Redcliffe Gold Project
Purpose Permit Application

Supporting Documentation: Assessment of Clearing Principles

M37/233, M37/1276, M37/1286, M37/1295 and M37/1348

Prepared by
Redcliffe Project Pty Ltd

February 2022 | Version 1.0

Revision Summary Table

Date	Revision	Document Name	Summary
09 02 2022	Version 1.0	Redcliffe Gold Project Purpose Permit Application Supporting Documentation: Assessment of Clearing Principles Tenements: M37/233, M37/1276, M37/1286, M37/1295 and M37/1348 Version 1.0	Native Vegetation Clearing Permit (NVCP) application requesting approval to progressively clear a total of 250.3 ha of native vegetation within a purpose permit area of 1,672.6 ha.

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1. INTRODUCTION

1.1 Background

This document has been prepared in support of a Native Vegetation Clearing Permit (NVCP) (Purpose Permit) application for the clearing associated with the development of the Redcliffe Gold Project (RGP). The RGP is owned and operated by Redcliffe Project Pty Ltd (Redcliffe), a wholly-owned subsidiary of Dacian Gold Limited (Dacian).

The RGP is located approximately 50 km northeast of Leonora, within the Shires of Leonora and Laverton, and in the North-Eastern Goldfields Region of Western Australia (Figure 1). It is accessed via the main public route of Leonora-Nambi Road.

All tenements associated with the RGP are held by Redcliffe apart from M37/233 which is held by Kin Mining NL (Kin Mining), where the disused Mertondale 5 open pit is located. Access to tenement M37/233 for works relating to the RGP has been provided to Redcliffe by Kin Mining the current holder of M37/233 through an Authorisation for Disturbance of Ground on M37/233 (Appendix 1).

The RGP consists of the following five mining leases extending 21 km from GTS/Mertondale 5 in the south to Redcliffe/Mesa in the north:

- M37/233 (GTS/Mertondale 5 – portion of the GTS open pit and storage of mine dewatering at the historic Mertondale 5 pit).
- M37/1276 (GTS open pit).
- M37/1286 (Redcliffe/Mesa – storage of mine dewatering at the historic Redcliffe/Mesa pits).
- M37/1295 (Bindy – accommodation camp, and access road/dewatering pipeline corridor).
- M37/1348 (Hub open pit).

This NVCP application relates to the mining of the Hub and Golden Terrace South (GTS) open pits and associated infrastructure. The proposed RGP site layouts are shown in Figure 2 to Figure 5.

Under Section 51C of the *Environmental Protection Act 1986* (Western Australia) (EP Act), the clearing of any native vegetation requires an approved clearing permit, unless an exemption applies. An exemption does not apply to the clearing of native vegetation within the RGP. Therefore, a NVCP is required.

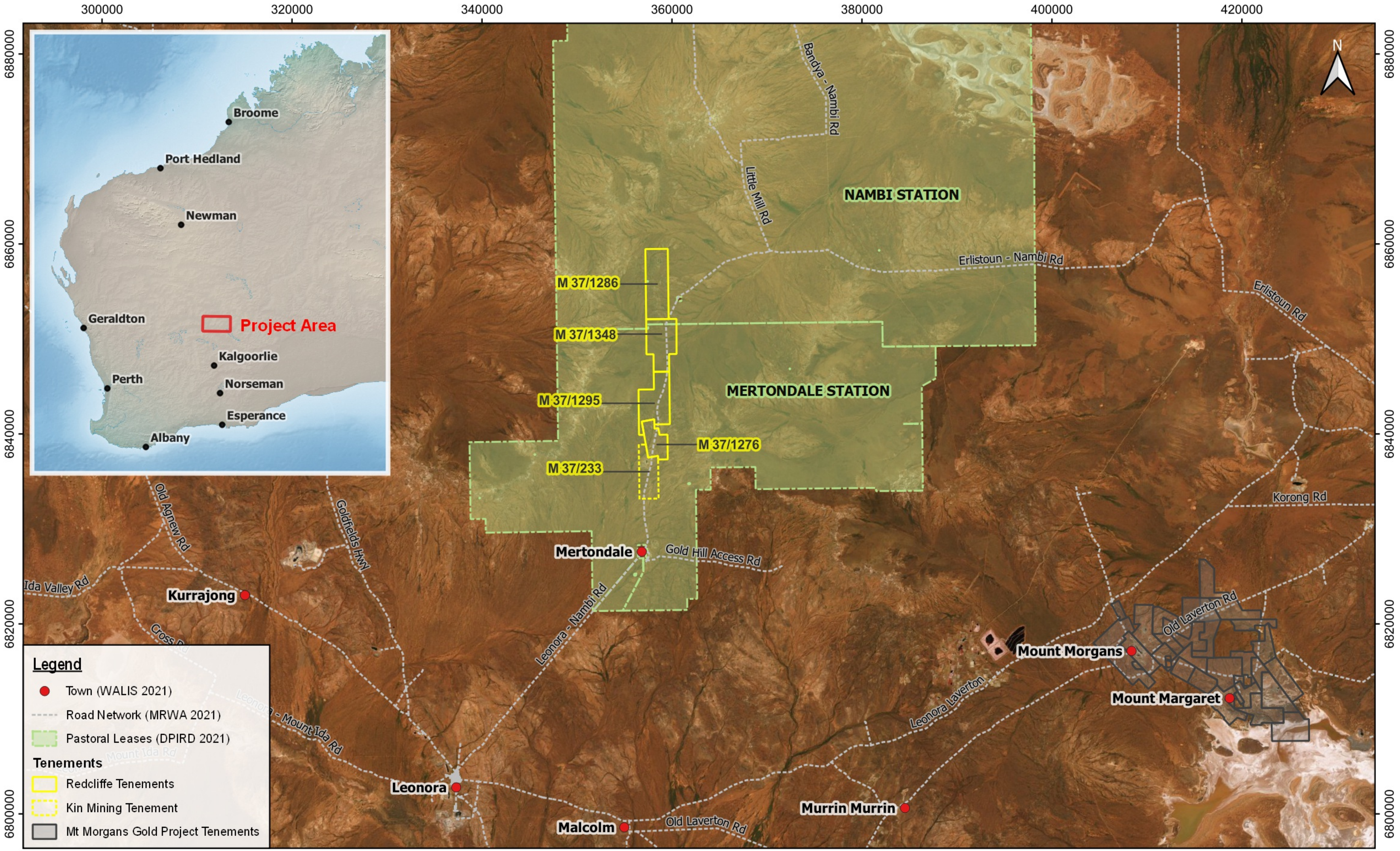
This NVCP application requests approval to progressively clear a total of 250.3 ha of native vegetation within a purpose permit area of 1,672.6 ha (Figure 6).

Note that the scope of the NVCP as described in the various attached survey reports is not the same as the current proposed scope of the RGP. The survey reports refer to the development of the Nambi Open Pit located within M37/1286, which is not currently part of the development of the RGP.

The location and key mine infrastructure for each of the individual RGP areas is provided in Table 1.

Table 1: NVCP Application – Project Areas

Project Area	Tenement	Figure(s)	Key Mine Infrastructure
Hub Open Pit Mine (Proposed).	M37/1348	Figure 1 Figure 3	• Hub Open Pits (North Pit and South Pit). • Hub Run of Mine (ROM) Pad. • Hub Waste Rock Dump (WRD – including Hub Landfill). • Dewatering and Supporting Infrastructure.
GTS Open Pit Mine (Proposed).	M37/1276	Figure 1 Figure 5	• GTS Open Pit. • GTS ROM Pad. • GTS WRD. • Dewatering and Supporting Infrastructure. • GTS Creek Diversion.
Redcliffe and Mesa Open Pit Mine (Existing / Historical). (NB: existing Nambi Open-pit lies within M37/1286 but is not part of the RGP).	M37/1286	Figure 1 Figure 2	• Redcliffe Open Pit. • Mesa Open Pit. • Redcliffe WRD (including proposed Redcliffe Landfill). • Mesa WRD. • Dewatering Discharge and Supporting Infrastructure.
Accommodation Camp and Administration Offices.	M37/1295	Figure 1 Figure 4	• Accommodation Camp. • Administration Offices. • Sewage treatment facility. • Reverse Osmosis (RO) Plant. • Dewatering and Supporting Infrastructure.
Mertondale 5 Open Pit Mine (Existing / Historical).	M37/233 (Held by Kin Mining NL)	Figure 1 Figure 5	• Mertondale 5 Open Pit. • Mertondale 5 WRD Open Pit. • Portion of GTS Open Pit (Proposed). • Dewatering Discharge and Supporting Infrastructure.



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Projection: GDA94 / MGA zone 51

0 5 10 15 20 km

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Figure 1

Location Plan

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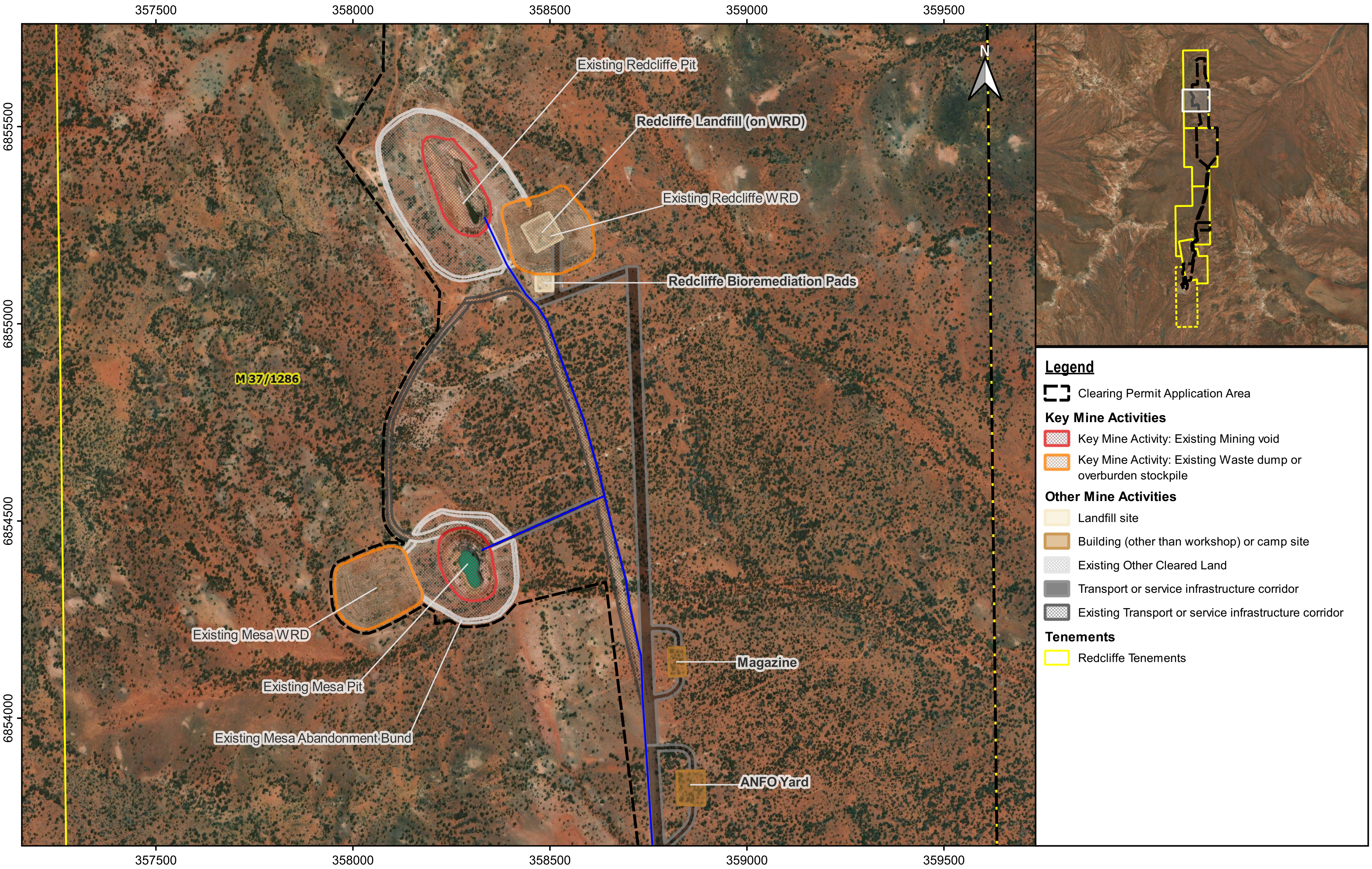

