Acacia aneura* over *Ptilotus sp., Solanum sp., Senna sp.* and isolated patches of tussock grasses. This habitat was impacted by tracks/ clearing associated with exploration, cattle/camel and rabbits. The sparse lower storey provided minimal cover for small mammals and reptiles, and the habitat did not contain a substantial amount of alternative shelters aside from the upper storey (woody debris, peeling bark etc.).	

Habitat type	Proportion of Study Area		Veg. Types	Condition	Value to fauna	Reference Photographs
	ha	%				
Low rocky hills with outcropping • Limited extent • Significant habitat • Moderate SRE potential	55.16	3.04	AiEllAt	'Degraded' to 'Excellent'	Rocky habitat comprising exposed bedrock and large rocky substrate covering most soil, with coarse fragments reaching ~20 – 60cm in some areas. Aspects of the outcropping habitat differed between the western area of the Study Area (pictured left) and the southeast (pictured right). Outcropping in the southeast contained isolated Acacia *pruinocarpa*, *Eremophila sp.*, including the Priority 4 *Eremophila pungens*, *Senna sp.* and in some areas *Melaleuca sp.*, while the western understorey was sparse and comprised *Eremophila sp.*, *Ptilotus schwartzii* and isolated tussock and spinifex grasses. The western outcrop also occurred on a relatively high hill with steeper slopes. Both supported an upper storey of *Acacia aneura*, which was denser in the west. This habitat contained a relatively complex substrate with rocky crevices that provide shelter for ground-dwelling fauna such as reptiles and mammals, and may serve as suitable habitat for the Long-tailed Dunnart (P4). These areas were not common throughout the Study Area, and as such species utilising this habitat may rely on rocky outcropping within the Study Area. SRE invertebrate species tend to have restricted distributions which are often aligned with mesic habitats, isolated habitats or both (Harvey 2002). Although the habitat is not particually mesic, it has a medium potential to support SRE invertebrates as the cracks and crevices form a unique microhabitat habitat that is not well represented or well connected in the surrounding plains.	 
Spinifex plain • Widespread extent • Significant habitat • Low SRE potential	241.96	13.33	AaEffTb; ApAiEcTm	'Degraded' to 'Excellent'	Plains with a sparse upper storey of *Acacia aneura* and *Acacia pruinocarpa* over low, long unburnt spinifex hummocks and sparse *Eremophila sp*. Spinifex plains contained some areas with a moderate upper storey associated with leaf litter, woody debris and peeling bark, and also contained large open areas lacking these features (pictured right). The substrate was compact and slightly stony. This habitat contained rabbit scats and was impacted by tracks associated with exploration and cattle. Spinifex habitat would provide low cover for various mammal and reptile species, and the substrate is suitable for foraging and burrowing (foraging evidence and two burrows were	 

Habitat type	Proportion of Study Area		Veg. Types	Condition	Value to fauna	Reference Photographs
	ha	%				
					observed during the survey). Areas containing a sparse Acacia upper storey and the associated peeling bark and woody debris would provide additional shelter for birds, mammals and reptiles. This habitat may be suitable for species such as the Brush-tailed Mulgara (P4) which was recorded within the habitat at three locations during the survey.	
Senna shrubland on stony plain • Widespread • Limited significance • Low SRE potential	37.04	2.04	SMSeSc	Very good – Degraded	Very open rocky plains with no upper storey and a sparse mid storey of *Senna sp.* Meekatharra (Bailey 1-26) hybrid over sparse *Sclerolaena eriacantha* and *Sclerolaena cuneata* (*Maireana* sp.). The substrate largely comprised bare soils and coarse rocky fragments, with minimal leaf litter and woody debris. This habitat was impacted by tracks. The open nature of the habitat and lack of tall vegetation provides minimal shelter for birds, mammals and reptiles. In some areas, large rocks may provide cover.	
Total	**1814.7**	**100**				

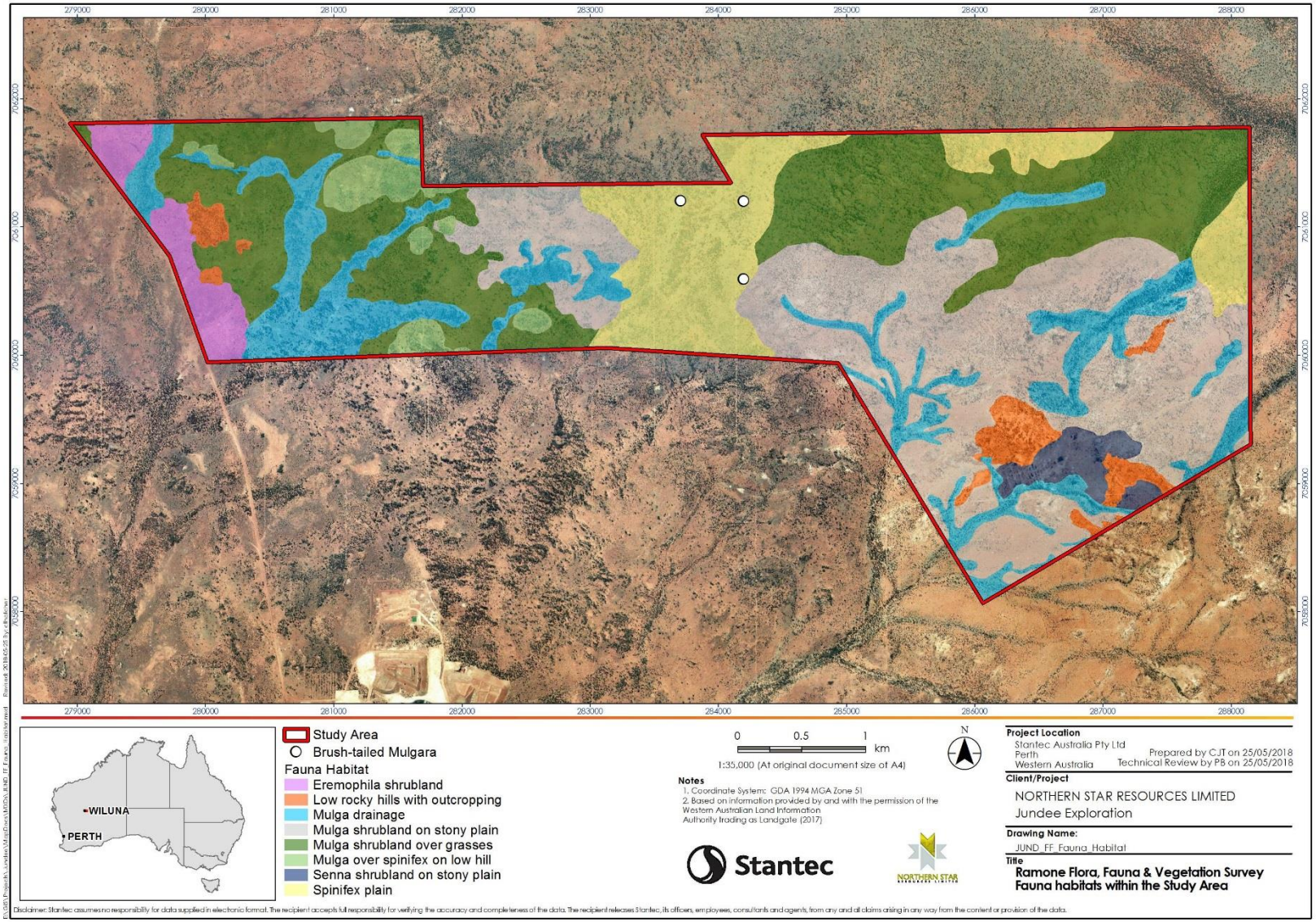


Figure 5-5: Fauna habitats within the Study Area

5.5.2 Fauna Assemblages

The field survey recorded a total of 41 species of vertebrate fauna, of which nine were mammals, 23 were birds and nine were reptiles (**Table 5-7**). One species of conservation significance was recorded; the Brush-tailed Mulgara (P4). Four introduced species were recorded; the dog, red fox, cat and camel.

Table 5-7: Vertebrate fauna species recorded from the Study Area during field survey

Species Name	Common Name	EPBC	WA
Tachyglossus aculeatus	Short-beaked Echidna		
Dasycercus blythi	Brush-tailed Mulgara		P4
Notomys alexis	Spinifex Hopping-mouse		
Osphranter robustus	Euro		
Osphranter rufus	Red Kangaroo		
Canis lupus	*Dog		
Vulpes vulpes	*Red Fox		
Felis catus	*Cat		
Camelus dromedarius	*Camel		
Aquila audax	Wedge-tailed Eagle		
Geopelia cuneata	Diamond Dove		
Ocyphaps lophotes	Crested Pigeon		
Falco berigora	Brown Falcon		
Falco cenchroides	Australian Kestrel		
Cacatua roseicapilla	Galah		
Melopsittacus undulatus	Budgerigar		
Platycercus zonarius	Australian Ringneck		
Malurus lamberti	Variegated Fairy-wren		
Malurus splendens	Splendid Fairy-wren		
Acanthagenys rufogularis	Spiny-cheeked Honeyeater		
Gavicalis virescens	Singing Honeyeater		
Manorina flavigula	Yellow-throated Miner		
Gerygone fusca	Western Gerygone		
Pomatostomus temporalis	Grey-crowned Babbler		
Cinclosoma castaneothorax	Western Chestnut-breasted Quail-thrush		
Artamus cinereus	Black-faced Woodswallow		
Cracticus tibicen	Australian Magpie		
Oreoica gutturalis	Crested Bellbird		
Colluricincla harmonica	Grey Shrike-thrush		
Pachycephala rufiventris	Rufous Whistler		
Rhipidura leucophrys	Willie Wagtail		
Petroica goodenovii	Red-capped Robin		
Gehyra variegata	Tree Dtella		
Diporiphora amphiboluroides	Mulga Dragon		
Pogona minor minor	Bearded Dragon		
Tympanocryptis pseudopsephos	Goldfields Pebble-mimic Dragons		
Egernia depressa	Southern Pygmy Spiny-tailed Skink		
Tiliqua multifasciata	Central Blue-tongue		

Species Name	Common Name	EPBC	WA
Varanus caudolineatus	Stripe-tailed Monitor		
Varanus gouldii	Sand Monitor		
Varanus panoptes	Yellow-spotted Monitor		

* Introduced species

5.5.3 Fauna of Conservation Significance

Of the 299 species of vertebrate fauna identified during the desktop, 38 species are listed as being of conservation significance, comprising 12 mammals, 25 birds and one reptile (**Table 5-8**). In addition, two invertebrate species of conservation significance, Moriarty's trapdoor spider (*Kwonkan moriartii*) and *Idiosoma clypeatum* (formerly recognised as the Shield-back Spider, *Idiosoma nigrum*) were identified. Of the 38 vertebrate species in the desktop study:

- 16 are listed as Threatened under the EPBC Act and/or BC Act;
- Seven are recognised by DBCA as Priority fauna. DBCA recognises several species that are not listed under the BC Act or the EPBC Act but for which there is some conservation concern, and has produced a supplementary list of Priority fauna;
- One species is recognised by the state (BC Act) to be in need of special protection; and
- 17 species are listed as Migratory under the EPBC Act and/or Schedule 5 under the BC Act.

Some of the species referred to above, listed as Threatened, Migratory and/or Priority fauna, may be included in multiple groups. The likelihood for species of conservation significance occurring in the Study Area was assessed and ranked based on the definitions described in the methodology. One species conservation significant vertebrate fauna was recorded within the Study Area during field survey; the Brush-tailed Mulgara (*Dasycercus blythi*, P4). Of the conservation significant species listed in the desktop study, seven are considered extinct in the region and were identified through fossil records or due to their reintroduction into predator proof enclosures Lorna Glen. These are considered Unlikely to occur, comprising:

- Barrow Island Golden Bandicoot (*Isoodon auratus barrowensis*) – Lorna Glen
- Barrow Island Burrowing Bettong (*Bettongia lesueur*) – Lorna Glen
- Rufous Hare-wallaby (*Lagorchestes hirsutus* ssp. (NTM U2430, Point Peron) – Lorna Glen
- Shark Bay Mouse (*Pseudomys fieldi*) – Lorna Glen
- Shark Bay Burrowing Bettong (*Bettongia lesueur lesueur*) – No records, identified in Protected Matters Search Tool
- Lesser Stick-nest Rat (*Leporillus apicalis*) – Fossil records
- Ghost Bat (*Macroderma gigas*) – Identified from 1961 record

One species, the Brush-tailed Mulgara (P4), was confirmed within the Study Area. Four species were considered to Possibly occur and the remaining 17 were assessed as Unlikely to occur.

Table 5-8: Fauna of conservation significance potentially occurring within the Study Area

Common name (*Scientific name*)	Conservation status		Broad habitat type	Likelihood of occurrence Reason for likelihood
	EPBC Act	In WA		
Mammals				
Brush-tailed Mulgara (*Dasycercus blythi*)	-	P4	Inhabit spinifex grass plains within the arid zone (van Dyck and Strahan 2008).	**Confirmed** The Study Area contains suitable spinifex plain habitat and occurs within the species range (van Dyck and Strahan 2008). The species was recorded at all three motion camera locations within Spinifex Plain habitat, equating to recordings on 18 nights (**Figure 5-5**). Thirteen of these were recorded at REC 44, which was deployed at foraging evidence of varying ages. This indicates the species may regularly use this area. The species has been recorded recently nearby, including during a 2014 – 2015 study ~56km south of the Study Area within similar habitat (Ecologia 2015), between 50km and 85km from the Study Area during 2014 (DBCA 2018d) and as recently as 2015 ~69km south of the Study Area (Engenium 2015).
Crest-tailed Mulgara (*Dasycercus cristicauda*)	Vu	P4	Sand dunes with sparse Sandhill Canegrass and salt lakes with Nitre Bush (van Dyck and Strahan 2008).	**Unlikely** Although two species of Mulgara are known to occur in Australia, it is now recognised that only the Brush-tailed Mulgara (*Dasycercus blythi*) (Priority 4 DBCA) occurs within Western Australia (DoEE 2018, (DoEE 2018b, van Dyck and Strahan 2008). The Crest-tailed Mulgara (*Dasycercus cristicauda*) (Vulnerable EPBC Act) is restricted in its distribution to the eastern portion of the Northern Territory, South Australia and potentially Queensland (DoEE 2018, (DoEE 2018b, van Dyck and Strahan 2008).
Long-tailed Dunnart (*Sminthopsis longicaudata*)	-	P4	Rocky, hilly areas, occasionally open areas with a stony, rocky mantle (van Dyck and Strahan 2008).	**Possible** The Study Area occurs within the species range and contains Low Rocky Hills with Outcropping, which may serve as suitable habitat (van Dyck and Strahan 2008). The species occurs within Lorna Glen (~30km northeast of the Study Area), and has also been recorded on seven occasions outside Lorna Glen from 2011 - 2015 (DBCA 2018d, DPaW 2015). The closest of these is a 2015 record ~53km east of the Study Area (DBCA 2018d).
Bilby (*Macrotis lagotis*)	Vu	S3	Occupy a range of habitats including sandplains and dune fields with spinifex, acacia shrubland on red soils and stony downs and Mitchell Grass near cracking clay (van Dyck and Strahan 2008).	**Unlikely** While the Study Area contains suitable habitat, it occurs outside of the species current range (van Dyck and Strahan 2008). The species was only identified via its reintroduction into Lorna Glen (~30km northeast of the Study Area) and secondary signs ranging from 2012 – 2014 recorded 143 – 168km north of the Study Area (DBCA 2018d). Due to this, the species is considered Unlikely to occur.
Black-footed Rock-wallaby (*Petrogale lateralis lateralis*)	En	S2	Occupies a wide range of habitats including spinifex on rocky hills, sandstone gorges and temperate rocky islands (van Dyck and Strahan 2008).	**Unlikely** The Study Area lies outside of the species current range, and only contains isolated low rocky/ outcrop areas unlikely to support the species (van Dyck and Strahan 2008). Secondary signs of species were recorded ~84km and ~109km southeast of the Study Area during 2009 and 2015 respectively, however these were on or near breakaway habitat absent in the Study Area (DBCA 2018d).
Birds				
Night parrot (*Pezoporus occidentalis*)	En	S1	Known to inhabit treeless or sparsely wooded long unburnt spinifex hummock plains often interspersed with chenopods (Pyke and Ehrlich 2014).	**Unlikely** While the Study Area does contain areas of long unburnt spinifex, these only formed small hummocks that may not be suitable for nesting. Furthermore, the species is incredibly rare and has not been recorded nearby (DBCA 2018d, Pizzey and Knight 2007).
Princess Parrot (*Polytelis alexandrae*)	Vu	P4	Often found far from fresh water, inhabits areas with spinifex under Eucalypts, acacias, desert oaks and poplars, hakeas and mistletoes or vegetation near saltlakes (Pizzey and Knight 2007).	**Unlikely** The species has not been recorded recently nearby, and the Study Area lies within the irregular species range (Pizzey and Knight 2007). Furthermore, the species is typically nomadic and rare (Pizzey and Knight 2007).
Striated Grasswren (*Amytornis striatus striatus*)	-	P4	Inhabits areas with Acacia and mallee over spinifex and inland and coastal scrubs (Pizzey and Knight 2007).	**Unlikely** While the Study Area contains suitable habitat, it lies outside of the species range (Pizzey and Knight 2007). The species has only been recently recorded nearby once in Wanjarri Nature Reserve with moderate certainty, ~84km from the Study Area during 2016 (DBCA 2018d).
Thick-billed Grass-wren (western ssp.) (*Amytornis textilis textilis*)	-	P4	Inhabits sandy lowland gibber plains with dense, low bush including saltbush, bluebush, cottonbush and nitre-bush, or in flood debris and dense cane-grass on the edges of water (Pizzey and Knight 2007).	**Unlikely** The Study Area lies outside of the species range and the species has not been recorded recently nearby.

Common name (*Scientific name*)	Conservation status		Broad habitat type	Likelihood of occurrence Reason for likelihood
	EPBC Act	In WA		
Malleefowl (*Leipoa ocellata*)	Vu	S3	Mainly scrubs and thickets of mallee, boree and bowgada, but also other litter forming shrublands (Johnstone and Storr 1998).	**Unlikely** The Study Area contains mallee, however lies north of the species range (Pizzey and Knight 2007). The species has most recently been recorded in 2010 via secondary signs 140km west of the Study Area. The most recent sighting was recorded in 2007 ~90km southwest of the Study Area, with most other sightings occurring in 2000 or earlier (DBCA 2018d). Due to the lack of recent sightings in the region and the species typically inhabiting areas to the south of the Study Area, the species is considered Unlikely to occur.
Fork-tailed Swift (*Apus pacificus*)	Mi	S5	Aerial species, which forages high above the tree canopy and rarely lower (Johnstone and Storr 1998). Occurs over a range of habitats including islands, open country, coasts, semi-deserts, urban, forests (Pizzey and Knight 2007).	**Possible** The Study area occurs within the species range and potentially contains suitable habitat (Pizzey and Knight 2007). However, the only recent nearby record of the species was recorded 109km southwest of the Study Area in 2015. Due to this, the species is considered Possible to occur.
• Yellow Wagtail (*Motacilla flava*) • Grey Wagtail (*Motacilla cinerea*)	Mi	S5	Yellow and Grey Wagtails are listed as rare vagrants to the Australian continent from the North. Inhabit areas associated with water including running water/ streams, sewage ponds, swamp margins and saltmarshes and lawns, ploughed fields and airfields (Pizzey and Knight 2007).	**Unlikely** The species are sparsely distributed in Murchison region, have not been recorded nearby and suitable habitat is not present within Study Area. The species were identified as the 'species or species habitat may occur in the area' (DoEE 2018a).
Twelve Sanderling, Sandpiper, Greenshank, Pratincole, Plover and Stint species from the families: • Scolopacidae • Glareolidae • Charadriidae	Mi	S5	Small to large sized shore birds. Inhabit shallow aquatic areas on coasts, mudflats, saltmarshes, estuaries, lake margins and other inland waters and bore or grassy plains (Johnstone and Storr 1998).	**Unlikely** The species have not been recorded nearby within the last 20 years, with the exception of the Sharp-tailed Sandpiper, which was observed in samphire flats habitat >40km west of the Study Area during 2010 (Outback Ecology 2011). However the Study Area does not contain suitable habitat and therefore the species are considered unlikely to utilise the Study Area.
Gull-billed Tern (*Sterna nilotica*)	Mi	S5	Shallow sheltered seas close to land, estuaries, tidal creeks; and inundated samphire flats, flooded saltlakes, claypans and watercourses in the interior (Johnstone and Storr 1998). Tends to breed on islands in inland lakes (Pizzey and Knight 2007).	**Unlikely** The Study Area does not contain suitable habitat, and the species has only been recorded twice nearby; 108km south west of the Study Area in 2015 and 75km north east of the Study Area in 2003 (DBCA 2018a, d, Pizzey and Knight 2007). Due to this, the species is considered unlikely to utilise the Study Area.
Glossy Ibis (Plegadis falcinellus)	Mi	S5	Freshwater wetlands, irrigated areas, margins of dams, floodplains, brackish and saline wetlands, tidal mudflats, pastures, lawns and public gardens (Johnstone *et al.* 2013)	**Unlikely** The species has not been recorded nearby since 1980 and the Study Area occurs outside the species range (DBCA 2018d, Pizzey and Knight 2007). The only aquatic habitat within the Study Area are drainage lines that temporarily contain water, and as such is unlikely to provide suitable habitat for the species.
Peregrine Falcon (*Falco peregrinus*)	-	S7	The species occurs along coastal cliffs, rivers and ranges as well as wooded watercourses and lakes nesting on cliffs, granite outcrops, quarries (Johnstone and Storr 1998).	**Possible** The species has been recorded on numerous occasions nearby, however only two of these occurred within the last 10 years (128km west in 2014 and 73km south in 2015) (DBCA 2018d, Engenium 2015). The Study contains suitable habitat and occurs within the species range, however the species tends to be uncommon (Pizzey and Knight 2007).
Grey Falcon (*Falco hypoleucos*)	-	S3	Mainly lightly wooded coastal and riverine plains (Johnstone and Storr 1998).	**Possible** The Grey Falcon has been recorded recently, including in 2012 and 2013 ~35km and 113km from the Study Area respectively, and the Study Area may contain suitable habitat (DBCA 2018d, Pizzey and Knight 2007). However the species is rare, the Study Area occurs within the irregular species range, and there are only four records of the species nearby since 2000 (DBCA 2018d, Pizzey and Knight 2007). Due to this, the species is considered to possibly occur.
Masked Owl (SW ssp.) (*Tyto novaehollandiae novaehollandiae*)	-	P3	Inhabits forests, open woodlands and farmlands with tall trees (Pizzey and Knight 2007).	**Unlikely** The species tends to inhabit south west and north WA, which occurs outside the Study Area (Pizzey and Knight 2007). The species is very sparsely distributed and no dated records occur near the Study Area since 1942 (DBCA 2018d, Pizzey and Knight 2007). As such, the Masked Owl is considered unlikely to occur.
Reptiles				
Great Desert Skink (*Liopholis kintorei*)	Vu	S3	Arid areas with spinifex sandflats and clay/ loamy soils (Wilson and Swan 2013).	**Unlikely** While the Study Area contains suitable habitat, the species has not been recorded nearby since 1964, and as such is considered unlikely to occur (DBCA 2018d).

Common name (*Scientific name*)	Conservation status		Broad habitat type	Likelihood of occurrence Reason for likelihood
	EPBC Act	In WA		
Invertebrates				
Idiosoma clypeatum		P3	-	**Unlikely** The *Idiosoma* genus has recently undergone taxonomic revision. *Idiosoma clypeatum* (formerly known by WAM identification code 'MYG018') is now recognised as a distinct species from *Idiosoma nigrum*. *Idiosoma nigrum* was identified by the Threatened Fauna DBCA database search as occurring in the vicinity of the Study Area, however it is now recoganised as only occurring in the central and central-western Wheatbelt bioregion (DBCA 2018b, d, Rix *et al.* 2018). *Idiosoma clypeatum* has recently been classified as P3, with a range extending "from near Paynes Find, the Blue Hill Range, Kadji Kadji Nature Reserve, and Karara in the south, north and north-east to at least Coolcalalaya Homestead, Jack Hills, Albion Downs, Yakabindie, and Yeelirrie" (Rix *et al.* 2018). The Study Area lies ~90km north east of the northern most point of the species range, and as such the species is considered unlikely to occur.
Moriarty's trapdoor spider (*Kwonkan moriartii*)	-	P2	-	**Unlikely** There are two records of the species collected ~95km south of the Study Area in 1962. Given that the date of collection (13/01/1962) is the same for both specimens it is possible that one of the records is erroneous. There are no other records of this species. Given that there has not been any records of the species within the last 50 years, it is unlikely the species occurs within the Study Area.

6. Discussion

The total number of flora taxa recorded from quadrats and opportunistic sampling amounted to 104.Of the flora taxa recorded, two were of conservation significance: *Aristida jerichoensis* var. *subspinulifera* (P3) and *Eremophila pungens* (P4). These taxa were found in the ApAaAcEllEfEfFd and AiEllAt vegetation types, respectively.

The floristic diversity is considered to be on the lower range for what would be expected from the Murchison bioregion based on a comparison to similar surveys in the vicinity of the Study Area. Despite recording above average rainfall in total in the 3 months preceding the survey, below average rainfall was received in March, one month prior to the survey. It is expected that the presence of annual species would increase the total species richness of the Study Area, following on from optimal rainfall conditions.

The vegetation types recorded within the Study Area are generally representative of what would be expected from similar landforms in the Murchison bioregion. Ten vegetation types were identified in the Study Area, none of which are analogous to any listed TECs or PECs. Vegetation condition ranged from 'Degraded' to 'Excellent', with most of the Study Area in a 'Very Good' condition. 'Degraded' vegetation condition was recorded where the the vegetation had been impacted by clearing for tracks and drill lines. Vegetation considered to be in 'Good' condition had been fragmented due to the network of tracks and drill lines that dissect the Study Area. Other types of disturbance within the Study Area included grazing and trampling by feral animals.

Weed diversity and density within the Study Area is considered to be low, with three (potentially four) introduced flora taxa recorded, none of which represent a declared prest or WONS. **Bidens bipinnata*, however, is easily dispersed via seed and has the potential to spread in response to disturbance. **Bidens bipinnata* was present within the AaAtS?sEs?bSeEe vegetation type

Eight fauna habitats were identified within the Study Area; mulga shrubland over grasses, mulga shrubland on stony plain, mulga drainage, mulga over spinifex on low hill, eremophila shrubland, low rocky hills with outcropping, spinifex plain and senna shrubland on stony plain. Of these, all habitats were considered to have low SRE potential with the exception of low rocky hills with outcropping. This was considered to have moderate SRE potential owing to its limited and isolated extent. Spinifex plains and low rocky hills with outcropping were considered to have the highest potential significance to fauna. This is owing to the limited extent of the complex and unique habitat provided by rocky outcrops, which may support the Long-tailed Dunnart (P4). Old, unburnt spinifex in the spinifex plain habitat provides habitat to the Brush-tailed Mulgara (P4), which was confirmed within this habitat in the Study Area.

A total of 41 species of vertebrate fauna were recorded during the field survey, of which one was of conservation significance; the Brush-tailed Mulgara (P4). The species was recorded at all three motion cameras deployed within spinifex plain habitat. Future development of suitable Brush-tailed Mulgara habitat (Spinifex Plain) should be minimised to reduce impacting the species. Four species of conservation significance were considered to possibly occur based on habitat suitability, species range and previous records; the Long-tailed Dunnart (P4), Fork-tailed Swift (Mi S5), Peregrine Falcon (S7) and the Grey falcon (S3).

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Appendices

Appendix A Codes and Terms Used to Describe Species of Conservation Significance

Flora and fauna may be accorded legislative protection by being listed under the Environment Protection and Biodiversity Conservation Act 1999 (Cwlth) (EPBC Act) and/or the Biodiversity Conservation Act 2016 (WA) (BC act), or by being listed on the WA Department of Environment and Conservation's Priority Species List. This Appendix presents a summary of the different rankings and listings used to describe conservation status. Some categories, such as 'extinct', 'extinct in the wild' and 'conservation dependent' (EPBC Act) are not presented here, as the table includes only the information needed to fully understand the codes presented in the preceding report. Refer to the relevant legislation for a full description of all codes in use, as well as their associated criteria.

Definitions of codes and terms used to describe flora and fauna of conservation significance

Categories used under the EPBC Act		
Status	**Code**	**Description**
Critically Endangered	**Cr**	Taxa that is considered to be facing an extremely high risk of extinction in the wild in the immediate future
Endangered	**En**	Taxa that is considered to be facing a very high risk of extinction in the wild in the near future
Vulnerable	**Vu**	Taxa that is considered to be facing a high risk of extinction in the wild in the medium-term future
Migratory	**Mi**	Species that migrate to, over and within Australia and its external territories

Schedules used under the BC Act			Description
Status	**Code**	**Schedule**	
Critically Endangered	**Cr**	**S1**	Taxa that is rare or likely to become extinct, as critically endangered taxa
Endangered	**En**	**S2**	Taxa that is rare or likely to become extinct, as endangered taxa
Vulnerable	**Vu**	**S3**	Taxa that is rare or likely to become extinct, as vulnerable taxa
Presumed Extinct	**Ex**	**S4**	Taxa that is presumed to be extinct
Migratory	**Mi**	**S5**	Birds that are subject to international agreements relating to the protection of migratory birds
Conservation Dependent	**CD**	**S6**	Taxa that are of special conservation need being species dependent on ongoing conservation intervention
Special Protection	**SP**	**S7**	Taxa that is in need of special protection

Appendix B Conservation Significant Flora Known to Occur, Likely to Occur, or Possibly Occurring in the Study Area Prior to the Field Survey

Species	Habitat	EPBC Act	BC Act	DBCA	Approximate Nearest Locality (km)	Likelihood of Occurrence
Aristida jerichoensis var. subspinulifera	Hardpan plains.			3	30 (N)	Confirmed within the Study Area
Atriplex yeelirrie	Self-mulching clay in depressions and is confined to clay flats underlain with calcrete (Western Botanical 2011).	T	T	T	85 (SW)	Unlikely: This taxon is known from only two populations and Study Area does not contain suitable habitat(Western Botanical 2011).
Baeckea sp. London Bridge (M.E. Trudgen 5393)	Gravel, sandstone. Rocky breakaways & hills.			3	172 (SW)	Unlikely: The Study Area lies outside its known distribution of this taxon
Baeckea sp. Sandstone (C.A. Gardner s.n. 26 Oct. 1963)	Orange sand. Flats.			3	154 (S)	Unlikely: The Study Area lies outside its known distribution of this taxon
Bossiaea eremaea	Deep red sand.			3	96 (SW)	Unlikely: The Study Area lies outside its known distribution of this taxon
Calytrix verruculosa	Sandy clay.			3	224 (W)	Unlikely: The Study Area lies outside its known distribution of this taxon
Cratystylis centralis	Red sandy loam with ironstone gravel. Flat plains, breakaway country.			3	61 (SE)	Unlikely: The Study Area lies outside its known distribution of this taxon
Dampiera plumosa	Red sandy soils.			1	180 (SW)	Unlikely: The Study Area lies outside its known distribution of this taxon
Eremophila anomala	Basalt outcrop.			1	120)N)	Unlikely: The Study Area lies outside its known distribution of this taxon
Eremophila arguta	Mulga washes.			1	44 (W)	Unlikely: The Study Area lies outside its known distribution of this taxon
Eremophila campanulata	Stony red/brown clay			3	140 (E)	Unlikely: The Study Area lies outside its known distribution of this taxon
Eremophila congesta	Lateritic outcrops in greenstone hills, stony quartzite slopes.			1	58 (W)	Unlikely: The Study Area lies outside its known distribution of this taxon
Eremophila flaccida subsp. attenuata	Stony clay over quartzite. Hillslopes, ridges.			3	500	Unlikely: The Study Area lies outside its known distribution of this taxon
Eremophila gracillima	Stony flats.			3	49(S)	Unlikely: The Study Area lies outside its known distribution of this taxon
Eremophila pungens	Associated vegetation: *Acacia pruinocarpa, A. aneura, A. tetragonophylla*. Sandy loam, clayey sand over laterite. Plains, ridges, breakaways.			4	Previously recorded in Study Area (Botanica Consulting 2007)	Confirmed within the Study Area
Eremophila sp. long pedicels (G. Cockerton 1975)	Drainage tract mulga shrublands (DRMS).			2	45 (SW)	Unlikely: The Study Area lies outside its known distribution of this taxon
Euryomyrtus inflata	Deep red sand. Flat plain.			3	58 (W)	Unlikely: The Study Area lies outside its known distribution of this taxon
Goodenia sp. Beyondie (L.W. Sage & S. van Leeuwen LWS 2518) PN	Dry, bare, clayey sand, saline soils. Near salt lake.			1	204 (N)	Unlikely: The Study Area lies outside its known distribution of this taxon
Grevillea inconspicua	Loam, gravel. Along drainage lines on rocky outcrops, creeklines.			4	83 (S)	Unlikely: The Study Area lies outside its known distribution of this taxon
Gunniopsis propinqua	Stony sandy loam. Lateritic outcrops, winter-wet sites.			3	91 (S)	Unlikely: The Study Area lies outside its known distribution of this taxon
Hemigenia exilis	Laterite. Breakaways, slopes.			4	43 (E)	Unlikely: The Study Area lies outside its known distribution of this taxon
Homalocalyx echinulatus	Laterite. Breakaways, sandstone hills.			3	77 (W)	Unlikely: The Study Area lies outside its known distribution of this taxon
Labichea eremaea	Red sand.			3	201 (SW)	Unlikely: The Study Area lies outside its known distribution of this taxon
Lepidium xylodes	Gravelly loam, clayey sand.			1	274 (W)	Unlikely: The Study Area lies outside its known distribution of this taxon