Legend

Clearing Permit Application Area

Key Mine Activities

- Key Mine Activity: Existing Mining void
- Key Mine Activity: Existing Waste dump or overburden stockpile

Other Mine Activities

- Landfill site
- Building (other than workshop) or camp site
- Existing Other Cleared Land
- Transport or service infrastructure corridor
- Existing Transport or service infrastructure corridor

Tenements

- Redcliffe Tenements

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Scale: 1:12000
Projection: GDA94 / MGA zone 51

0 100 200 300 400 500 m

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Figure 2

Site Layout - Redcliffe and Mesa

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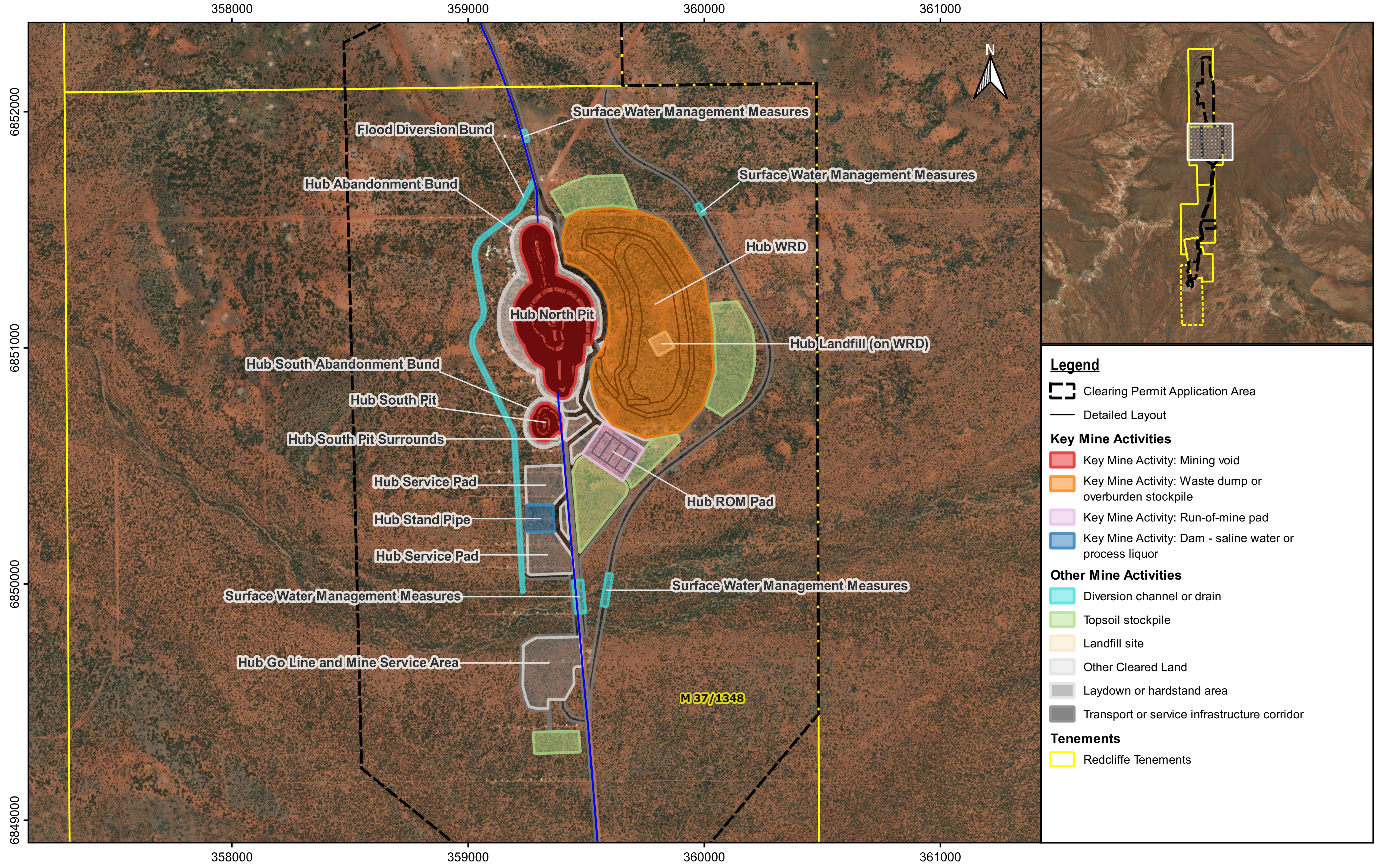

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Figure 3

Site Layout - Hub

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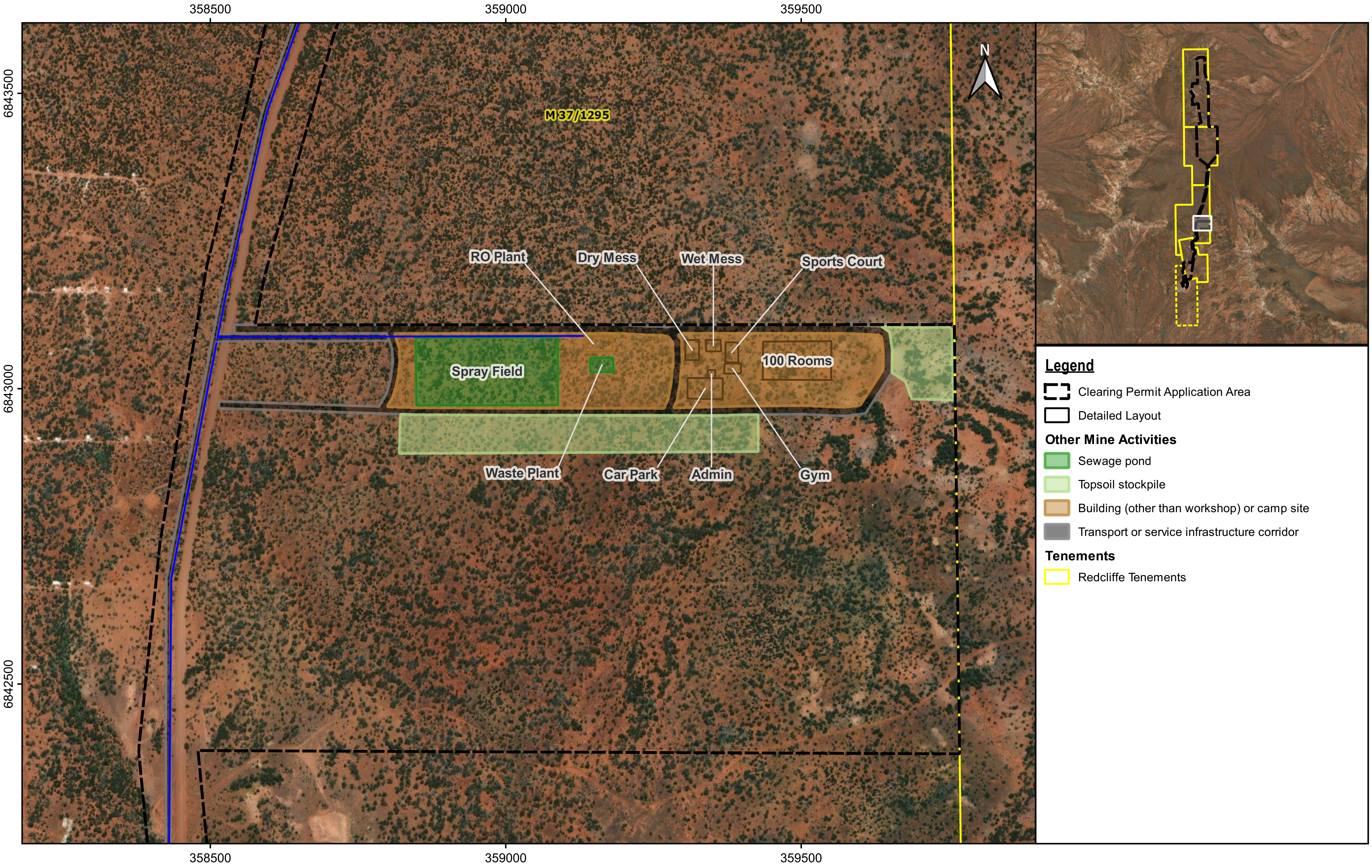

Original Size: A4 Aerial: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community Scale: 1:8000 Projection: GDA94 / MGA zone 51 0 100 200 300 400 m	Dacian Gold Limited Redcliffe Gold Project Clearing Permit 2022	Figure 4 Site Layout - Camp	DACIAN GOLD LIMITED

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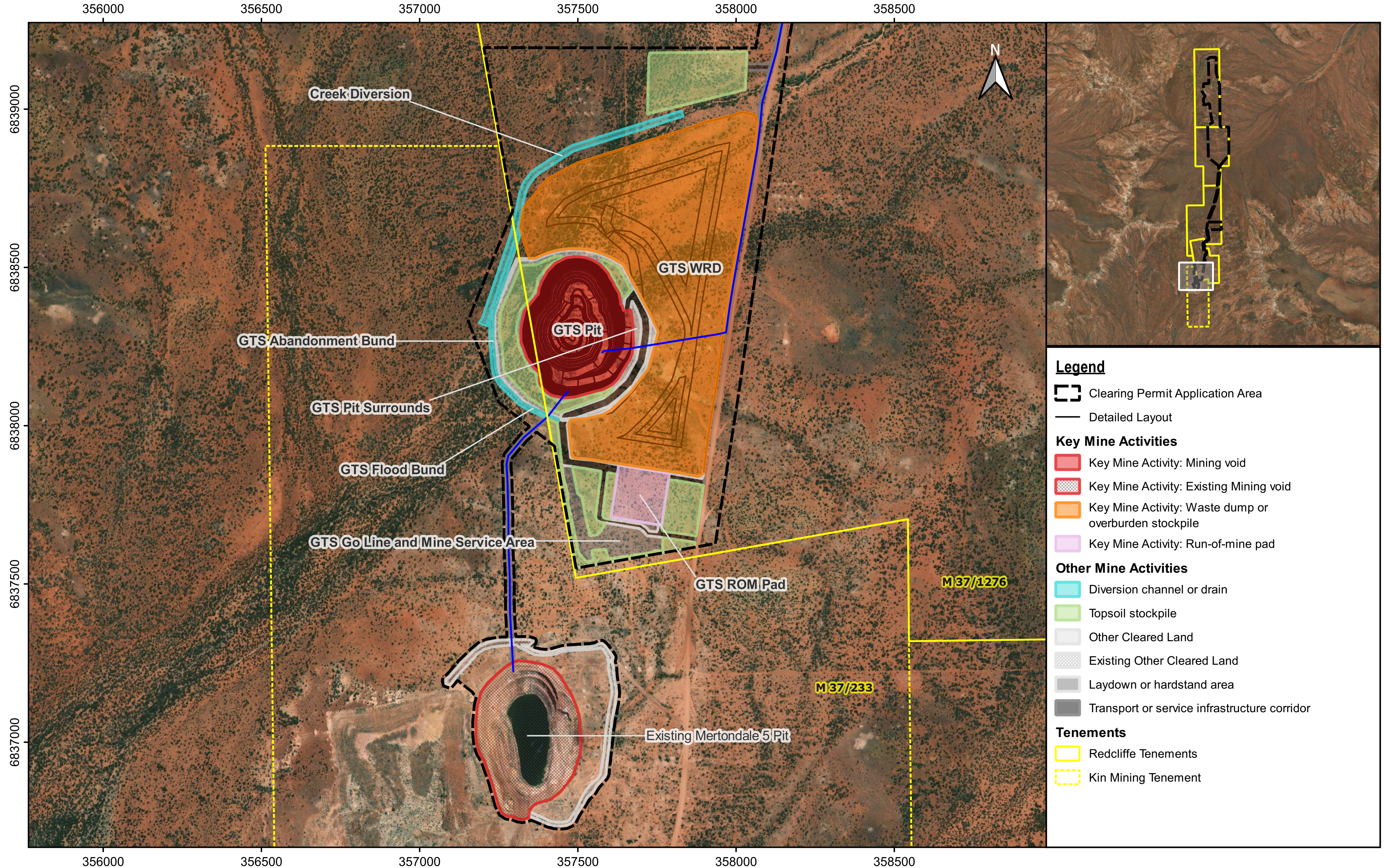

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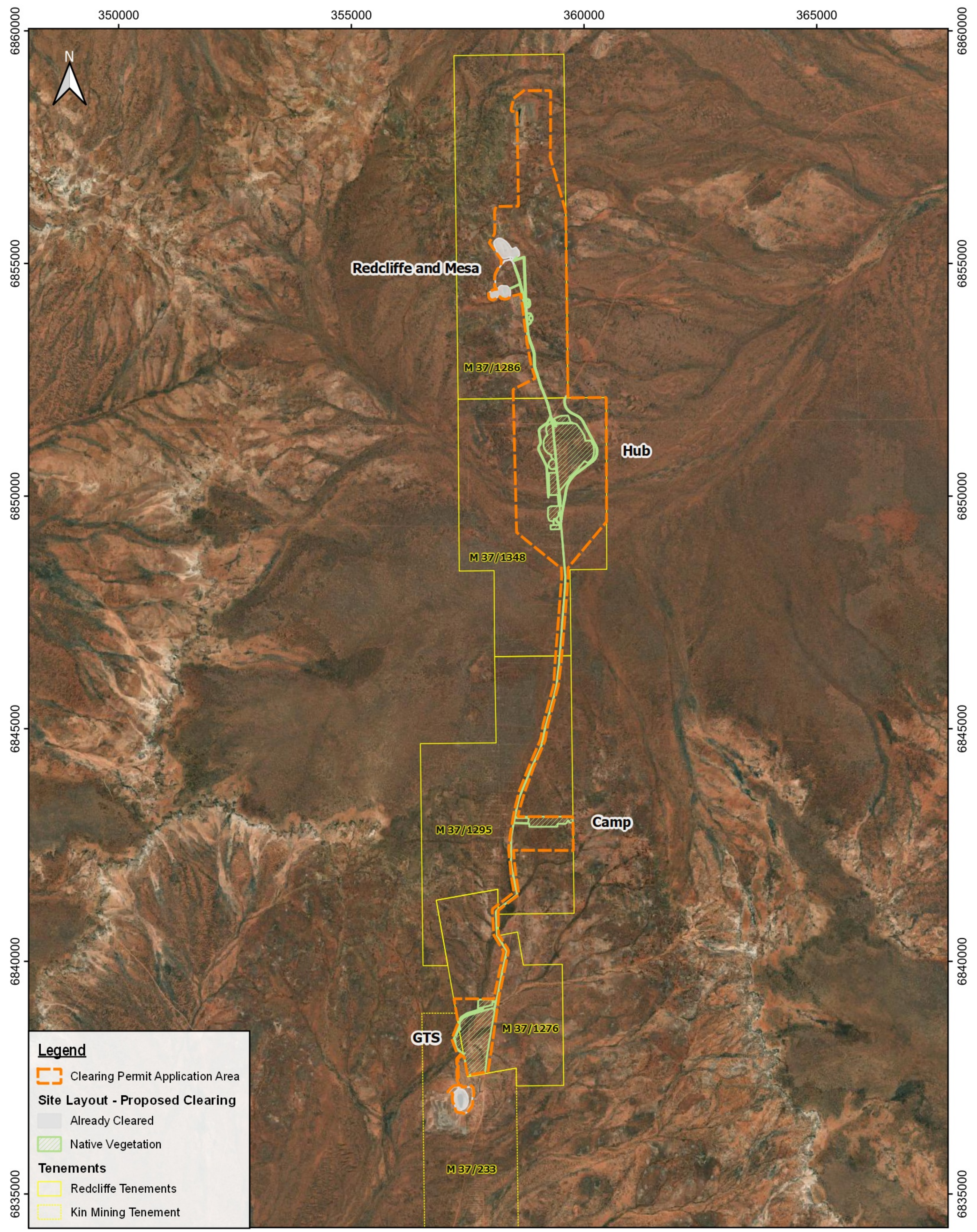

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Projection: GDA94 / MGA zone 51
0 1 2 3 4 km

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Figure 6

Clearing Permit Application Area

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1.2 Purpose of Clearing Permit Application

The purpose of this NVCP supporting document is to present the results of an assessment of the clearing aspects of this proposal against the ten clearing principles as outlined in Schedule 5 of the Part V EP Act. This NVCP application supporting document report identifies the potential environmental impacts associated with the proposal based on the current available data.

This report and accompanying NVCP Purpose Permit application form will be submitted to the Department of Mines, Industry Regulation and Safety (DMIRS) for assessment.

1.3 Proposed Timeframe

Clearing is proposed to commence in Q2 2022 with mining likely to be completed in 2024.

1.4 Proponent

The RGP is owned and operated by Redcliffe, a wholly-owned subsidiary of Dacian.

All compliance and regulatory requirements regarding this NVCP application document should be forwarded by email, post, or courier to the following address:

Proponent: Redcliffe Project Pty Ltd
Level 19, 58 Mounts Bay Road
Perth WA 6000

Contact: Peter Dunstan
Title: Manager Redcliffe
Company: Redcliffe Project Pty Ltd
Phone: (08) 6323 9000
E-mail: Peter.Dunstan@daciangold.com.au

2. ENVIRONMENTAL SETTING

2.1 Regional Setting

The project is located in the Eastern subregion of the Murchison bioregion of Western Australia (Environment Australia, 2000). The Eastern Murchison area is typically large areas of red desert sandplains, red-brown soils, and breakaway complexes. Undulating sandplains and granite outcrops with northerly trending ridges are controlled by the strike of greenstone belts and broad valleys containing playa lakes. There is a gradual elevation in topography towards the north (MBS 2021a).

2.2 Geology

2.2.1 Regional Geology

The RGP is situated over a large portion of the Mertondale Shear Zone (MSZ). The MSZ trends north to south between the Keith-Kilkenny and Celia tectonic zones. The MSZ is the major source of gold within the RGP area. The MSZ is bound by strongly altered and mineralised fault systems with the Mertondale fault to the east and the Great Western fault system to the west. An Archaean felsic volcanoclastic and sedimentary sequence is located to the west of the shear zone and Archaean predominantly mafic volcanics comprising basalt and dolerite are located to the east. The MSZ includes intrusions of felsic porphyries and Proterozoic dolerite dykes (MBS 2021b).

Gold mineralisation is associated with the Archaean greenstones which generally occur in a north to south bearing in the Murchison and Eastern Goldfields (MBS 2021b).

2.2.2 Project Geology

Hub Deposit

A package of northerly striking, folded, sub-vertical to steep east dipping felsic volcanics (rhyodacite), mafic, intermediate to felsic volcaniclastics and black shales comprise the Hub geological sequence. The deposit area has been intruded by both dolerite and lamprophyre dykes which brecciate and stope out the mineralised zones. A distinctive volcanic unit (rhyolite) is to the west of the shear, variably 5-20 m downhole (MBS 2021b).

Mineralisation at Hub is characterised by:

- Increased deformation.
- Increased pyrrhotite content (up to 15%).
- Crenulation fabric (defined by wispy, white, late carbonate infill).