Species	Habitat	EPBC Act	BC Act	DBCA	Approximate Nearest Locality (km)	Likelihood of Occurrence
Mirbelia stipitata	Red sandy loam.			3	81 (SW)	Unlikely: The Study Area lies outside its known distribution of this taxon
Neurachne lanigera	Red sand, laterite. Rocky outcrops, plains.			1	105 (SW)	Unlikely: The Study Area lies outside its known distribution of this taxon
Olearia mucronata	Schistose hills, along drainage channels.			3	79 (N)	Unlikely: The Study Area lies outside its known distribution of this taxon
Paspalidium distans	Loam. River banks			4	54 (S)	Unlikely: The Study Area lies outside its known distribution of this taxon
Pityrodia canaliculata	Red sand.			1	298 (SW)	Unlikely: The Study Area lies outside its known distribution of this taxon
Prostanthera ferricola	Shallow red-brown skeletal sandy loam on banded ironstone, laterite, basalt or quartz. Gently inclined mid to upper slopes of hills, rocky crests, and outcrops.			3	97 (W)	Unlikely: The Study Area lies outside its known distribution of this taxon
Rhagodia sp. Yeelirrie Station (K.A. Shepherd et al. KS 1396)	Shrubland on calcrete.			1	112 (W)	Unlikely: The Study Area lies outside its known distribution of this taxon
Sauropus sp. Woolgorong (M. Officer s.n. 10/8/94)	Red sand. Plains.			3	109 (SW)	Unlikely: The Study Area lies outside its known distribution of this taxon
Sida picklesiana	Acacia (*A. aneura, A. quadrimarginea, A. pruinocarpa, A. balsamea*) woodlands and shrublands on a variety of substrates, often on exposed, rocky habitats on hills of BIF and granite breakways, on footslopes of BIF hills, on stony plains (ironstone and quartz) and near creeklines (Markey *et al.* 2011).			3	30 (N)	Likely: The Study Area lies close to the known location, and contains suitable habitat
Stackhousia clementii	Skeletal soils. Sandstone hills.			3	70 (W)	Unlikely: The Study Area lies outside its known distribution of this taxon
Stenanthemum mediale	Red clayey sand.			1	87 (W)	Unlikely: The Study Area lies outside its known distribution of this taxon
Tecticornia sp. Lake Way (P. Armstrong 05/961)	Salt lakes.			1	47 (S)	Unlikely: The Study Area lies outside its known distribution of this taxon
Tribulus adelacanthus	*Eremophila forrestii* subsp. *forrestii* and/or *Eremophila glaeata* isolated shrubs over *Solanum lasiophyllum. Aristida contorta* isolated herbs and tussock grasses.			3	28 (N)	Likely: The Study Area lies close to the known location, and contains suitable habitat
Triodia infesta	Associated vegetation: no mulga; *Eremophila* sp., *Dodonaea viscosa, Solanum* sp., *Euphorbia* sp., Goodeniaceae spp., rare *Triodia basedowii*.			2	100(E)	Unlikely: The Study Area lies outside its known distribution of this taxon
Xanthoparmelia nashii	Scrub to woodland to hummock grasslands. On sheltered dry stone on ground layer. Plains to outcrops to flood plains with various dry brown-grey soils.			3	22 (SW)	Very Likely: The Study Area lies close to the known location, and contains suitable habitat

Sources: DBCA (2018c), DBCA (2018a) and Australian Government (2018)

Appendix C Vertebrate Fauna Identified from the Desktop Assessment

Legend:

A Current Survey

Database searches:

B Birdata: Custom Atlas Bird List (Birdlife Australia 2018)

C Threatened and Priority Fauna Search (DBCA 2018d)

D NatureMap Database (DBCA 2018a)

E Protected Matters Search Tool (DoEE 2018c)

Literature Review

F Lorna Glen (Matuwa) small vertebrate fauna monitoring program 2002-2010 – Preliminary Analysis and Review (DPaW 2015)

G Lake Maitland to Millipede Haul Road Vertebrate Fauna and Fauna Habitat Assessment Draft Report (Ecologia 2015)

H Level 2 Vertebrate Fauna & Targeted Reptile Survey Report (Engenium 2015)

I Wiluna Uranium Project: Targeted Terrestrial Fauna Survey and Habitat Assessment (Outback Ecology 2012)

J Wiluna Uranium Project: Terrestrial Fauna Assessment (Outback Ecology 2011)

K Main Roads WA: Goldfields Highway - Wiluna to Magellan Section. Preliminary Environmental Impact Assessment and Biological Survey (GHD 2005)

L Preliminary Analysis of Fauna Sampling for CALM's Feral Cat Research Program at Lorna Glen (Cowan 2004)

Family	Species Name	Common Name	EPBC	WA	A	B	C	D	E	F	G	H	I	J	K	L
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked Echidna			x							x		x		
Dasyuridae	*Dasycercus blythi*	Brush-tailed Mulgara		P4	x		x	x			x	x				
	Dasycercus cristicauda	Crest-tailed Mulgara	Vu	P4			x									
	Ningaui ridei	Wongai Ningaui						x		x	x	x		x		x
	Pseudantechinus woolleyae	Woolley's Pseudantechinus						x		x						
	Sminthopsis crassicaudata	Fat-tailed Dunnart								x		x		x		
	Sminthopsis dolichura	Little long-tailed Dunnart						x			x					
	Sminthopsis hirtipes	Hairy-footed Dunnart														x
	Sminthopsis longicaudata	Long-tailed Dunnart		P4			x			x						x
	Sminthopsis macroura	Stripe-faced Dunnart						x		x		x		x		x
	Sminthopsis ooldea	Ooldea Dunnart						x		x	x	x				x
	Sminthopsis youngsoni	Lesser Hairy-footed Dunnart								x						
Peramelidae	*Isoodon auratus barrowensis*	Barrow Island Golden Bandicoot	Vu	S3					x							
Thylacomyidae	*Macrotis lagotis*	Bilby	Vu	S3			x			x						
Phalangeridae	*Trichosurus vulpecula hypoleucus*	Koomal														
Potoroidae	*Bettongia lesueur graii*	Burrowing Bettong	Ex	S4			x									
	Bettongia lesueur lesueur	Shark Bay Burrowing Bettong	Vu	S6					x							
	Bettongia lesueur 'Barrow Island form'	Barrow Island Burrowing Bettong	Vu	S6						x						
Macropodidae	*Osphranter robustus*	Euro			x			x			x	x				
	Osphranter rufus	Red Kangaroo			x			x			x	x			x	
	Petrogale lateralis lateralis	Black-footed Rock-wallaby	En	S2			x									
	Lagorchestes hirsutus ssp. (NTM U2430)	Rufous Hare-wallaby (Point Peron)	En	S2						x						
Muridae	*Leporillus apicalis*	Lesser Stick-nest Rat	Ex	S4			x									
	Mus musculus	*House Mouse						x	x		x	x		x		x
	Notomys alexis	Spinifex Hopping-mouse			x					x	x	x				x
	Pseudomys bolami	Bolam's Mouse								x						
	Pseudomys desertor	Desert Mouse								x	x	x				x
	Pseudomys hermannsburgensis	Sandy Inland Mouse						x		x	x	x				x
Rodentia	*Pseudomys fieldi*	Shark Bay Mouse	Vu	S3						x						
Leporidae	*Oryctolagus cuniculus*	*Rabbit							x		x	x	x	x	x	
Megadermatidae	*Macroderma gigas*	Ghost Bat	Vu	S3			x									
Molossidae	*Austronomus australis*	White-striped Freetail-bat									x	x				
Vespertilionidae	*Chalinolobus gouldii*	Gould's Wattled Bat									x	x		x		
	Nyctophilus geoffroyi	Lesser Long-eared Bat						x			x	x		x		
	Scotorepens balstoni	Inland Broad-nosed Bat						x			x	x		x		
	Scotorepens greyii	Little Broad-nosed Bat										x				
	Vespadelus baverstocki	Inland Forest Bat												x		
	Vespadelus finlaysoni	Finlayson's Cave Bat										x		x		
Canidae	*Canis lupus*	*Dog			x						x	x				
	Vulpes vulpes	*Red Fox			x				x			x		x		
Felidae	*Felis catus*	*Cat			x			x	x		x	x		x		
Equidae	*Equus asinus*	*Donkey							x					x		
	Equus caballus	*Horse												x		
Camelidae	*Camelus dromedarius*	*Camel			x				x		x		x			

Family	Species Name	Common Name	EPBC	WA	A	B	C	D	E	F	G	H	I	J	K	L
Bovidae	*Bos taurus*	*European Cattle									x	x	x	x		
Bovidae	*Capra hircus*	*Goat							x						x	
Dromaiidae	*Dromaius novaehollandiae*	Emu				x		x			x	x			x	
Anatidae	*Anas gracilis*	Grey Teal				x		x				x	x			
	Anas rhynchotis	Australasian Shoveler				x		x				x				
	Anas superciliosa	Pacific Black Duck				x		x				x				
	Aythya australis	Hardhead				x		x								
	Biziura lobata	Musk Duck				x		x								
	Chenonetta jubata	Australian Wood Duck				x		x				x				
	Cygnus atratus	Black Swan				x		x				x				
	Malacorhynchus membranaceus	Pink-eared Duck				x		x				x				
	Tadorna tadornoides	Australian Shelduck				x		x				x	x			
Megapodiidae	*Leipoa ocellata*	Malleefowl	Vu	S3			x		x							
Podicipedidae	*Poliocephalus poliocephalus*	Hoary-headed Grebe				x		x				x				
	Tachybaptus novaehollandiae	Australasian Grebe				x		x								
Threskiornithidae	*Plegadis falcinellus*	Glossy Ibis	Mi	S5			x									
Ardeidae	*Ardea modesta*	Eastern Great Egret							x							
	Ardea novaehollandiae	White-faced Heron				x		x								
	Ardea pacifica	White-necked Heron				x										
Accipitridae	*Accipiter cirrocephalus*	Collared Sparrowhawk				x						x				
	Accipiter fasciatus	Brown Goshawk				x		x			x	x				
	Aquila audax	Wedge-tailed Eagle			x	x		x			x	x		x	x	
	Circus assimilis	Spotted Harrier				x		x								
	Elanus caeruleus axillaris	Australian Black-shouldered Kite				x		x				x				
	Haliastur sphenurus	Whistling Kite				x		x				x		x		
	Hamirostra melanosternon	Black-breasted Buzzard				x		x				x		x		
	Hieraaetus morphnoides	Little Eagle				x						x				
Otididae	*Ardeotis australis*	Australian Bustard				x		x			x	x				
Rallidae	*Fulica atra*	Eurasian Coot				x		x				x				
	Tribonyx ventralis	Black-tailed Native-hen				x		x								
Turnicidae	*Turnix velox*	Little Button-quail				x		x								
Burhinidae	*Burhinus grallarius*	Bush Stone-curlew									x	x				
Recurvirostridae	*Cladorhynchus leucocephalus*	Banded Stilt				x										
	Himantopus himantopus	Black-winged Stilt						x				x				
	Recurvirostra novaehollandiae	Red-necked Avocet										x	x			
Charadriidae	*Charadrius melanops*	Black-fronted Dotterel				x						x				
	Charadrius ruficapillus	Red-capped Plover				x		x				x				
	Charadrius veredus	Oriental Plover	Mi	S5			x		x							
	Erythrogonys cinctus	Red-kneed Dotterel				x		x						x		
	Peltohyas australis	Inland Dotterel						x				x				
	Pluvialis fulva	Pacific Golden Plover	Mi	S5			x									
	Vanellus tricolor	Banded Lapwing				x		x				x		x		
Scolopacidae	*Calidris acuminata*	Sharp-tailed Sandpiper	Mi	S5			x		x					x		
	Calidris alba	Sanderling	Mi	S5			x									

Family	Species Name	Common Name	EPBC	WA	A	B	C	D	E	F	G	H	I	J	K	L
	Calidris ferruginea	Curlew Sandpiper	Cr; Mi	S3; S5			x									
	Calidris melanotos	Pectoral Sandpiper	Mi	S5			x		x							
	Calidris ruficollis	Red-necked Stint	Mi	S5			x									
	Calidris subminuta	Long-toed Stint	Mi	S5			x									
	Tringa glareola	Wood Sandpiper	Mi	S5			x									
	Tringa hypoleucos	Common Sandpiper	Mi	S5					x							
	Tringa nebularia	Common Greenshank	Mi	S5			x									
Glareolidae	*Glareola maldivarum*	Oriental Pratincole	Mi	S5			x									
Laridae	*Sterna hybrida*	Whiskered Tern				x										
	Sterna nilotica	Gull-billed Tern	Mi	S5			x									
Columbidae	*Columba livia*	*Domestic Pigeon							x							
	Geopelia cuneata	Diamond Dove			x	x		x				x				
	Ocyphaps lophotes	Crested Pigeon			x	x		x			x	x		x	x	
	Phaps chalcoptera	Common Bronzewing				x		x			x	x		x	x	
Cuculidae	*Cacomantis pallidus*	Pallid Cuckoo				x		x				x				
	Chrysococcyx basalis	Horsfield's Bronze Cuckoo				x		x			x	x				
	Chrysococcyx lucidus	Shining Bronze Cuckoo						x								
	Chrysococcyx osculans	Black-eared Cuckoo				x		x								
Tytonidae	*Tyto alba*	Barn Owl				x										
	Tyto alba delicatula	Eastern Barn Owl										x				
	Tyto novaehollandiae novaehollandiae	Masked Owl (SW ssp.)		P3			x									
Podargidae	*Podargus strigoides*	Tawny Frogmouth										x				
	Podargus strigoides brachypterus							x								
Caprimulgidae	*Eurostopodus argus*	Spotted Nightjar				x		x			x	x				
Aegothelidae	*Aegotheles cristatus*	Australian Owlet-nightjar				x		x				x		x		
Apodidae	*Apus pacificus*	Fork-tailed Swift	Mi	S5			x									
Alcedinidae	*Todiramphus pyrrhopygius*	Red-backed Kingfisher				x										
Meropidae	*Merops ornatus*	Rainbow Bee-eater						x	x		x			x		
Falconidae	*Falco berigora*	Brown Falcon			x	x		x			x	x			x	
	Falco cenchroides	Australian Kestrel			x	x		x			x	x		x	x	
	Falco hypoleucos	Grey Falcon		S3			x	x								
	Falco longipennis	Australian Hobby				x		x			x	x				
	Falco peregrinus	Peregrine Falcon		S7		x	x					x				
Cacatuidae	*Cacatua leadbeateri*	Major Mitchell's Cockatoo						x								
	Cacatua roseicapilla	Galah			x	x		x			x	x			x	
	Cacatua sanguinea	Little Corella				x						x				
	Nymphicus hollandicus	Cockatiel				x		x				x				
Psittacidae	*Melopsittacus undulatus*	Budgerigar			x	x		x			x	x				
	Neophema bourkii	Bourke's Parrot									x					
	Pezoporus occidentalis	Night Parrot	En	S1					x							
	Platycercus varius	Mulga Parrot				x		x			x	x			x	
	Platycercus zonarius	Australian Ringneck			x	x		x			x	x			x	
	Polytelis alexandrae	Princess Parrot	Vu	P4			x		x							
Ptilonorhynchidae	*Ptilonorhynchus maculatus guttatus*	Western Bowerbird				x		x			x	x				

Family	Species Name	Common Name	EPBC	WA	A	B	C	D	E	F	G	H	I	J	K	L
Maluridae	*Amytornis striatus striatus*	Striated Grasswren		P4			x									
	Amytornis textilis textilis	Thick-billed Grass-wren (western ssp.)		P4			x	x								
	Malurus lamberti	Variegated Fairy-wren			x	x		x			x	x		x		
	Malurus leucopterus	White-winged Fairy-wren				x		x			x	x	x	x		
	Malurus splendens	Splendid Fairy-wren			x	x		x			x	x		x		
	Stipiturus ruficeps	Rufous-crowned Emu-wren				x					x	x				
Meliphagidae	*Acanthagenys rufogularis*	Spiny-cheeked Honeyeater			x	x		x			x	x		x	x	
	Certhionyx variegatus	Pied Honeyeater				x		x				x				
	Epthianura aurifrons	Orange Chat				x		x				x				
	Epthianura tricolor	Crimson Chat				x		x			x	x				
	Gavicalis virescens	Singing Honeyeater			x	x					x	x			x	
	Lichmera indistincta	Brown Honeyeater				x		x				x				
	Manorina flavigula	Yellow-throated Miner			x	x		x			x	x	x	x	x	
	Ptilotula keartlandi	Grey-headed Honeyeater				x										
	Ptilotula penicillatus	White-plumed Honeyeater				x						x				
	Ptilotula plumulus	Grey-fronted Honeyeater				x						x				
	Purnella albifrons	White-fronted Honeyeater				x		x			x	x			x	
	Sugomel niger	Black Honeyeater				x										
Pardalotidae	*Pardalotus rubricatus*	Red-browed Pardalote				x										
	Pardalotus striatus	Striated Pardalote				x		x								
Acanthizidae	*Acanthiza apicalis*	Inland Thornbill				x		x			x	x		x		
	Acanthiza chrysorrhoa	Yellow-rumped Thornbill				x		x			x	x		x		
	Acanthiza robustirostris	Slaty-backed Thornbill				x		x			x	x		x		
	Acanthiza uropygialis	Chestnut-rumped Thornbill				x		x			x	x		x		
	Aphelocephala leucopsis	Southern Whiteface				x		x			x					
	Calamanthus campestris	Rufous Fieldwren				x						x				
	Gerygone fusca	Western Gerygone			x	x		x			x	x				
	Pyrrholaemus brunneus	Redthroat				x		x			x	x		x		
	Smicrornis brevirostris	Weebill				x		x			x	x		x		
Pomatostomidae	*Pomatostomus superciliosus*	White-browed Babbler				x		x			x	x			x	
	Pomatostomus temporalis	Grey-crowned Babbler			x	x		x			x	x		x		
Psophodidae	*Psophodes occidentalis*	Western Wedgebill										x		x		
	Cinclosoma castaneothorax	Western Chestnut-breasted Quail-thrush			x	x		x			x		x	x	x	
	Cinclosoma castanotum	Chestnut quail-thrush				x						x				
Artamidae	*Artamus cinereus*	Black-faced Woodswallow			x	x		x			x	x		x		
	Artamus personatus	Masked Woodswallow				x		x			x	x			x	
Cracticidae	*Cracticus nigrogularis*	Pied Butcherbird				x		x			x	x	x	x		
	Cracticus tibicen	Australian Magpie			x	x		x			x	x	x	x	x	
	Cracticus torquatus	Grey Butcherbird				x		x			x	x		x	x	
Campephagidae	*Coracina maxima*	Ground Cuckoo-shrike				x					x	x				
	Coracina novaehollandiae	Black-faced Cuckoo-shrike				x		x			x	x	x	x	x	
	Lalage tricolor	White-winged Triller				x		x			x	x				
Neosittidae	*Daphoenositta chrysoptera*	Varied Sittella									x					
Oreoicidae	*Oreoica gutturalis*	Crested Bellbird			x	x		x			x	x				

Family	Species Name	Common Name	EPBC	WA	A	B	C	D	E	F	G	H	I	J	K	L
Pachycephalidae	*Colluricincla harmonica*	Grey Shrike-thrush			x	x		x			x	x				
	Pachycephala rufiventris	Rufous Whistler			x	x		x			x	x		x		
Rhipiduridae	*Rhipidura albiscapa*	Grey Fantail				x										
	Rhipidura leucophrys	Willie Wagtail			x	x		x			x	x	x	x	x	
Monarchidae	*Grallina cyanoleuca*	Magpie-lark				x		x			x	x			x	
Corvidae	*Corvus bennetti*	Little Crow				x		x			x	x		x		
	Corvus orru	Torresian Crow				x		x			x	x			x	
Petroicidae	*Melanodryas cucullata*	Hooded Robin				x		x			x					
	Microeca fascinans	Jacky Winter				x		x						x		
	Petroica goodenovii	Red-capped Robin			x	x		x			x	x		x		
Hirundinidae	*Cheramoeca leucosternus*	White-backed Swallow				x						x				
	Hirundo neoxena	Welcome Swallow				x		x			x	x			x	
	Petrochelidon ariel	Fairy Martin				x										
	Petrochelidon nigricans	Tree Martin				x						x			x	
Locustellidae	*Eremiornis carteri*	Spinifex-bird									x	x				
	Megalurus cruralis	Brown Songlark				x					x	x				
	Megalurus mathewsi	Rufous Songlark				x										
Dicaeidae	*Dicaeum hirundinaceum*	Mistletoebird				x		x								
Estrildidae	*Taeniopygia guttata*	Zebra Finch				x		x			x	x			x	
Motacillidae	*Anthus australis*	Australian Pipit				x		x			x	x				
	Motacilla cinerea	Grey Wagtail	Mi	S5					x							
	Motacilla flava	Yellow Wagtail	Mi	S5					x							
Cheluidae	*Chelodina steindachneri*	Flat-shelled Turtle										x				
Carphodactylidae	*Nephrurus laevissimus*									x				x		x
	Nephrurus vertebralis									x	x	x		x		x
	Nephrurus wheeleri											x				
	Underwoodisaurus milii	Southern Barking Gecko										x				
Diplodactylidae	*Diplodactylus conspicillatus*	Variable Fat-tailed Gecko						x		x	x	x		x		x
	Diplodactylus granariensis									x						
	Diplodactylus granariensis rex							x								
	Diplodactylus laevis	Desert Fat-tailed Gecko										x				
	Diplodactylus pulcher							x		x		x				
	Lucasium damaeum													x		
	Lucasium maini									x						
	Lucasium squarrosum									x	x					
	Lucasium stenodactylum									x		x		x		x
	Rhynchoedura ornata	Western Beaked Gecko						x		x	x	x		x		x
	Strophurus elderi							x		x		x		x		x
	Strophurus strophurus									x		x		x		x
	Strophurus wellingtonae							x		x	x					x
Gekkonidae	*Gehyra purpurascens*									x		x				
	Gehyra variegata				x			x		x	x	x	x	x		x
	Heteronotia binoei	Bynoe's Gecko						x		x	x	x		x		
Pygopodidae	*Delma butleri*							x		x						x

Family	Species Name	Common Name	EPBC	WA	A	B	C	D	E	F	G	H	I	J	K	L
	Delma nasuta							x		x		x				x
	Lialis burtonis									x	x	x				x
	Pygopus nigriceps							x		x	x	x		x		
Agamidae	*Ctenophorus caudicinctus*	Ring-tailed Dragon						x		x	x					
	Ctenophorus isolepis	Military Dragon						x		x	x	x		x		x
	Ctenophorus isolepis gularis							x								
	Ctenophorus nuchalis	Central Netted Dragon						x		x		x		x		x
	Ctenophorus reticulatus	Western Netted Dragon						x		x	x					
	Ctenophorus salinarum	Salt Pan Dragon									x	x	x		x	
	Ctenophorus scutulatus							x		x	x	x		x		
	Diporiphora amphiboluroides				x					x	x					
	Diporiphora winneckei	Canegrass Dragon														x
	Gowidon longirostris	Long-nosed Dragon						x								x
	Moloch horridus	Thorny Devil						x		x		x				x
	Pogona minor minor	Bearded Dragon			x			x		x	x	x				x
	Tympanocryptis cephalus	Coastal Pebble-mimic dragons								x						
	Tympanocryptis pseudopsephos	Goldfields Pebble-mimic dragons			x											
Scincidae	*Cryptoblepharus buchananii*									x						
	Cryptoblepharus plagiocephalus									x		x				
	Ctenotus ariadnae							x		x	x					x
	Ctenotus atlas											x				
	Ctenotus calurus							x		x	x	x				x
	Ctenotus dux									x						x
	Ctenotus grandis									x		x				x
	Ctenotus grandis grandis							x								
	Ctenotus helenae							x		x	x			x		x
	Ctenotus inornatus											x				
	Ctenotus leonhardii							x		x	x	x				
	Ctenotus pantherinus	Leopard Ctenotus						x		x	x	x				x
	Ctenotus pantherinus ocellifer							x						x		
	Ctenotus quattuordecimlineatus							x		x		x		x		
	Ctenotus schomburgkii							x		x	x	x				x
	Ctenotus severus													x		
	Ctenotus uber							x		x						
	Egernia depressa	Southern Pygmy Spiny-tailed Skink			x			x		x	x	x		x		
	Egernia formosa									x						
	Eremiascincus richardsonii	Broad-banded Sand Swimmer						x		x		x				
	Lerista bipes							x		x		x		x		x
	Lerista desertorum							x		x	x	x		x		x
	Lerista kingi											x				
	Lerista muelleri							x						x		x
	Lerista timida							x			x	x				
	Liopholis inornata									x						x
	Liopholis kintorei	Great Desert Skink	Vu	S3			x									

Family	Species Name	Common Name	EPBC	WA	A	B	C	D	E	F	G	H	I	J	K	L
	Liopholis multiscutata															x
	Liopholis striata	Night Skink								x						
	Menetia greyii							x		x	x	x		x		x
	Morethia butleri							x		x		x		x		
	Morethia ruficauda									x						x
	Tiliqua multifasciata	Central Blue-tongue			x					x		x				
Varanidae	*Varanus brevicauda*	Short-tailed Pygmy Monitor						x		x	x	x				x
	Varanus caudolineatus				x			x		x	x	x				x
	Varanus eremius	Pygmy Desert Monitor								x	x	x				x
	Varanus giganteus	Perentie												x		
	Varanus gouldii	Sand Monitor			x					x	x	x		x		x
	Varanus panoptes	Yellow-spotted Monitor			x					x	x	x				
	Varanus tristis	Racehorse Monitor						x		x						x
Typhlopidae	*Anilios hamatus*									x		x				
	Anilios waitii									x						x
Pythonidae	*Antaresia stimsoni*	Stimson's Python								x		x				
Elapidae	*Brachyurophis approximans*													x		
	Brachyurophis fasciolatus									x						
	Brachyurophis semifasciatus									x		x				
	Demansia psammophis	Yellow-faced Whipsnake						x		x						x
	Furina ornata	Moon Snake								x		x				
	Parasuta monachus							x		x		x		x		
	Pseudonaja mengdeni	Western Brown Snake									x	x				
	Pseudonaja modesta	Ringed Brown Snake						x		x	x			x		x
	Pseudonaja nuchalis	Gwardar; Northern Brown Snake								x						
	Simoselaps bertholdi	Jan's Banded Snake						x		x	x	x		x		
	Suta fasciata	Rosen's Snake								x						x
Hylidae	*Cyclorana maini*	Sheep Frog						x				x				
	Cyclorana platycephala	Western Water-holding Frog										x				
	Litoria rubella	Little Red Tree Frog						x			x					x
Limnodynastidae	*Neobatrachus aquilonius*	Northern Burrowing Frog						x								
	Neobatrachus sutor	Shoemaker Frog						x								x
	Neobatrachus wilsmorei	Plonking Frog						x								
	Notaden nichollsi	Desert Spadefoot										x				x

Appendix D Vegetation Condition Scale

Code	Description
Excellent	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.
Very Good	Vegetation structure altered obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
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 their 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 E Vegetation Structure Scale

	Cover Characteristics							
	Foliage cover *	70-100	30-70	10-30	<10	≈0	0-5	unknown
	Crown cover **	>80	50-80	20-50	0.25-20	<0.25	0-5	unknown
	% Crown cover ***	>80	50-80	20-50	0.25-20	<0.25	0-5	unknown
	Cover code	d	c	i	r	bi	bc	unknown

Growth Form	Height ranges (m)	Structural Formation Classes						
tree, palm	>30 Tall 10-30 Mid <10 Low	closed forest	open forest	woodland	open woodland	isolated trees	isolated clumps of trees	trees
tree mallee	10-30 Tall <10 Mid <3 Low	closed mallee forest	open mallee forest	mallee woodland	open mallee woodland	isolated mallee trees	isolated clumps of mallee trees	mallee trees
shrub, cycad, grass-tree, fern	>2 Tall 1-2 Mid <1 Low	closed shrubland	shrubland	open shrubland	sparse shrubland	isolated shrubs	isolated clumps of shrubs	shrubs
mallee shrub	10-30 Tall <10 Mid <3 Low	closed mallee shrubland	mallee shrubland	open mallee shrubland	sparse mallee shrubland	isolated mallee shrubs	isolated clumps of mallee shrubs	mallee shrubs

Growth Form	Height ranges (m)	Structural Formation Classes						
heath shrub	>2 Tall		heathland	open heathland				heath shrubs

Growth Form	Height ranges (m)	Structural Formation Classes						
	1-2 Mid <1 Low	closed heathland			sparse heathland	isolated heath shrubs	isolated clumps of heath shrubs	
chenopod shrub	>2 Tall 1-2 Mid <1 Low	closed chenopod shrubland	chenopod shrubland	open chenopod shrubland	sparse chenopod shrubland	isolated chenopod shrubs	isolated clumps of chenopod shrubs	chenopod shrubs
samphire shrub	>0.5 Mid <0.5 Low	closed samphire shrubland	samphire shrubland	open samphire shrubland	sparse samphire shrubland	isolated samphire shrubs	isolated clumps of samphire shrubs	samphire shrubs
hummock grass	>2 Tall <2 Low	closed hummock grassland	hummock grassland	open hummock grassland	sparse hummock grassland	isolated hummock grasses	isolated clumps of hummock grasses	hummock grasses
tussock grass	>0.5 Mid <0.5 Low	closed tussock grassland	tussock grassland	open tussock grassland	sparse tussock grassland	isolated tussock grasses	isolated clumps of tussock grasses	tussock grasses
other grass	>0.5 Mid <0.5 Low	closed grassland	grassland	open grassland	sparse grassland	isolated grasses	isolated clumps of grasses	other grasses
sedge	>0.5 Mid <0.5 Low	closed sedgeland	sedgeland	open sedgeland	sparse sedgeland	isolated sedges	isolated clumps of sedges	sedges
rush	>0.5 Mid <0.5 Low	closed rushland	rushland	open rushland	sparse rushland	isolated rushes	isolated clumps of rushes	rushes
forb	>0.5 Mid <0.5 Low	closed forbland	forbland	open forbland	sparse forbland	isolated forbs	isolated clumps of forbs	forbs
fern	>2 Tall 1-2 Mid <1 Low	closed fernland	fernland	open fernland	sparse fernland	isolated ferns	isolated clumpsof ferns	ferns

Growth Form	Height ranges (m)	Structural Formation Classes						
bryophyte	<0.5	closed bryophyte land	bryophyte land	open bryophyte land	sparse bryophyte land	isolated bryophytes	isolated clumps of bryophytes	bryophytes
lichen	<0.5	closed lichenland	lichenland	open lichenland	sparse lichenland	isolated lichens	isolated clumps of lichens	lichens
vine	>30 Tall 10-30 Mid <10 Low	closed vineland	vineland	open vineland	sparse vineland	isolated vines	isolated clumps of vines	vines
aquatic	<1 Tall 0-0.5 Low	closed aquatic bed	aquatic bed	open aquatic bed	sparse aquatics	isolated aquatics	isolated clumps of aquatics	aquatics
seagrass	<1 Tall	closed seagrass bed	Seagrass bed	open seagrass bed	sparse seagrass bed	isolated seagrasses	isolated clumps of seagrasses	seagrasses

Appendix F Flora Quadrats and Mapping Notes

Jundee – Ramone – Mn01

Site Details:

Described by: Alice Bott

Date: 2018-04-14

Type: Mapping Note (unbounded)

MGA Zone: 51J 279965mE 7060704mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

FLORA AND VEGETATION DATA

Description: *Acacia aptaneura, Acacia pteraneura* tall shrubland over *Eremophila* spp. open shrubland

Veg Condition:	Excellent	Fire Age:	Unknown (no evidence)
Weeds:	N/A	Fire Notes:	N/A

SITE PHOTOGRAPH

Jundee – Ramone – Mn02

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-16

Type: Mapping Note (unbounded)

MGA Zone: 51J 281697mE 7060145mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

FLORA AND VEGETATION DATA

Description: *Acacia aneura* tall shrubland over *Eremophila citrina* open low heath over *Triodia melvillei* very open grassland

Veg Condition:	Excellent	Fire Age:	Unknown (no evidence)
Weeds:	N/A	Fire Notes:	N/A

SITE PHOTOGRAPH

Jundee – Ramone – Mn03

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-15

Type: Mapping Note (unbounded)

MGA Zone: 51J 283499mE 7060735mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

FLORA AND VEGETATION DATA

Description: *Acacia aneura* tall shrubland over *Eremophila citrina* open low heath over *Triodia melvillei* very open grassland

Veg Condition:	Excellent	Fire Age:	Unknown (no evidence)
Weeds:	N/A	Fire Notes:	N/A

SITE PHOTOGRAPH

Jundee – Ramone – Mn04

Site Details:

Described by: Alice Bott

Date: 2018-04-16

Type: Mapping Note (unbounded)

MGA Zone: 51J 284142mE 7060313mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

FLORA AND VEGETATION DATA

Description: *Acacia pruinocarpa* open low woodland over *Acacia incurvaneura* open tall shrubland over *Eremophila citrina* low shrubland over *Triodia melvillei* hummock grassland

Veg Condition:	Excellent	Fire Age:	Unknown (no evidence)
Weeds:	N/A	Fire Notes:	N/A

SITE PHOTOGRAPH

Jundee – Ramone– R01

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-11

Type: Quadrat (20m x 20m)

MGA Zone: 51J 285883mE 7061679mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Sandy loam

Soil Colour: Orange brown

Rock Type: N/A

Coarse Surface Particles:

Site coverage: 0

Size: N/A

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Erosion: N/A

Introduced species:

Human disturbance: Tracks, drill-holes

FLORA AND VEGETATION DATA

Description: *Acacia pteraneura, Acacia aneura* open low woodland over *Acacia aneura* open shrubland over *Eremophila forrestii* subsp. *forrestii* low shrubland over *Triodia basedowii* hummock grassland over *Thyridolepis mitchelliana* very open tussock grassland

Species List

Species Name	Height (m)	Cover (%)
Acacia aneura	1.5	3.5
Acacia pteraneura	5.5	2
Aristida contorta	0.15	0.1
Eragrostis eriopoda	0.35	0.1
Eremophila forestii subso. Forrestii	1	25
Eremophila spectabilis subsp. ? brevis	0.4	0.1
Psydrax latifolia	0.45	0.1
Psydrax suaveolens	1.1	0.1
Solanum lasiophyllum	0.2	0.1
Thyridolepis mitchelliana	0.2	7
Triodia basedowii	0.5	60

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	40	1	59

Veg Condition:	Excellent	Fire Age:	3 to 5
Weeds:	None	Fire Notes:	Well-developed hummocks

SITE PHOTOGRAPH

Jundee – Ramone– R02

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-11

Type: Quadrat (20m x 20m)

MGA Zone: 51J 285765mE 7060364mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Loamy sand

Soil Colour: Brown

Rock Type: Quartz

Coarse Surface Particles:

Site coverage: 20-50

Size: 60-200

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Erosion: N/A

Introduced species:

Human disturbance: Track

FLORA AND VEGETATION DATA

Description: *Acacia incurvaneura* and *Acacia pteraneura* open low woodland

Species List

Species Name	Height (m)	Cover (%)
Acacia incurvaenura	3.2	7
Acacia pteraneura	2.1	1
Aristida contorta	0.2	0.5
Cyperaceae sp..	0.05	0.1
Eragrostis ? falcata	0.25	0.1
Eremophila fraseri	1.6	1
Eremophila latrobei subsp. latrobei	0.6	0.1
Eremophila spectabilis subsp. ? brevis	0.3	0.1
Eriachne mucronata	0.2	0.1
Psydrax suaveolens	1.6	0.1
Ptilotus schwartzii	0.25	0.1
Solanum lasiophyllum	0.4	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
25	30	1	44

Veg Condition:	Very Good	Fire Age:	Unknown (no evidence)
Weeds:	None	Fire Notes:	N/A

SITE PHOTOGRAPH

Jundee – Ramone– R03

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-12

Type: Quadrat (20m x 20m)

MGA Zone: 51J 287259mE 7059673mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Loam

Soil Colour: Brown

Rock Type: Quartz

Coarse Surface Particles:

Site coverage: 20-50

Size: 2-6,6-20

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Erosion: N/A

Introduced species:

Human disturbance: Track

FLORA AND VEGETATION DATA

Description: *Acacia aptaneura, Acacia pteraneura* low woodland

Species List

Species Name	Height (m)	Cover (%)
Acacia aptaneura	4	10
Acacia pteraneura	2	2.5
Acacia tetragonophylla	1.2	1
Aristida contorta	0.1	0.1
Enteropogon ramosus	0.35	0.1
Eremophila forrestii subsp. forrestii	0.2	0.1
Eremophila fraseri	0.8	0.1
Eremophila latrobei subsp. filiformis	0.5	0.1
Eragrostis eriopoda	0.2	1
Eriachne mucronata	0.2	0.1
Neurachne minor	0.3	0.1
Ptilotus schwartzii	0.35	0.1
Sida ectogama	0.4	0.1
Solanum lasiophyllum	0.3	0.1
Tripogonella loliiformis	0.15	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	60	0.1	30

Veg Condition:	Very Good	Fire Age:	3-5 years
Weeds:	None	Fire Notes:	N/A

SITE PHOTOGRAPH

Jundee – Ramone– R04

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-12

Type: Quadrat (10m x 40m)

MGA Zone: 51J 287446mE 7061328mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Loam

Soil Colour: Orange

Rock Type: Quartz

Coarse Surface Particles:

Site coverage: 20-50

Size: 2-6,6-20

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Introduced species: Camels

Erosion: N/A

Human disturbance: Feral trampling

FLORA AND VEGETATION DATA

Description: *Acacia pteraneura, Acacia aptaneura* x ? over *Eragrostis eriopoda* tussock grassland

Species List

Species Name	Height (m)	Cover (%)
Acacia aptaneura x ?	3.2	3
Acacia pteraneura	6	11
Aristida contorta	0.2	0.1
Cheilanthes sp.	0.15	0.1
Codonocarpus cotinifolius	1.2	0.1
Cymbopogon obtectus	0.4	0.1
Cyperaceae sp.	0.15	0.1
Eragrostis eriopoda	0.35	50
Eremophila forrestii subsp. forrestii	0.5	0.1
Eremophila fraseri	1.1	1
Eremophila latrobei subsp. latrobei	0.5	1
Eremophila spectabilis subsp. ? brevis	0.5	0.1
Eriachne mucronata	0.2	0.1
Eriachne sp.	0.2	0.1
Neurachne minor	0.4	0.1

Species Name	Height (m)	Cover (%)
Psydrax latifolia	0.4	0.1
Psydrax rigidula	1.4	0.1
Ptilotus schwartzii	0.4	0.1
Sida ectogama	0.45	0.1
Solanum lasiophyllum	0.15	0.1
Teucrium teucriiflorum	0.4	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	35	0.1	74.9

Veg Condition:	Very Good	Fire Age:	3-5 years
Weeds:	None	Fire Notes:	N/A

SITE PHOTOGRAPH

Jundee – Ramone– R05

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-12

Type: Quadrat (20m x 20m)

MGA Zone: 51J 287961E 7060610mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:		**Coarse Surface Particles:**	
Soil Texture:	Sandy Loam	Site coverage:	<2
Soil Colour:	Brown	Size:	2-6
Rock Type:	Ironstone	Outcropping:	N/A

Impacts:

Waterlogging:	No - Never	Erosion:	N/A
Introduced species:	-	Human disturbance:	Feral trampling

FLORA AND VEGETATION DATA

Description: *Acacia pruinocarpa* open low woodland over *Acacia incurvaneura* flat open tall shrubland over *Triodia melvillei (Triodia basedowii)* hummock grassland with *Thyridiolepis mitchelliana* very open tussock grassland.

Species List

Species Name	Height (m)	Cover (%)
Acacia incurvaenura	4	2
Acacia pruinocarpa	7	3
Acacia tetragonophylla	0.6	0.1
Eragrostis eriopoda	0.4	4
Eriachne mucronata	0.2	0.1
Psydrax suaveolens	1.4	0.1
Rhagodia ? eremaea	1.1	0.1
Sida ectogama	0.3	0.1
Solanum lasiophyllum	0.25	0.1
Teucrium teucriiflorum	0.6	0.1
Triodia basedowii	0.25	0.5
Triodia melvillei	0.4	65

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	20	20	70

Veg Condition:	Excellent	Fire Age:	1-3 years
Weeds:	None	Fire Notes:	Well-developed hummocks

SITE PHOTOGRAPH

Jundee – Ramone– R06

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-12

Type: Quadrat (20m x 20m)

MGA Zone: 51J 285190E 7060416mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:		**Coarse Surface Particles:**	
Soil Texture:	Clay loam	Site coverage:	20-50
Soil Colour:	Orange	Size:	2-6,6-20,20-60
Rock Type:	Quartz	Outcropping:	N/A

Impacts:

Waterlogging:	No - Never	Erosion:	N/A
Introduced species:	-	Human disturbance:	Tracks

FLORA AND VEGETATION DATA

Description: *Acacia pruinocarpa* open low woodland over *Acacia incurvaneura* flat open tall shrubland over *Triodia melvillei (Triodia basedowii)* hummock grassland with *Thyridiolepis mitchelliana* very open tussock grassland.

Species List

Species Name	Height (m)	Cover (%)
Acacia aptaneura	2	30
Acacia pteraneura	2	2
Acacia tetragonophylla	1.6	1
Aristida contorta	0.15	0.1
Calandrinia sp.	0.05	0.1
Chenopodiaceae sp	0.15	0.1
Eremophila forrestii subsp. forrestii	0.6	0.1
Eremophila fraseri	1.2	2
Eremophila latrobei subsp. latrobei	0.3	0.1
Psydrax suaveolens	0.15	0.1
Ptilotus roei	0	0.1
Ptilotus schwartzii	0.4	0.1

Species Name	Height (m)	Cover (%)
Senna sp. Meekatharra (E. Bailey 1-26) hybrid	0.6	0.1
Sida ectogama	0.8	0.1
Solanum lasiophyllum	0.2	0.1
Teucrium teucriiflorum	0.4	0.1
Tripogonella loliiformis	0.35	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
2	40	0.1	59.9

Veg Condition: Good

Fire Age: 3-5 years

Weeds: None

Fire Notes: N/A

SITE PHOTOGRAPH

Jundee – Ramone– R07

Site Details:

Described by: Alice Bott

Date: 2018-04-13

Type: Quadrat (20m x 20m)

MGA Zone: 51J 286391mE 7059443mN

Environmental Variables:

Landform: Outcrop

Slope: Moderately inclined (5-15°) - south-east

Soils:

Soil Texture: Sandy loam

Soil Colour: Light brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 50-90

Size: 2-6

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Introduced species: -

Erosion: N/A

Human disturbance: Tracks

FLORA AND VEGETATION DATA

Description: *Acacia incurvaneura* open tall shrubland over *Neurachne minor* and *Thyridiolepis mitchelliana* open tussock grassland.

Species List

Species Name	Height (m)	Cover (%)
? Ptilotus	0.1	0.1
Acacia ? incurvaneura	2.4	3
Aristida contorta	0.15	0.1
Eragrostis falcata	0.25	0.1
Eremophila latrobei subsp. *latrobei*	0.6	0.1
Eriachne mucronata	0.25	0.1
Eriachne pulchella subsp. *pulchella*	0.08	0.1
Malvaceae sp.	0.3	0.1
Neurachne minor	0.25	12
Ptilotus obovatus	0.4	0.1
Ptilotus schwartzii	0.25	0.1
Thyridolepis mitchelliana	0.5	2

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
75	25	1	30

Veg Condition:	Very Good	Fire Age:	3-5 years
Weeds:	None	Fire Notes:	N/A

SITE PHOTOGRAPH

Jundee – Ramone– R08

Site Details:

Described by: Alice Bott

Date: 2018-04-13

Type: Quadrat (20m x 20m)

MGA Zone: 51J 286688mE 7059341mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Silty loam

Soil Colour: Brown

Rock Type: Quartz

Coarse Surface Particles:

Site coverage: 20-50

Size: 20-60,6-20,2-6

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Introduced species: -

Erosion: N/A

Human disturbance: Tracks

FLORA AND VEGETATION DATA

Description: *Senna* sp. Meekatharra (E. Bailey 1-26) hybrid low shrubland over *Sclerolaena eriacantha*, ? *Maireana* sp. very open herbland

Species List

Species Name	Height (m)	Cover (%)
? Maireana sp.	0.15	0.1
Aristida contorta	0.3	1
Dactyloctenium radulans	0.15	0.1
Enneapogon polyphyllus	0.25	0.1
Enteropogon ramosus	0.4	0.1
Eremophila fraseri	0.35	0.1
Eremophila latrobei subsp. *latrobei*	0.45	0.1
Eremophila spectabilis subsp. *? brevis*	0.5	0.1
Maireana sp.	0.1	0.1
Malvaceae sp.	0.3	0.1
Ptilotus nobilis	0.1	0.1
Ptilotus obovatus	0.3	1
Ptilotus rotundifolius	0.4	0.1
Ptilotus schwartzii	0.2	0.1

Species Name	Height (m)	Cover (%)
Sclerolaena eriacantha	0.15	2
Senna sp. Meekatharra (E. Bailey 1-26) hybrid	0.6	15
Solanum lasiophyllum	0.25	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	50	0	50

Veg Condition: Very Good

Fire Age: 3-5 years

Weeds:

Fire Notes: N/A

SITE PHOTOGRAPH

Jundee – Ramone– R09

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-13

Type: Quadrat (20m x 20m)

MGA Zone: 51J 287190mE 7059315mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:		**Coarse Surface Particles:**	
Soil Texture:	Sandy loam	Site coverage:	20-50
Soil Colour:	Dark brown	Size:	200-600
Rock Type:	Quartz	Outcropping:	N/A

Impacts:

Waterlogging:	No - Prone to Ponding	Erosion:	N/A
Introduced species:	-	Human disturbance:	Tracks

FLORA AND VEGETATION DATA

Description: *Senna* sp. Meekatharra (E. Bailey 1-26) hybrid open low shrubland over *Sclerolaena eriacantha* and *Sclerolaena cuneata* (*Maireana sp*.) very open herbland.

Species List

Species Name	Height (m)	Cover (%)
Aristida contorta	0.15	0.1
Eremophila ? platycalyx	0.2	0.1
Eremophila fraseri	7	0.1
Maireana sp.	0.08	0.1
Ptilotus nobils	0.05	0.1
Ptilotus obovatus	0.15	0.1
Ptilotus rotundifolius	0.25	0.1
Ptilotus schwartzii	0.2	0.1
Scaevola spinescens	0.8	0.1
Sclerolaena cuneata	0.1	2.5
Sclerolaena eriacantha	0.12	2.5
Senna sp. Meekatharra (E. Bailey 1-26) hybrid	0.9	5
Solanum lasiophyllum	0.25	0.1

Species Name	Height (m)	Cover (%)
Tripogonella loliiformis	0.05	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	70	0	5

Veg Condition: Very Good

Fire Age: 3-5 years

Weeds:

Fire Notes: N/A

SITE PHOTOGRAPH

Jundee – Ramone– R10

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-13

Type: Quadrat (20m x 20m)

MGA Zone: 51J 287237mE 7059038mN

Environmental Variables:

Landform: Outcrop

Slope: Gently inclined (3-5°), south

Soils:

Soil Texture: Skeletal soils

Soil Colour: Red

Rock Type: Granite

Coarse Surface Particles:

Site coverage: 50-90

Size: 2-6,6-20,20-60,60-200

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Introduced species: -

Erosion: N/A

Human disturbance: Tracks

FLORA AND VEGETATION DATA

Description: *Acacia incurvaneura* open tall shrubland over *Acacia pteraneura* open shrubland over *Eremophila latrobei* subsp. *latrobei, Eremophila ? pungens* open low shrubland

Species List

Species Name	Height (m)	Cover (%)
Acacia pteraneura	4.5	8
Acacia tetragonophylla	1.1	2.5
Aristida contorta	0.15	0.1
Eragrostis eriopoda	0.4	0.1
Eremophila fraseri	0.4	0.5
Eremophila latrobei subsp. *latrobei*	0.6	2.5
Goodenia triodiophila	0.12	0.1
Maireana thesioides	73	0.1
Neurachne minor	0.2	0.1
Psydrax suaveolens	1.7	0.1
Ptilotus schwartzii	0.25	0.1
Rhagodia ? eremaea	0.15	0.1
Scaevola spinescens	0.8	2.5
Sclerolaena eriacantha	0.15	0.1

Species Name	Height (m)	Cover (%)
Senna sp. Meekatharra (E. Bailey 1-26) hybrid	1.8	0.1
Solanum lasiophyllum	0.15	0.1
Teucrium teucriiflorum	0.4	0.1
Triodia melvillei	0.45	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
50	25	0	25

Veg Condition: Excellent

Fire Age: Unknown (no evidence)

Weeds:

Fire Notes: N/A

SITE PHOTOGRAPH

Jundee – Ramone– R11

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-13

Type: Quadrat (20m x 20m)

MGA Zone: 51J 287257mE 7059140mN

Environmental Variables:

Landform: Outcrop

Slope: Gently inclined (3-5°), west

Soils:

Soil Texture: Clayey sand

Soil Colour: Light brown

Rock Type: Laterite, granite

Coarse Surface Particles:

Site coverage: 50-90

Size: 2-6,6-20,20-60,60-200

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Introduced species: -

Erosion: N/A

Human disturbance: Tracks

FLORA AND VEGETATION DATA

Description: *Acacia pteraneura* tall shrubland over *Acacia tetragonaphylla, Scaevola spinescens* and *Eremophila latrobei* subsp. *latrobei* open low shrubland to low shrubland

Species List

Species Name	Height (m)	Cover (%)
Aristida contorta	0.15	0.1
Eremophila ? platycalyx	0.2	0.1
Eremophila fraseri	7	0.1
Maireana sp.	0.08	0.1
Ptilotus nobilis	0.05	0.1
Ptilotus obovatus	0.15	0.1
Ptilotus rotundifolius	0.25	0.1
Ptilotus schwartzii	0.2	0.1
Scaevola spinescens	0.8	0.1
Sclerolaena cuneata	0.1	2.5
Sclerolaena eriacantha	0.12	2.5
Senna sp. Meekatharra (E. Bailey 1-26) hybrid	0.9	5
Solanum lasiophyllum	0.25	0.1
Tripogonella loliiformis	0.05	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
50	25	0	25

Veg Condition: Excellent

Fire Age: 1-3 years

Weeds:

Fire Notes: Presence of dead branches, bare ground

SITE PHOTOGRAPH

Jundee – Ramone– R12

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-13

Type: Quadrat (20m x 20m)

MGA Zone: 51J 287201mE 7060064mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Brown

Rock Type: Granite

Coarse Surface Particles:

Site coverage: 20-50

Size: 2-6,6-20,20-60,60-200

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Introduced species: -

Erosion: N/A

Human disturbance: N/A

FLORA AND VEGETATION DATA

Description: *Acacia aptaneura, Grevillea berryana* open tall shrubland over *Acacia tetragonaphylla, Eremophila pungens (Eremophila latrobei subsp. latrobei, Scaevola spinescens*) open shrubland

Species List

Species Name	Height (m)	Cover (%)
Acacia ? aptaneura	2.3	7
Acacia tetragonophylla	2	4
Aristida contorta	0.2	0.1
Enteropogon ramosus	0.25	0.1
Eragrostis eriopoda	0.4	0.1
Eragrostis forrestii subsp. Forrestii	0.35	0.1
Eremophila fraseri	0.5	0.1
Eremophila latrobei subsp. latrobei	0.6	1
Eremophila pungens	0.5	2
Goodenia triodiophila	0.15	0.1
Grevillea berryana	3	2
Psydrax latifolia	2.5	0.1
Psydrax rigidula	1.8	1
Psydrax suaveolens	0.65	0.1
Ptilotus aervoides	0	0.1

Species Name	Height (m)	Cover (%)
Ptilotus schwartzii	0.25	0.1
Scaevola spinescens	0.45	1
Senna sp. Meekatharra (E. Bailey 1-26) hybrid	0.1	0.1
Sida ectogama	0.35	0.1
Tripogonella loliiformis	0.15	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
3	60	0	40

Veg Condition:	Excellent	Fire Age:	3-5 years
Weeds:	None	Fire Notes:	N/A

SITE PHOTOGRAPH

Jundee – Ramone– R13

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-14

Type: Quadrat (20m x 20m)

MGA Zone: 51J 280187mE 7060211mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Brown

Rock Type: Granite

Coarse Surface Particles:

Site coverage: 20-50

Size: 6-20,20-60,60-200,2-6

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Introduced species: Camel

Erosion: N/A

Disturbance: Feral trampling

FLORA AND VEGETATION DATA

Description: *Eremophila linearis shrubland* to tall shrubland over *Ptilotus obovatus* herbland over *Sclerolaena eriacantha, ? Maireana* sp. open chenopods

Species List

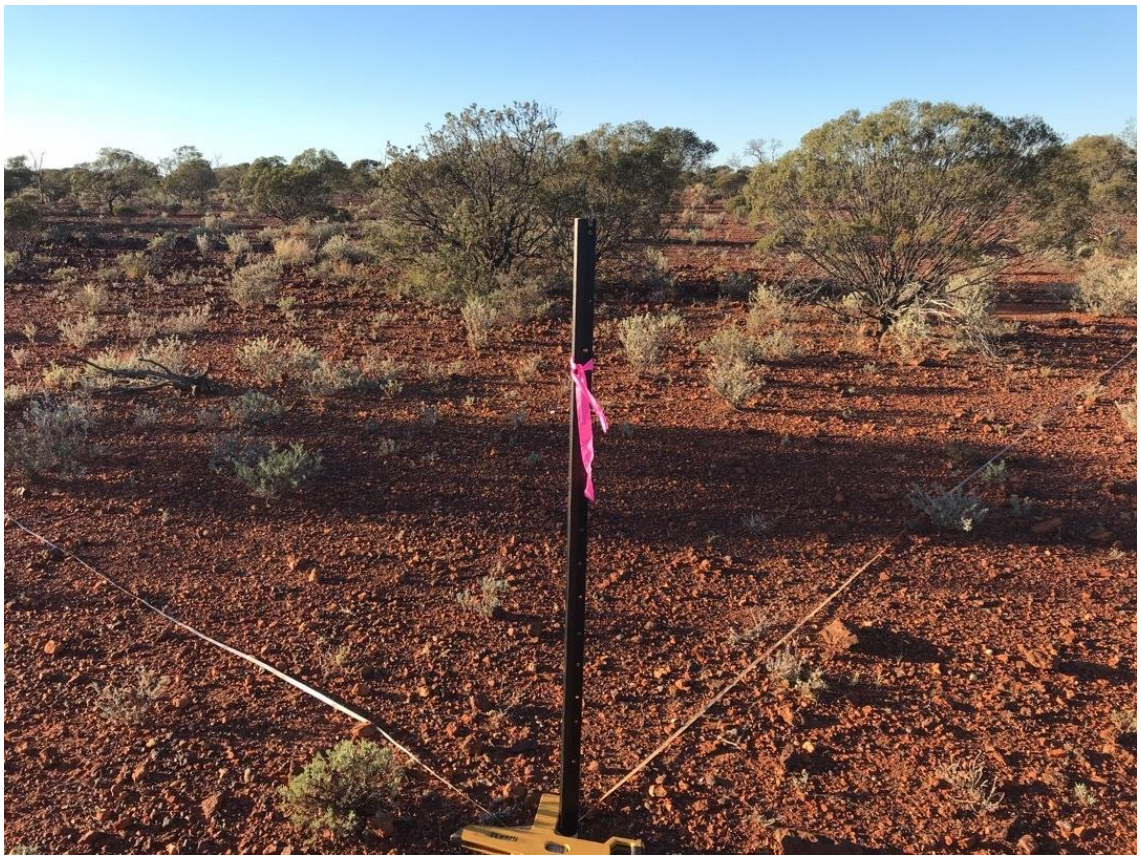
Species Name	Height (m)	Cover (%)
? Maireana sp.	0.2	5
Sclerolaena eriacantha	0.15	10
Ptilotus obovatus	0.4	32
Sclerolaena cuneata	0.2	0.1
Aristida contorta	0.15	0.1
Acacia tetragonophylla	0.8	0.1
Enteropogon ramosus	0.25	0.1
Scaevola spinescens	0.4	0.1
Grevillea sarissa subsp. *succincta*	2.3	1
Solanum lasiophyllum	0.2	0.1
Ptilotus nobilis	0.1	0.1
Eremophila linearis	20	0.1
Rhagodia eremaea	0.2	0.1
Sclerolaena densiflora	0.15	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
20	40	0	40

Veg Condition:	Excellent	Fire Age:	1-3 years
Weeds:	None	Fire Notes:	N/A

SITE PHOTOGRAPH



Jundee – Ramone– R14

Site Details:

Described by: Alice Bott

Date: 2018-04-14

Type: Quadrat (20m x 20m)

MGA Zone: 51J 279793mE 7060658mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°), north

Soils:

Soil Texture: Clay loam

Soil Colour: Orange

Rock Type: Ironstone, quartz

Coarse Surface Particles:

Site coverage: 20-50

Size: 20-60

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Introduced species: Camel

Erosion: N/A

Disturbance: Tracks, feral trampling

FLORA AND VEGETATION DATA

Description: *Eremophila linearis* and *Acacia craspedocarpa* (hybrid) tall shrubland to open scrub over *Sclerolaena ericantha* and ? *Maireana* sp. very open chenopods.

Species List

Species Name	Height (m)	Cover (%)
? Maireana sp.	0.25	0.5
Acacia craspedocarpa (hybrid)	2.4	3
Acacia tetragonophylla	0.6	0.1
Aristida contorta	0.15	0.1
Enteropogon ramosus	0.4	0.1
Eragrostis eriopoda	0.25	0.1
Eremophila linearis	2.4	31
Maireana sp.	0.12	0.1
Ptilotus nobils	0.2	0.1
Ptilotus obovatus	0.3	0.1
Rhagodia eremaea	0.4	0.1
Sclerolaena cuneata	0.12	0.1
Sclerolaena eriacantha	0.25	2
Sclerolaena sp.	0.3	0.1

Species Name	Height (m)	Cover (%)
Senna sp. Meekatharra (E. Bailey 1-26) hybrid	0.6	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	30	1	40

Veg Condition: Very Good

Weeds:

Fire Age: 3-5 years

Fire Notes: Presence of dead branches, bare ground

SITE PHOTOGRAPH

Jundee – Ramone– R15

Site Details:

Described by: Alice Bott

Date: 2018-04-14

Type: Quadrat (20m x 20m)

MGA Zone: 51J 280016mE 7060637mN

Environmental Variables:

Landform: Outcrop

Slope: Gently inclined (3-5°), north-west

Soils:

Soil Texture: Clay loam

Soil Colour: Orange

Rock Type: Granite

Coarse Surface Particles:

Site coverage: 20-50

Size: 20-60

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Erosion: N/A

Introduced species:

Disturbance:

FLORA AND VEGETATION DATA

Description: *Acacia incurvaneura* and *Acacia pruinocarpa* tall shrubland over *Acacia tetragonaphylla* and *Eremophila latrobei* subsp. *latrobei* open shrubland over *Ptilotus obovatus* open low shrubland

Species List

Species Name	Height (m)	Cover (%)
? Maireana sp.	0.12	0.1
Acacia incurvaenura	4	20
Acacia pruinocarpa	3.2	3.5
Acacia tetragonophylla	0.6	2
Anthobolus leptomerioides	1.2	0.1
Aristida contorta	0.12	0.1
Enteropogon ramosus	0.25	0.1
Eragrostis eriopoda	0.35	0.1
Eremophila latrobei subsp. latrobei	0.6	1
Eremophila linearis	1.1	0.1
Eremophila platycalyx subsp. platycalyx	1.6	0.1
Hibiscus burtonii	0.25	0.1
Maireana triptera	0.12	0.1
Marsdenia australis	0	0.1
Poaceae sp.	0.25	0.1
Psydrax latifolia	1.6	0.1
Psydrax rigidula	1.3	0.1

Species Name	Height (m)	Cover (%)
Psydrax suaveolens	0.45	0.1
Ptilotus nobilis	0.15	0.1
Ptilotus helipterioides	0.08	0.1
Ptilotus obovatus	0.4	5
Scaevola spinescens	0.6	0.1
Sclerolaena eriacantha	0.2	0.1
Sclerolaena sp.	0.2	0.1
Senna sp. Meekatharra (E. Bailey 1-26) hybrid	0.7	0.1
Solanum lasiophyllum	0.15	0.1
Triodia melvillei	0.3	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
30	2	1	40

Veg Condition: Excellent

Weeds:

Fire Age: 3-5 years

Fire Notes: Lack of fire scars, lack of grasses.

SITE PHOTOGRAPH

Jundee – Ramone– R16

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-14

Type: Quadrat (20m x 20m)

MGA Zone: 51J 280084mE 7060994mN

Environmental Variables:

Landform: Stony plain

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Skeletal soils

Soil Colour: Brown

Rock Type: Dolerite

Coarse Surface Particles:

Site coverage: 20-50

Size: 2-6,6-20,20-60,60-200

Outcropping: <2

Impacts:

Waterlogging: No - Never

Erosion: N/A

Introduced species:

Disturbance:

FLORA AND VEGETATION DATA

Description: *Acacia incurvaneura* tall open shrubland over *Eremophila latrobei* subsp. *latrobei* open low shrubland over *Eragrostis eriopoda* very open grassland

Species List

Species Name	Height (m)	Cover (%)
? Gyrostemon sp.	0.6	0.1
? Maireana sp.	0.12	1
Acacia craspedocarpa (hybrid)	1.6	1
Acacia tetragonophylla	0.4	0.1
Aristida contorta	0.12	0.1
Enteropogon ramosus	0.3	0.1
Eragrostis eriopoda	0.2	0.1
Eremophila latrobei subsp. latrobei	0.4	0.1
Eremophila linearis	2.4	28
Eremophila platycalyx subsp. platycalyx	0.3	0.1
Lawrencia densiflora	0.1	0.1
Psydrax rigidula	0.3	0.1
Ptilotus nobilis	0.08	0.1
Ptilotus obovatus	0.5	1

Species Name	Height (m)	Cover (%)
Ptilotus roei	0	0.1
Ptilotus rotundifolius	0.15	0.1
Sclerolaena cuneata	0.1	0.1
Sclerolaena densiflora	0.3	0.1
Sclerolaena eriacantha	0.15	1
Senna glutinosa subsp. chatelainiana	1.8	0.1
Senna sp. Meekatharra (E. Bailey 1-26) hybrid	1.5	6
Solanum lasiophyllum	0.4	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
65	5	0	35

Veg Condition:	Excellent	Fire Age:	3-5 years
Weeds:	None	Fire Notes:	Lack of fire scars, lack of grasses.

SITE PHOTOGRAPH

Jundee – Ramone– R17

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-14

Type: Quadrat (20m x 20m)

MGA Zone: 51J 279614.83 mE 7061175.41mN

Environmental Variables:

Landform: Temporary drainage network

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Light clay

Soil Colour: Brown

Rock Type: N/A

Coarse Surface Particles:

Site coverage: 0

Size: N/A

Outcropping: <2

Impacts:

Waterlogging: Yes - Temporary

Introduced species: **Bidens bipinnata*, **Malvastrum americanum*

Erosion: N/A

Disturbance: Weeds, tracks

FLORA AND VEGETATION DATA

Description: *Acacia pruinocarpa, Acacia aneura* open woodland over *Acacia craspedocarpa* (hybrid), *Senna artemisioides* subsp. X *artemisioides* open shrubland over *Perotis rara,* Eriachne flaccida closed tussock grassland

Species List

Species Name	Height (m)	Cover (%)
Cyperus iria	0.1	0.1
Abutilon fraseri	0.1	
Acacia aneura	5	3
Acacia craspedocarpa (hybrid)	1.2	2
Acacia pruinosa	8.5	5
Alternanthera denticulata	0.1	0.1
**Bidens bipinnata*	0.4	1
Boerhavia coccinea	0.1	0.1
Digitaria brownii	0.2	0.1
Eragrostis kennedyae	0.45	0.1
Eriachne flaccida	0.45	2
Malvastrum americanum	0.25	0.1
Marsdenia australis	0	0.1
Marsilea exarata	0.05	0.1

Species Name	Height (m)	Cover (%)
Perotis rara	0.15	3
Santalum ? spicatum	2.1	0.1
Senna artemisioides subsp. Filifolia	0.8	0.1
Senna artemisioides subsp. x artemisioides	0.5	2
Themeda triandra	0.65	0.1
Velleia glabrata	0.1	0.1
Velleia glabrata	0.1	0.1
Vittadinia sulcata	0.1	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	20	5	75

Veg Condition:	Degraded	Fire Age:	3-5 years
Weeds:	**Bidens bipinnata*	Fire Notes:	Presence of tall adult mulgas.

SITE PHOTOGRAPH

Jundee – Ramone– R18

Site Details:

Described by: Alice Bott

Date: 2018-04-14

Type: Quadrat (20m x 20m)

MGA Zone: 51J 2792992mE 7061175.41mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Dark loam

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 20-50

Size: 6-20, 20-60

Outcropping: <2

Impacts:

Waterlogging: No- Never

Introduced species: Camel, cattle

Erosion: N/A

Disturbance: Grazing

FLORA AND VEGETATION DATA

Description: *Eremophila linearis* tall shrubland over *Acacia craspedocarpa* (hybrid) and *Senna sp.* Meekatharra (E. Bailey 1-26) open shrubland to shrubland over *Sclerolaena eriacantha* and ? *Maireana* sp. very open chenopods.

Species List

Species Name	Height (m)	Cover (%)
Acacia ? aneura (hybrid)	7	2
Acacia incurvaenura	0.4	0.1
Acacia pteraneura	7	40
Acacia quadrimarginea	2.5	1
Acacia tetragonophylla	3.5	2
Aristida contorta	0.35	0.1
Cheilanthes sp.	0.1	0.1
Digitaria brownii	0.35	0.1
Enneapogon polyphyllus	0.4	40
Eragrostis eriopoda	0.3	0.1
Eragrostis falcata	0.35	3
Eragrostis kennedyae	0.4	40
Eragrostis mucronata	0.25	3
Eremophila latrobei subsp. *latrobei*	0.5	5

Species Name	Height (m)	Cover (%)
Eremophila platycalyx subsp. platycalyx	0.4	0.1
Eremophila punctata	0.1	0.4
Eriachne mucronata	0.25	0.1
Fimbristylis dichotoma	0.25	20
Malvaceae sp.	0.1	0.1
Neurachne minor	0.35	0.1
Perotis rara	0.25	0.1
Poaceae sp.	0.3	0.1
Psydrax latiofolia	0.4	0.1
Psydrax rigidula	0.3	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
2	12	4	40

Veg Condition:	Excellent	Fire Age:	3-5 years
Weeds:	None	Fire Notes:	Very few grasses and shrubs are mature.

SITE PHOTOGRAPH

Jundee – Ramone– R19

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-15

Type: Quadrat (20m x 20m)

MGA Zone: 51J 286975mE 7060206mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:		**Coarse Surface Particles:**	
Soil Texture:	Clay loam	Site coverage:	<2
Soil Colour:	Brown	Size:	2-6
Rock Type:	N/A	Outcropping:	0

Impacts:

Waterlogging:	No- Never	Erosion:	N/A
Introduced species:	Cattle	Disturbance:	Feral scats

FLORA AND VEGETATION DATA

Description: *Acacia pteraneura, Acacia ? aneura (hybrid), Acacia tetragonaphylla* open scrub over *Eremophila latrobei* subsp. *latrobei* open shrubland over *Eragrostis kennedyae, Eriachne flaccida, Thyridiolepis mitchelliana, Eragrostis falcata* closed tussock grassland over *Fimbristylis dichotoma* open sedgeland

Species List

Species Name	Height (m)	Cover (%)
Acacia aptaneura	4.5	3
Acacia craspedocarpa (hybrid)	3	10
Acacia pteraneura	6	20
Acacia tetragonophylla	0.2	0.1
Aristida contorta	0.2	0.1
Aristida jerichoensis var. *subspinulifera*	0.4	0.1
Cheilanthes sp.	0.12	0.1
Digitaria brownii	0.35	0.1
Eragrostis eriopoda	0.5	2
Eragrostis falcata	0.5	0.1
Eremophila ? georgei	1.2	0.1
Eremophila citrina	0.5	0.1
Eremophila fraseri	0.3	0.1
Eremophila latrobei subsp. latrobei	1.6	2

Species Name	Height (m)	Cover (%)
Eragrostis falcata	0.3	1
Eriachne mucronata	0.4	0.1
Fimbristylis dichotoma	0.08	8
Malvaceae sp.	0.25	0.1
Marsdenia australis	0	0.1
Neurachne minor	0.4	0.1
Psydrax latifolia	0.45	0.1
Psydrax rigidula	0.2	0.1
Psydrax suaveolens	0.3	0.1
Ptilotus obovatus	0.3	0.1
Senna glutinosa subsp. *chatelainiana*	1.1	0.1
Sida ectogama	1.2	0.1
Sida sp.	0.4	0.1
Solanum lasiophyllum	0.6	0.1
Teucrium teucriiflorum	0.6	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	10	20	75

Veg Condition: Excellent

Weeds:

Fire Age: 3-5 years

Fire Notes: Presence of tall adult mulgas.