7.2.2.2 Golden Terrace South (GTS) Deposit

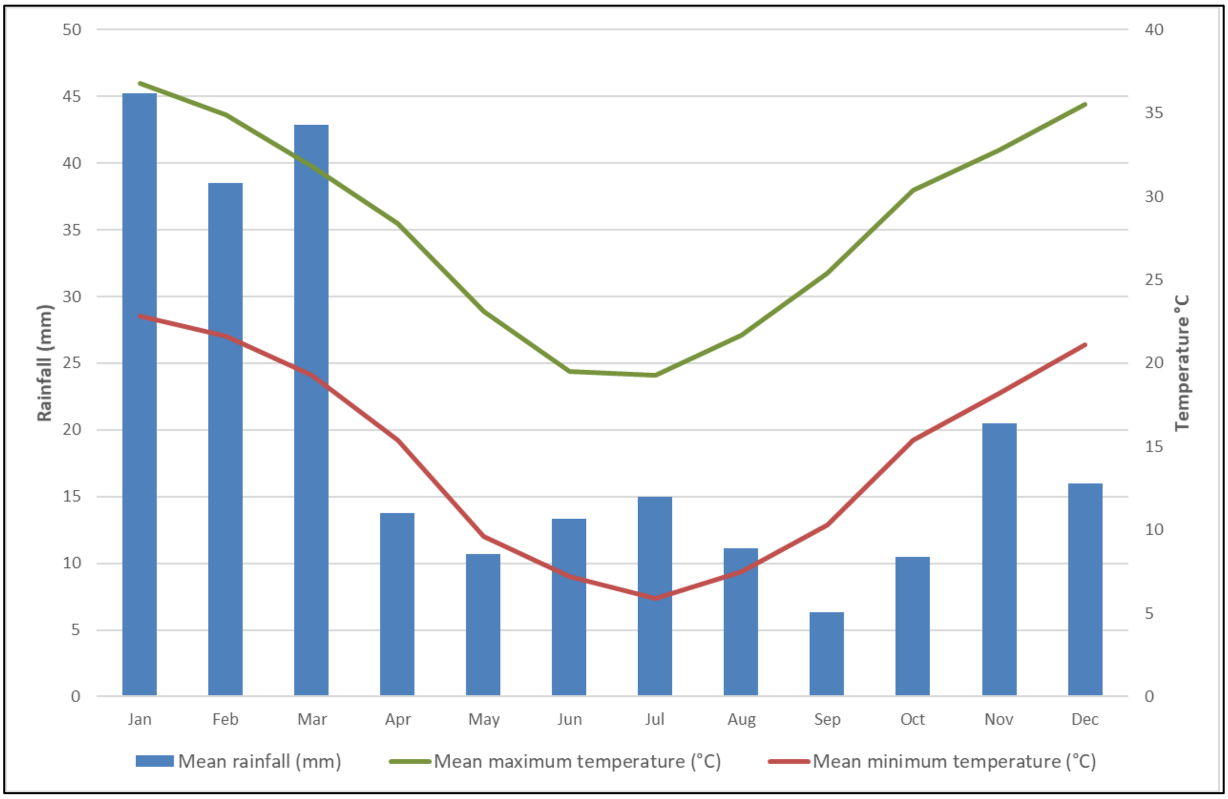
A poorly exposed south-plunging synclinal structure is reported to exist in the RGP area. The rocks are reported to be sub-vertical with steep dips to both east and west and strike between 320 and 340 degrees. Small subsidiary folds with a parallel plunge locally accompany a prominent lineation that dips 50 degrees southwards. Minor displacement is evident by several cross fault sets that strike approximately 45 and 100 degrees (MBS 2021b).

The dominant lithologies present are interbedded basaltic lavas and tuffs, tuffaceous sediments, and carbonaceous (graphitic) shales, and in places intruded by dolerite. All units have been metamorphosed to upper greenschist-lower amphibolites facies, which lead to the development of quartz-mica and quartz-chlorite mica schists from tuffs and sediments and fine-grained amphibolites from basaltic volcanics. Original textures are well preserved in many tuffaceous lithologies (MBS 2021b).

2.3 Climate

The climate of the area is characterised by low annual rainfall and a large temperature range, with evaporation exceeding rainfall annually. Climatic information from the nearest Bureau of Meteorology (BoM) meteorological site, Leonora Aerodrome (site number: 12241) is shown in Figure 7 (MBS 2021b). Temperatures can reach a mean maximum of 45°C in January and a mean minimum of 7°C in July. The mean annual rainfall is 254 mm with the majority of this rainfall recorded during the later summer months of January to March.

Figure 7: Monthly Rainfall and Temperature 2007 - 2021 (Leonora Aero, 2021)



2.4 Soils and Landforms

In December 2021, MBS Environmental completed a Soils and Landform Assessment for the RGP (MBS 2021a) and this is provided in Appendix 2. A summary of this assessment is provided in the following subsections.

2.4.1 Landforms

The following landforms were identified within the RGP and were also common throughout the larger region:

- Irregular low ironstone hills with stony lower slopes supporting mulga shrublands.
- Extensive sandplains supporting spinifex hummock grasslands.
- Extensive plains with deep sandy or loamy soils, supporting mulga and wanderrie grasses.
- Hardpan plains with ironstone gravel mantles, supporting mulga shrublands.
- Hardpan plains with occasional sandy banks, supporting mulga tall shrublands and wanderrie grasses.
- Undulating stony and gravelly plains and low rises, supporting mulga shrublands.
- Granite domes, hills, and tors with gritty-surfaced plains supporting mulga and granite wattle shrublands.
- Granite breakaways and extensive granitic plains, with mulga shrublands and minor halophytic shrublands.

In addition, the following landmarks were identified within the project area:

- Dillon Creek runs through tenement M37/1348, whilst creeks associated with this drainage system run through M37/1286.
- Mt Redcliffe (553 mAHD) is within tenement M37/1286.

There are no known scientific or evolutionary values associated with the landforms within the project area.

- The closest geoheritage site to the project area, the Lake Teague (Shoemaker Impact Structure) – lies approximately 289 km to the north of the RGP.
- The closest nature reserves to the RGP are the Wanjarri, De La Poer Range, and Yeo Lake reserves which are all between 130-246 km from the project boundaries.

2.4.2 Soils – Physical Properties

The key physical properties of Redcliffe soils are outlined below:

- The dominant soil types within the project area were red loamy earths (Department of Agriculture and Food Western Australia (DAFWA) Soil Group 544), red shallow loams (DAFWA Soil Group 522) and red-brown hardpan shallow loams (DAFWA Soil Group 523).
- Red loamy earth were the dominant soils in the Hub development area, whilst red-brown hardpan shallow loams were most common in the GTS area.
- The red loamy earth from the Hub development area contained lower gravel contents (14% - 45%), higher fines contents (23% clay, 13% silt in the <2 mm fraction) and were spontaneously dispersive (Emerson Class 1-2).
- The red-brown hardpan shallow loams from the GTS area contained similar gravel contents (14% - 47%) to soils in the Hub area. These soils contained limited fines contents (13% clay, 11% silt in the <2 mm fraction) and were generally considered to be spontaneously dispersive (Emerson Class 1-2).
- Soils from the Hub development area, appear the most prone to erosion on sloping surfaces due to the combination of relatively abundant dispersive clay/silt materials and relatively low gravel contents.

2.4.3 Soil Geochemistry

The key geochemical properties of Redcliffe soils are outlined below:

- The red loamy earth from the Hub area were:
  - Generally acidic (pH 4.3 – 7.4), with samples becoming more alkaline with depth.
  - Non-saline (<11 mS/m).
  - Low to moderately sodicity (Exchangeable Sodium Percentage [ESP] 2 – 10%) and also contained low to moderate exchangeable cation concentrations.
  - Unlikely to express aluminium or manganese toxicity due to high base saturation percentages of >87%.
  - Very low concentrations of extractable micronutrients such as boron, cobalt, molybdenum, or nickel plus soils contained low organic carbon and total nitrogen concentrations.
  - Unlikely to contain elevated concentrations of metals and/or metalloids considered to be environmental contaminants.
- The red-brown hardpan shallow loams from the GTS area were:
  - Slightly acidic to slightly alkaline (pH 5.5 - 8.7) with soils becoming more alkaline with depth and likely underlain by calcrete.

    - Extremely saline in subsoils (<420 mS/m) and non-saline in surface soils (<23 mS/m).
    - Unlikely to be either sodic (ESP <9%) or express aluminium/manganese toxicity (Base Saturation percentage [BS] >99%) and contained moderate to high exchangeable cation concentrations.
    - Very low concentrations of extractable micronutrients such as boron, cobalt, molybdenum, and nickel plus soils contained low organic carbon and total nitrogen concentrations.
    - Unlikely to contain elevated concentrations of metals and/or metalloids considered to be environmental contaminants.
- Overall, the majority of surface soils assessed here will be largely suitable for rehabilitation purposes. Major findings in the context of soil chemistry include:
    - pH at GTS being of no concern. Surface soils (0-10 cm) in the Hub area are highly acidic, however, given the subsoils (>10 cm) are more alkaline, the blending of material during excavation and stockpiling should alleviate any concerns regarding its ability to support vegetative growth.
    - Surface soils (0-10 cm) are generally non-saline, however, subsoils, particularly in the GTS areas contain pockets of extremely saline material which may be hostile to vegetation.
    - The risks of sodicity and aluminium/manganese toxicity are rated as low in all areas.
    - Most surface soils contain low concentrations of extractable micronutrients such as boron, cobalt, molybdenum, and nickel plus contain low organic carbon and total nitrogen concentrations. It is uncertain whether these concentrations indicate deficiencies that may limit the potential for vegetation to recolonise and thus rehabilitate the landscape, although the use of fertilisers should eliminate any nutrient deficiencies. Excessive fertiliser use may, however, encourage weed growth and also lead to plant densities that are not sustainable during periods of drought.
    - No soils contained total or bioavailable concentrations of metals and/or metalloids that are considered possible environmental contaminants.

2.5 Flora and Vegetation

Botanica Consulting was engaged to complete a detailed flora and vegetation survey of the RGP in July 2021 (Botanica 2021, Appendix 3). The assessment was conducted in accordance with the requirements of a detailed survey as defined in the Environmental Protection Authority (EPA) *Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment – December 2016* (EPA, 2016a).

The NatureMap search identified 90 vascular flora species as occurring within 40 km of the survey area, representing 50 genera from 25 families. The most diverse families were Scrophulariaceae (16 species), Fabaceae (13 species) and Asteraceae (10 species). Significant genera were *Eremophila* (16 species), *Acacia* (10 species) and *Sclerolaena*, *Atriplex*, *Maireana* and *Eucalyptus* (three species each). This total includes no introduced (weed) species.

The desktop review identified eight introduced flora (weed) species as potentially occurring in the vicinity of the survey area, representing six families. One species, *Cylindropuntia* spp. (Prickly Pear) is listed as a Declared Pest on the DAFWA Western Australian Organism List (WAOL) (DAF 2017) under the *Biosecurity and Agriculture Management Act 2007* (BAM Act - Western Australia) and as a Weeds of National Significance (WONS). In addition, *Tamarix aphylla* (Athel Tamarisk) is also listed as a WONS.

A site survey was carried out by a Jim Williams (Director/Principal Botanist, Diploma of Horticulture and Jennifer Jackson Senior Botanist (BSc (Honours) Environmental Management), from 13 - 15 July 2021, with the area traversed on foot and 4WD. A total of 44 quadrats were installed and surveyed, and opportunistic observations were taken throughout the survey.