SITE PHOTOGRAPH

Jundee – Ramone– R20

Site Details:

Described by: Alice Bott

Date: 2018-04-15

Type: Quadrat (20m x 20m)

MGA Zone: 51J 285863mE 7059829mN

Environmental Variables:

Landform: Narrow drainage line not incised. Ephemeral system

Slope: Level (0-3°), North-west

Soils:		**Coarse Surface Particles:**	
Soil Texture:	Loam	Site coverage:	2-6
Soil Colour:	Brown	Size:	6-20,20-60
Rock Type:	Ironstone	Outcropping:	2

Impacts:

Waterlogging:	No- Prone to ponding	Erosion:	N/A
Introduced species:	Cattle	Disturbance:	Feral trampling, tracks

FLORA AND VEGETATION DATA

Description: *Acacia pteraneura, Acacia aptaneura* and *Acacia craspedocarpa* open scrub over *Eremophila latrobei* subsp. *latrobei* open shrubland over *Aristida jerichoensis* var. *subspinulifera (Eragrostis falcata* and *Eragrostis eriopoda)* closed tussock grassland with *Fimbristylis dichotoma* very open sedgeland.

Species List

Species Name	Height (m)	Cover (%)
Acacia aneura	6.5	2
Acacia pteraneura	5	5
Acacia tetragonophylla	0.5	3
Aristida contorta	0.2	0.1
Aristida jerichoensis var. *subspinulifera*	0.5	45
Cheilanthes sp.	0.15	0.1
Digitaria brownii	6	3
Enneapogon polyphyllus	0.4	30
Eragrostis eriopoda	0.3	0.1
Eragrostis falcata	0.25	0.1
Eremophila latrobei subsp. *latrobei*	1.5	1
Eremophila platycalyx subsp. *platycalyx*	0.4	0.1
Eremophila spectabilis subsp. *? brevis*	0.6	0.1
Eriachne mucronata	0.3	0.1

Species Name	Height (m)	Cover (%)
Fimbristylis dichotoma	0.1	30
Psydrax latifolia	0.9	0.1
Psydrax rigidula	0.3	0.1
Psydrax suaveolens	0.5	0.1
Senna glutinosa subsp. *chatelainiana*	0.2	0.1
Sida sp. Verrucose glands F.H. Mollemans 2423)	0.2	0.1
Solanum lasiophyllum	0.25	0.1
Teucrium teucriiflorum	1.1	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	20	10	80

Veg Condition: Good

Fire Age: 3-5 years

Weeds:

Fire Notes: Presence of mature mulga.

SITE PHOTOGRAPH

Jundee – Ramone– R22

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-15

Type: Quadrat (20m x 20m)

MGA Zone: 51J 281663mE 7060916mN

Environmental Variables:

Landform: Hill

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Skeletal soils and outcropping

Soil Colour: Brown

Rock Type: Basalt

Coarse Surface Particles:

Site coverage: >90

Size: 2-6,6-20,20-60,60-200,200-600

Outcropping: 50-90

Impacts:

Waterlogging: No- Never

Introduced species: Cattle

Erosion: N/A

Disturbance: Feral trampling, tracks

FLORA AND VEGETATION DATA

Description: *Acacia ? incurvaneura* tall shrubland over *Eremophila citrina* open low heath to open heath

Species List

Species Name	Height (m)	Cover (%)
Acacia ? incurvaneura	3	12
Eragrostis eriopoda	0.3	0.1
Eremophila citrina	0.9	45
Eriachne mucronata	0.3	0.1
Triodia melvillei	0.6	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
70	0	0	30

Veg Condition:	Excellent	Fire Age:	3-5 years
Weeds: None		Fire Notes:	Presence of mature mulga.

SITE PHOTOGRAPH

Jundee – Ramone– R23

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-15

Type: Quadrat (20m x 20m)

MGA Zone: 51J 281615mE 7061388mN

Environmental Variables:

Landform: Hill

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Skeletal soils

Soil Colour: Brown

Rock Type: Basalt

Coarse Surface Particles:

Site coverage: 20-50

Size: 2-6,6-20

Outcropping: <2

Impacts:

Waterlogging: No- Never

Introduced species: N/A

Erosion: N/A

Disturbance: N/A

FLORA AND VEGETATION DATA

Description: *Acacia pruinocarpa* open low woodland over *Acacia incurvaneura* open tall shrubland over open *Eremophila citrina* open low heath over *Triodia melvillei* hummock grassland

Species List

Species Name	Height (m)	Cover (%)
Acacia ? incurvaneura	4.5	8
Acacia pruinocarpa	5	3
Eremophila citrina	0.85	40
Triodia melvillei	0.55	40

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
30	30	0	40

Veg Condition: Excellent

Weeds:

Fire Age: 3-5 years

Fire Notes: Presence of mature mulga.

SITE PHOTOGRAPH

Jundee – Ramone– R24

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-15

Type: Quadrat (20m x 20m)

MGA Zone: 51J 281615mE 7061279mN

Environmental Variables:

Landform: Hill

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Skeletal soils

Soil Colour: Brown

Rock Type: Basalt

Coarse Surface Particles:

Site coverage: 50-90

Size: 2-6,6-20,20-60,60-200

Outcropping: 0

Impacts:

Waterlogging: No- Never

Introduced species: N/A

Erosion: N/A

Disturbance: N/A

FLORA AND VEGETATION DATA

Description: *Acacia aneura* tall shrubland over *Eremophila citrina* open low heath over *Triodia melvillei* very open grassland

Species List

Species Name	Height (m)	Cover (%)
Acacia aneura	3.2	12
Aristida contorta	0.15	0.1
Eragrostis eriopoda	0.3	0.1
Eremophila citrina	0.85	40
Senna sp. Meekatharra (E. Bailey 1-26) hybrid	1.6	0.1
Triodia melvillei	0.6	5

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
60	0	0	40

Veg Condition:	Excellent	Fire Age:	3-5 years
Weeds:	None	Fire Notes:	Presence of mature mulga.

SITE PHOTOGRAPH

Jundee – Ramone– R25

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-15

Type: Quadrat (20m x 20m)

MGA Zone: 51J 283841mE 7061194mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Silty clay loam

Soil Colour: Red

Rock Type: Basalt

Coarse Surface Particles:

Site coverage: 50-90

Size: 2-6,6-20,20-60,60-200

Outcropping: 0

Impacts:

Waterlogging: Yes - Temporary

Introduced species: Cattle, camels

Erosion: N/A

Disturbance: Feral scats, feral trampling

FLORA AND VEGETATION DATA

Description: *Acacia pruinocarpa* open low woodland over *Acacia ? aneura, Acacia ramulosa var linophylla* tall shrubland over *Eremophila forrestii* subsp. *forrestii, Eremophila spectabilis* subsp. *brevis* open shrubland over *Triodia melvillei* hummock grassland

Species List

Species Name	Height (m)	Cover (%)
Acacia aneura	3.2	12
Aristida contorta	0.15	0.1
Eragrostis eriopoda	0.3	0.1
Eremophila citrina	0.85	40
Senna sp. Meekatharra (E. Bailey 1-26) hybrid	1.6	0.1
Triodia melvillei	0.6	5

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	20	5	75

Veg Condition:	Very Good	Fire Age:	3-5 years
Weeds:	None	Fire Notes:	Presence of mature mulga.

SITE PHOTOGRAPH

Jundee – Ramone– R26

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-16

Type: Quadrat (20m x 20m)

MGA Zone: 51J 281667mE 7060624mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°), south-east

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: N/A

Coarse Surface Particles:

Site coverage: 20-50

Size: 2-6

Outcropping: 0

Impacts:

Waterlogging: No - Never

Introduced species: Cattle, camels

Erosion: N/A

Disturbance: Feral scats, feral trampling

FLORA AND VEGETATION DATA

Description: *Acacia craspedocarpa* (hybrid) and *Acacia ? aneura* open tall shrubland over *Eragrostis eriopoda* and *Aristida contorta* very open tussock grassland.

Species List

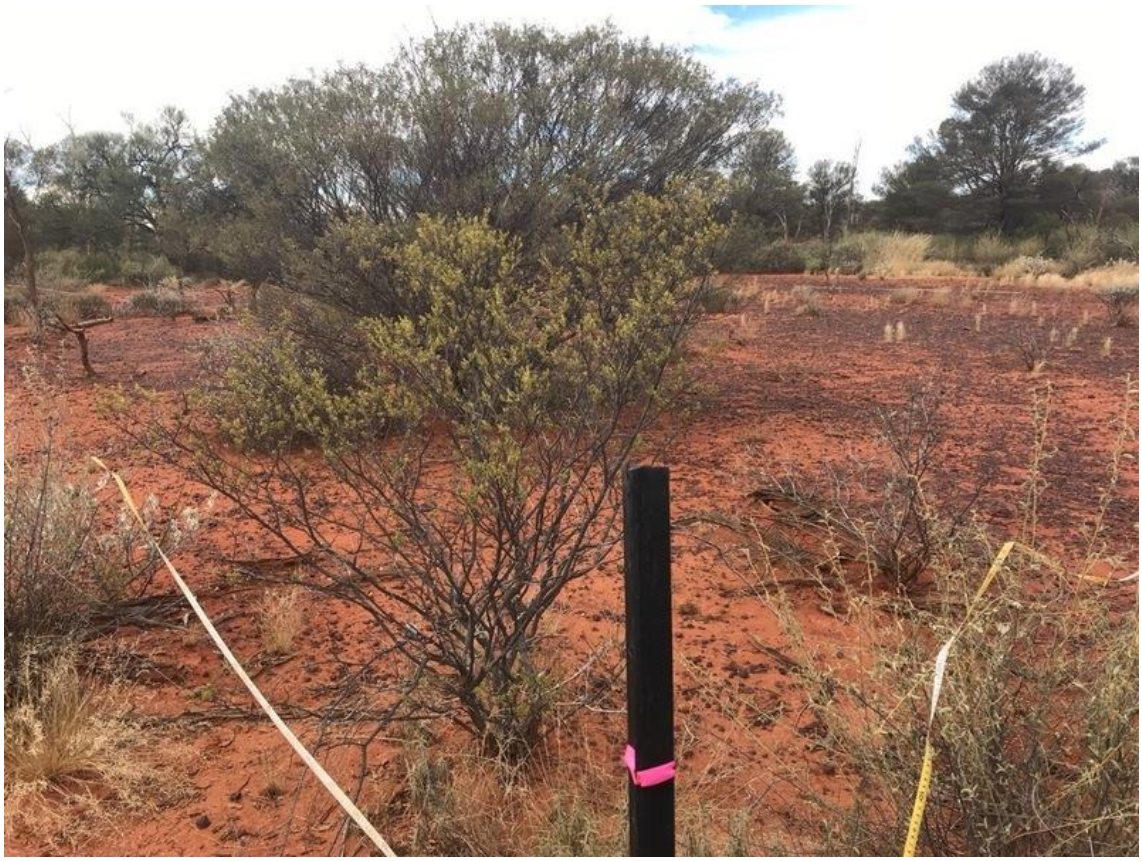
Species Name	Height (m)	Cover (%)
? Maireana sp.	0.15	0.1
Acacia ? aneura	2.5	1
Acacia craspedocarpa (hybrid)	3	2
Acacia tetragonophylla	0.25	0.1
Aristida contorta	0.35	0.5
Eragrostis eriopoda	0.35	1
Eremophila forrestii subsp. *forrestii*	0.6	0.1
Eremophila fraseri	0.5	0.1
Eremophila latrobei subsp. *latrobei*	1.5	0.1
Eremophila platycalyx subsp. *platycalyx*	0.45	0.1
Eremophila spectabilis subsp. *? brevis*	0.45	0.1
Psydrax latifolia	1.3	0.1
Rhagodia eremaea	0.25	0.1
Sclerolaena eriacantha	0.2	0.1
Sida sp.	1.2	0.1
Solanum lasiophyllum	0.35	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	60	3	27

Veg Condition:	Very Good	Fire Age:	3-5 years
Weeds:	None	Fire Notes:	Presence of mature mulga.

SITE PHOTOGRAPH



Jundee – Ramone– R27

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-16

Type: Quadrat (20m x 20m)

MGA Zone: 51J 280861mE 7060107mN

Environmental Variables:

Landform: Un-channeled, temporary drainage network. Surface flow only.

Slope: Level (0-3°)

Soils:

Soil Texture: Light clay

Soil Colour: Orange

Rock Type: N/A

Coarse Surface Particles:

Site coverage: N/A

Size: N/A

Outcropping: 0

Impacts:

Waterlogging: No - Never

Introduced species: Cattle, camels

Erosion: N/A

Disturbance: Feral scats, feral trampling

FLORA AND VEGETATION DATA

Description: *Acacia pruinocarpa* open woodland over *Acacia aneura* tall open shrubland over *Sida ectogama* open *shrubland* over *Eremophila spectabilis* subsp. *brevis* open low heath

Species List

Species Name	Height (m)	Cover (%)
Abutilon cryptopetalum	0.3	0.1
Acacia aneura	4.5	45
Acacia pruinocarpa	12	4
Aristida contorta	0.4	0.1
Bidens bipinnata	0.3	0.1
Cheilanthes sp.	0.1	0.1
Digitaria brownii	0.3	0.1
Dodonaea petiolaris	1.4	0.1
Eragrostis eriopoda	0.35	0.1
Eremophila forrestii subsp. *forrestii*	1.2	0.1
Eremophila spectabilis subsp. ? *brevis*	0.7	60
Maireana villosa	0.35	0.1
Marsdenia australis	0	0.1
Paspalidium basicladum	0.15	0.1
Perotis rara	0.1	0.1
Psydrax latifolia	0.45	0.1

Species Name	Height (m)	Cover (%)
Psydrax suaveolens	0.4	0.1
Ptilotus obovatus	0.5	0.1
Sida ectogama	0.35	5
Sida sp. Verrucose glands F.H. Mollemans 2423)	0.3	0.1
Solanum lasiophyllum	0.2	0.1
Teucrium teucriiflorum	0.45	0.1
Thyridolepis mitchelliana	0.35	2

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	25	5	70

Veg Condition: Good

Weeds: None

Fire Age: 3-5 years

Fire Notes: Presence of mature mulga.

SITE PHOTOGRAPH

Jundee – Ramone– R28

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-16

Type: Quadrat (20m x 20m)

MGA Zone: 51J 281327mE 7060894mN

Environmental Variables:

Landform: Un-channeled, temporary drainage network.

Slope: Level (0-3°)

Soils:

Soil Texture: Light clay

Soil Colour: Orange

Rock Type: N/A

Coarse Surface Particles:

Site coverage: N/A

Size: N/A

Outcropping: 0

Impacts:

Waterlogging: Yes - temporary

Introduced species: Cattle, camels

Erosion: N/A

Disturbance: Grazing, feral scats, feral trampling

FLORA AND VEGETATION DATA

Description: *Acacia pteraneura, Acacia aptaneura, Psydrax latifolia, Acacia tetragonaphylla, Santalum ? spicatum* tall shrubland over *Eremophila spectabilis* subsp. *brevis (Sida ectogama, Eremophila forrestii subsp. forrestii)* open low heath over *Eragrostis eriopoda (Thyridolepis mitchelliana)* tussock grassland

Species List

Species Name	Height (m)	Cover (%)
Acacia ? aneura	4	0.1
Acacia aptaneura	5	2
Acacia tetragonophylla	4	4
**Bidens bipinnata*	0.35	0.1
Cheilanthes sp.	0.2	0.1
Cucumis sp.*?myriocarpus*	0	0.1
Digitaria brownii	0.4	0.1
Eragrostis eriopoda	0.35	50
Eremophila forrestii subsp. *forrestii*	1	1
Eremophila spectabilis subsp. *? brevis*	0.4	45
Indigofera georgei	0.6	0.1
Maireana villosa	0.15	0.1
Monachather paradoxus	0.35	0.1
Perotis rara	0.1	0.1
Portulaca pilosa	0.05	0.1
Psydrax latifolia	4	4

Species Name	Height (m)	Cover (%)
Psydrax rigidula	1.8	0.1
Psydrax suaveolens	0.7	0.1
Ptilotus obovatus	0.4	0.1
Santalum ? spicatum	4	2
Senna stricta	1	0.1
Sida ectogama	0.65	3
Sida sp.	0.8	0.1
Sida sp. Verrucose glands F.H. Mollemans 2423)	0.4	0.1
Solanum lasiophyllum	0.4	0.1
Thyridolepis mitchelliana	0.35	3

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	25	5	70

Veg Condition: Good

Fire Age: 3-5 years

Weeds: None

Fire Notes: Presence of mature mulga.

SITE PHOTOGRAPH

Jundee – Ramone– R29

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-16

Type: Quadrat (20m x 20m)

MGA Zone: 51J 280718mE 7060991mN

Environmental Variables:

Landform: Temporary drainage network

Slope: Level (0-3°)

Soils:

Soil Texture: Light clay

Soil Colour: Orange

Rock Type: N/A

Coarse Surface Particles:

Site coverage: N/A

Size: N/A

Outcropping: 0

Impacts:

Waterlogging: Yes - temporary

Introduced species: Cattle, camel, rabbit

Erosion: N/A

Disturbance: Grazing, feral scats, feral trampling

FLORA AND VEGETATION DATA

Description: *Acacia aneura (Santalum ? spicatum, Acacia tetragonaphylla)* open scrub over *Eremophila spectablis* subsp. *brevis, Sida ectogama* open heath over *Ptilotus obovatus* open low shrubland over *Eragrostis eriopoda, Aristida contorta* open tussock grassland

Species List

Species Name	Height (m)	Cover (%)
Abutilon cryptopetalum	0.25	0.1
Acacia aneura	5	35
Acacia tetragonophylla	2.5	1
Aristida contorta	0.25	10
**Bidens bipinnata*	0.15	0.1
Boerhavia coccinea	0.3	0.1
Cheilanthes sp.	0.1	0.1
Digitaria brownii	0.4	0.1
Eragrostis eriopoda	0.3	15
Eragrostis falcata	0.2	0.1
Eremophila fraseri	2	0.1
Eremophila spectabilis	1.2	8
Eriachne pulchella subsp. pulchella	0.1	0.1
Maireana villosa	0.15	0.1
Marsdenia australis	0	0.1
Perotis rara	0.1	0.1

Species Name	Height (m)	Cover (%)
Psydrax latifolia	1.5	0.1
Psydrax rigidula	0.5	0.1
Psydrax suaveolens	0.4	0.1
Ptilotus macrocephalus	0.1	0.1
Ptilotus obovatus	0.4	5
Rhagodia ? eremaea	0.3	0.1
Santalum ? spicatum	3	2
Sclerolaena cuneata	0.25	0.1
Sida ectogama	1.1	25
Sida sp. Verrucose glands F.H. Mollemans 2423)	0	0.1
Solanum lasiophyllum	0.4	0.1
Thyridolepis mitchelliana	0.2	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	25	5	75

Veg Condition: Degraded

Fire Age: 3-5 years

Weeds: **Bidens bipinnata*

Fire Notes: Presence of mature mulga.

SITE PHOTOGRAPH

Jundee – Ramone– R30

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-16

Type: Quadrat (20m x 20m)

MGA Zone: 51J 283570mE 7060712mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Light clay

Soil Colour: Orange

Rock Type: N/A

Coarse Surface Particles:

Site coverage: N/A

Size: N/A

Outcropping: 0

Impacts:

Waterlogging: No - Never

Introduced species: Cattle, camel, rabbit

Erosion: N/A

Disturbance: Grazing, feral scats, feral trampling

FLORA AND VEGETATION DATA

Description: *Acacia pruinocarpa* open low woodland over *Acacia incurvaneura* open tall shrubland over *Eremophila citrina* low *shrubland* over *Triodia melvillei* hummock grassland

Species List

Species Name	Height (m)	Cover (%)
Acacia ? aneura	4	4
Acacia aneura	2.2	4
Acacia pruinocarpa	4.5	2
Acacia ramulosa var. linophylla	2	4
Aristida contorta	0.2	0.1
Eragrostis eriopoda	0.3	0.1
Eremophila forrestii subsp. *forrestii*	0.4	2
Eremophila spectabilis subsp. *? brevis*	0.8	5
Eriachne mucronata	0.35	0.1
Psydrax suaveolens	0.4	0.1
Sida sp.	0.4	0.1
Solanum lasiophyllum	0.4	0.1
Triodia melvillei	1.2	55

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	40	5	55

Veg Condition:	Excellent	Fire Age:	3-5 years
Weeds:	None	Fire Notes:	Presence of mature mulga.

SITE PHOTOGRAPH

Jundee – Ramone– R31

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-17

Type: Quadrat (20m x 20m)

MGA Zone: 51J 286508mE 7061685mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Orange

Rock Type: N/A

Coarse Surface Particles:

Site coverage: N/A

Size: N/A

Outcropping: 0

Impacts:

Waterlogging: No - Never

Introduced species: Camel

Erosion: N/A

Disturbance: Grazing, feral scats, feral trampling

FLORA AND VEGETATION DATA

Description: *Acacia ? incurvaneura (Acacia pteraneura)* open tall shrubland over *Eremophila forrestii* subsp. *forrestii* open low shrubland over *Triodia basedowii* hummock grassland

Species List

Species Name	Height (m)	Cover (%)
Acacia ? incurvaneura	4	7
Acacia pteraneura	3.8	1
Eragrostis eriopoda	0.4	0.1
Eremophila forrestii subsp. *forrestii*	0.85	2
Eremophila latrobei	0.85	0.1
Eremophila latrobei subsp. *latrobei*	0.5	0.1
Eriachne mucronata	0.3	0.1
Psydrax latifolia	0.25	0.1
Psydrax rigidula	0.3	0.1
Psydrax suaveolens	0.25	0.1
Ptilotus schwartzii	0.3	0.1
Solanum lasiophyllum	0.35	0.1
Thyridolepis mitchelliana	0.25	0.1
Triodia basedowii	0.65	60
Triodia melvillei	0.6	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	40	3	57

Veg Condition:	Very Good	Fire Age:	3-5 years
Weeds:	None	Fire Notes:	Presence of mature mulga.

SITE PHOTOGRAPH

Jundee – Ramone– R32

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-17

Type: Quadrat (20m x 20m)

MGA Zone: 51J 285016mE 7061441mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:		**Coarse Surface Particles:**	
Soil Texture:	Clayey loam	Site coverage:	N/A
Soil Colour:	Orange	Size:	N/A
Rock Type:	N/A	Outcropping:	0

Impacts:

Waterlogging:	No - Never	Erosion:	N/A
Introduced species:	Camel, cattle	Disturbance:	Grazing, feral scats, feral trampling

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FLORA AND VEGETATION DATA

Description: *Acacia aneura* tall open shrubland over *Eremophila spectabilis* subsp. ? *brevis* open low shrubland over *Eragrostis eriopoda* open tussock grassland

Species List

Species Name	Height (m)	Cover (%)
Acacia aneura	5	5
Acacia pruinocarpa	3	1
Eragrostis eriopoda	0.35	20
Eremophila forrestii subsp. *forrestii*	0.45	0.1
Eremophila latrobei subsp. *latrobei*	1	0.1
Eremophila spectabilis subsp. ? *brevis*	0.8	3
Maireana villosa	0.2	0.1
Psydrax rigidula	0.4	0.1
Ptilotus obovatus	0.35	0.1
Rhagodia ermaea	0.35	0.1
Senna glutinosa subsp. *chatelainiana*	1.1	0.1
Solanum lasiophyllum	0.4	0.1
Thyridolepis mitchelliana	0.25	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	40	3	57

Veg Condition: Very Good

Fire Age: 3-5 years

Weeds:

Fire Notes: Presence of mature mulga.

SITE PHOTOGRAPH

Jundee – Ramone– R33

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-17

Type: 20m x 20m

MGA Zone: 51J 286226mE 7061648mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Sandy loam

Soil Colour: Orange

Rock Type: N/A

Coarse Surface Particles:

Site coverage: N/A

Size: N/A

Outcropping: 0

Impacts:

Waterlogging: No - Never

Introduced species: Camel, cattle

Erosion: N/A

Disturbance: Clearing, tracks

FLORA AND VEGETATION DATA

Description: *Acacia aneura* tall open shrubland over *Eremophila forrestii* subsp. *forrestii* low open shrubland over *Triodia basedowii (melvillei)*

Species List

Species Name	Height (m)	Cover (%)
Acacia ? incurvaneura	4	5
Eremophila forrestii subsp. *forrestii*	0.65	20
Eremophila spectabilis subsp. *? brevis*	0.25	0.1
Ptilotus obovatus	0.3	0.1
Solanum lasiophyllum	0.15	0.1
Thyridolepis mitchelliana	0.35	0.1
Triodia basedowii	0.6	40

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	35	0	65

Veg Condition:	Very Good	Fire Age:	1-3 years
Weeds:	None	Fire Notes:	Presence of mature mulga.

SITE PHOTOGRAPH

Jundee – Ramone – R34

Site Details:

Described by: Crystal Heydenrych

Date: 2018-04-13

Type: 20m x 20m

MGA Zone: 51J 287402mE 7058930mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

FLORA AND VEGETATION DATA

Description: *Senna sp. Meekatharra* (E. Bailey 1-26) hybrid open low shrubland over *Sclerolaena eriacantha* and *Sclerolaena cuneata* (*Maireana sp*.) very open herbland.

Veg Condition:	Very Good	Fire Age:	Unknown (no evidence)
Weeds:	N/A	Fire Notes:	N/A

Species List

Species Name	Height (m)	Cover (%)
Senna sp. Meekatharra (E. Bailey 1-26)	0.5	12
Sclerolaena cuneata	0.15	3
Scleolaena eriacantha	0.15	2
Maireana sp.	0.15	2

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
2	83	0	15

Veg Condition:	Very Good	Fire Age:	Unknown (no evidence)
Weeds:	None	Fire Notes:	N/A

SITE PHOTOGRAPH

Appendix G Inventory of Vascular Flora Recorded

Table G-1: Vascular flora recorded in the Study Area

Family	Species
Amaranthaceae	*Alternanthera denticulata*
	Ptilotus nobilis
	Ptilotus helipteroides
	Ptilotus macrocephalus
	Ptilotus obovatus
	Ptilotus roei
	Ptilotus rotundifolius
	Ptilotus schwartzii
Apocynaceae	*Marsdenia australis*
Asteraceae	**Bidens bipinnata*
	Vittadinia sulcata
Chenopodiaceae	*Chenopodiaceae sp.*
	Maireana sp.
	Maireana thesioides
	Maireana triptera
	Maireana villosa
	Rhagodia eremaea
	Salsola australis
	Sclerolaena cuneata
	Sclerolaena densiflora
	Sclerolaena eriacantha
	Sclerolaena sp.
	Dysphania rhadinostachya
Cucurbitaceae	*Cucurbitaceae*
Cyperaceae	*Cyperaceae sp.*
	Cyperus iria
	Fimbristylis dichotoma
Fabaceae	*Acacia ?aneura (hybrid)*
	Acacia ?incurvaneura
	Acacia aneura
	Acacia aptaneura
	Acacia aptaneura x ?
	Acacia craspedocarpa (hybrid)
	Acacia mulganeura
	Acacia pruinocarpa
	Acacia pteraneura
	Acacia quadrimarginea
	Acacia ramulosa var. linophylla
	Acacia ramulosa var. ramulosa
	Acacia rhodophloia
	Acacia tetragonophylla
	Indigofera georgei
	Senna stricta
	Senna artemisioides subsp. x artemisioides
	Senna glaucifolia

Family	Species
	Senna glutinosa subsp. chatelainiana
	Senna sp. Meekatharra (E. Bailey 1-26) hybrid
Goodeniaceae	*Goodenia triodiophila*
	Scaevola spinescens
	Velleia glabrata
Gyrostemonaceae	*? Gyrostemon sp.*
	Codonocarpus cotinifolius
Lamiaceae	*Teucrium teucriiflorum*
Malvaceae	*Abutilon cryptopetalum*
	Abutilon fraseri
	Hibiscus burtonii
	Lawrencia densiflora
	Malvaceae sp.
	**Malvastrum americanum*
	Sida ectogama
	Sida sp.
	Sida sp. verrucose glands F.H. Mollemans 2423)
Marsileaceae	*Marsilea exarata*
Montiaceae	*Calandrinia sp.*
Myrtaceae	*Hysterobaeckea occlusa*
Nyctaginaceae	*Boerhavia coccinea*
	Nicotiana rosulata subsp. rosulata
Poaceae	*Aristida contorta*
	Aristida jerichoensis var. subspinulifera [P3]
	Cymbopogon obtectus
	Dactyloctenium radulans
	Digitaria brownii
	Enneapogon caerulescens
	Enneapogon polyphyllus
	Enteropogon ramosus
	Eragrostis eriopoda
	Eragrostis falcata
	Eragrostis kennedyae
	Eriachne flaccida
	Eriachne mucronata
	Eriachne pulchella subsp. pulchella
	Eriachne sp.
	Monachather paradoxus
	Neurachne minor
	Paspalidium basicladum
	Perotis rara
	Poaceae sp.
	Thyridolepis mitchelliana
	Triodia basedowii
	Triodia melvillei
	Tripogonella loliiformis

Family	Species
Portulacaceae	**Portulaca pilosa*
Proteaceae	*Grevillea berryana*
	Grevillea sarissa subsp. succincta
	Hakea lorea subsp. lorea
Pteridaceae	*Cheilanthes sp.*
Rubiaceae	*Psydrax latifolia*
	Psydrax rigidula
	Psydrax suaveolens
Santalaceae	*Anthobolus leptomerioides*
	Santalum ? spicatum
Sapindaceae	*Dodonaea petiolaris*
Scrophulariaceae	*Eremophila ? georgei*
	Eremophila ? platycalyx
	Eremophila citrina
	Eremophila forrestii subsp. forrestii
	Eremophila fraseri subsp. ?
	Eremophila latrobei subsp. filiformis
	Eremophila latrobei subsp. latrobei
	Eremophila linearis
	Eremophila platycalyx subsp. platycalyx
	Eremophila punctata
	Eremophila pungens **P4**
	Eremophila spectabilis subsp. ? brevis
Solanaceae	*Solanum lasiophyllum*

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APPENDIX D – BOTANICA 2023B

Vause Gourdis Project

Flora and Fauna Assessment

Prepared for Northern Star Resources Limited

Final
May 2023

Prepared by

BOTANICA CONSULTING

33 Brewer St PERTH WA 6000 | 0419 916 034

Document Information

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Disclaimer

Quality Assurance

An internal quality review process has been implemented to each project task undertaken by BC. Each document and its contents is carefully reviewed by core members of the Consultancy team and signed off at Director Level prior to issue to the client. Draft documents are submitted to the client for comment and acceptance prior to final production.

Cover Photo: Vause Gourdis survey area vegetation (taken 14th March 2023)

Prepared by: Lauren Pick
Senior Environmental Consultant
Botanica Consulting Pty Ltd

Reviewed by: Andrea Williams
Director
Botanica Consulting Pty Ltd

Approved by: Jim Williams
Director
Botanica Consulting Pty Ltd

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APPENDICES

1 EXECUTIVE SUMMARY

Botanica Consulting Pty Ltd (Botanica) was commissioned by Northern Star Resources Limited (NSR) to undertake a detailed flora/ vegetation survey and basic fauna survey surrounding the Vause Gourdis Project (referred to as the 'survey area'). The survey area is located 33km south-east of the Jundee Project and approximately 55 km east of Wiluna, Western Australia. The survey area encompasses an approximate area of 1,798 ha. The survey was conducted from the 12th to 15th March 2023. The flora/vegetation and fauna assessment were conducted in accordance with Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment – December 2016 (EPA, 2016a), and with the requirements of a basic terrestrial fauna survey as defined in Technical Guidance - Terrestrial Fauna Surveys for Environmental Impact Assessment – June 2020 (EPA, 2020), respectively.

Five vegetation types were identified within the survey area which was represented by a total of 19 families and 72 taxa. No Threatened Flora or Threatened Ecological Communities as listed under the Western Australian *Biodiversity Conservation (BC) Act 2016* or Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* were identified within the survey area. No Priority Flora or Priority Ecological Communities (as listed by DBCA) were identified within the survey area.

Based on the vegetation condition rating scale specified in the (EPA, 2016a), vegetation was rated as 'good' to 'very good'. No introduced flora were identified within the survey area.

Four fauna habitats were identified within the survey area. 12 fauna species were observed during the field survey (including two introduced taxa). No Threatened fauna or other specially protected species as listed under the Western Australian BC Act or the Commonwealth EPBC Act was identified within the survey area. No Priority fauna as listed by DBCA were recorded within the survey area.

There are no wetlands of international importance (Ramsar Wetlands) or national importance (Australian Nature Conservation Agency Wetlands) within the survey area. The survey area is not located within an Environmentally Sensitive Area (ESA) as listed under the *Environmental Protection (EP) Act 1986.* The survey area is not located within any vested or proposed Conservation Reserves.

Based on the outcomes from the survey undertaken, as presented in this report, Botanica considers that clearing is 'not at variance' or 'unlikely' to be at variance with majority of the native vegetation clearing principles listed under Schedule 5 of the EP Act. Due to the presence of minor ephemeral drainage lines within the survey area, clearing may be at variance with clearing principle f.

2 INTRODUCTION

Botanica Consulting Pty Ltd (Botanica) was commissioned by Northern Star Resources Limited (NSR) to undertake a detailed flora/ vegetation survey and basic fauna survey surrounding the Vause Gourdis Project (referred to as the 'survey area'). The survey area is located 33km south-east of the Jundee Project and approximately 55 km east of Wiluna, Western Australia (Figure 2-1). The survey area encompasses an approximate area of 1,798 ha. The survey was conducted from the 12th to 15th March 2023.

2.1 Objectives

The flora/vegetation assessment was conducted in accordance with the requirements of a detailed survey as defined in *Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment – December 2016* (EPA, 2016a). The objectives of the assessment were to:

1. Gather background information on flora and vegetation in the survey area (literature review, database and map-based searches);
2. Conduct a field survey to verify / ground truth the desktop assessment;
3. Define and map vegetation communities of the survey area to a scale appropriate for the Bioregion and described according to the National Vegetation Information System (NVIS) classification (NVIS Level V – Association);
4. Record the species composition of each vegetation community within the survey area and compile a species list for the survey area by vegetation type;
5. Provide quadrat-based data from plots representative of each vegetation type (minimum of three quadrats per vegetation type) according to Environmental Protection Authority (EPA, 2016a) guidelines;
6. Assess the species composition of each quadrat;
7. Determine the local and regional significance of flora and vegetation within the survey area;
8. Identify and record the locations of any significant flora/vegetation within the survey area;
9. Identify and record the locations of any introduced flora species (including Declared Pests) within the survey area;
10. Provide a map showing the distribution of significant flora/vegetation within the survey area; and
11. Define and map the condition of vegetation within the survey area in accordance with the vegetation condition rating scale specified in the Environmental Protection Authority (EPA) *Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment – December 2016* (EPA, 2016a).

The fauna assessment was conducted in accordance with the requirements of a basic terrestrial fauna survey as defined in *Technical Guidance - Terrestrial Fauna Surveys for Environmental Impact Assessment – June 2020* (EPA, 2020). The objectives of the assessment were to:

1. Undertake a literature review, including map-based information searches of all current and relevant literature sources and databases relating to the survey area;
2. Conduct fauna habitat mapping and identify habitat types which are suitable for each significant fauna considered likely or possible to occur, or fauna recorded in the survey area;
3. Compile an inventory of fauna species occurrences within the survey area;
4. Undertake opportunistic, low intensity sampling of fauna; and
5. Report on the conservation status of species present using the Western Australian Museum and *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) databases for presence of Threatened and Priority listed fauna species within the survey area.

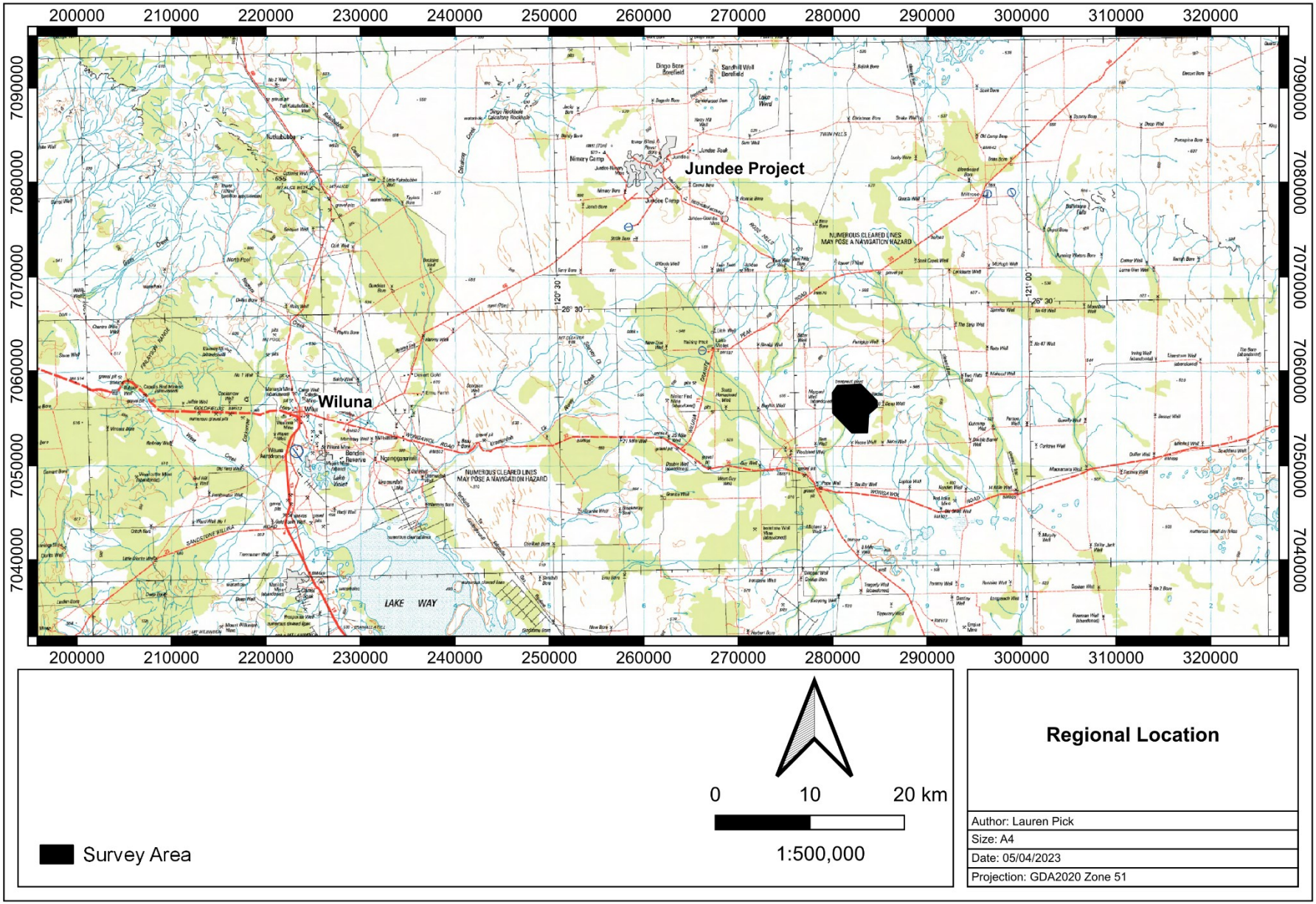


Figure 2-1: Regional map of the survey area

3 REGIONAL BIOPHYSICAL ENVIRONMENT

3.1 Regional Environment

The survey area lies within the Eremaean Province of Western Australia. Based on the Interim Biogeographic Regionalisation of Australia (IBRA), Version 7 (DotEE, 2012), the survey area is located within the Murchison Bioregion. The Murchison Bioregion is further divided into subregions with the survey area located within the Eastern Murchison subregion (MUR02) of the Murchison Bioregion (Figure 3-1).

The Eastern Murchison comprises the northern parts of the craton's Southern Cross and Eastern Goldfields Terrains and is characterised by internal drainage and extensive areas of elevated red desert sandplains with minimal dune development. Salt Lake systems are associated with the occluded paleodrainage system. Broad plains of red-brown soils and breakaways complexes as well as red sandplains are widespread. Vegetation is dominated by Mulga woodlands and is often rich in ephemerals, hummock grasslands, saltbush shrublands and *Tecticornia* shrublands (Cowan, 2001).

Figure 3-1: Map of IBRA Bioregions in relation to the survey area

3.2 Soil Landscape Systems

Based on geographic information provided by DPIRD (2019), the survey area is located within the South-eastern Zone of Ancient Drainage (250) of the Murchison Province

The Murchison Province consists of hardpan wash plains and sandplains (with some stony plains, hills, mesas and salt lakes) on the granitic rocks and greenstone of the Yilgarn Craton. The Murchison Province is located in the inland Mid-west and northern Goldfields between Three Springs, the Gascoyne River, Wiluna, Cosmo Newberry and Menzies. Soil types consist of red loamy earths, red sandy earths, red shallow loams, red deep sands and red-brown hardpan shallow loams with some red shallow sands and red shallow sandy duplexes present. Vegetation communities are predominately Mulga shrublands with spinifex grasslands, with areas of bowgada shrublands, Eucalypt woodlands and halophytic shrublands (Tille, 2006).

The Murchison Province is further divided into soil-landscape zones, with the survey area located within the Salinaland Plains Zone (279). The Salinaland Plains Zone comprises of sandplains (with hardpan wash plains and some mesas, stony plains and salt lakes) on granitic rocks (and some greenstone) of the Yilgarn Craton. Soils include red sandy earths, red deep sands, red shallow loams and red loamy earths with some red-brown hardpan shallow loams, salt lake soils and red shallow sandy duplexes. Vegetation consists of mulga shrublands with spinifex grasslands (and some halophytic shrublands and eucalypt woodlands). This zone is located in the northern Goldfields from Lakes Barlee and Ballard to Wiluna and Laverton (Tille, 2006).

The Salinaland Plains Zone (279) is further divided into soil landscape systems within the soil landscape systems of the survey area described in Table 3-1.

Table 3-1: Soil landscape systems within the survey area

Landscape System/ Mapping Unit	Description
Jundee System	Hardpan plains with variable gravelly mantles and minor sandy banks supporting weakly groved mulga shrublands.
Violet System	Gently undulating gravelly plains on greenstone, laterite and hardpan, with low stony rises and minor saline plains; supporting groved mulga and bowgada shrublands and occasionally chenopod shrublands.
Wiluna System	Low greenstone hills with occasional lateritic breakaways and broad stony slopes, lower saline stony plains and broad drainage tracts; supporting sparse mulga and other acacia shrublands with patches of halophytic shrubs.
Yanganoo System	Almost flat hardpan wash plains, with or without small wanderrie banks and weak groving; supporting mulga shrublands and wanderrie grasses on banks.

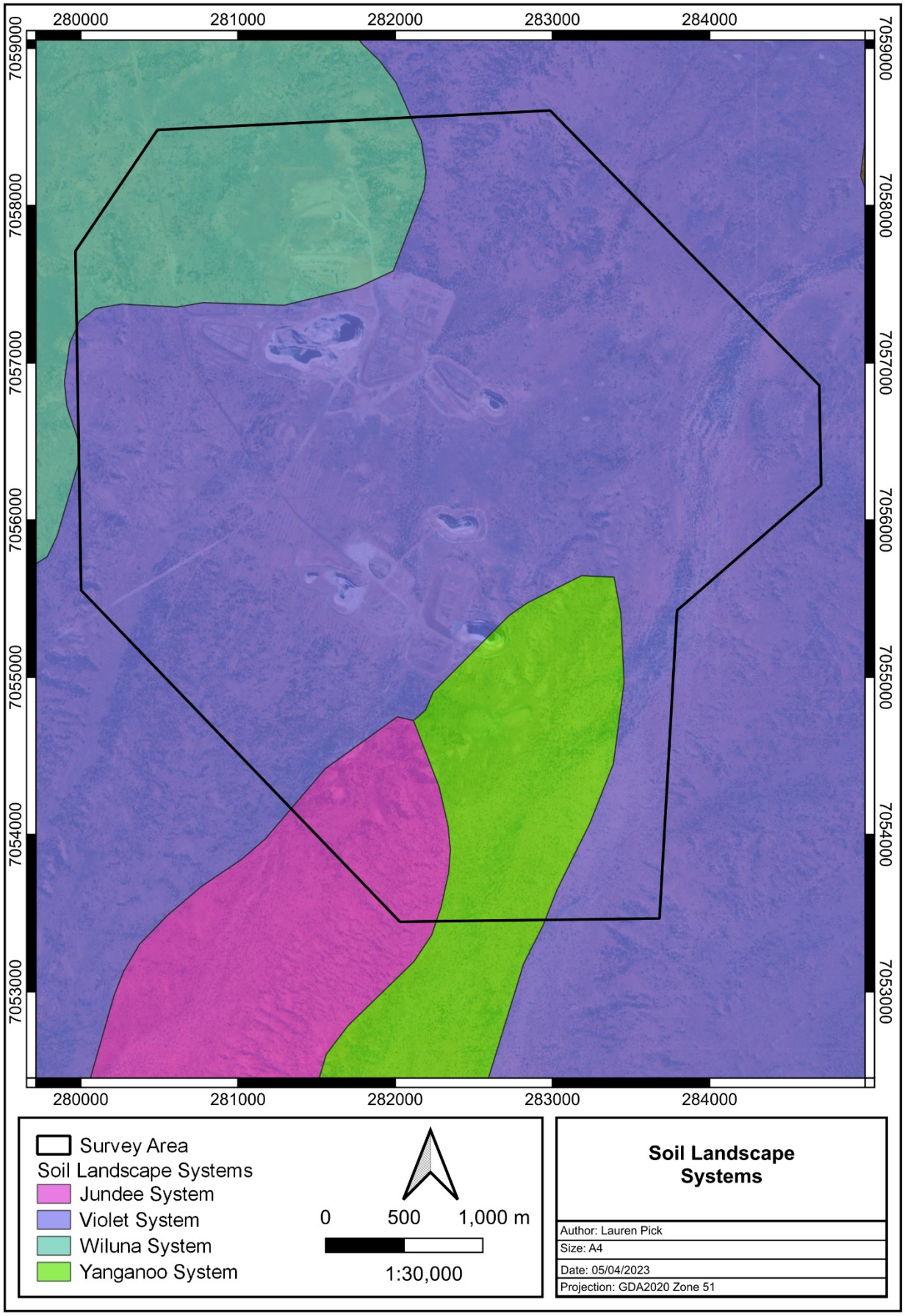


Figure 3-2: Soil landscape systems within the survey area

3.3 Vegetation

The survey area is located within the Austin Botanical District within the Eremaean Botanical Province. This botanical district is predominantly Mulga low woodlands on plains, often rich in ephemerals, which reduce to scrub on hills. It is also characterised by hummock grasslands, Saltbush shrublands and Samphire shrublands (Beard, 1990). The Eremaean Province is the largest of the three botanical provinces within Western Australia. The vegetation of the Austin Botanical District of the Murchison Region is predominantly low mulga (*Acacia aneura*) woodlands on plains and reduced to scrub on hills. This district is often associated with a tree steppe of *Eucalyptus* spp. and *Triodia basedowii* on sand plains.

The DPIRD GIS file (2021) indicates that the survey area is located within Pre-European Beard vegetation associations Wiluna 18 and Wiluna 39. The extent of these vegetation associations as specified in the *2018 Statewide Vegetation Statistics* (Government of Western Australia, 2019) is provided in Table 3-2.

Areas retaining less than 30% of their pre-European vegetation extent generally experience exponentially accelerated species loss, while areas with less than 10% are considered “endangered” (EPA, 2000).

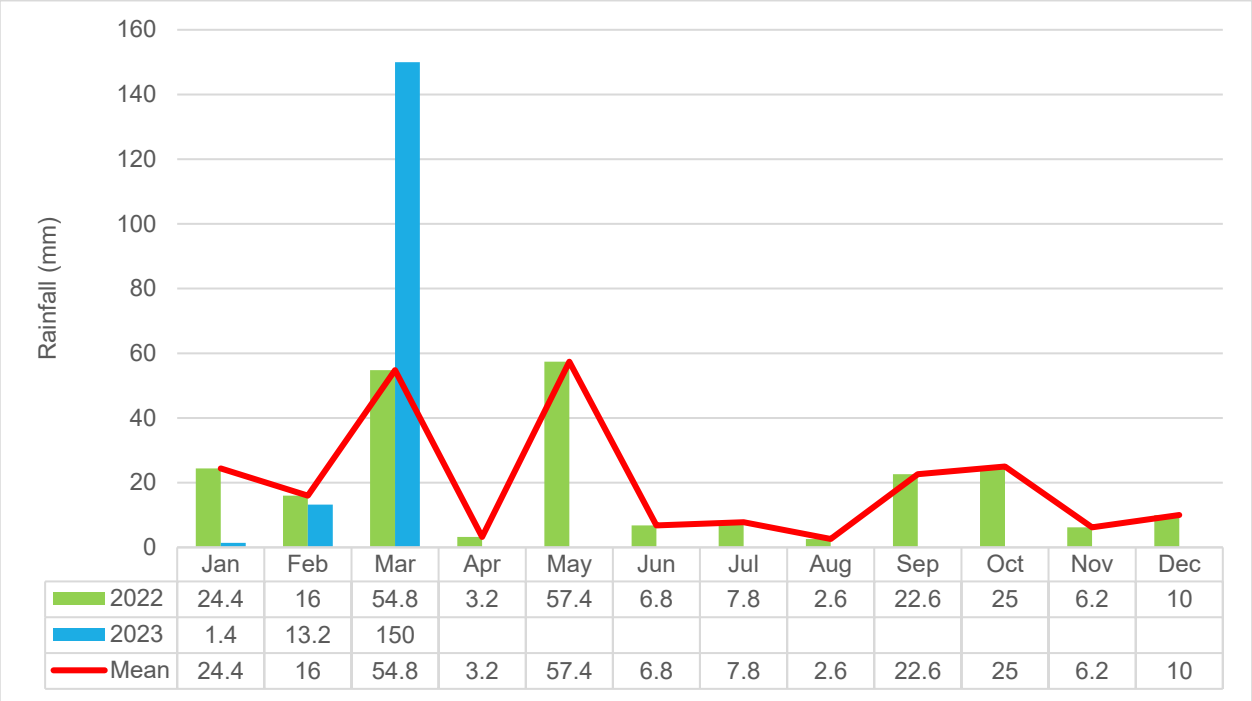
Table 3-2: pre-European vegetation associations within the survey area

Vegetation Association	Pre-European Extent (ha)	Pre-European extent remaining (%)	% of Current extent within DBCA managed lands	Vegetation Description (Beard, 1990)
Wiluna 18	4,273,509.57	99.59	1.05	Low woodland; mulga (*Acacia aneura*)
Wiluna 39	411,278.07	98.77	0	Shrublands; mulga scrub

Figure 3-3: pre-European vegetation associations within the survey area

3.4 Climate

The climate of the Eastern Murchison subregion is characterised as an arid climate with mainly winter rainfall and annual rainfall of approximately 200 mm (Beard, 1990; Cowan, 2001). Rainfall data for the Wiluna Aero weather station (#13044) located approximately 55 km west of the survey area is shown in Figure 3-2 (BoM, 2023a). Rainfall received in the months preceding the survey (Jan-Feb 2023) was below average. Survey work was undertaken in mid-March, within the EPA recommended timing for primary surveys of the Eremaean Province (i.e. Autumn) (EPA, 2016a).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2022	24.4	16	54.8	3.2	57.4	6.8	7.8	2.6	22.6	25	6.2	10
2023	1.4	13.2	150									
Mean	24.4	16	54.8	3.2	57.4	6.8	7.8	2.6	22.6	25	6.2	10

Figure 3-4: Monthly rainfall and mean monthly rainfall (January 2017 – March 2023) for the Wiluna Aero weather station #3044 (BoM, 2023a)

3.5 Hydrology

According to the Geoscience Australia database (2015) no inland waters or perennial drainage lines intersect the survey area. Two minor ephemeral drainage lines intersect the survey area (Figure 3-5).

Groundwater Dependent Ecosystems (GDE) includes biological assemblages of species such as wetlands or woodlands that use groundwater either opportunistically or as their primary water source. For the purposes of this report, a GDE is defined as any vegetation community that derives part of its water budget from groundwater and must be assumed to have some degree of groundwater dependency. According to the BoM *Atlas of Groundwater Dependent Ecosystems* (BoM, 2022b) database, there are no known or potential aquatic or terrestrial GDEs located within the survey area.

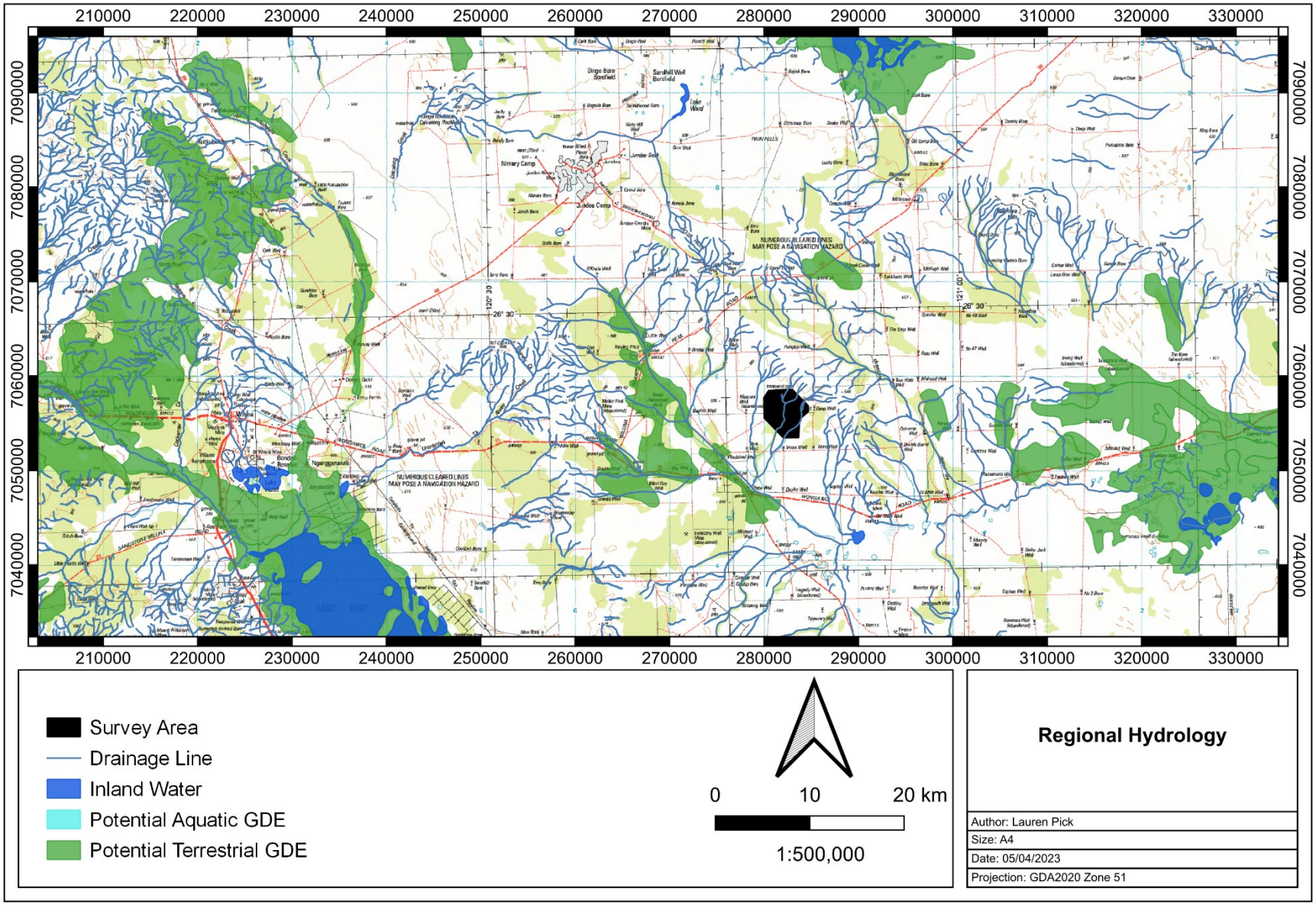


Figure 3-5: Regional hydrology of the survey area

3.6 Land Use

The dominant land uses of the Eastern Murchison subregion have been defined as grazing – native pastures (85.47%), Unallocated Crown Land (UCL) and Crown Reserves (11.34%), mining (1.79%) and Conservation Reserves which account for 1.4% of the land use (Cowan, 2001).

4 SURVEY METHODOLOGY

4.1 Desktop Assessment

Prior to the field assessment a literature review was undertaken of previous flora and fauna assessments conducted within the local region. Documents reviewed included:

- Animal Plant Mineral (2015). Vegetation Clearing Permit Application, Matilda Gold Project, Support Information for Matilda Mine Site Native Vegetation Clearing (Purpose) Permit Application, October 2015.
- Biota Environmental Sciences (2004). Waterloo and Amorac Extension Fauna Site Inspection. Unpublished report for LionOre.
- Botanica Consulting (2014). Level 1 Flora and Vegetation Survey of the Thunderbox to Bannockburn Project.
- Botanica Consulting (2016). Level 1 Flora and Fauna Survey Julius Project, Prepared for Echo Resources Limited.
- Botanica Consulting (2019a). Reconnaissance Flora/ Vegetation and Fauna Survey Orelia Project. Prepared for Echo Resources Limited.
- Botanica Consulting (2019b). Reconnaissance Flora/ Vegetation & Fauna Survey. Mt Joel Project. Prepared For Echo Resources Limited.
- Botanica Consulting (2020a). Detailed Flora/ Vegetation Survey Lake Way Potash Project. Prepared for Salt Lake Potash Limited.
- Botanica Consulting (2020b). Reconnaissance Flora/ Vegetation & Fauna Survey within M53/191. Prepared for Northern Star Resources Limited.
- Ecologia (1995). Jundee Gold Project Environmental Assessment.
- Engenium (2015). Lake Maitland - Level 2 Vertebrate Fauna and Targeted Reptile Survey Report. Unpublished report for Toro Energy Limited
- Hall, N.J., Newbey, K.R., McKenzie, N.L., Keighery, G.J., Rolfe, J.K & Youngson, W. K., (1993). *The Biological survey of the Eastern Goldfields of Western Australia Part 7: Sandstone-Sir Samuel. Laverton-Leonora study area,* West. Aust. Mus. Suppl. 47.
- Outback Ecology (2008a). Bronzewing – Mt McClure, Application for a Purpose Permit to Clear Native Vegetation at the Bronzewing – Mt McClure Project – Corboys Prospect M53/15, prepared for View Resources
- Outback Ecology (2008b). Bronzewing – Mt McClure, Report on the distribution of *Eremophila pungens* (P4) within the Bronzewing – Mt McClure Gold Project, prepared for View Resources.
- Paul Armstrong and Associates (2001). Rare Flora Search, and Flora and Vegetation Survey of the Exploration and Mine Lease of Thunderbox.
- Paul Armstrong and Associates (2004). Rare Flora Search and Vegetation Survey at the Waterloo Prospects.
- Trudgen, M (1989). A Flora and Vegetation Survey of Part of the Cyprus Gold Mount McClure Gold Mining Leases. Report prepared for Cyprus Gold for inclusion in the Mt McClure Project Feasibility Study, Volume 2 Environmental Study

Searches of the following databases were undertaken to aid in the compilation of a list of flora, vegetation and fauna taxa within the survey area:

- Department of Biodiversity, Conservation and Attractions (DBCA) Priority/ Threatened Flora Database Search (DBCA, 2022a);
- DBCA Priority/ Threatened Ecological Communities Database Search (DBCA, 2022b);
- DBCA NatureMap Database (DBCA, 2021); and

- Department of Climate Change, Energy the Environment and Water Protected Matters search tool (DCCEEW, 2022).

It should be noted that these lists are based on observations from a broader area (i.e., within a 40 km radius from the survey area). It is on this basis it may include taxa not present. The databases also often include very old records that may be incorrect or in some cases the taxa in question have become locally or regionally extinct.

Information from the above sources should therefore be taken as indicative only and local knowledge and information also need to be taken into consideration when determining what actual species may be present within the specific area being investigated.

The significance of flora and fauna taxa was assessed using data from the following sources:

- *Environment Protection and Biodiversity Conservation* (EPBC) *Act 1999*. Administered by the Australian Government (DCCEEW);
- *Biodiversity Conservation* (BC) *Act 2016*. Administered by the WA Government (DBCA);
- Red List produced by the Species Survival Commission (SSC) of the World Conservation Union (also known as the IUCN Red List – the acronym derived from its former name of the International Union for Conservation of Nature and Natural Resources). The Red List has no legislative power in Australia but is used as a framework for State and Commonwealth categories and criteria; and
- Priority Flora/ Fauna list. A non-legislative list maintained by DBCA for management purposes (fauna list released 7th October 2022; flora list released 22nd June 2022).

The EPBC Act also requires the compilation of a list of migratory species that are recognised under international treaties including the:

- Japan Australia Migratory Bird Agreement 1981 (JAMBA)[1];
- China Australia Migratory Bird Agreement 1998 (CAMBA);
- Republic of Korea-Australia Migratory Bird Agreement 2007 (ROKAMBA); and
- Bonn Convention 1979 (The Convention on the Conservation of Migratory Species of Wild Animals).

Most but not all migratory bird species listed in the annexes to these bilateral agreements are protected in Australia as Matters of National Environmental Significance (MNES) under the *EPBC Act*. Descriptions of significant species and communities are provided in Appendix 1.

Flora of significance identified during the literature review and database searches as previously being recorded in the general area were assessed and ranked for their likelihood of occurrence within the survey area. The rankings and criteria used were:

- Unlikely: Area is outside of the currently documented distribution for the species/no suitable habitat (type, quality and extent) was identified as being present during the field/desktop study.

[1] Most but not all species listed under JAMBA are also specially protected under Specially Protected Species of the BC Act.

- Possible: Area is within the known distribution of the species in question and habitat of at least marginal quality was identified as being present during the field/desktop study, supported in some cases by recent records being documented from within or near the area.

- Known to Occur: The species in question was positively identified as being present during previous field surveys.

Fauna of significance identified during the literature review and database searches as previously being recorded in the general area were assessed and ranked for their likelihood of occurrence within the survey area. The rankings and criteria used were:

- Would Not Occur: There is no suitable habitat for the species in the survey area and/or there is no documented record of the species in the general area since records have been kept and/or the species is generally accepted as being locally/regionally extinct (supported by a lack of recent records).

- Locally Extinct: Populations no longer occur within a small part of the species natural range, in this case within 10 or 20 km of the survey area. Populations do however persist outside of this area.

- Regionally Extinct: Populations no longer occur in a large part of the species natural range, in this case within the goldfields region. Populations do however persist outside of this area.

- Unlikely to Occur: The survey area is outside of the currently documented distribution for the species in question, or no suitable habitat (type, quality and extent) was identified as being present during the field assessment. Individuals of some species may occur occasionally as vagrants/transients especially if suitable habitat is located nearby but the site itself would not support a population or part population of the species.

- Possibly Occurs: Survey area is within the known distribution of the species in question and habitat of at least marginal quality was identified as likely to be present during the field survey and literature review, supported in some cases by recent records being documented in literature from within or near the survey area. In some cases, while a species may be classified as possibly being present at times, habitat may be marginal (e.g. poor quality, fragmented, limited in extent) and therefore the frequency of occurrence and/or population levels may be low.

- Known to Occur: The species in question has been positively identified as being present (for sedentary species) or as using the survey area as habitat for some other purpose (for non-sedentary/mobile species) during field surveys within or near the survey area. This information may have been obtained by direct observation of individuals or by way of secondary evidence (e.g. tracks, foraging debris, scats). In some cases, while a species may be classified as known to occur, habitat may be marginal (e.g. poor quality, fragmented, limited in extent) and therefore the frequency of occurrence and/or population levels may be low.

4.2 Flora and Vegetation Field Assessment

Botanica conducted a detailed flora and vegetation survey of the 1,798 ha survey area from the 12th to 15th March 2023. The survey area was traversed by two Botanica staff members on foot and four-wheel drive (Figure 4-1).

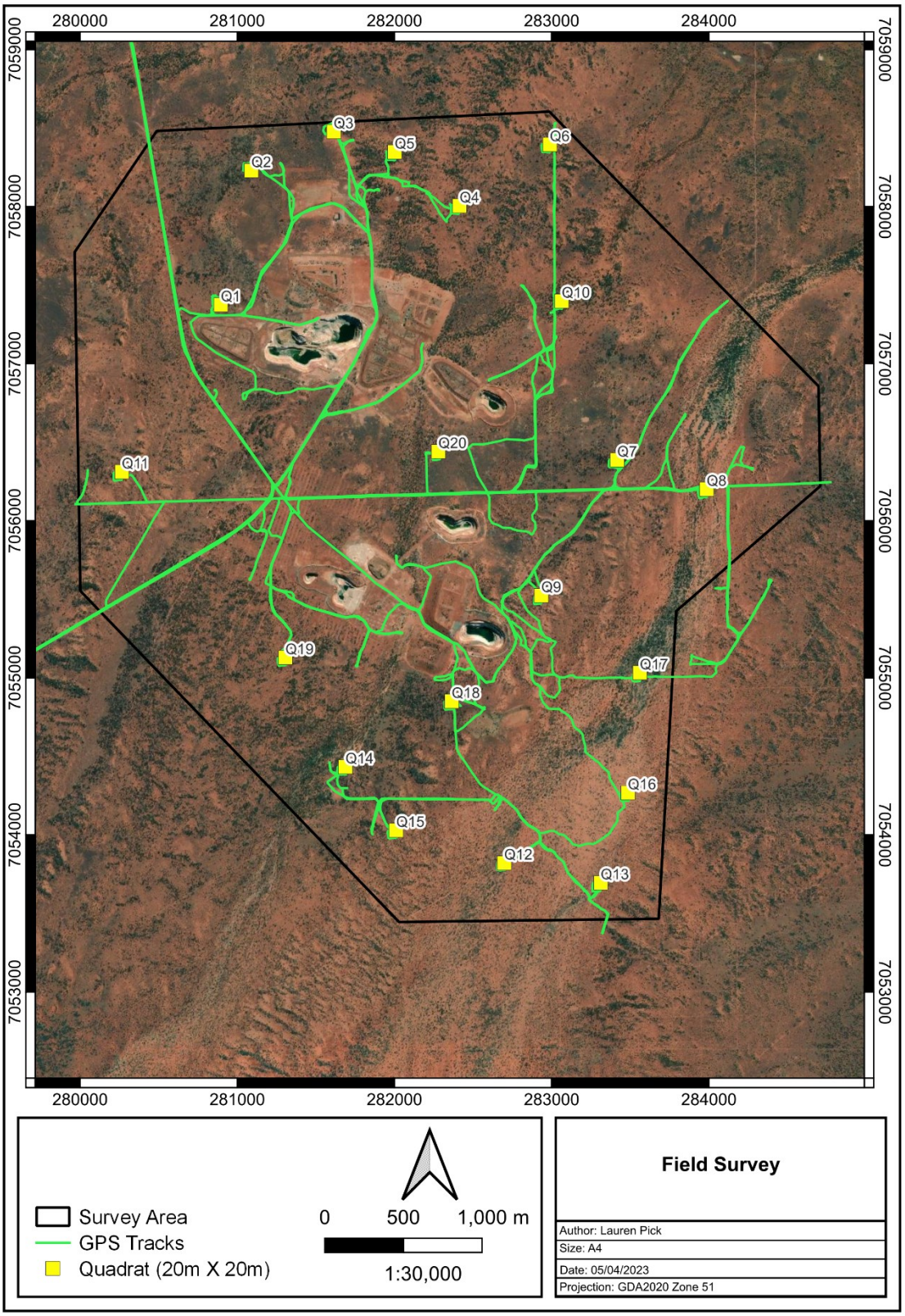


Figure 4-1: Quadrat locations, survey area boundary and GPS tracks traversed throughout the survey area

4.2.1 Vegetation Mapping

Prior to the commencement of field work, aerial photography was inspected and obvious differences in the vegetation assemblages were identified. The different vegetation types identified were then inspected during the field survey to assess their validity. A handheld GPS unit was used to record the coordinates of the boundaries between vegetation types.

At each sample point, the following information was recorded:

- GPS location;
- Photograph of vegetation;
- Dominant taxa for each stratum (including height and percentage cover of dominant taxa);
- All vascular taxa (including annual taxa);
- Landform classification;
- Vegetation condition rating;
- Collection and documentation of unknown plant specimens; and
- Collection of flora of significance if encountered.

Vegetation types were classified in accordance with the NVIS Level V-Association classification.

4.2.2 Detailed Flora and Vegetation Survey

Twenty 50 m X 50 m quadrats were established within the survey area (Figure 4-1 and Appendix E). The recommended quadrat size specified in the Environmental Protection Authority (EPA) Guidelines for the Murchison Bioregion is 20 m X 20 m, however 50 m X 50 m were established due to the low species richness in the survey area. The quadrats were established by inserting metal pickets into the NW corner, and measuring the length of the resultant boundaries to verify the quadrats were 50 m X 50 m (square quadrats). The objective was to have at least three quadrats per vegetation type to capture the floristic variations within the survey area.