The field survey identified 122 vascular flora taxa within the survey area. These taxa represented 62 genera across 31 families, with the most diverse families being *Fabaceae* (19 species), *Scrophulariaceae* (17 species) and

Asteraceae (14 species). The most diverse genera were *Eremophila* (17 species), *Acacia* (14 species) and *Maireana* (six species). There were no recorded declared weed species as regulated under the BAM Act.

There is no evidence of the survey area containing any Threatened Ecological Community (TEC) and analysis of the Priority Ecological Communities within the Midwest region did not identify any significant communities as likely or possibly occurring within the survey area.

The survey area is not located within an Environmentally Sensitive Area (ESA) and there are no Department of Biodiversity, Conservation and Attractions (DBCA) managed or interest lands located within or adjacent to the survey area.

No Threatened flora species were recorded within the survey area. No Priority or otherwise significant flora were recorded within the survey area. No significant vegetation was identified within the survey area

A total of eight broad-scale vegetation communities were identified within the survey area. These occurred within the following six landforms:

- Breakaway (B).
- Drainage Depression (DD).
- Open Depression (OD).
- Quartz Rocky Plain (QRP).
- Rocky Hillslope (RH).
- Sand-Loam Plain (SLP).

The summary of the vegetation community impacted areas is provided in Table 2. The full vegetation community type descriptions and vegetation mapping can be seen in the attached Flora and Vegetation Survey of the RGP (Botanica 2021, Appendix 3) and Figure 8 and Figure 9. Native vegetation within the survey area was rated as 'good to 'very good' as defined by Keighery (1994).

Table 2: Summary of Vegetation Community Impacted Areas

Vegetation Community	Impacted Area (ha)	Total Area Mapped (ha)	% Impact
SLP-AFW1 – Low open forest of *Acacia caesaneura*/*A. incurvaneura* over mid shrubland of *Eremophila forrestii* subsp. *forrestii/Eremophila margarethae* and low tussock grassland of *Eragrostis eriopoda* on sand-loam plain.	52.9393	396.6808	13%
QRP-AFW1 – Low open forest of *Acacia caesaneura/A. incurvaneura* over tall open shrubland of *Acacia ramulosa/A. tetragonophylla* and low shrubland of *Ptilotus obovatus*/low tussock grassland of *Eragrostis eriopoda* on quartz-rocky plain.	136.9436	732.4249	19%
OD-AFW1 – Low open forest of *Acacia caesaneura/A. incurvaneura* over tall shrubland of *Acacia ramulosa/A. tetragonophylla* and low tussock grassland of *Eragrostis eriopoda* in drainage line.	15.778	275.4974	6%
RH-AFW1 – Low open forest of *Acacia incurvaneura/A. quadrimarginea* over tall shrubland of *Acacia ramulosa* and low shrubland of *Ptilotus obovatus*/low tussock grassland of *Eragrostis eriopoda* on rocky hillslope	0.9015	16.0489	6%
DD-AFW1 – Low woodland of Acacia incurvaneura, A. tetragonophylla and A. burkittii over sparse shrubland of Eremophila citrina, Senna artemisioides subsp. artemisioides and Grevillea deflexa over low sparse shrubland of Ptilotus obovatus var. obovatus, Lepidium platypetalum and Roepera eremaea.	39.6167	54.5608	73%

Vegetation Community	Impacted Area (ha)	Total Area Mapped (ha)	% Impact
B-AFW1 – Low woodland of Acacia quadrimarginea over tall shrubland of Acacia ramulosa var. linophylla/Thryptomene decussata and low open shrubland of Calytrix uncinata/Eremophila latrobei on breakaway.	0.0000	24.4925	0%
B-MWS1 – Mid open mallee forest of Eucalyptus carnei over mid sparse shrubland of Eremophila pantonii and low shrubland of Olearia muelleri/Ptilotus obovatus on breakaway.	0.0000	9.4052	0%
SLP-AFW2 – Open mallee shrubland of Eucalyptus youngiana/Low open forest of Acacia caesaneura/A. incurvaneura over mid hummock grassland of Triodia scariosa on sand-loam plain.	4.1221	113.5355	4%
Cleared Vegetation	28.6087	108.4409	-
No Mapping Available - Already Cleared	20.0263	20.0263	-

2.5.1 Groundwater Dependent Ecosystem

A search was undertaken of the online Groundwater Dependent Ecosystem (GDE) Atlas managed by the BoM, to determine if any aquatic or terrestrial ecosystems were likely to be impacted from the Redcliffe land clearing. No known or potential aquatic GDE's within the survey or immediate project area. The survey area has low potential to contain a terrestrial GDE, described as 'hardpan plains with occasional sandy banks supporting mulga tall shrublands and wanderrie grasses' (Botanica, 2021).

Legend

Proposed Site Layout

Tenements

Redcliffe Tenements

Vegetation Mapping (Botanica 2021)

- Low open forest of Acacia caesaneura/ A. incurvaneura over mid shrubland of Anthotroche pannosa/ Eremophila forrestii subsp. forrestii/ Eremophila margarethae and low tussock grassland of Eragrostis eriopoda on sand-loam plain
- Low open forest of Acacia caesaneura/ A. incurvaneura over tall open shrubland of Acacia ramulosa/ A. tetragonophylla and low shrubland of Ptilotus obovatus/ low tussock grassland of Eragrostis eriopoda on quartz-rocky plain
- Low open forest of Acacia caesaneura/ A. incurvaneura over tall shrubland of Acacia ramulosa/ A. tetragonophylla and low tussock grassland of Eragrostis eriopoda in drainage line
- Low open forest of Acacia incurvaneura/ A. quadrimarginea over tall shrubland of Acacia ramulosa and low shrubland of Ptilotus obovatus/ low tussock grassland of Eragrostis eriopoda on rocky hillslope
- Low woodland of Acacia quadrimarginea over tall shrubland of Acacia ramulosa var. linophylla/ Thryptomene decussata and low open shrubland of Calytrix uncinata/ Eremophila latrobei on breakaway
- Mid open mallee forest of Eucalyptus carnei over mid sparse shrubland of Eremophila pantonii and low shrubland of Olearia muelleri/ Ptilotus obovatus on breakaway
- Open mallee shrubland of Eucalyptus youngiana/ Low open forest of Acacia caesaneura/ A. incurvaneura over mid hummock grassland of Triodia scariosa on sand-loam plain
- Cleared Vegetation

Original Size: A4
Aerial: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Scale: 1:50000
Projection: GDA94 / MGA zone 51

0 500 1,000 1,500 2,000 m

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Figure 8

Vegetation Mapping North

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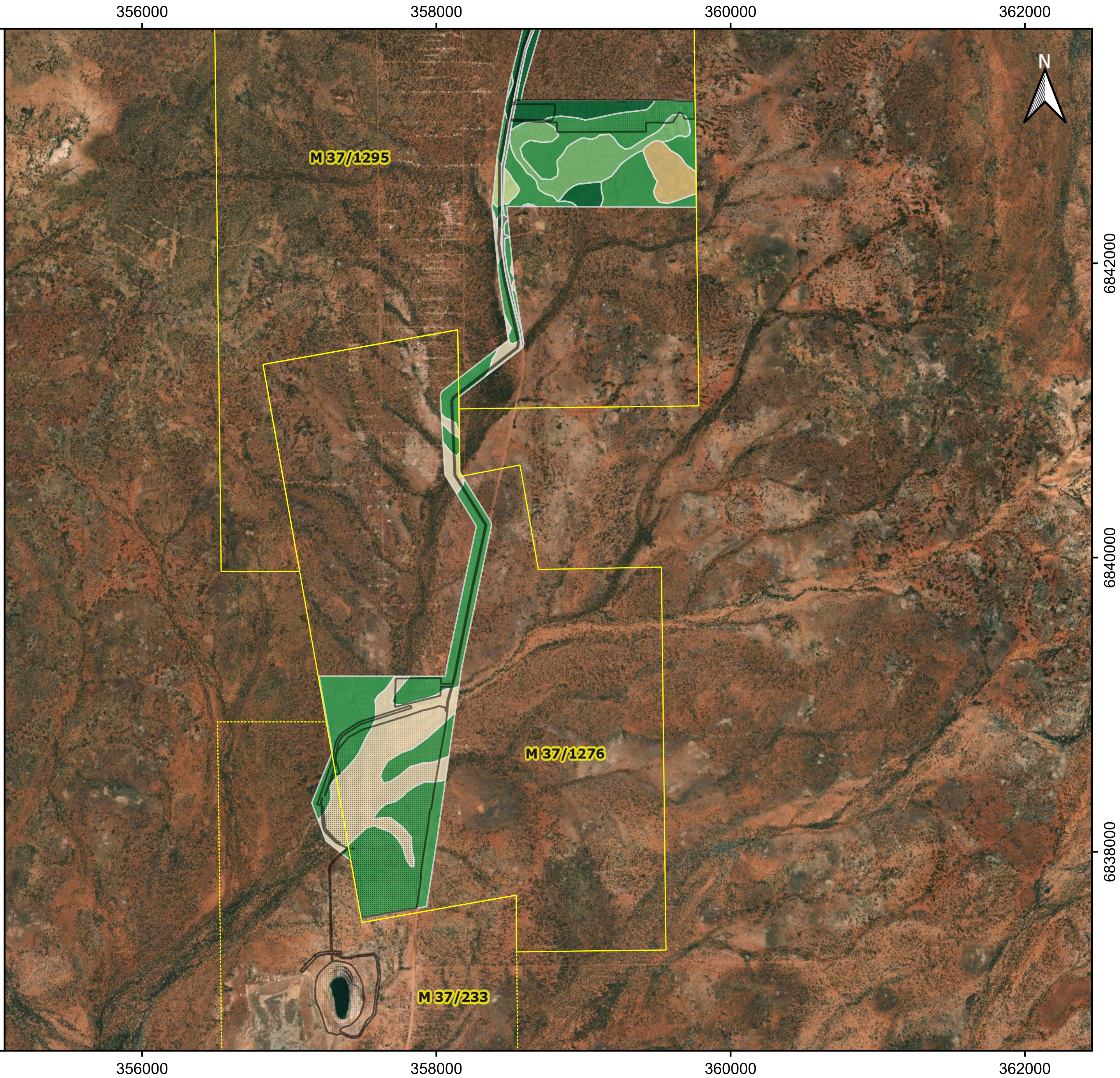

Legend

Proposed Site Layout

Tenements

Redcliffe Tenements

Kin Mining Tenement

Vegetation Mapping (Botanica 2021)