Following their establishment and boundary verification, the NW corner of each quadrat was recorded by GPS (Appendix E) and three photographs of the quadrat were taken from the NW corner (Appendix G). All vascular plants within the quadrat were recorded (Appendix F). This included recording of dominant taxa from the upper, middle and lower stratum, and sampling of all unknown taxa. Unknown taxa were identified using Botanica's own reference herbarium and relevant taxonomic keys or by a taxonomic consultant. Data on level of disturbance, presence of coarse fragments on surface, topographical position, elevation, aspect, percentage litter, percentage bare ground, percentage surface rock (bedrock and surface deposits), soil types (colour, profile, field texture and surface type), and vegetation structure were collected from each quadrat (Appendix F). Methods of recording data from these quadrats largely follow those outlined in CSIRO's *Australian Soil and Land Survey Field Handbook* (McDonald *et al.* 1998) and in accordance with EPA Guidelines (2016). Presence/absence data of taxa from sample sites were used to compile the representative vegetation types.

4.2.3 Flora Identification

Unknown specimens collected during the survey were identified with the aid of samples housed at the Botanica Herbarium and the Western Australian Herbarium.

4.3 Data Analysis Tools

Following field assessments, vegetation types and condition were mapped using the GIS program QGIS, and the hectare area/ percentage area of each vegetation type and condition within the survey area was calculated. Spatial maps illustrating the location of vegetation types and any significant flora/ vegetation and fauna were generated using QGIS.

4.3.1 PATN Analysis

The PATN software package was used to assess the similarities/ dissimilarities between quadrats based on presence/absence of species. One sterile taxon was recorded during the survey which was excluded from the analysis. Singleton taxa were included in the analysis (12 taxa). Two subspecies were reconciled to a single species. A total of 46 taxa recorded within the quadrats were included in the analysis.

The analysis produced a quantitative estimate of the relationship between species composition of each quadrat. The classifications were based upon a Bray-Curtis association matrix using a flexible Unweighted Pair Group Arithmetic Mean (UPGMA) method (with a beta value of -0.1) which standardises the data enabling the analysis to be completed. Semi-strong hybrid (SSH) ordination of the quadrat is then undertaken to show spatial relationships between groups and to elucidate possible environmental correlates with the classification.

The analysis also produced a stress value which is a measure of the 'strength' of the analysis (i.e., how well the quadrats are grouped together into the appropriate floristic groups). The lower the stress value the greater the strength of the analysis with a value of less than 0.3 showing that the analysis appropriately grouped quadrats. A stress value greater than 0.3 suggests that the analysis was unable to group quadrats appropriately due to extraneous variables (i.e., other factors influencing differences in floristic groups other than species composition e.g., fire, clearing disturbance etc.).

4.3.2 EstimateS

EstimateS software was used to estimate species richness present using the Chao2 richness estimator. For any number of samples, the estimator uses the existing pattern of species accumulation to estimate the true number of species at a site. The estimators tend to under-estimate species number when sample size is small, hence the estimated number of true species can be seen to increase with sample size. This software was also used to compute Coleman rarefaction curves estimates which were used to calculate species accumulation curves.

4.4 Terrestrial Fauna Field Assessment

Botanica conducted a basic fauna survey of the 1,798 ha survey area from the 12th to 15th March 2023. The survey area was traversed by two people on foot (Figure 4-1).

Fauna habitat types were identified across the survey area based on broad major vegetation groups and associated landform. A handheld GPS unit was used to record the coordinates of the boundaries between fauna habitats and each habitat was photographed. The main aim of the fauna habitat assessment was to determine the likelihood of a species of significance utilising habitat within the survey area. The habitat information obtained was also used to aid in finalising the overall potential fauna list. Available information on the habitat requirements of the species of significance listed as possibly occurring in the area (determined from the desktop assessment) was researched. During the field survey, the habitats within the survey area were assessed and specific elements identified, if present, to determine the likelihood of listed Threatened and Priority species utilising habitat within the survey area. Opportunistic observations of fauna species were made during all field survey work.

4.5 Scientific Licences

Table 4-1: Scientific Licenses of Botanica Staff coordinating the survey

Licensed Staff	Permit Number	Date of Expiry
Lauren Pick	FB62000457(licence to take flora for scientific purposes)	04/08/2025

4.6 Survey Limitations and Constraints

It is important to note that flora/ vegetation and fauna surveys will entail limitations notwithstanding careful planning and design. Potential limitations are listed in Table 4-2.

Table 4-2: Limitations and constraints associated with the flora/ vegetation and fauna survey

Variable	Potential Impact on Survey	Details
Access problems	Not a constraint	The survey was conducted on foot. Access was readily available from existing access tracks located within the survey area.
Competency/ Experience	Not a constraint	The Botanica personnel that conducted the survey were regarded as suitably qualified and experienced. **Coordinating Staff**: Jim Williams (Botanist) & Lauren Pick (Botanist/ Zoologist) **Field Staff**: Lauren Pick and Kaitlyn Coyle **Data Interpretation**: Jim Williams and Lauren Pick
Timing of survey, weather & season	Minor constraint	Survey work was undertaken in March 2023 within the EPA recommended timing for primary surveys of the Eremaean Province (i.e. post wet season; March-June) (EPA, 2016a) but occurred following below average rainfall. No annual taxa were recorded during the survey.
Area disturbance	Not a constraint	Vegetation within the survey area was in good to very good condition and comprised of native vegetation.
Survey Effort/ Extent	Not a constraint	Survey intensity was appropriate for the size/significance of the area with a detailed flora survey and basic fauna survey completed to identify vegetation types/ fauna habitats and significant flora, fauna and vegetation.
Availability of contextual information at a regional and local scale	Not a constraint	Significant flora database searches provided by the DBCA were used to identify any potential locations of Threatened/Priority flora species. BoM, DWER, DPIRD, DBCA and DCCEEW databases were reviewed to obtain appropriate regional desktop information on the biophysical environment of the local region. Botanica has conducted a number of surveys within the Forrestania region and were able to obtain information about the area from previous research conducted within the area. Results of previous assessments in the local area were reviewed to provide context on the local environment.
Data Analysis	Minor constraint	Botanica staff conducting the PATN statistical analyses are not statistical analysts and have basic statistics training. These analyses were used to provide basic information on the relationships between vegetation communities delineated in the field.
Completeness	Not a constraint	In the opinion of Botanica, the survey area was covered sufficiently in order to identify vegetation assemblages. Survey work was conducted during the EPA recommended timeframe for primary surveys however rainfall was below average with limited flora in flower and no annual taxa present within the survey area. The vegetation associations were based on visual descriptions of locations in the field. The distribution of these vegetation associations outside the survey area is not known, however vegetation associations identified were categorised via comparison to vegetation distributions throughout WA given on NVIS (DotEE, 2017).

5 RESULTS

5.1 Desktop Assessment

5.1.1 Flora/ Vegetation

According to the results of the NatureMap search (DBCA, 2021), a total of 206 flora taxa have been recorded within a 40 km radius of the survey area. Dominant genera include *Acacia* and *Eremophila.* Combined results of database searches (DBCA, 2021 and DCCEEW, 2022) identified five introduced taxa as potentially occurring within 40km of the survey area (Table 5-1). According to the Department of Primary Industries and Regional Development Western Australian Organism List (DPIRD, 2020), none of these taxa are listed as a Declared Pest under the *Biosecurity and Agriculture Management* (BAM) *Act 2007.* No taxa are listed as a Weed of National Significance (WoNS).

Table 5-1: Introduced flora within 40km radius of the survey area

Taxon	Common Name
Carrichtera annua	Wards weed
Cenchrus ciliaris	Buffel Grass
Cynodon dactylon	Couch
Polypogon monspeliensis	Annual Beard grass
Tribulus terrestris	Caltrop

The results of the literature review, combined search of the DBCA's Flora of Conservation Significance databases (DBCA, 2012a) and DCCEEW protected matters search (DCCEEW, 2023) recorded no Threatened Flora or Priority Flora within the survey area. No Threatened Flora and a total of nine Priority Flora taxa were listed on the databases as occurring within a 40km radius of the survey area (map of flora locations provided in Appendix B). A description of the known habitat for each taxon is provided in Table 5-2.

Table 5-2: Flora of Conservation Significance identified as possible to occur within the survey area

Taxon	Conservation Code			Description (DBCA, 2022a; WAHERB, 2023)	Likelihood of Occurrence
	EPBC Act	BC Act	Priority Listing		
Aristida jerichoensis var. *subspinulifera*			P3	Hardpan plains.	Possible
Eremophila arguta			P1	Loamy soils, floodplains.	Unlikely
Eremophila congesta			P1	Lateritic outcrops in greenstone hills, stony quartzite slopes.	Possible
Eremophila pungens			P4	Sandy loam, clayey sand over laterite. Plains, ridges, breakaways.	Possible
Hemigenia exilis			P4	Rocky lower slopes of hill sides, drainage lines.	Unlikely
Ptilotus luteolus			P3	Rocky slopes, screes, and ridges	Unlikely
Sida picklesiana			P3	Breakaways and outcrops, banded ironstone.	Unlikely
Stackhousia clementii			P3	Skeletal soils. Sandstone hills.	Unlikely
Tribulus adelacanthus			P3	Lower slopes. Gravelly loam soils.	Unlikely

5.1.2 Fauna

According to the results of the NatureMap search (DBCA, 2021), a total of 152 vertebrate fauna taxa have been recorded within a 40 km radius of the survey area including 87 bird species, 5 amphibians, 16 mammals and 44 reptiles. Combined results of database searches identified nine introduced taxa as potentially occurring within the survey area, these being:

1. *Camelus dromedaries* (Camel)
2. *Canis lupus familiaris* (Dog)
3. *Capra hircus* (Goat)
4. *Columba livia* (Rock Pigeon)
5. *Equus asinus* (Donkey)
6. *Felis catus* (Cat)
7. *Mus musculus* (House Mouse)
8. *Oryctolagus cuniculus* (Rabbit)
9. *Vulpes vulpes* (Red Fox)

Vertebrate fauna of conservation significance identified during the literature review as previously being recorded in the general area were assessed and ranked for their likelihood of occurrence within the survey area itself (Table 5-3).

Table 5-3: Likelihood of Occurrence – Fauna Species of Conservation Significance

Species	Conservation Status			Habitat Description	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA Priority		
Grey Falcon *Falco hypoleucos*	VU	VU	-	Occurs in arid and semi-arid Australia. The species is mainly found where annual rainfall is less than 500 mm, except when wet years are followed by drought, when the species might become marginally more widespread, although it is essentially confined to the arid and semi-arid zones at all times. The species frequents timbered lowland plains, particularly acacia shrublands that are crossed by tree-lined water courses.	Possibly Occurs aerially over survey area on very rare occasions. No suitable breeding habitat.
Malleefowl *Leipoa ocellata*	VU	VU	-	Occurs in unburned mallee and woodland with abundant litter and low scrub.	Unlikely to Occur. No recent records nearby and habitat unsuitable/very marginal.
Night Parrot *Pezoporus occidentalis*	EN	CR	-	Broad habitat requirements include areas of old-growth spinifex (*Triodia*) for roosting and nesting, together with foraging habitats that are likely to include various native grasses and herbs and may or may not contain shrubs or low trees. (DPaW, 2017).	Unlikely to Occur. No recent records nearby and no suitable habitat.
Peregrine Falcon *Falco peregrinus*	-	OS	-	Diverse from rainforest to arid shrublands, from coastal heath to alpine Mainly about cliffs along coasts, rivers and ranges and about wooded watercourses and lakes. The species utilises the ledges, cliff faces and large hollows/broken spouts of trees for nesting. It will also occasionally use the abandoned nests of other birds of prey.	Possibly occurs aerially over survey area on very rare occasions. No suitable breeding habitat.
Princess Parrot *Polytelis alexandrae*	VU	-	P4	Inhabits sand dunes and sand flats in the arid zone of western and central Australia. It occurs in open savanna woodlands and shrublands that usually consist of scattered stands of *Eucalyptus* (including *E. gongylocarpa*, *E. chippendalei* and mallee species), *Casuarina* or *Allocasuarina* trees; an understorey of shrubs such as *Acacia* (especially *A. aneura*), *Cassia*, *Eremophila*, *Grevillea*, *Hakea* and *Senna*; and a ground cover dominated by *Triodia* species (DCCEEW, 2023)	Unlikely to Occur. Rarely recorded this far south and no recent records nearby.
Grey Wagtail *Motacilla cinerea*	MI	IA	-	Running water in disused quarries, sandy, rocky streams in escarpments and rainforest, sewerage ponds, ploughed fields and airfields (Morecombe 2004).	Would Not Occur. No documented records in the region.
Yellow Wagtail *Motacilla flava*	MI	IA	-	Occurs in a variety of damp or wet habitats with low vegetation, from rushy pastures, meadows, hay fields and marshes to damp steppe and grassy tundra (Morecombe 2004).	Would Not Occur. No documented records in the region.
Migratory shorebirds (various species)	MI	MI	P4	Migratory shorebirds generally prefer muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation. This includes lagoons, swamps, lakes and pools near the coast, and dams, waterholes, soaks, bore drains and bore swamps, saltpans and hypersaline salt lakes inland.	Would not occur. No suitable habitat.
Brush-tailed Mulgara *Dasycercus blythi*	-	-	P4	Occurs on sand dunes with sparse cover of sandhill cain grass or areas around salt lakes (DCCEEW, 2023).	Unlikely to Occur. No recent records nearby and habitat unsuitable/very marginal.

Species	Conservation Status			Habitat Description	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA Priority		
Greater Bilby *Macrotis lagotis*	VU	VU		Suitable habitat includes; open tussock grassland (both grasses and forbs) growing on uplands and hills, mulga woodland/shrubland (both pure mulga and mixed stands of mulga/witchetty bush) growing on ridges and rises, and hummock grassland growing on sand plains and dunes, drainage systems, salt lake systems and other alluvial areas Pavey, C., 2006).	Unlikely to Occur. No recent records nearby and habitat unsuitable/very marginal.
Great Desert Skink *Liopholis kintorei*	VU	VU		The Great Desert Skink generally occurs on red sandplains and sand ridges (DCCEEW, 2023).	Would not occur. No suitable habitat.

5.2 Field Assessment

5.2.1 Vegetation Types

Five vegetation types were identified within the survey area which was represented by a total of 19 families and 72 taxa. The total species list is provided in Appendix C. A map showing the vegetation types present in the survey area is provided in Figure 4-1 and a summary of the vegetation types are presented in Table 5-4.

Table 5-4: Summary of vegetation types within the survey area

Landform	NVIS Major Vegetation Group	Vegetation Type	Vegetation Code	Image
Clay-Loam Plain	Acacia Forests and Woodland (MVG 6)	Low woodland of *Acacia incurvaneura* over mid open shrubland of *Acacia tetragonophylla/ Psydrax latifolia* and low shrubland of *Eremophila margarethae* on clay-loam plain	CLP-AFW1 395 ha (22.0%)	
Drainage Depression	Acacia Forests and Woodland (MVG 6)	Low forest of *Acacia incurvaneura* over tall open shrubland of *Acacia aptaneura/ A. tetragonophylla* and low open shrubland of *Eremophila forrestii* subsp. *forrestii* / *Eremophila margarethae* in drainage depression	DD-AFW1 248 ha (13.8%)	

Landform	NVIS Major Vegetation Group	Vegetation Type	Vegetation Code	Image
Quartz-Rocky Plain	Acacia Forests and Woodland (MVG 6)	Low forest of *Acacia incurvaneura* over mid open shrubland of *Eremophila fraseri / E. jucunda / E. margarethae* and low hummock grassland of *Triodia basedowii* on quartz-rocky plain	QRP-AFW1 407 ha (22.6%)	
Rocky Hillslope	Acacia Forests and Woodland (MVG 6)	Low forest of *Acacia incurvaneura* over mid open shrubland of *Eremophila jucunda / Eremophila linearis/ Senna* sp. Meekatharra (E. Bailey 1-26) and low open shrubland of *Ptilotus obovatus* on rocky hillslope	RH-AFW1 54 ha (3.0%)	

Landform	NVIS Major Vegetation Group	Vegetation Type	Vegetation Code	Image
Sand-Loam Plain	Acacia Forests and Woodland (MVG 6)	Low forest of *Acacia incurvaneura* over mid open shrubland of *Acacia balsamea/ Eremophila forrestii* subsp. *forrestii* and low hummock grassland of *Triodia basedowii/ T. melvillei* on sand-loam plain	SLP-AFW1 326 ha (20.5%)	
N/A	N/A	Cleared Vegetation	CV 326 ha (18.1%)	

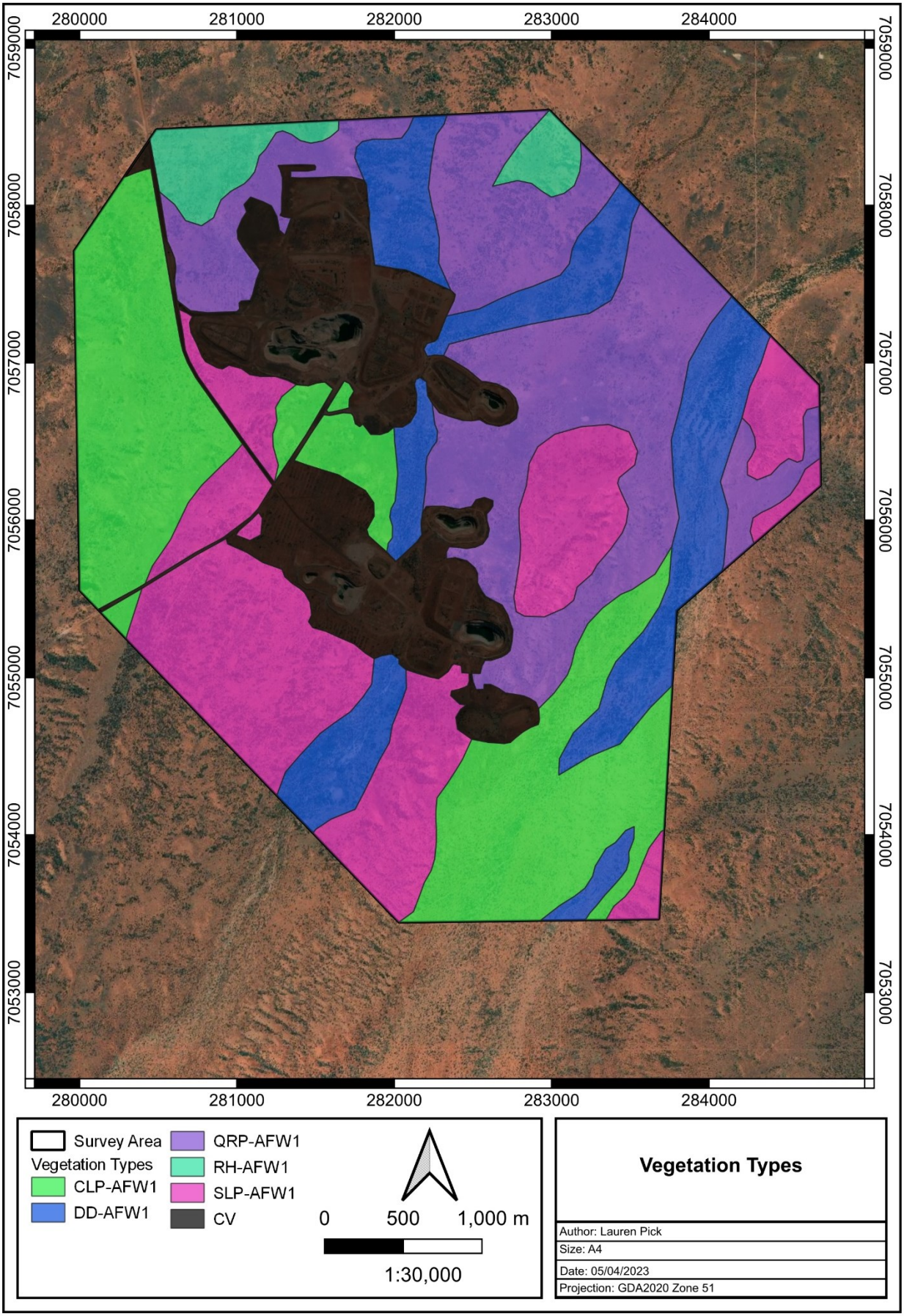


Figure 5-1: Vegetation types within the survey area

5.2.2 Floristic Composition

Statistical analysis was conducted on quadrat data obtained from the survey to determine the similarities or differences in floristic composition between the flora quadrats. Appendix H provides the dendrogram, two-way table and ordination graph generated from the PATN statistical analysis. The PATN analysis produced a stress value of 0.2065.

Table 5-5: Vegetation types and associated flora quadrats

Vegetation Type	Vegetation Code	Associated Quadrats
Low woodland of *Acacia incurvaneura* over mid open shrubland of *Acacia tetragonophylla/ Psydrax latifolia* and low shrubland of *Eremophila margarethae* on clay-loam plain	CLP-AFW1	Q11, Q12, Q16
Low forest of *Acacia incurvaneura* over tall open shrubland of *Acacia aptaneura/ A. tetragonophylla* and low open shrubland of *Eremophila forrestii* subsp. *forrestii* / *Eremophila margarethae* in drainage depression	DD-AFW1	Q5, Q8, Q10, Q13, Q14, Q17
Low forest of *Acacia incurvaneura* over mid open shrubland of *Eremophila fraseri / E. jucunda / E. margarethae* and low hummock grassland of *Triodia basedowii* on quartz-rocky plain	QRP-AFW1	Q1, Q4, Q20
Low forest of *Acacia incurvaneura* over mid open shrubland of *Eremophila jucunda / Eremophila linearis/ Senna* sp. Meekatharra (E. Bailey 1-26) and low open shrubland of *Ptilotus obovatus* on rocky hillslope	RH-AFW1	Q2, Q3, Q6
Low forest of *Acacia incurvaneura* over mid open shrubland of *Acacia balsamea/ Eremophila forrestii* subsp. *forrestii* and low hummock grassland of *Triodia basedowii/ T. melvillei* on sand-loam plain	SLP-AFW1	Q7, Q9, Q15, Q18, Q19

Five species groups were identified in the analysis (species group A to E) as shown in the two-way table (Appendix H). The first floristic group comprised of four quadrats; two quadrats from the QRP-AFW1 and RH-AFW1 vegetation types and two SLP-AFW1 quadrats. This floristic group was mostly characterised by species group A (see two-way table provided in Appendix H) with an average species richness of 8 taxa per quadrat (ranged from 6 to 9 species per quadrat).

The second floristic group comprised of two quadrats from the QRP-AFW1 and RH-AFW1 vegetation types. This floristic group was mostly characterised by species group E (see two-way table provided in Appendix H) with an average species richness of 10 taxa per quadrat (ranged from 9 to 11 species per quadrat).

The third floristic group comprised of seven quadrats including majority of the DD-AFW1 quadrats and two CLP-AFW1 quadrats and one quadrat from each of the CLP-AFW1, QRP-AFW1 and RH-AFW1 vegetation types. This floristic group was mostly characterised by species group A and C (see two-way table provided in Appendix H) with an average species richness of 14 taxa per quadrat (ranged from 8 to 18 species per quadrat).

The fourth floristic group comprised of the two remaining quadrats from the CLP-AFW1 and DD-AFW1 vegetation types. This floristic group was mostly characterised by species group A (see two-way table provided in Appendix H) with an average species richness of 10 taxa per quadrat (ranged from 8 to 11 species per quadrat).

The fifth floristic group comprised of the three remaining SLP-AFW1 quadrats. This floristic group was mostly characterised by species group A and B (see two-way table provided in Appendix H) with an average species richness of 7 taxa per quadrat (ranged from 5 to 10 species per quadrat).

Species Richness and Accumulation Estimates

The Chao 2 richness estimator provided an estimated species richness of 53 species in 30 sample sites (quadrats). Species richness recorded for the 20 quadrats surveyed was 48 species. A species accumulation curve was created to display the rate of species accumulation. The R^2 value (0.98) suggests that the data "fits" the species accumulation curve shown in Figure 5-2. Species accumulation ranged from seven to two species per quadrat from 1-9 sample sites and reduced to one species per quadrat beyond 10 sample sites. Botanica has determined that according to this data a sufficient number of quadrats were established in the survey area to adequately assess the floristic composition of the area.

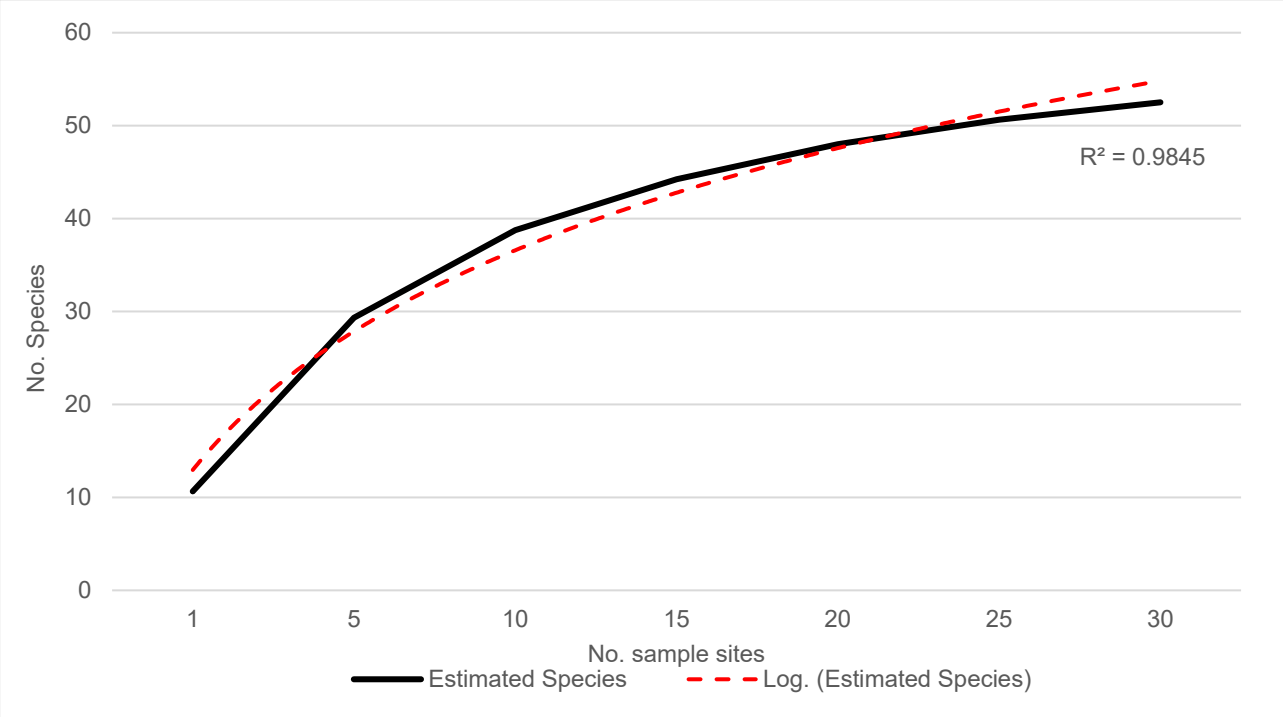


Figure 5-2: Species accumulation curve

5.2.3 Significant Flora

According to the EPA *Environmental Factor Guideline for Flora and Vegetation* (EPA, 2016b) significant flora includes:

- flora being identified as Threatened or Priority species;
- locally endemic flora or flora associated with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems);
- new species or anomalous features that indicate a potential new species;
- flora representative of the 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; and
- flora with relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

No Threatened Flora taxa listed under Commonwealth or State legislation were identified within the survey area. No Priority Flora taxa as listed by DBCA was identified in the survey area. No other significant flora (as described above) were identified within the survey area.

5.2.4 Significant Vegetation

According to the EPA *Environmental Factor Guideline for Flora and Vegetation* (EPA, 2016b) significant vegetation includes:

- vegetation being identified as Threatened or Priority Ecological Communities;
- vegetation with restricted distribution;
- vegetation subject to a high degree of historical impact from threatening processes;
- vegetation which provides a role as a refuge; and
- vegetation providing an important function required to maintain ecological integrity of a significant ecosystem.

No Threatened Ecological Communities listed under Commonwealth or State legislation were identified within the survey area. No Priority Ecological Communities as listed by DBCA was identified in the survey area. No other significant vegetation (as described above) were identified within the survey area.

5.2.5 Vegetation Condition

Based on the vegetation condition rating scale obtained from the EPA (2016) provided in

Appendix D, vegetation was rated as 'good' to 'very good' condition (Table 5-6 and Figure 5-3). Disturbance within the survey area was a result of existing mining, pastoral land use and exploration. Approximately 326 ha (18.1% of the total survey area) comprised of cleared vegetation (excluding minor access tracks).

Table 5-6: Vegetation condition within the survey area

Vegetation Condition Rating	Description (EPA, 2016)	Extent within survey area
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.	930 ha (51.7%)
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.	542 ha (30.1%)

Figure 5-3: Vegetation condition within the survey area

5.2.6 Introduced Flora

No introduced species were identified within the survey area.

5.2.7 Fauna Habitat

Four broad scale terrestrial fauna habitats were identified within the survey area as described in Table 5-8 below and shown in Figure 5-4.

During the field survey opportunistic observations of fauna species were made with a total of 11 fauna species observed (including two introduced fauna).

Table 5-7: Fauna species observed during the field survey

Taxon	Common Name
Barnardius zonarius	Australian Ringneck
Ocyphaps lophotes	Crested Pigeon
Melopsittacus undulatus	Budgerigar
Eolophus roseicapilla	Galah
Psephotellus varius	Mulga Parrot
Aquila audax	Wedge-tailed Eagle
Coracina novaehollandiae	Black-faced Cuckooshrike
Varanus gouldii	Bungarra
Ctenophorus cristatus	Bicycle Dragon
Bos primigenius taurus	European Cattle
Oryctolagus cuniculus	Rabbit

Table 5-8: Main terrestrial fauna habitats within the survey area

Fauna Habitat	Description	Representative Fauna Attributes	Example Image
Clay-Loam Plain: Acacia Woodland 395 ha (22.0%)	Clay-loam plain comprising of Mulga woodland over mixed low shrubs	• Substrate moderately suited to a variety of burrowing small mammals and reptiles. • Moderately diiverse vegetation strata supporting diverse avifauna assemblage. • Limited leaf litter and tree logs/ hollows for fauna refuge.	
Drainage Depression: Acacia Woodland 248 ha (13.8%)	Drainage depression comprising of Mulga woodland over mixed low shrubs and occasional tussock grassland	• Substrate moderately suited to a variety of burrowing small mammals and reptiles. • Diverse vegetation strata supporting diverse avifauna assemblage. • Moderate leaf litter and tree logs/ hollows for fauna refuge. • Freshwater source during periods of high rainfall	

Fauna Habitat	Description	Representative Fauna Attributes	Example Image
Rocky Plain/ Hillslope: Acacia Woodland 461 ha (25.6%)	Rocky plain/ hillslope comprising of Mulga woodland over mixed low shrubs	• Substrate not well suited for burrowing. • Moderately diverse vegetation strata supporting diverse avifauna assemblage. • Limited leaf litter and tree logs/ hollows for fauna refuge. • Rocky substrate providing shelter for small mammals and reptiles.	
Sand-Loam Plain: Acacia Woodland 368 ha (20.5%)	Sand-loam plain comprising of Mulga woodland over mixed low shrubs and spinifex grassland	• Substrate very well suited to a variety of burrowing small mammals and reptiles. • Less diverse vegetation strata supporting a less diverse avifauna assemblage. • Limited leaf litter and tree logs/ hollows for fauna refuge.	

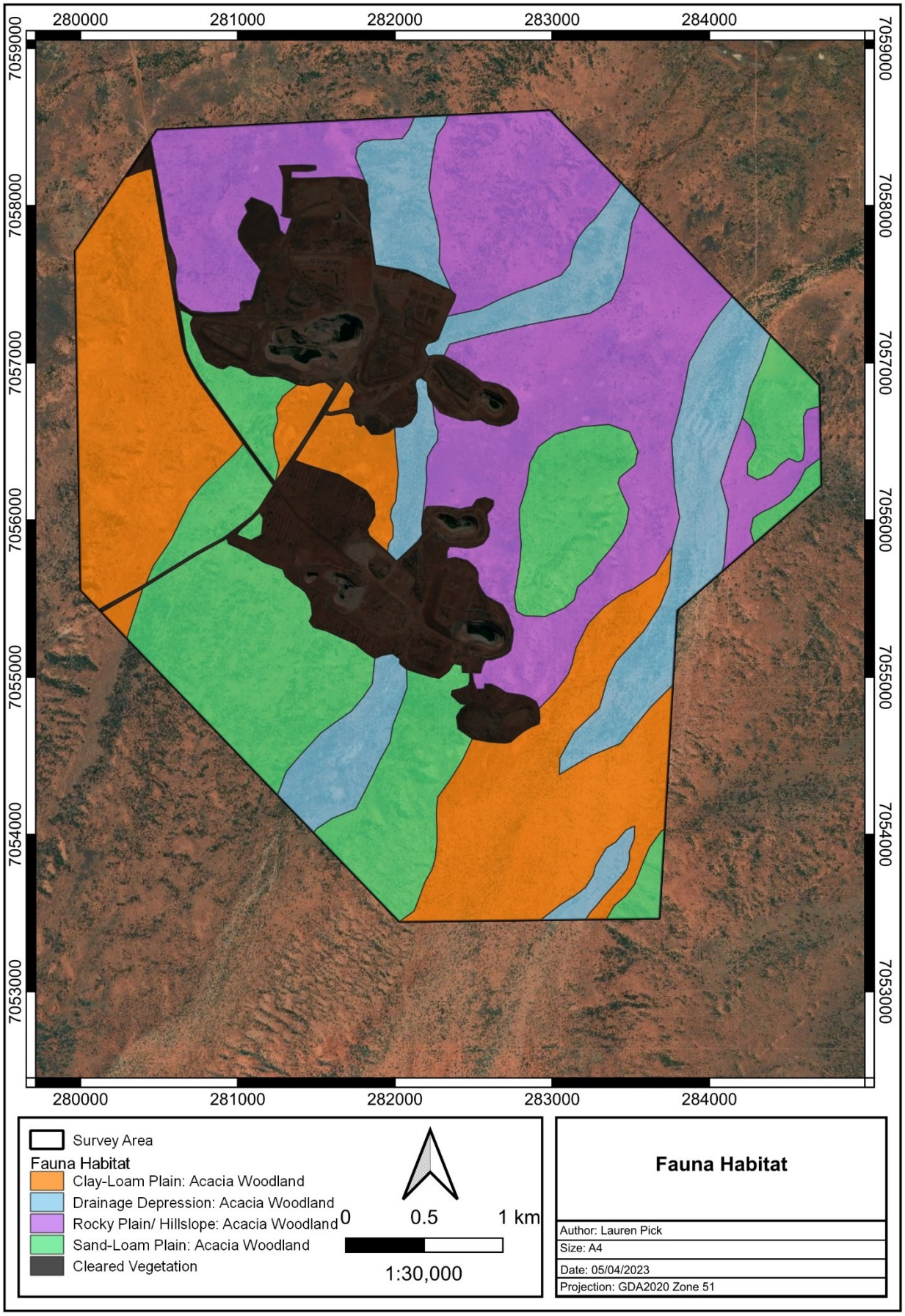


Figure 5-4: Fauna habitats within the survey area

5.2.8 Significant Fauna

According to the EPA *Environmental Factor Guideline for Terrestrial Fauna* (EPA, 2016c) significant fauna includes:

- Fauna being identified as a Threatened or Priority species;
- Fauna species with restricted distribution;
- Fauna subject to a high degree of historical impact from threatening processes; and
- Fauna providing an important function required to maintain the ecological integrity of a significant ecosystem.

No significant fauna taxa were confirmed as occurring within the survey area. The current status of some species on site and/or in the general area is difficult to determine, however, based on the habitats present and/ or recent nearby records, the following species of significance can be regarded as possibly occurring in the wider area (but not necessarily within the survey area):

- **Grey Falcon *Falco hypoleucos* – Vulnerable (EPBC Act & BC Act)**
  The species potentially utilises some sections of the survey area as part of a much larger home range, though records in this area are rare and therefore it is only likely to be present very occasionally. No suitable breeding habitat. No significant impact likely.

- **Peregrine Falcon *Falco peregrinus* – Other Specially Protected Species (BC Act)**
  This species potentially occurs aerially over the survey area as part of a much larger home range, though records in this area are rare and therefore it is likely to be present occasionally. No suitable breeding habitat. No significant impact likely.

It should be noted that while habitats onsite for the species listed above are considered possibly suitable, some or all may be marginal in extent/quality and therefore the fauna species considered as possibly occurring may in fact only visit the area for short periods as infrequent vagrants. The result of the literature review and observations made during the field survey suggest that the probability of any of the above-mentioned fauna species actually occurring with the survey area would be low.

5.3 Matters of National Environmental Significance

5.3.1 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act protects matters of national environmental significance, and is used by the Commonwealth DAWE to list threatened taxa and ecological communities into categories based on the criteria set out in the Act (www.environment.gov.au/epbc/index.html). The Act provides a national environmental assessment and approval system for proposed developments and enforces strict penalties for unauthorised actions that may affect matters of national environmental significance. Matters of national environmental significance as defined by the Commonwealth EPBC Act include:

- Nationally threatened flora species;
- World heritage properties;
- National heritage places;
- Wetlands of international importance (often called 'Ramsar' wetlands after the international treaty under which such wetlands are listed);
- Nationally threatened ecological communities;
- Commonwealth marine area;
- The Great Barrier Reef Marine Park; and
- Nuclear actions (including uranium mining) a water resource, in relation to coal seam gas development and large coal mining development.

No matters of national environmental significance as defined by the Commonwealth EPBC Act were identified within the survey area.

5.4 Matters of State Environmental Significance

5.4.1 *Environmental Protection Act WA 1986*

The EP Act provides for the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment. The Act is administered by The Department of Water and Environment Regulation (DWER), which is the State Government's environmental regulatory agency.

Under Section 51C of the EP Act and the *Environmental Protection (Clearing of Native Vegetation) Regulations (Regulations) WA 2004* any clearing of native vegetation in Western Australia that is not eligible for exemption under Schedule 6 of the *EP Act 1986* or under the Regulations 2004 requires a clearing permit from the DWER or DMIRS. Under Section 51A of the *EP Act 1986* native vegetation includes aquatic and terrestrial vegetation indigenous to Western Australia, and intentionally planted vegetation declared by regulation to be native vegetation, but not vegetation planted in a plantation or planted with commercial intent. Section 51A of the *EP Act 1986* defines clearing as "the killing or destruction of; the removal of; the severing or ringbarking of trunks or stems of; or the doing of substantial damage to some or all of the native vegetation in an area, including the flooding of land, the burning of vegetation, the grazing of stock or an act or activity that results in the above". Exemptions under Schedule 6 of the EP Act and the EP Regulations do not apply in ESAs as declared under Section 51B of the EP Act or TEC listed under State and Commonwealth legislation.

No evidence of the survey area containing any TEC or Threatened Flora or Fauna was identified during the survey. The survey area is not located within any ESA's as listed under the EP Act (as shown in Appendix B).

5.4.2 *Biodiversity Conservation Act 2016*

This Act is used by the Western Australian DBCA for the conservation and protection of biodiversity and biodiversity components in Western Australia and to promote the ecologically sustainable use of biodiversity components in the State. Taxa are classified as 'Threatened" when their populations are geographically restricted or are threatened by local processes (see following sections for Threatened definitions). Under this Act all native flora and fauna are protected throughout the State. Financial penalties are enforced under this Act if threatened species are collected without an appropriate licence.

Under Section 54(1) of the BC Act, habitat is eligible for listing as critical habitat if:

(a) it is critical to the survival of a threatened species or a threatened ecological community; and
(b) its listing is otherwise in accordance with the ministerial guidelines.

No threatened species or critical habitat listed under the BC Act were recorded within the survey area.

5.4.3 Conservation Reserves

The survey area is not located within a vested or proposed Conservation Reserve and is not located within any DBCA managed land. The closest DBCA managed land is the ex. Lorna Glenn UCL, which is located approximately 36km north-east of the survey area.

A map showing conservation areas in relation to the survey area is provided in Appendix B.

5.5 Native Vegetation Clearing Principles

Based on the outcomes from the survey undertaken, as presented in this report, Botanica provides the following comments regarding the native vegetation clearing principles listed under Schedule 5 of the EP Act (Table 5-9).

Table 5-9: Assessment of development within the survey area against native vegetation clearing principles

Letter	Principle	Assessment	Outcome
Native vegetation should not be cleared if it:			
(a)	comprises a high level of biological diversity.	Vegetation identified within the survey area is not considered to be of high biological diversity and is well represented in the local area.	Clearing is unlikely to be at variance to this principle
(b)	comprises the whole or part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to WA.	No significant fauna were observed within the survey area. Majority of the survey area comprises of broad fauna habitats that are typical of those in the wider region.	Clearing is unlikely to be at variance to this principle
(c)	includes, or is necessary for the continued existence of rare flora.	No Threatened Flora taxa, pursuant to the BC Act and the EPBC Act were identified within the survey area.	Clearing is unlikely to be at variance to this principle
(d)	comprises the whole or part of or is necessary for the maintenance of a threatened ecological community (TEC).	No TEC listed under the EPBC Act or by the BC Act occur within the survey area.	Clearing is unlikely to be at variance to this principle
(e)	is significant as a remnant of native vegetation in an area that has been extensively cleared	The survey area occurs within the pre-European Beard vegetation associations Wiluna 18 and 39 which retain >98% of the original pre-European vegetation extent.	Clearing is unlikely to be at variance to this principle
(f)	is growing, in, or in association with, an environment associated with a watercourse or wetland	There are no inland waters (lakes/ playas) or perennial drainage lines within the survey area. Multiple minor ephemeral drainage lines intersect the survey area. One vegetation type (DD-AFW1) was associated with these drainage lines which occupies 13.8% of the survey area.	Clearing may be at variance to this principle
(g)	Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.	The Project area occurs within the pre-European Beard vegetation association Wiluna 18 and 39 which retain >98% of the original pre-European vegetation extent. Clearing within these vegetation associations is not likely to lead to land degradation issues such as salinity, water logging or acidic soils.	Clearing is unlikely to be at variance to this principle
(h)	Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.	The survey area is not located within a conservation area. The closest conservation reserve is the ex. Lorna Glenn UCL, which is located approximately 36km north-east of the survey area. Given the distance from the survey area, impacts to the environmental values of this conservation reserve are unlikely.	Clearing is unlikely to be at variance to this principle
(i)	Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.	There are no inland waters (lakes/ playas) or perennial drainage lines within the survey area. Multiple minor ephemeral drainage lines intersect the survey area. One vegetation type (DD-AFW1) was associated with these drainage lines which occupies 13.8% of the survey area. Most rainfall is lost by evaporation or surface runoff. Only a small portion infiltrates the soil and recharges the groundwater.	Clearing is unlikely to be at variance to this principle
(j)	Native vegetation should not be cleared if clearing the vegetation is likely to cause,	Rainfall is unreliable and highly variable with an average rainfall of 200mm and an evaporation rate of 2461mm. The region is not prone to flooding and	Clearing is unlikely to be at variance to this principle

Letter	Principle	Assessment	Outcome
Native vegetation should not be cleared if it:			
	or exacerbate, the incidence of flooding	there are no inland waters (lakes/ playas) or perennial drainage lines within the survey area.	

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Appendix A:
Significant Species/ Communities Categories (BC Act and EPBC Act)

Definitions of Conservation Significant Species

Code	Category
State categories of Threatened and Priority species	
Threatened Species (T) Listed by order of the Minister as Threatened in the category of critically endangered, endangered or vulnerable under section 19(1), or is a rediscovered species to be regarded as Threatened species under section 26(2) of the Biodiversity Conservation Act 2016 (BC Act).	
CR	**Critically Endangered** Threatened species considered to be "facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as critically endangered under section 19(1)(a) of the BC Act in accordance with the criteria set out in section 20 and the ministerial guidelines. Published under schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for critically endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for critically endangered flora.
EN	**Endangered** Threatened species considered to be "facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as endangered under section 19(1)(b) of the BC Act in accordance with the criteria set out in section 21 and the ministerial guidelines. Published under schedule 2 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for endangered flora.
VU	**Vulnerable** Threatened species considered to be "facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as vulnerable under section 19(1)(c) of the BC Act in accordance with the criteria set out in section 22 and the ministerial guidelines. Published under schedule 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for vulnerable fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for vulnerable flora.
Extinct species Listed by order of the Minister as extinct under section 23(1) of the BC Act as extinct or extinct in the wild.	
EX	**Extinct** Species where "*there is no reasonable doubt that the last member of the species has died*", and listing is otherwise in accordance with the ministerial guidelines (section 24 of the BC Act). Published as presumed extinct under schedule 4 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for extinct fauna or the *Wildlife Conservation (Rare Flora) Notice 2018* for extinct flora.
EW	**Extinct in the Wild** Species that *"is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere in its past range, despite surveys over a time frame appropriate to its life cycle and form*", and listing is otherwise in accordance with the ministerial guidelines (section 25 of the BC Act). Currently there are no Threatened fauna or Threatened flora species listed as extinct in the wild. If listing of a species as extinct in the wild occurs, then a schedule will be added to the applicable notice.
Specially protected species Listed by order of the Minister as specially protected under section 13(1) of the BC Act. Meeting one or more of the following categories: species of special conservation interest; migratory species; cetaceans; species subject to international agreement; or species otherwise in need of special protection. Species that are listed as Threatened species (critically endangered, endangered or vulnerable) or extinct species under the BC Act cannot also be listed as Specially Protected species.	
IA	**International Agreement/ Migratory** Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and listing is otherwise in accordance with the ministerial guidelines (section 15 of the BC Act). Includes birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and fauna subject to the *Convention on the Conservation of Migratory Species of Wild Animals* (Bonn Convention), an environmental treaty under the United Nations Environment Program. Migratory species listed under the BC Act are a subset of the migratory animals, that are known to visit Western Australia, protected under the international agreements or treaties, excluding species that are listed as Threatened species.

Code	Category
	Published as migratory birds protected under an international agreement under schedule 5 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018*.
CD	**Species of special conservation interest** Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as Threatened, and listing is otherwise in accordance with the ministerial guidelines (section 14 of the BC Act). Published as conservation dependent fauna under schedule 6 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018*.
OS	**Other specially protected species** Fauna otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18 of the BC Act). Published as other specially protected fauna under schedule 7 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018*.
Priority species Possibly Threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 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 Fauna or 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 or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.	
P1	**Priority 1: Poorly-known species** Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.
P2	**Priority 2: Poorly-known species** Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.
P3	**Priority 3: Poorly-known species** Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.
P4	**Priority 4: Rare, Near Threatened and other species in need of monitoring** (a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as Conservation Dependent. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.
Commonwealth categories of Threatened species	
EX	**Extinct** Taxa where there is no reasonable doubt that the last member of the species has died.
EW	**Extinct in the Wild** Taxa where it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.

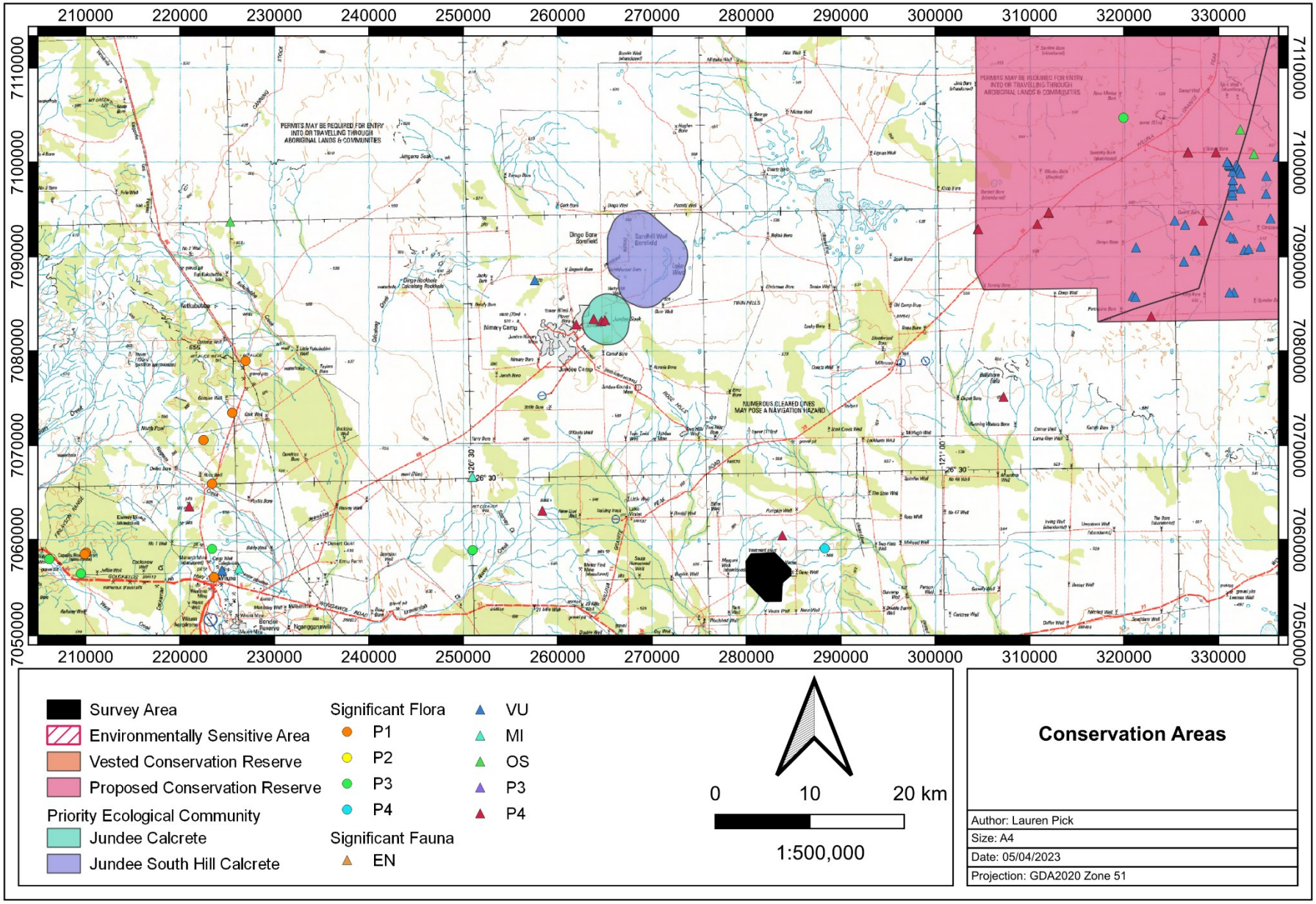
Code	Category
CR	**Critically Endangered** Taxa that are facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
EN	**Endangered** Taxa which are not critically endangered and is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
VU	**Vulnerable** Taxa which are not critically endangered or endangered and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
CD	**Conservation Dependent** Taxa which are the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or (b) the following subparagraphs are satisfied: (i) the species is a species of fish; (ii) the species is the focus of a plan of management that provides for actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long term survival in nature are maximised; (iii) the plan of management is in force under a law of the Commonwealth or of a State or Territory; (iv) cessation of the plan of management would adversely affect the conservation status of the species.

Definitions of conservation significant communities

Category Code	Category
State categories of Threatened Ecological Communities (TEC)	
PD	**Presumed Totally Destroyed**
	An ecological community will be listed as Presumed Totally Destroyed if there are no recent records of the community being extant and either of the following applies:
	• records within the last 50 years have not been confirmed despite thorough searches or known likely habitats or;
	• all occurrences recorded within the last 50 years have since been destroyed.
CR	**Critically Endangered**
	An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future, meeting any one of the following criteria:
	The estimated geographic range and distribution has been reduced by at least 90% and is either continuing to decline with total destruction imminent, or is unlikely to be substantially rehabilitated in the immediate future due to modification;
	The current distribution is limited i.e. highly restricted, having very few small or isolated occurrences, or covering a small area;
	The ecological community is highly modified with potential of being rehabilitated in the immediate future.
EN	**Endangered**
	An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. The ecological community must meet any one of the following criteria:
	The estimated geographic range and distribution has been reduced by at least 70% and is either continuing to decline with total destruction imminent in the short-term future, or is unlikely to be substantially rehabilitated in the short-term future due to modification;
	The current distribution is limited i.e. highly restricted, having very few small or isolated occurrences, or covering a small area;
	The ecological community is highly modified with potential of being rehabilitated in the short-term future.
VU	**Vulnerable**

Category Code	Category
	An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing high risk of total destruction in the medium to long term future. The ecological community must meet any one of the following criteria:
	The ecological community exists largely as modified occurrences that are likely to be able to be substantially restored or rehabilitated;
	The ecological community may already be modified and would be vulnerable to threatening process, and restricted in range or distribution;
	The ecological community may be widespread but has potential to move to a higher threat category due to existing or impending threatening processes.
Commonwealth categories of Threatened Ecological Communities (TEC)	
CE	**Critically Endangered** If, at that time, an ecological community is facing an extremely high risk of extinction in the wild in the immediate future (indicative timeframe being the next 10 years).
EN	**Endangered** If, at that time, an ecological community is not critically endangered but is facing a very high risk of extinction in the wild in the near future (indicative timeframe being the next 20 years).
VU	**Vulnerable** If, at that time, an ecological community is not critically endangered or endangered, but is facing a high risk of extinction in the wild in the medium–term future (indicative timeframe being the next 50 years).
Priority Ecological Communities	
P1	**Poorly-known ecological communities**
	Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist.
P2	**Poorly-known ecological communities**
	Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, un-allocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation.
P3	**Poorly known ecological communities**
	Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or:
	Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or;
	Communities made up of large, and/or widespread occurrences, that may or not be represented in the reserve system but are under threat of modification across much of their range from processes such as grazing and inappropriate fire regimes.
P4	**Ecological communities that are adequately known, rare but not threatened** or meet criteria for near threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.
P5	**Conservation Dependent ecological communities**
	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Appendix B:
Regional map of the survey area in relation to areas of significance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PERMITS MAY BE REQUIRED FOR ENTRY INTO OR TRAVELLING THROUGH ABORIGINAL LANDS & COMMUNITIES
NUMEROUS CLEARED LINES MAY POSE A NAVIGATION HAZARD
Survey Area
Environmentally Sensitive Area
Vested Conservation Reserve
Proposed Conservation Reserve
Priority Ecological Community
Jundee Calcrete
Jundee South Hill Calcrete
Significant Flora
P1
P2
P3
P4
Significant Fauna
EN
VU
MI
OS
P3
P4
0
10
20 km
1:500,000
Conservation Areas
Author: Lauren Pick
Size: A4
Date: 05/04/2023
Projection: GDA2020 Zone 51

Appendix C:
Flora species list

(A) blue text-denotes annual taxa

Family	Taxon	CLP-AFW1	DD-AFW1	QRP-AFW1	RH-AFW1	SLP-AFW1
Amaranthaceae	*Ptilotus obovatus*	*	*	*	*	*
	Ptilotus schwartzii	*		*		*
Apocynaceae	*Leichhardtia australis*	*	*			
Asteraceae	*Cratystylis subspinescens*			*		
Boraginaceae	*Halgania solanacea*	*				
Chenopodiaceae	*Enchylaena tomentosa*	*	*	*	*	*
	Maireana carnosa	*				
	Maireana convexa	*				
	Maireana georgei	*				
	Maireana pentatropis	*				
	Maireana thesioides	*				
	Maireana tomentosa	*				
	Maireana triptera	*			*	
	Rhagodia eremaea	*				*
	Sclerolaena cuneata		*	*	*	
	Sclerolaena densiflora	*			*	
	Sclerolaena diacantha	*			*	*
	Sclerolaena eurotioides	*		*	*	
Euphorbiaceae	*Euphorbia drummondii*	*				
Fabaceae	*Acacia aptaneura*		*	*	*	*
	Acacia balsamea					*
	Acacia burkittii		*			
	Acacia caesaneura	*		*		*
	Acacia craspedocarpa	*	*			
	Acacia cuthbertsonii	*	*			
	Acacia effusifolia					*
	Acacia incurvaneura	*	*	*	*	*
	Acacia mulganeura	*	*	*	*	*
	Acacia pruinocarpa	*	*	*	*	*
	Acacia pteraneura	*	*	*		
	Acacia ramulosa var. *ramulosa*		*			
	Acacia tetragonophylla	*	*	*	*	*
	Senna artemisioides subsp. *filifolia*	*				*
	Senna artemisioides subsp. *helmsii*	*	*		*	*
	Senna glutinosa					*

Family	Taxon	CLP-AFW1	DD-AFW1	QRP-AFW1	RH-AFW1	SLP-AFW1
	Senna sp. Meekatharra (E. Bailey 1-26)			*	*	*
Goodeniaceae	*Scaevola spinescens*	*	*	*	*	
Lamiaceae	*Teucrium teucriiflorum*	*	*			*
Loranthaceae	*Amyema miquelii*				*	*
Malvaceae	*Abutilon cryptopetalum*	*				*
	Hibiscus burtonii	*				*
	Sida arenicola		*			
	Sida calyxhymenia	*	*	*	*	
	Sida ectogama	*	*			
	Sida fibulifera		*		*	*
	Sida sp. Excedentifolia (J.L. Egan 1925)	*	*	*		*
Poaceae	*Eragrostis eriopoda*		*			
	sp. (sterile)	*	*			
	Triodia basedowii	*	*	*	*	*
	Triodia melvillei	*		*		*
Proteaceae	*Grevillea striata*	*				
	Hakea loreus					*
	Hakea preissii	*				
Pteridaceae	*Cheilanthes sieberi*	*	*			
Rubiaceae	*Psydrax latifolia*	*	*	*	*	*
	Psydrax suaveolens	*				*
Santalaceae	*Anthobolus leptomerioides*	*				*
	Exocarpos aphyllus			*		
Scrophulariaceae	*Eremophila forrestii* subsp. *forrestii*	*		*	*	*
	Eremophila fraseri	*	*	*	*	*
	Eremophila galeata	*				*
	Eremophila jucunda			*	*	
	Eremophila latrobei subsp. *filiformis*					*
	Eremophila latrobei subsp. *latrobei*	*	*		*	*
	Eremophila linearis	*			*	*
	Eremophila margarethae	*	*	*		*
	Eremophila oldfieldii subsp. *angustifolia*	*				
	Eremophila spectabilis subsp. brevis	*				
Solanaceae	*Lycium australe*			*	*	
	Solanum lasiophyllum	*	*	*		*
	Solanum orbiculatum	*				
Thymelaeaceae	*Pimelea trichostachya*		*	*		

Appendix D:
Vegetation Condition Rating

Vegetation Condition Rating	South West and Interzone Botanical Provinces	Eremaean and Northern Botanical Provinces
Pristine	Pristine or nearly so, no obvious signs of disturbance or damage caused by human activities since European settlement.	
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species. Damage to trees caused by fire, the presence of non-aggressive weeds and occasional vehicle tracks.	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.
Very Good	Vegetation structure altered, obvious signs of disturbance. Disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.	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	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.	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	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds at high density, partial clearing, dieback and grazing.	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	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees and shrubs.	Areas that are completely or almost completely without native species in the structure of their 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 E:
Quadrat Locations (NW Corner-GDA94)

Quadrat	Vegetation Code	Zone	Easting	Northing	Elevation
Q1	QRP-AFW1	51 J	280895	7057374	542 m
Q2	RH-AFW1	51 J	281089	7058229	542 m
Q3	RH-AFW1	51 J	281613	7058476	538 m
Q4	QRP-AFW1	51 J	282414	7058004	535 m
Q5	DD-AFW1	51 J	282001	7058347	533 m
Q6	RH-AFW1	51 J	282988	7058394	540 m
Q7	SLP-AFW1	51 J	283417	7056386	533 m
Q8	DD-AFW1	51 J	283986	7056200	536 m
Q9	SLP-AFW1	51 J	282934	7055523	531 m
Q10	DD-AFW1	51 J	283064	7057398	540 m
Q11	CLP-AFW1	51 J	280265	7056310	533 m
Q12	CLP-AFW1	51 J	282698	7053820	526 m
Q13	DD-AFW1	51 J	283312	7053694	525 m
Q14	DD-AFW1	51 J	281688	7054432	525 m
Q15	SLP-AFW1	51 J	282011	7054028	522 m
Q16	CLP-AFW1	51 J	283485	7054267	523 m
Q17	DD-AFW1	51 J	283561	7055031	522 m
Q18	SLP-AFW1	51 J	282364	7054849	523 m
Q19	SLP-AFW1	51 J	281306	7055128	520 m
Q20	QRP-AFW1	51 J	282279	7056440	524 m

Appendix F:
Quadrat Datasheets

Project Name: Vause Gourdis		
Date: 14/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 992-994
Quadrat No: Q1	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 542m
Coordinates (GDA94): 51 J 280895 7057374		**Accuracy:** 2m
Aspect: South East	**Fire (yrs):** <10 years	**Condition rating:** Good
Landform: Quartz/ Rocky Plain		
Coarse fragments on the surface:		
Rock outcrop (abundance/runoff): Nil/ Very Slow		
Soil (profile/field texture/soil surface): Red-Brown		
Cover leaf litter: 50%		
Cover bare ground: 90%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Hummock grass
Height: <10m	**Height:** 1-2m	**Height:** <1m
Crown cover: 10-30%	**Crown cover:** 30-70%	**Crown cover:** 10-30%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Eremophila jucunda*	*Triodia basedowii*

ALL TAXA
Acacia caesaneura
Acacia incurvaneura
Acacia mulganeura
Acacia pruinocarpa
Eremophila jucunda
Ptilotus obovatus
Scaevola spinescens
Solanum lasiophyllum
Triodia basedowii

Project Name: Vause Gourdis		
Date: 14/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 996-998
Quadrat No: Q2	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 542m
Coordinates (GDA94): 51 J 281089 7058229		**Accuracy:** 1m
Aspect: South East	**Fire (yrs):** >20 years	**Condition rating:** Very Good
Landform: Mild Slope/ Hillslope		
Coarse fragments on the surface: Extremely; very abundant (>90%), Coarse gravelly; large pebbles (20-60mm), Angular		
Rock outcrop (abundance/runoff): Nil/ Moderately rapid		
Soil (profile/field texture/soil surface): Brown/ Sandy clay loam/ Hard setting		
Cover leaf litter: 20%		
Cover bare ground: 40%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5m	**Height:** 1-3m	**Height:** 0.5-1m
Crown cover: 30-70%	**Crown cover:** 10-30%	**Crown cover:** <10%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Eremophila jucunda*	*Ptilotus obovatus*

ALL TAXA
Acacia incurvaneura
Acacia mulganeura
Eremophila jucunda
Eremophila forrestii subsp. *forrestii*
Ptilotus obovatus
Triodia basedowii

Project Name: Vause Gourdis		
Date: 14/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 999-002
Quadrat No: Q3	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 538m
Coordinates (GDA94): 51 J 281613 7058476		**Accuracy:** 1m
Aspect: North East	**Fire (yrs):** >20 years	**Condition rating:** Very Good
Landform: Mild Slope/ Hillslope		
Coarse fragments on the surface: Extremely; very abundant (>90%), Medium gravelly; medium pebbles (6-20mm), Subrounded		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Sandy clay loam/ Hard setting		
Cover leaf litter: <10%		
Cover bare ground: 60%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Chenopod shrub
Height: 3-5m	**Height:** 1-3m	**Height:** <0.25m
Crown cover: <10%	**Crown cover:** 10-30%	**Crown cover:** 10-30%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Eremophila linearis*	*Sclerolaena cuneata*

ALL TAXA
Acacia aptaneura
Acacia incurvaneura
Eremophila forrestii subsp. *forrestii*
Eremophila linearis
Psydrax latifolia
Scaevola spinescens
Sclerolaena cuneata
Sclerolaena diacantha
Sclerolaena eurotioides
Senna artemisioides subsp. *helmsii*
Senna sp. Meekatharra (E. Bailey 1-26)
Sida fibulifera

Project Name: Vause Gourdis		
Date: 14/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 003-005
Quadrat No: Q4	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 535m
Coordinates (GDA94): 51 J 282414 7058004		**Accuracy:** 1m
Aspect: South West	**Fire (yrs):** >20 years	**Condition rating:** Very Good
Landform: Lower Slope/ Hillslope		
Coarse fragments on the surface: Extremely; very abundant (>90%), Coarse gravelly; large pebbles (20-60mm), Subrounded		
Rock outcrop (abundance/runoff): Nil/ Slow		
Soil (profile/field texture/soil surface): Brown/ Sandy clay loam/ Hard setting		
Cover leaf litter: 20%		
Cover bare ground: 60%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5m	**Height:** 1-3m	**Height:** 0.5-1m
Crown cover: 10-30%	**Crown cover:** <10%	**Crown cover:** 10-30%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Acacia tetragonophylla*	*Eremophila margarethae*

ALL TAXA
Acacia aptaneura
Acacia incurvaneura
Acacia pruinocarpa
Acacia tetragonophylla
Eremophila fraseri
Eremophila forrestii subsp. *forrestii*
Eremophila margarethae
Enchylaena tomentosa
Exocarpos aphyllus
Lycium australe
Pimelea trichostachya
Ptilotus obovatus
Scaevola spinescens
Sida fibulifera
Sida sp. Excedentifolia (J.L. Egan 1925)
Sida calyxhymenia
Triodia basedowii

Project Name: Vause Gourdis		
Date: 14/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 008-010
Quadrat No: Q5	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 533m
Coordinates (GDA94): 51 J 282001 7058347		**Accuracy:** 1m
Aspect: East	**Fire (yrs):** >20 years	**Condition rating:** Very Good
Landform: Open depression		
Coarse fragments on the surface: No coarse fragments		
Rock outcrop (abundance/runoff): Nil/ Very slow		
Soil (profile/field texture/soil surface): Red- brown/ Clay loam/ Firm		
Cover leaf litter: 60%		
Cover bare ground: 20%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5m	**Height:** 1-3m	**Height:**
Crown cover: 30-70%	**Crown cover:** 10-30%	**Crown cover:** 10-30%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Acacia aptaneura*	*Eremophila forrestii* subsp. *forrestii*
		Eremophila margarethae

ALL TAXA
Acacia aptaneura
Acacia burkittii
Acacia incurvaneura
Acacia mulganeura
Acacia ramulosa var. *ramulosa*
Enchylaena tomentosa
Eremophila forrestii subsp. *forrestii*
Eremophila margarethae
Pimelea trichostachya
Ptilotus obovatus
Psydrax latifolia
Sida fibulifera
Solanum lasiophyllum
Teucrium teucriiflorum

Project Name: Vause Gourdis		
Date: 14/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 011-013
Quadrat No: Q6	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 540m
Coordinates (GDA94): 51 J 282988 7058394		**Accuracy:** 1m
Aspect: North	**Fire (yrs):** >20 years	**Condition rating:** Very Good
Landform: Lower Slope/ Hillslope		
Coarse fragments on the surface: Extremely; very abundant (>90%), Coarse gravelly; large pebbles (20-60mm), Angular		
Rock outcrop (abundance/runoff): Nil/ Slow		
Soil (profile/field texture/soil surface): Brown/ Sandy clay loam/ Hard setting		
Cover leaf litter: 20%		
Cover bare ground: 70%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5m	**Height:** 1-3m	**Height:** 0.5-1m
Crown cover: 10-30%	**Crown cover:** 10-30%	**Crown cover:** 10-30%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Eremophila fraseri*	*Ptilotus obovatus*

ALL TAXA
Acacia aptaneura
Acacia incurvaneura
Acacia pruinocarpa
Acacia tetragonophylla
Amyema miquelii
Eremophila forrestii subsp. *forrestii*
Eremophila fraseri
Eremophila latrobei subsp. *latrobei*
Lycium australe
Ptilotus obovatus
Scaevola spinescens
Sclerolaena diacantha
Sida calyxhymenia

Project Name: Vause Gourdis		
Date: 14/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 014-016
Quadrat No: Q7	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 533m
Coordinates (GDA94): 51 J 283417 7056386		**Accuracy:** 1m
Aspect: South West	**Fire (yrs):** 10 years	**Condition rating:** Good
Landform: Flat/ Plain		
Coarse fragments on the surface: Very; abundant (50-90%), Fine gravelly; small pebbles (2-6mm), Subrounded		
Rock outcrop (abundance/runoff): Nil/ Very slow		
Soil (profile/field texture/soil surface): Red-brown/ Sandy clay loam/ Hard setting		
Cover leaf litter: 20%		
Cover bare ground: 30%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Hummock grass
Height: 3-5m	**Height:** 1-3m	**Height:** 0.5-1m
Crown cover: 30-70%	**Crown cover:** 10-30%	**Crown cover:** 30-70%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Eremophila forrestii* subsp. *forrestii*	*Triodia basedowii*
ALL TAXA		
Acacia incurvaneura		
Enchylaena tomentosa		
Eremophila forrestii subsp. *forrestii*		
Eremophila linearis		
Psydrax latifolia		
Ptilotus obovatus		
Triodia basedowii		