- Low open forest of Acacia caesaneura/ A. incurvaneura over mid shrubland of Anthotroche pannosa/ Eremophila forrestii subsp. forrestii/ Eremophila margarethae and low tussock grassland of Eragrostis eriopoda on sand-loam plain
- Low open forest of Acacia caesaneura/ A. incurvaneura over tall open shrubland of Acacia ramulosa/ A. tetragonophylla and low shrubland of Ptilotus obovatus/ low tussock grassland of Eragrostis eriopoda on quartz-rocky plain
- Low open forest of Acacia caesaneura/ A. incurvaneura over tall shrubland of Acacia ramulosa/ A. tetragonophylla and low tussock grassland of Eragrostis eriopoda in drainage line
- Low open forest of Acacia incurvaneura/ A. quadrimarginea over tall shrubland of Acacia ramulosa and low shrubland of Ptilotus obovatus/ low tussock grassland of Eragrostis eriopoda on rocky hillslope
- Low woodland of Acacia incurvaneura, A. tetragonophylla and A. burkittii over sparse shrubland of Eremophila citrina, Senna artemisioides subsp. artemisioides and Grevillea deflexa over low sparse shrubland of Ptilotus obovatus and Lepidium platypetalum
- Low woodland of Acacia quadrimarginea over tall shrubland of Acacia ramulosa var. linophylla/ Thryptomene decussata and low open shrubland of Calytrix uncinata/ Eremophila latrobei on breakaway
- Cleared Vegetation

Original Size: A4
Aerial: Esri, DigitalGlobe, GeoEye, i-cubed, USDA FSA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Scale: 1:40000
Projection: GDA94 / MGA zone 51

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Figure 9

Vegetation Mapping South

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2.6 Fauna and Habitat

A Fauna and Habitat Survey for the RGP was completed by Phoenix Environmental Sciences in December 2021 (Phoenix 2021a, Appendix 4). This survey was undertaken in accordance with:

- EPA Environmental Factor Guideline: Terrestrial fauna (EPA 2016b).
- EPA Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020).
- EPA Technical Guidance: Sampling of short-range endemic invertebrate fauna (EPA 2016c).

The desktop and field survey field survey were undertaken during September 2021. A further Targeted Malleefowl (*Leipoa ocellata*) and Chuditch (*Dasyurus geoffroii*) field survey was undertaken by Phoenix Environmental in November 2021. The objectives of these fauna surveys were to undertake:

- Fauna habitat mapping.
- Broadscale surveys for vertebrate fauna and Short-Range Endemic (SRE) invertebrates.
- Complete a targeted searches for Malleefowl and Chuditch in suitable habitat within potential project disturbance areas. Malleefowl, is listed as Vulnerable under the Biodiversity and Conservation Act 2016 (Western Australia) (BC Act) as well as the Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth) (EPBC Act). Chuditch is listed as Vulnerable (VU) under both the EPBC Act and the BC Act.

The key findings of the vertebrate fauna survey (Phoenix 2021a, Appendix 4) are summarised below and significant records and habitat types shown in Figure 10 and Figure 11:

- Nine habitat types were delineated and mapped:
  - 1. Breakaway and upper slope with open shrubland.
  - 2. Groved mulga on lower slopes, minor drainages.
  - 3. Mallee over mulga shrubland with hummock grass on sandplain.
  - 4. Mulga tall shrubland on sandplain.
  - 5. Mulga woodland/tall shrubland on drainage.
  - 6. Open pit with pool.
  - 7. Open shrubland on lower slopes/plains
  - 8. Open/sparse shrubland on slopes and stony plains.
  - 9. Other cleared/disturbed.
- Habitat types 3 (Mallee over mulga shrubland with hummock grass on sandplain) and 4 (Mulga tall shrubland on sandplain), were assessed as highly suitable foraging and potential breeding habitat for Malleefowl (Leipoa ocellata). Habitat Types 3 and 4 occur in the northern half of the project area within M37/1286, M37/1348 and M37/1295.
- Evidence of Malleefowl (tracks and foraging signs) were recorded in habitat types 3 and 4. High intensity targeted searches along transects were conducted in ‘High’ and ‘Medium’ suitability habitats in November and found no evidence of either active or inactive Malleefowl nest mounds.

- Habitat type 1 (Breakaway and upper slope with open shrubland) was assessed as highly suitable foraging, dispersal, and possible denning habitat for Chuditch (*Dasyurus geoffroii*). Searches along several kilometres of breakaway (habitat type 1) recorded skeletal remains of indeterminate age, and two recent (but not fresh) potential scats of this species). However, DNA testing of these scats could not confirm that these were Chuditch scats. Habitat Type 1 occurs in M37/1286 and lies outside of the project area, north of the historic Redcliffe Open Pit.
- It is concluded that both Malleefowl and Chuditch use the study area intermittently for dispersal and foraging, but the evidence does not indicate resident or breeding populations.

The summary of the fauna habitat impacted areas is provided in Table 3.

Table 3: Summary of Fauna Habitat Vegetation Impacted Areas

Fauna Habitat Type	Impacted Area (ha)	Total Area Mapped (ha)	% Impact
Breakaway and upper slope with open shrubland	0.0000	9.8278	0%
Groved mulga on lower slopes, minor drainages etc	140.4966	637.4519	22%
Mallee over mulga shrubland with hummock grass on sandplain	3.0474	44.9913	7%
Mulga tall shrubland on sandplain	9.2477	177.5491	5%
Mulga woodland/tall shrubland on drainage	34.2879	147.7183	23%
Open pit with pool	8.1398	13.3647	61%
Open shrubland on lower slopes/plains	32.7373	330.737	10%
Open/sparse shrubland on slopes and stony plains	40.6038	324.6558	13%
Other cleared/disturbed	10.3495	44.7898	-
Not mapped - cleared/disturbed	20.0259	20.0259	-

2.6.1 Invertebrate/SRE Fauna

The key findings of the invertebrate fauna survey (Phoenix 2021a, Appendix 4) are summarised as follows:

- Potential SRE's - Three previously unknown species of mygalomorph spider and one previously unknown species of centipede were collected from within M37/1286, north of the Hub mining area:
  - *Aname* 'Phoenix0077'.
  - *Kwonkan* 'Phoenix0078'.
  - *Idiosoma* 'Phoenix0079'.
  - *Mecistocephalus* 'Phoenix0075'.

It is considered likely that the discovery of previously unknown species is a result of the lack of surveys having been carried out in the region, rather than these taxa being true SREs. All specimens from SRE groups were obtained from habitats either widespread within the study area or habitats that are limited within the study area but are connected to similar and extensive habitat outside the study area.

Only one habitat type within the study area was deemed as having high potential to support SRE taxa. This was described as hills capped with weathered volcanic rock forming breakaway with overhangs, caves and/or boulder piles, with open mid shrubland of mulga, other Acacia, and mixed shrubs. This habitat primarily occurs in the north of the study area and extends out of the study area to the west and is not within the proposed clearing area. The remaining eight habitats were deemed as having low potential to support SRE taxa.

Despite several new and potential SRE species being discovered during this survey, it is unlikely that these species are restricted to the study area. All specimens from SRE groups were obtained from habitats either widespread within the study area or habitats that are limited within the study area but are connected to similar and extensive habitat outside the study area.

2.6.2 Subterranean Fauna

A subterranean fauna desktop assessment and field study was completed for the RGP in December 2021 (Phoenix 2021b) (Appendix 5). This survey was undertaken in accordance with:

- EPA Technical Guidance Subterranean Fauna Survey (EPA 2016d).
- EPA Technical Guidance Sampling Methods for Subterranean Fauna (EPA 2016e).
- EPA Environmental Factor Guideline Subterranean Fauna (EPA 2016f).

The results of this subterranean fauna assessment are summarised in the following sub-sections.

Stygofauna

Stygofauna are obligate, groundwater dwelling fauna known from a number of habitats in a variety of rock types including karst, larval tubes, alluvial sediments, fractured rock aquifers and subterranean carbonate deposits (calcrete aquifers) with alluvial and carbonate deposits typically thought to be the most productive habitats.

A total of 16 locations were sampled for stygofauna across the study area, comprising ten samples from Hub and six from GTS. There were not a sufficient number of suitable bores at GTS to allow for sampling of ten bores, however a Level 2 subterranean fauna survey had already been conducted in this area previously (Phoenix, 2010). Several potential stygofauna species were collected within the Project area. Due to the potential for these species to be significant stygofauna species further analysis with regard to their status as actual stygofauna and potential conservation value was conducted.

After further analysis Phoenix Environmental (Phoenix, 2021b) confidently deemed that the study area supports a fauna community that is not dependant on subterranean environments and that fauna that is present are stygophiles (which have the ability to inhabit subterranean environments (where suitable) and surface water habitats). Stygophiles are not considered to be SRE's and as such no further surveys or conservation management measures were recommended.

The full survey report detailing methodologies and results can be found in Appendix 5.

Legend

- Proposed Site Layout

Tenements

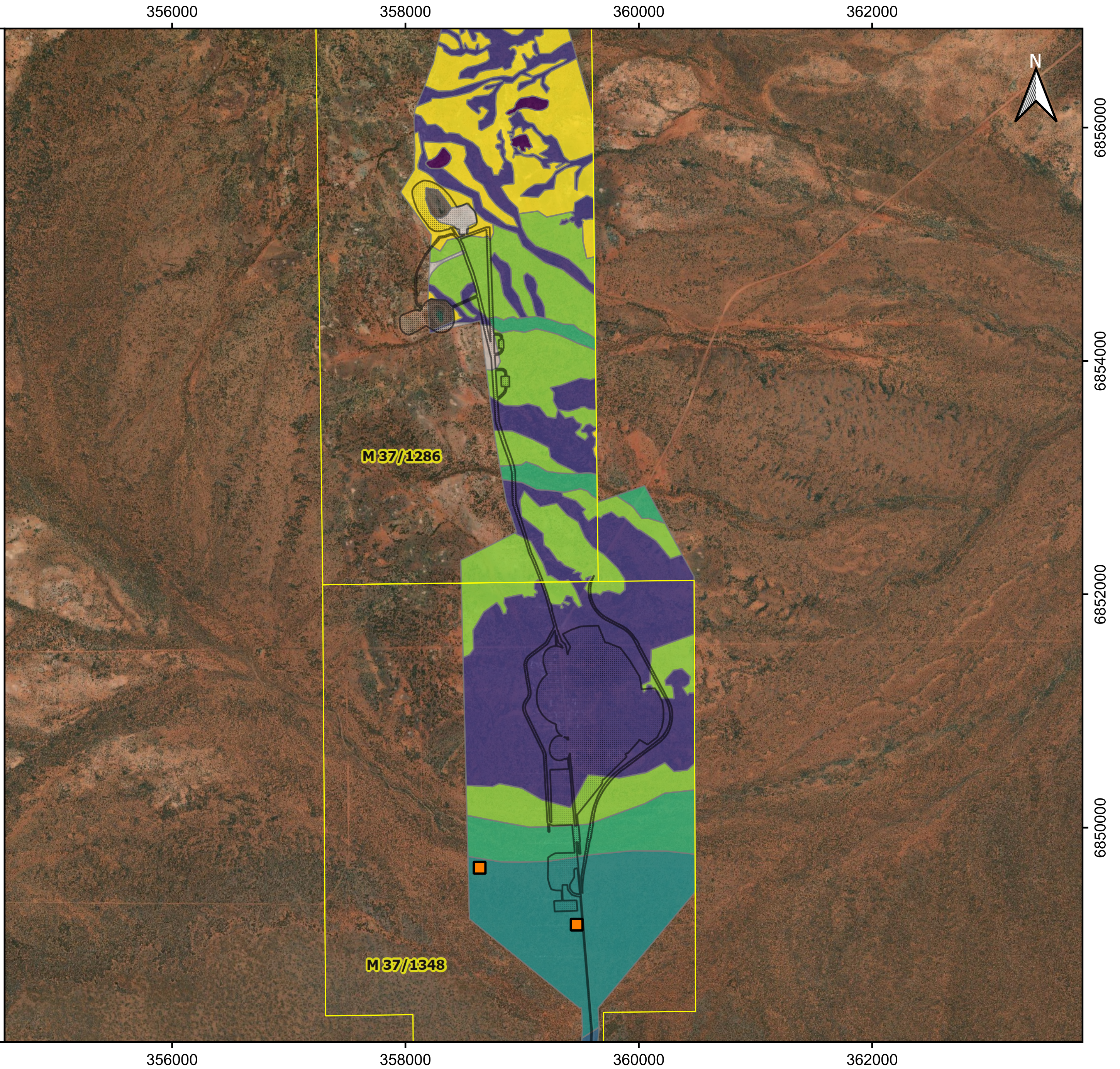
- Redcliffe Tenements

Conservation Significant Fauna (Phoenix Environmental Services 2021)

- Leipoa ocellata (VU)

Fauna Habitat (Phoenix Environmental Services 2021)

- Breakaway and upper slope with open shrubland
- Groved mulga on lower slopes, minor drainages etc
- Mallee - mulga - triodia on sandplain
- Mulga tall shrubland on sandplain
- Mulga woodland/tall shrubland on drainage
- Open shrubland on lower slopes/plains
- Open/sparse shrubland on slopes and stony plains
- Other cleared/disturbed
- Open pit with pool



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Scale: 1:50000
Projection: GDA94 / MGA zone 51

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Figure 10

Fauna Habitats North

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Legend

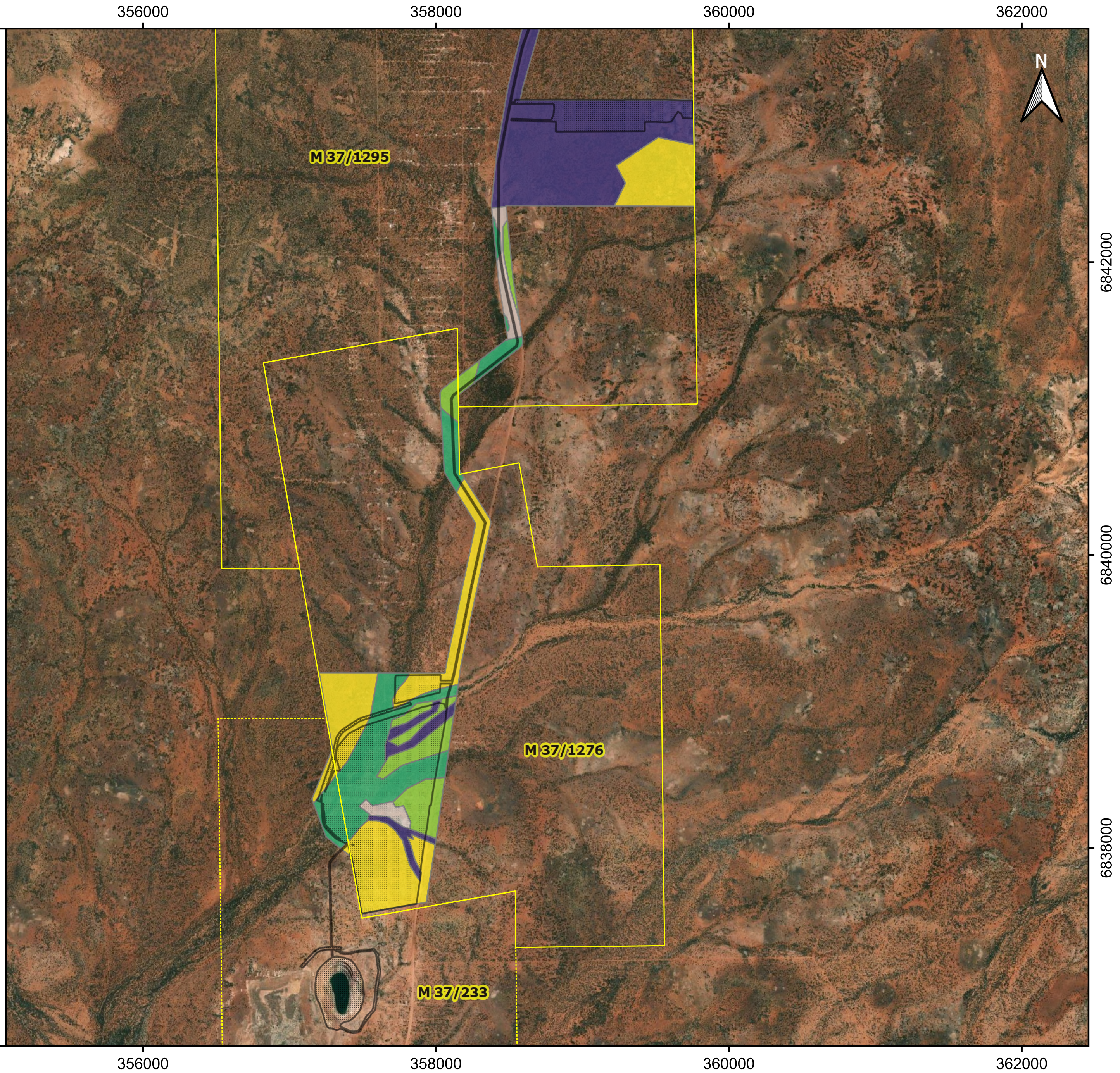
- Proposed Site Layout

Tenements

- Redcliffe Tenements
- Kin Mining Tenement

Fauna Habitat (Phoenix Environmental Services 2021)

- Groved mulga on lower slopes, minor drainages etc
- Mulga woodland/tall shrubland on drainage
- Open shrubland on lower slopes/plains
- Open/sparse shrubland on slopes and stony plains
- Other cleared/disturbed



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Scale: 1:40000
Projection: GDA94 / MGA zone 51

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Figure 11

Fauna Habitats South

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2.7 Hydrology

Groundwater Resource Management Pty Ltd (GRM) completed a hydrological assessment of the RGP in October 2021 (Appendix 6, GRM 2021a). This comprised the following hydrological baseline assessment components:

- Hydrological desktop study – defined the project catchment areas and determined key catchment characteristics.
- Flood risk assessment site visit – GRM's civil engineering hydrologist completed a site visit in October 2021, in order to assess the existing surface water regime in the vicinity of the proposed mining area. In addition to evaluating the potential flood risks and impacts from the proposed mining infrastructure on the local environment.

A summary of the findings of this hydrological assessment is provided in the following sub-sections and shows local hydrology of the Redcliffe project area.

2.7.1 Catchment Characteristics

All the proposed RGP mining areas are located within Department of Water and Environmental Regulation (DWER's) vast, internally draining Salt Lake Basin (area of 441,000 km^2) which extends across much of central WA. There are no major river systems in the vicinity of the proposed mining areas and any watercourses or drainages that do exist are ephemeral and only convey flow periodically, following significant rainfall.

The Hub mining area is located in the upper headwaters of the Lake Carey Catchment (area of 113,780 km^2), while the GTS mining area is located immediately to the south of the regional watershed divide with the Lake Raeside-Ponton Catchment (area of 115,965 km^2) (GRM, 2021a).

Hub Catchment Area

The Hub mining area is located approximately 8 km north of the regional watershed divide with the Lake Raeside-Ponton Catchment. The catchment physiography in the vicinity of the proposed Hub mining area can be generally described as comprising low hills and rises with limonitic duricrust and stony plains that support mulga and halophytic shrubs.

Two catchment areas were delineated upstream of the Hub mining area comprising:

- Hub North (2.807 km^2).
- Hub South/Dillon Creek (43.776 km^2).

GTS Catchment Area

The GTS mining area is located approximately 5 km south of the regional watershed divide with the Lake Carey Catchment. There are several unnamed drainages that rise at the watershed divide and cross the proposed mining area in a roughly northeast to southwest direction before terminating in a number of poorly defined soaks and claypans about 10 km to the southwest.

The catchment physiography in the vicinity of the proposed GTS mining area is similar to that at the Hub and is typified by low hills and rises with limonitic duricrust and stony plains that support mulga and halophytic shrubs. The GTS has an upstream catchment area of approximately 28.330 km^2 which reports to the northeast corner of the proposed WRD. There are two main channels; one from the eastern half of the catchment which crosses the Leonora-Nambi Road via an existing floodway and a second channel which drains the northern half of the catchment and joins the eastern channel about 450 m west of the Leonora Nambi Road. Downstream of the confluence the channels continue in a westerly direction for a further 300 m or so before turning towards the south and flowing away from the proposed GTS mining area. Both channels are between 5-10 m wide and 1-2 m deep and have a good deal (>0.5 m thick) of sand-gravel sized sediment deposited along their bases, indicating previous slow-moving floodwater.

Accommodation Camp and Explosives Magazine Hydrological Setting

The proposed RGP accommodation camp and explosives magazine facilities have been situated to lessen potential impacts on the local hydrological regime and to require minimal, if any, significant surface water management measures.

The proposed accommodation camp is located about 4.5 km north of the GTS mining area immediately to the south of the regional watershed boundary between the Lake Carey catchment to the north and Lake Raeside-Ponton to the south. As such the proposed accommodation camp area has essentially no upstream catchment area and drainage measures for roads, carparks, building pads etc. need only to take direct precipitation into consideration. Therefore, no specific surface water management measures are required.

2.8 Hydrogeology

Groundwater Resource Management Pty Ltd (GRM 2021b) completed a hydrogeological assessment of the RGP. A summary of the findings is provided in the following sub-sections with the report provided as Appendix 7.

2.8.1 Regional Hydrogeology

The region is characterised by low relief and a southerly draining palaeo-drainage systems, underlain by Archean sequences. Groundwater typically occurs in the following (from deepest to shallowest):

- Fresh and weathered Archean basement fractured rock aquifers.
- Tertiary palaeochannel sands.
- Surficial deposits including lacustrine sediments, alluvium / colluvium, and calcrete.