Project Name: Vause Gourdis		
Date: 14/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 019-021
Quadrat No: Q8	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 536m
Coordinates (GDA94): 51 J 283986 7056200		**Accuracy:** 1m
Aspect: South West	**Fire (yrs):** >20 years	**Condition rating:** Very Good
Landform: Open depression		
Coarse fragments on the surface: Very; abundant (50-90%), Fine gravelly; small pebbles (2-6mm)		
Rock outcrop (abundance/runoff): Nil/ Very slow		
Soil (profile/field texture/soil surface): Red-brown/ Sandy clay loam/ Hard setting		
Cover leaf litter: 40%		
Cover bare ground: 30%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: <10%	**Height:** 1-3m	**Height:** <1m
Crown cover: 30-70%	**Crown cover:** 10-30%	**Crown cover:** 10-30%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Acacia aptaneura*	*Acacia tetragonophylla*

ALL TAXA
Acacia aptaneura
Acacia burkittii
Acacia caesaneura
Acacia incurvaneura
Acacia mulganeura
Acacia tetragonophylla
Eremophila fraseri
Eremophila latrobei subsp. *latrobei*
Poaceae sp. (sterile)
Psydrax latifolia
Sida arenicola
Solanum lasiophyllum

Project Name: Vause Gourdis		
Date: 14/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 022-024
Quadrat No: Q9	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 531m
Coordinates (GDA94): 51 J 282934 7055523		**Accuracy:** 1m
Aspect: North West	**Fire (yrs):** >20 years	**Condition rating:** Very Good
Landform: Flat/ Plain		
Coarse fragments on the surface: Extremely; very abundant (>90%), Fine gravelly; small pebbles (2-6mm), Rounded.		
Rock outcrop (abundance/runoff): Nil/ Very Slow		
Soil (profile/field texture/soil surface): Red-brown/ Sandy clay loam/ Hard setting		
Cover leaf litter: <10%		
Cover bare ground: 50%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Hummock grass
Height: 3-5m	**Height:** 0.5-1m	**Height:** 0.5-1m
Crown cover: 30-70%	**Crown cover:** <1%	**Crown cover:** 30-70%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Eremophila margarethae*	*Triodia basedowii*
ALL TAXA		
Acacia burkittii		
Acacia incurvaneura		
Amyema miquelii		
Eremophila forrestii subsp. *forrestii*		
Eremophila margarethae		
Ptilotus schwartzii		
Solanum lasiophyllum		
Triodia basedowii		

Project Name: Vause Gourdis		
Date: 14/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 025-027
Quadrat No: Q10	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 540m
Coordinates (GDA94): 51 J 283064 7057398		**Accuracy:** 1m
Aspect: North East	**Fire (yrs):** >20 years	**Condition rating:** Very Good
Landform: Open depression/ Drainage depression		
Coarse fragments on the surface: Moderately; many (20-50%), Medium gravelly; medium pebbles (6-20mm), Subrounded		
Rock outcrop (abundance/runoff): Nil/ Very Slow		
Soil (profile/field texture/soil surface): Red-brown/ Sandy clay loam/ Hard setting		
Cover leaf litter: 40%		
Cover bare ground: 40%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5m	**Height:** 1-3m	**Height:** 0.5-1m
Crown cover: 30-70%	**Crown cover:** 30-70%	**Crown cover:** 10-30%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Acacia aptaneura*	*Eremophila fraseri*
		Eremophila margarethae

ALL TAXA
Acacia aptaneura
Acacia burkittii
Acacia caesaneura
Acacia incurvaneura
Acacia pruinocarpa
Acacia tetragonophylla
Cheilanthes sieberi
Eremophila fraseri
Eremophila forrestii subsp. *forrestii*
Eremophila margarethae
Pimelea trichostachya
Psydrax latifolia
Sida fibulifera
Teucrium teucriiflorum

Project Name: Vause Gourdis		
Date: 14/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 028-030
Quadrat No: Q11	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 533m
Coordinates (GDA94): 51 J 280265 7056310		**Accuracy:** 1m
Aspect: North	**Fire (yrs):** >20 years	**Condition rating:** Good
Landform: Flat/ Plain		
Coarse fragments on the surface: No qualifier; common (10-20%), Fine gravelly; small pebbles (2-6mm), Rounded		
Rock outcrop (abundance/runoff): Nil/ Very Slow		
Soil (profile/field texture/soil surface): Brown/ Clay loam/ Hard setting		
Cover leaf litter: 40%		
Cover bare ground: 60%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5m	**Height:** 1-3m	**Height:** 0.5-1m
Crown cover: 10-30%	**Crown cover:** 10-30%	**Crown cover:** 10-30%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Psydrax latifolia*	*Eremophila margarethae*

ALL TAXA
Acacia aptaneura
Acacia caesaneura
Acacia incurvaneura
Acacia pruinocarpa
Eremophila linearis
Eremophila margarethae
Psydrax latifolia
Teucrium teucriiflorum

Project Name: Vause Gourdis		
Date: 15/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 031-033
Quadrat No: Q12	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 526m
Coordinates (GDA94): 51 J 282698 7053820		**Accuracy:** 1m
Aspect: North East	**Fire (yrs):** >20 years	**Condition rating:** Very Good
Landform: Flat/ Plain		
Coarse fragments on the surface: Moderately; many (20-50%), Fine gravelly; small pebbles (2-6mm), Rounded		
Rock outcrop (abundance/runoff): Nil/ Very Slow		
Soil (profile/field texture/soil surface): Brown/ Clay loam/ Hard setting		
Cover leaf litter: 50%		
Cover bare ground: 30%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Hummock grass
Height: 3-6m	**Height:** 1-3m	**Height:** 0.5-1m
Crown cover: 30-70%	**Crown cover:** 30-70%	**Crown cover:** 30-70%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Acacia caesaneura*	*Triodia melvillei*
	Acacia tetragonophylla	
ALL TAXA		
Acacia caesaneura		
Acacia craspedocarpa		
Acacia incurvaneura		
Acacia mulganeura		
Acacia tetragonophylla		
Eremophila fraseri		
Halgania solanacea		
Psydrax latifolia		
Triodia melvillei		

Project Name: Vause Gourdis		
Date: 15/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 035-037
Quadrat No: Q13	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 525m
Coordinates (GDA94): 51 J 283312 7053694		**Accuracy:** 1m
Aspect: South West	**Fire (yrs):** >20 years	**Condition rating:** Very Good
Landform: Open depression/ Drainage depression		
Coarse fragments on the surface: Moderately; many (20-50%), Fine gravelly; small pebbles (2-6mm), Rounded		
Rock outcrop (abundance/runoff): Nil/ Very Slow		
Soil (profile/field texture/soil surface): Brown/ Sandy clay loam/ Firm		
Cover leaf litter: 10%		
Cover bare ground: 70%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Tussock grass
Height: 3-6m	**Height:** 1-3m	**Height:** <0.25m
Crown cover: 10-30%	**Crown cover:** <10%	**Crown cover:** <10%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Eremophila fraseri*	*Eragrostis eriopoda*

ALL TAXA
Acacia aptaneura
Acacia caesaneura
Acacia incurvaneura
Acacia pruinocarpa
Acacia tetragonophylla
Amyema miquelii
Cheilanthes sieberi
Eremophila fraseri
Eremophila latrobei subsp. *latrobei*
Eragrostis eriopoda
Psydrax latifolia
Ptilotus obovatus
Sida arenicola
Sida fibulifera
Sida calyxhymenia
Solanum lasiophyllum
Teucrium teucriiflorum

Project Name: Vause Gourdis		
Date: 15/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 038-040
Quadrat No: Q14	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 525m
Coordinates (GDA94): 51 J 281688 7054432		**Accuracy:** 1m
Aspect: North	**Fire (yrs):** >20 years	**Condition rating:** Very Good
Landform: Open depression/ drainage depression		
Coarse fragments on the surface: Moderately; many (20-50%), Medium gravelly; medium pebbles (6-20mm), Subrounded		
Rock outcrop (abundance/runoff): Nil/ Very Slow		
Soil (profile/field texture/soil surface): Brown/ Sandy clay loam/ Hard setting		
Cover leaf litter: 60%		
Cover bare ground: 20%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-6m	**Height:** 1-3m	**Height:** 0.25-0.5m
Crown cover: 30-70%	**Crown cover:** 10-30%	**Crown cover:** <10%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Eremophila fraseri*	*Sida calyxhymenia*
	Eremophila linearis	
ALL TAXA		
Acacia aptaneura		
Acacia caesaneura		
Acacia incurvaneura		
Acacia tetragonophylla		
Amyema miquelii		
Eremophila fraseri		
Eremophila margarethae		
Eremophila linearis		
Leichhardtia australis		
Psydrax latifolia		
Ptilotus obovatus		
Scaevola spinescens		
Senna artemisioides subsp. *helmsii*		
Sida fibulifera		
Sida calyxhymenia		
Sclerolaena diacantha		
Teucrium teucriiflorum		
Triodia basedowii		

Project Name: Vause Gourdis		
Date: 15/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 041-043
Quadrat No: Q15	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 522m
Coordinates (GDA94): 51 J 282011 7054028		**Accuracy:** 1m
Aspect: North	**Fire (yrs):** >20 years	**Condition rating:** Very Good
Landform: Flat/ Plain		
Coarse fragments on the surface: Moderately; many (20-50%), Fine gravelly; small pebbles (2-6mm), Rounded		
Rock outcrop (abundance/runoff): Nil/ Very Slow		
Soil (profile/field texture/soil surface): Red-Brown/ Sandy loam/ Hard setting		
Cover leaf litter: 20%		
Cover bare ground: 40%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Hummock grass
Height: 3-6m	**Height:** 0.5-1m	**Height:** 0.25-0.5m
Crown cover: 30-70%	**Crown cover:** <10%	**Crown cover:** 30-70%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Eremophila fraseri*	*Triodia melvillei*
	Eremophila margarethae	
ALL TAXA		
Acacia balsamea		
Acacia caesaneura		
Acacia incurvaneura		
Acacia pruinocarpa		
Eremophila fraseri		
Eremophila latrobei subsp. *filiformis*		
Eremophila margarethae		
Solanum lasiophyllum		
Teucrium teucriiflorum		
Triodia melvillei		

Project Name: Vause Gourdis		
Date: 15/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 044-046
Quadrat No: Q16	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 523m
Coordinates (GDA94): 51 J 283485 7054267		**Accuracy:** 1m
Aspect: North West	**Fire (yrs):** >20 years	**Condition rating:** Very Good
Landform: Flat/ Plain		
Coarse fragments on the surface: No qualifier; common (10-20%), Medium gravelly; medium pebbles (6-20mm), Rounded		
Rock outcrop (abundance/runoff): Nil/ Very Slow		
Soil (profile/field texture/soil surface): Brown/ Clay loam/ Hard setting		
Cover leaf litter: 10%		
Cover bare ground: 80%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5m	**Height:** 1-3m	**Height:** 0.25-0.5m
Crown cover: 10-30%	**Crown cover:** 10-30%	**Crown cover:** <10%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Acacia balsamea*	*Ptilotus obovatus*

ALL TAXA
Acacia aptaneura
Acacia balsamea
Acacia incurvaneura
Acacia mulganeura
Eremophila fraseri
Ptilotus obovatus
Sida calyxhymenia
Sida fibulifera

Project Name: Vause Gourdis		
Date: 15/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 047-049
Quadrat No: Q17	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 522m
Coordinates (GDA94): 51 J 283561 7055031		**Accuracy:** 1m
Aspect: North East	**Fire (yrs):** >20 years	**Condition rating:** Very Good
Landform: Open depression/ Drainage depression		
Coarse fragments on the surface: No coarse fragments		
Rock outcrop (abundance/runoff): Nil/ Very slow		
Soil (profile/field texture/soil surface): Brown/ Clay loam/ Hard setting		
Cover leaf litter: 20%		
Cover bare ground: 30%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Chenopod shrub
Height: 3-6m	**Height:** 1-3m	**Height:** <0.25m
Crown cover: 30-70%	**Crown cover:** 30-70%	**Crown cover:** 10-30%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia caesaneura	*Acacia balsamea*	*Sclerolaena diacantha*
Acacia incurvaneura	*Acacia effusifolia*	
ALL TAXA		
Acacia aptaneura		
Acacia balsamea		
Acacia caesaneura		
Acacia effusifolia		
Acacia incurvaneura		
Acacia tetragonophylla		
Psydrax latifolia		
Sclerolaena diacantha		
Sida calyxhymenia		
Senna sp. Meekatharra (E. Bailey 1-26)		

Project Name: Vause Gourdis		
Date: 15/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 050-052
Quadrat No: Q18	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 523m
Coordinates (GDA94): 51 J 282364 7054849		**Accuracy:** 1m
Aspect: North East	**Fire (yrs):** >20 years	**Condition rating:** Very Good
Landform: Flat/ Plain		
Coarse fragments on the surface: Very; abundant (50-90%), Fine gravelly; small pebbles (2-6mm), Rounded		
Rock outcrop (abundance/runoff): Nil/ Very slow		
Soil (profile/field texture/soil surface): Red-brown/ Sandy clay loam/ Hard setting		
Cover leaf litter: 40%		
Cover bare ground: 30%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Hummock grass
Height: 3-5m	**Height:** 1-3m	**Height:** 0.25-0.5m
Crown cover: 30-70%	**Crown cover:** 30-70%	**Crown cover:** 30-70%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Acacia balsamea*	*Triodia melvillei*
	Acacia effusifolia	
ALL TAXA		
Acacia balsamea		
Acacia effusifolia		
Acacia incurvaneura		
Acacia pruinocarpa		
Acacia tetragonophylla		
Eremophila margarethae		
Ptilotus obovatus		
Triodia melvillei		

Project Name: Vause Gourdis		
Date: 15/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 053-055
Quadrat No: Q19	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 520m
Coordinates (GDA94): 51 J 281306 7055128		**Accuracy:** 1m
Aspect: North East	**Fire (yrs):** >20 years	**Condition rating:** Good
Landform: Flat/ Plain		
Coarse fragments on the surface: Very; abundant (50-90%), Medium gravelly; medium pebbles (6-20mm), Subangular		
Rock outcrop (abundance/runoff): Nil/ Very slow		
Soil (profile/field texture/soil surface): Red-brown/ Sandy loam/ Hard setting		
Cover leaf litter: 50%		
Cover bare ground: 50%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Hummock grass
Height: 3-6m	**Height:** 0.5-1m	**Height:** 0.25-0.5m
Crown cover: 30-70%	**Crown cover:** <10%	**Crown cover:** 10-30%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Eremophila margarethae*	*Triodia melvillei*

ALL TAXA
Acacia balsamea
Acacia caesaneura
Acacia incurvaneura
Eremophila margarethae
Triodia melvillei

Project Name: Vause Gourdis		
Date: 15/03/2023	**Botanist:** LP + KC	**Photo number (NW corner):** 056-058
Quadrat No: Q20	**Quadrat size/shape:** 50m x 50m/ Square	**Elevation (m):** 524m
Coordinates (GDA94): 51 J 282279 7056440		**Accuracy:** 1m
Aspect: North	**Fire (yrs):** >20 years	**Condition rating:** Very Good
Landform: Lower Slope/ Hillslope		
Coarse fragments on the surface: Extremely; very abundant (>90%), Coarse gravelly; large pebbles (20-60mm), Subrounded.		
Rock outcrop (abundance/runoff): Nil/ Slow		
Soil (profile/field texture/soil surface): Red-Brown/ Sandy clay loam/ Hard setting		
Cover leaf litter: 30%		
Cover bare ground: 40%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Chenopod shrub
Height: 1-3m	**Height:** 1-3m	**Height:** <0.25m
Crown cover: 10-30%	**Crown cover:** 30-70%	**Crown cover:** 10-30%
Dominant taxa:	**Dominant taxa:**	**Dominant taxa:**
Acacia incurvaneura	*Senna* sp. Meekatharra (E. Bailey 1-26)	*Sclerolaena diacantha*
	Eremophila linearis	*Sclerolaena eurotioides*
		Sclerolaena cuneata
ALL TAXA		
Acacia aptaneura		
Acacia incurvaneura		
Eremophila linearis		
Maireana triptera		
Ptilotus obovatus		
Sclerolaena cuneata		
Sclerolaena diacantha		
Sclerolaena eurotioides		
Senna sp. Meekatharra (E. Bailey 1-26)		

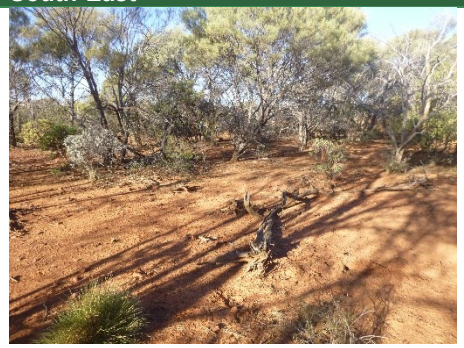
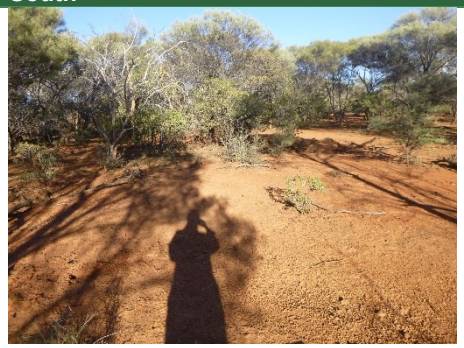
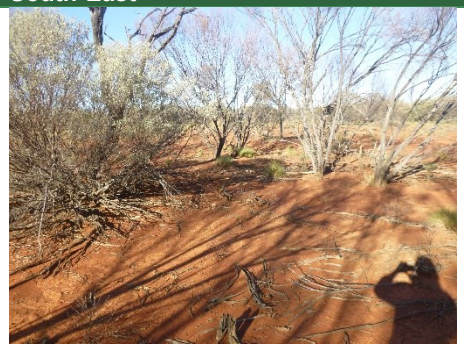
Appendix G:
Quadrat Photographs

Quadrat 1			
Direction	**East**	**South-East**	**South**
Quadrat 2			
Direction	**East**	**South-East**	**South**
Quadrat 3			
Direction	**East**	**South-East**	**South**

Quadrat 4			
Direction	**East**	**South-East**	**South**
Quadrat 5			
Direction	**East**	**South-East**	**South**
Quadrat 6			
Direction	**East**	**South-East**	**South**

Quadrat 7			
Direction	**East**	**South-East**	**South**
Quadrat 8			
Direction	**East**	**South-East**	**South**
Quadrat 9			
Direction	**East**	**South-East**	**South**

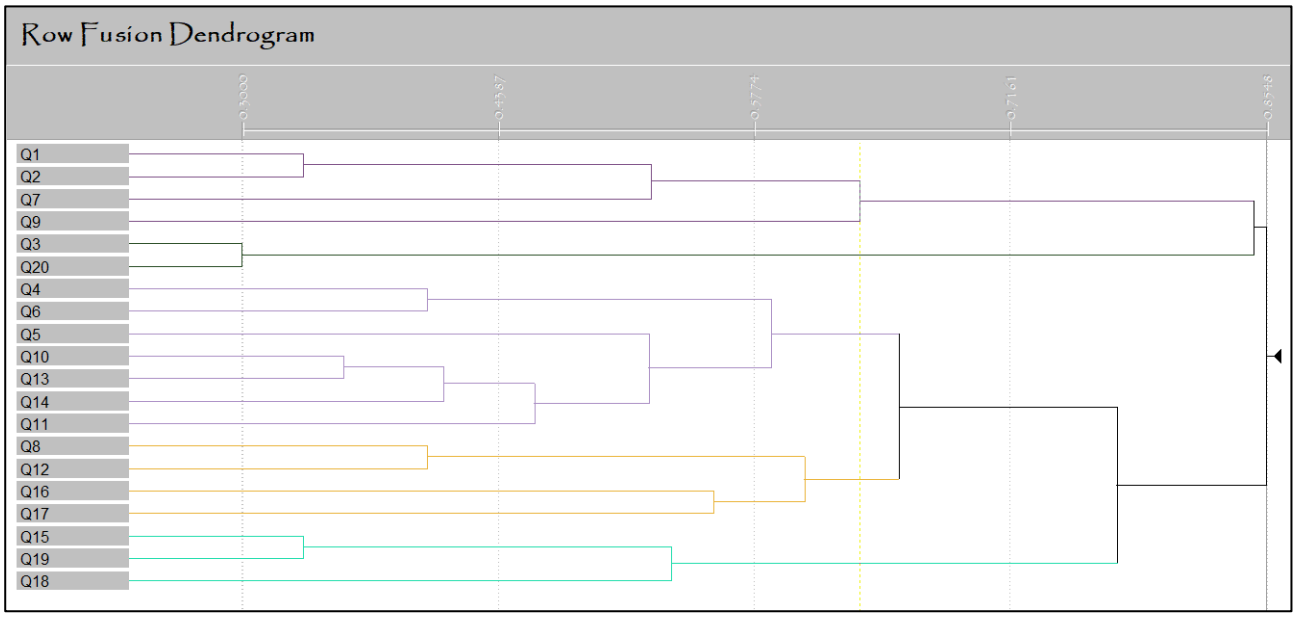
Quadrat 10			
Direction	**East**	**South-East**	**South**
Quadrat 11			
Direction	**East**	**South-East**	**South**
Quadrat 12			
Direction	**East**	**South-East**	**South**

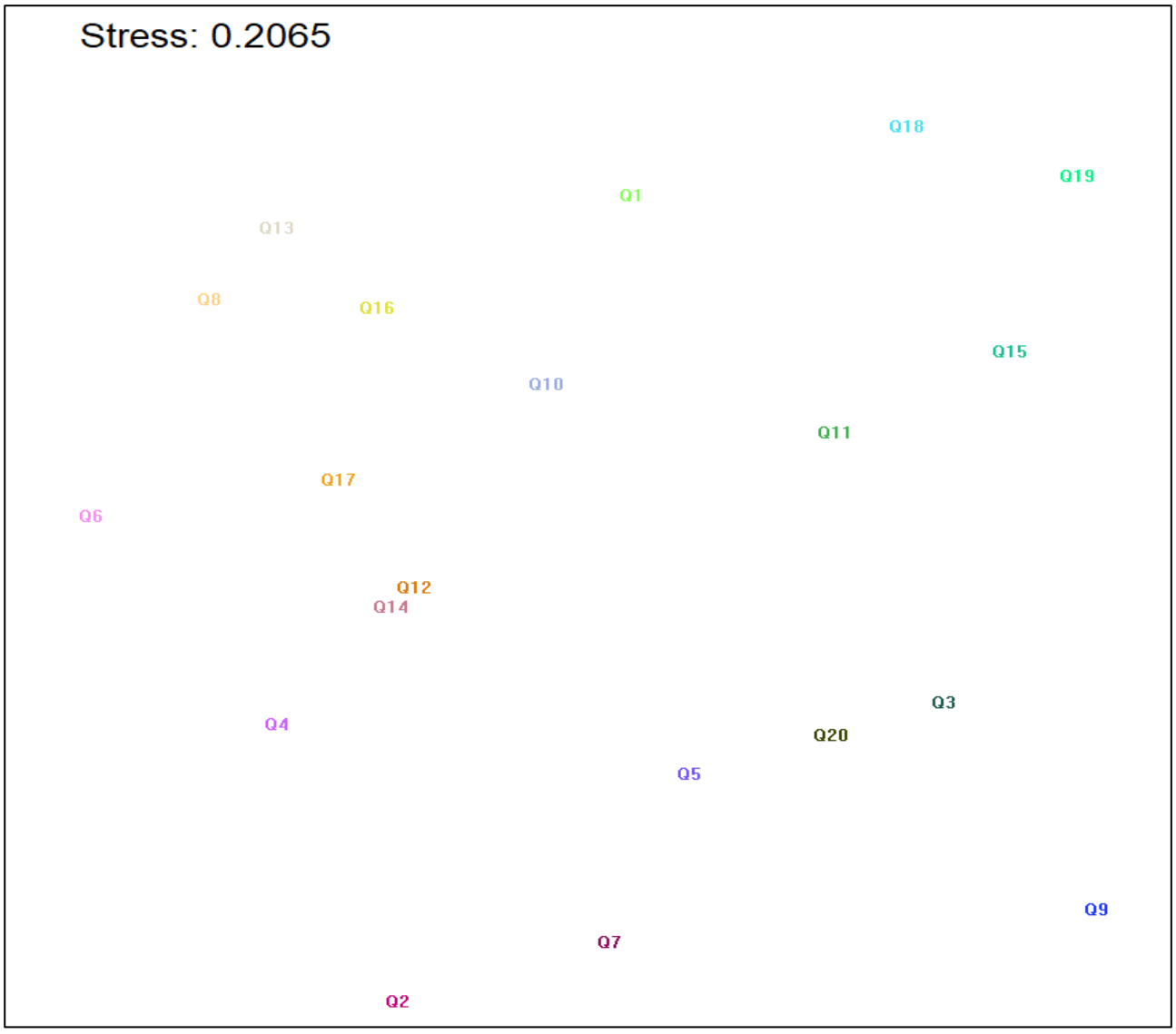
Quadrat 13			
Direction	**East**	**South-East**	**South**
Quadrat 14			
Direction	**East**	**South-East**	**South**
Quadrat 15			
Direction	**East**	**South-East**	**South**

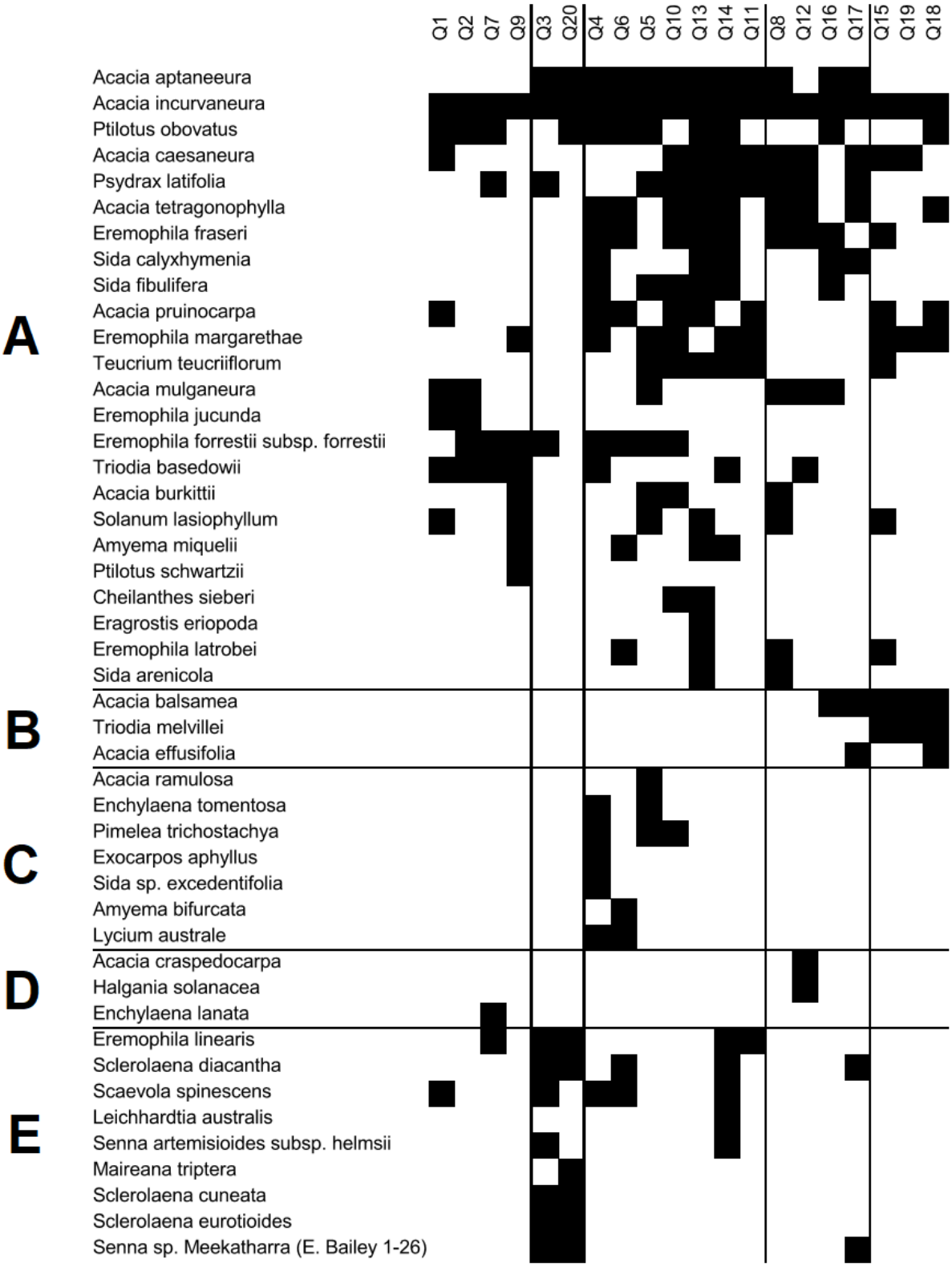
Quadrat 16			
Direction	**East**	**South-East**	**South**
Quadrat 17			
Direction	**East**	**South-East**	**South**
Quadrat 18			
Direction	**East**	**South-East**	**South**

Quadrat 19			
Direction	**East**	**South-East**	**South**
Quadrat 20			
Direction	**East**	**South-East**	**South**

Appendix H:
PATN Analysis Results


Row Fusion Dendrogram
0.3000
0.4587
0.6174
0.7761
0.9348
Q1
Q2
Q7
Q9
Q3
Q20
Q4
Q6
Q5
Q10
Q13
Q14
Q11
Q8
Q12
Q16
Q17
Q15
Q18
Q19


Stress: 0.2065
Q18
Q19
Q1
Q13
Q8
Q16
Q15
Q10
Q11
Q17
Q6
Q12
Q14
Q3
Q4
Q20
Q5
Q9
Q7
Q2


Q1
Q2
Q7
Q9
Q3
Q20
Q4
Q6
Q5
Q10
Q13
Q14
Q11
Q8
Q12
Q16
Q17
Q15
Q19
Q18
A
Acacia aptaneeura
Acacia incurvaneura
Ptilotus obovatus
Acacia caesaneura
Psydrax latifolia
Acacia tetragonophylla
Eremophila fraseri
Sida calyxhymenia
Sida fibulifera
Acacia pruinocarpa
Eremophila margarethae
Teucrium teucriiflorum
Acacia mulganeura
Eremophila jucunda
Eremophila forrestii subsp. forrestii
Triodia basedowii
Acacia burkittii
Solanum lasiophyllum
Amyema miquelii
Ptilotus schwartzii
Cheilanthes sieberi
Eragrostis eriopoda
Eremophila latrobei
Sida arenicola
B
Acacia balsamea
Triodia melvillei
Acacia effusifolia
C
Acacia ramulosa
Enchylaena tomentosa
Pimelea trichostachya
Exocarpos aphyllus
Sida sp. excedentifolia
Amyema bifurcata
Lycium australe
D
Acacia craspedocarpa
Halgania solanacea
Enchylaena lanata
E
Eremophila linearis
Sclerolaena diacantha
Scaevola spinescens
Leichhardtia australis
Senna artemisioides subsp. helmsii
Maireana triptera
Sclerolaena cuneata
Sclerolaena eurotioides
Senna sp. Meekatharra (E. Bailey 1-26)

Appendix I:
Database Search Results

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 08-May-2023

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	7
Listed Migratory Species:	6

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at https://www.dcceew.gov.au/parks-heritage/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	8
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	None
Regional Forest Agreements:	None
Nationally Important Wetlands:	None
EPBC Act Referrals:	1
Key Ecological Features (Marine):	None
Biologically Important Areas:	None
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Listed Threatened Species			[Resource Information]
Status of Conservation Dependent and Extinct are not MNES under the EPBC Act. Number is the current name ID.			
Scientific Name	Threatened Category	Presence Text	Buffer Status
BIRD			
Aphelocephala leucopsis Southern Whiteface [529]	Vulnerable	Species or species habitat known to occur within area	In feature area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat known to occur within area	In feature area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat likely to occur within area	In feature area
Polytelis alexandrae Princess Parrot, Alexandra's Parrot [758]	Vulnerable	Species or species habitat may occur within area	In feature area
MAMMAL			
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat may occur within area	In feature area
REPTILE			
Liopholis kintorei Great Desert Skink, Tjakura, Warrarna, Mulyamiji [83160]	Vulnerable	Species or species habitat may occur within area	In feature area

Listed Migratory Species			[Resource Information]
Scientific Name	Threatened Category	Presence Text	Buffer Status
Migratory Terrestrial Species			

Scientific Name	Threatened Category	Presence Text	Buffer Status
Motacilla cinerea			
Grey Wagtail [642]		Species or species habitat may occur within area	In feature area
Motacilla flava			
Yellow Wagtail [644]		Species or species habitat may occur within area	In feature area
Migratory Wetlands Species			
Actitis hypoleucos			
Common Sandpiper [59309]		Species or species habitat likely to occur within area	In feature area
Calidris acuminata			
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area	In feature area
Calidris melanotos			
Pectoral Sandpiper [858]		Species or species habitat may occur within area	In feature area
Charadrius veredus			
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area	In feature area

Other Matters Protected by the EPBC Act

Listed Marine Species			[Resource Information]
Scientific Name	Threatened Category	Presence Text	Buffer Status
Bird			
Actitis hypoleucos			
Common Sandpiper [59309]		Species or species habitat likely to occur within area	In feature area
Calidris acuminata			
Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area	In feature area
Calidris melanotos			
Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Chalcites osculans as Chrysococcyx osculans			
Black-eared Cuckoo [83425]		Species or species habitat known to occur within area overfly marine area	In feature area
Charadrius veredus			
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area overfly marine area	In feature area
Merops ornatus			
Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area	In feature area
Motacilla cinerea			
Grey Wagtail [642]		Species or species habitat may occur within area overfly marine area	In feature area
Motacilla flava			
Yellow Wagtail [644]		Species or species habitat may occur within area overfly marine area	In feature area

Extra Information

EPBC Act Referrals				[Resource Information]
Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Not controlled action				
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	Not Controlled Action	Completed	In feature area

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact us page.

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