Groundwater occurrences in the fresh bedrock are associated with discrete interconnected fractures. The fracturing is characterised by secondary permeability resulting from tectonic and decompression fracturing enhanced by chemical dissolution. Permeability of the fractures is often further enhanced by the deep weathering profile common in the region. Fractured bedrock aquifers occur more commonly in mafic, ultramafic, and granitic rocks than in sedimentary, felsic volcanic and volcanoclastic units. In contrast the mafic and ultramafic dykes which are prevalent in the region can form hydraulic barriers to groundwater flow.

Fractured bedrock aquifers in the region can be high yielding. However, as a result of their discrete nature (i.e., having low storage characteristics and limited extents), they can dewater rapidly and consequently are not always reliable as a long term water supply, but are important to consider for mine dewatering. Permeability in the basement rocks away from these features is low, with low storage characteristics.

2.8.2 Local Hydrogeology

The local hydrogeology in the Redcliffe project area, is dominated by fractured rock aquifers, hosted within a north trending sequence of mafic and ultramafic rocks. However, the basement rocks have undergone a significant degree of metamorphism, up to around greenschist facies.

In the Hub and GTS areas, deep weathering profiles have developed adjacent to ancient and modern drainages and overlie the fractured bedrock. The near surface is dominated by laterite and lateritic clays to a few meters below surface, with a thick sequence of saprolite clay extending below this horizon up to around 60 m below surface. The saprolite transitions to fresh, weakly jointed, low permeability bedrock through a saprock zone which has generally variable low- to moderate permeability.

The thick clay sequences at Hub and GTS form a local confining layer with the piezometric surface around 8-10 metres below ground level (mbgl) at Hub and about 15 mbgl at GTS.

Groundwater quality is fresh to brackish at Hub and GTS, less than 5,000 mg/L TDS. With a regional surface water divide striking northwest between the Hub and Redcliffe/Mesa deposits. The regional groundwater flow direction north of this divide is towards a tributary paleochannel of the Carey Palaeovalley, which is located just south of the Hub deposit and runs in a north-easterly direction.

2.9 Heritage and Social Setting

2.9.1 Land Use and Community

Pastoral (cattle grazing), mining and exploration activities are the primary land uses of the RGP area. The RGP area falls within the Mertondale Station Pastoral Lease (N049506) which is owned by the Australian Government Department of Defence and Nambi Pastoral Lease (N049822) which is owned by Minara Resources Pty Ltd. The local Traditional Owners (TO's), the Tjupan Group, have been consulted as to proposed activities on their lands. The Tjupan Group are part of the Darlot Native Title Claim and have a long term historical, traditional, and ancestral affiliations with the region within which the RGP is located.

The Project area is relatively remote, with the surrounding area sparsely populated. The nearest residences are the Mertondale homestead 10 km to the south, and the Nambi Pastoral Station homestead is approximately 11 km to the east of the RGP.

The town of Leonora is located 50 km south-southwest of the RGP. Leonora is located between the towns of Kalgoorlie and Laverton and is a significant support centre for the local community, tourism, Aboriginal communities, and Pastoral Lease holders. According to the Australian Bureau of Statistics (ABS) 2016 census, Leonora has a population of 781 people and of this, Aboriginal and/or Torres Strait Islander People comprise of 22.7% of the population (ABS, 2016).

The closest major mining operation to the RGP is the Great Western Gold Mine approximately 37 km to the west.

2.9.2 Aboriginal Heritage

Three recent Aboriginal heritage surveys and assessments have been completed for the RGP area which provide an understanding of the location of heritage sites (both archaeological and ethnographic). These Aboriginal heritage surveys and assessments comprise:

- Czerwinski, P. (2021a). Dacian Gold Redcliffe & MMGO Projects Aboriginal Heritage Desktop Report. Prepared for Dacian Gold Limited.
- Czerwinski, P. (2021b). Archaeological Survey Report, Dacian Gold Redcliffe Project, Leonora, Goldfields, WA. Prepared for Dacian Gold Limited.
- Daniel de Gand & Associates Pty Ltd (2021). Report on an Aboriginal Heritage Assessment of the Hub, Nambi, GTS and Bindy Project Areas, Located Northeast of Leonora in Western Australia, for Dacian Gold Limited.

The key findings and recommendations of the above Aboriginal heritage surveys and assessments are:

- The key Aboriginal group that has been consulted in respect to the recent Aboriginal heritage assessments of the RGP area is the Tjupan (Harris) Group, due to their historic involvement with the project during the NTM Gold Limited (NTM) exploration stage of the project (prior to 2021). The Tjupan (Harris) Group are part of the Darlot Native Title Claim and have a long-term historical, traditional and ancestral affiliations with the region within which the RGP is located.
- On 9 July 2021, the Darlot Native Title Claim Group, registered the Darlot Native Title Claim under the *Native Title Act 1993* (Commonwealth), this native title claim covers the RGP area. The claim has been accepted for registration, but currently has not been granted.

- There is one previously recorded Aboriginal heritage site on the Department of Planning, Lands and Heritage (DPLH) Aboriginal Heritage Inquiry System (AHIS) within the RGP area. The Mt Redcliffe ethnographic site (DPLH #1491) and is partially located within M37/1286, and lies outside of the project area, approximately 1 km to the north of the historic Redcliffe Open Pit.
- No other Aboriginal heritage sites of significance have been recorded for the RGP area.
- An ethnographic survey was conducted with the Tjupan (Harris) Group in August 2021 and outlined in the October 2021 Report on an Aboriginal Heritage Assessment (Daniel de Gand & Associates 2021). The de Gand (2021) Report identifies the Mt Redcliffe (DPLH #1491) as the breakaway area to the West of the historic Nambi pit and outlines a buffer zone from the breakaway. The de Gand (2021) Report clears the Hub and GTS of ethnographic sites but recommends that for both GTS and Hub drilling activity should avoid the existing creeks and any existing drill holes located in the creek area should be removed until an Archaeological survey can be conducted over the area.
- An Archaeological survey was conducted in September 2021 (Czerwinski 2021b) covering the proposed footprint of the RGP area. During the survey one archaeological site, a rockshelter with an associated artefact scatter, was recorded in the breakaway country within DPLH #1491 in M37/1286. This archaeological site has been designated as Mt Redcliffe Rockshelter 01 and lies outside the project area. The Heritage Information Submission Form for the registration of this site on the Register of Aboriginal Sites, was submitted to DPLH on 28 October 2021.
- The survey detailed that once away from these breakaways and on the mulga covered sand plains only isolated artefacts are found, with these mainly found along creek lines. Artefacts identified along these creeks have been redeposited by erosion events. The few isolated artefacts identified on the plains country are the result of Aboriginal people hunting or travelling through this open mulga woodland country rather than sustained camping.
- As a follow up from de Gand (2021) ethnographic survey, consultation and archaeological survey occurred with Nicky Harris from the Tjupan (Harris) group at two specific areas. This archaeological fieldwork confirmed that creeklines in the GTS and Hub areas do not contain archaeological sites.
- Requests were made during the survey by the Tjupan (Harris) Group representative that Redcliffe not drill within 50 m of the creek line at GTS, and that further consultation occurs for the accommodation camp and explosive magazine locations (Czerwinski, 2021b).
- A meeting was held with the Darlot Native Title Claim Group in December 2021, as an introduction to the Native Title Group and to present an overview of the RGP. It was discussed in the meeting that a further session will be held in the new year to review previous heritage and archaeological surveys conducted and discuss a possible Heritage Protection Agreement.
- Procedures will be put in place to:
  - Define the process to obtain heritage clearance from the relevant parties, should Redcliffe come upon an Aboriginal Site or significant cultural material during any stage of the project development and operation. This process will be defined within the Redcliffe Aboriginal Heritage Site Discovery Procedure. This process should emphasise that site is not disturbed and that heritage clearance from the relevant parties is obtained, prior to the works continuing.
  - Define the process for consultation and heritage assessment for any new proposed project works that are situated outside of the current surveyed areas.

2.9.3 European Heritage

There are no sites of European Heritage significance within or near the RGP. The site for the historic abandoned township of Mertondale, lies within the pastoral lease, Merton's Reward, approximately 11 km south of the RGP area. The site for the historic abandoned township of Mertondale is not listed with the Heritage Council WA.

2.10 Environmental Threats and Other Factors

2.10.1 Weeds

The Botanica Consulting flora and vegetation survey of the RGP in July 2021 did not record any declared weed species as regulated under the BAM Act.

2.10.2 Dust

There are no nearby sensitive residences in respect to potential impacts from site dust emissions. The nearest sensitive residences are the Mertondale homestead 10 km to the south and the Nambi Pastoral Station homestead 11 km to the east of the RGP.

Dust can smother vegetation, thereby reducing a plant's ability to photosynthesise. Similarly, dust may become a nuisance to native fauna and employees of the Project. Dust may be generated from:

- Construction activities.
- Haulage of ore to the processing plant.
- Haulage of waste ore to the waste rock dump.
- Vehicle movement on unsealed roads.

Dust suppression for the RGP will comprise the regular watering of roads and open areas with a water truck.

2.10.3 Wildfire

Fires may arise within the Project area from:

- Uncontrolled wildfires.
- Regulated Department of Fire and Emergency Services (DFES) fire burns.
- Operation of vehicles and equipment.

Fire management within the Project area will comprise:

- Emergency response personnel being trained in the use of available firefighting equipment e.g., fire extinguishers, water truck and advised on the plan of action in case of a fire.
- All hot work (such as welding/cutting/grinding) activities will be undertaken in designated areas designed for such activities (e.g. boilermaker workshop) or in low-risk weather conditions if outside of these areas.
- There will be no deliberate burning of any vegetation.

3. PROPOSED LAND CLEARING

As outlined in Section 1.1, the total purpose permit area is 1,672.6 ha (Figure 6) which is comprised of:

- Hub Open Pit Mine (Proposed – Figure 3).
- GTS Open Pit Mine (Proposed – Figure 5).
- Redcliffe and Mesa Open Pit Mine (Existing / Historical – Figure 2, NB: the historical Nambi Open pit lies within M37/1286 but is not part of the RGP).
- Accommodation Camp and Administration Offices (Proposed – Figure 4).
- Mertondale 5 Open Pit Mine (Existing / Historical – Figure 5).

From this, the total disturbance area is 304.3 ha which is comprised of:

- Existing land disturbance: 54 ha.
- Proposed native vegetation clearing: 250.3 ha.

This NVCP application requests approval to progressively clear a total of 250.3 ha of native vegetation within a purpose permit area of 1,672.6 ha.

The proposed clearing of native vegetation is to allow for construction of open pits, waste rock dumps and supporting infrastructure over all Hub and GTS Project areas, accommodation camp and administration offices, and supporting dewatering infrastructure. Note that supporting infrastructure includes (but is not limited to) the construction and upgrade of landfills, topsoil stockpiles, pipelines, roads, bioremediation pad, flood bunds, workshops, mine offices, laydown areas, abandonment bunds, flood bunds, creek diversion channel, leach drains, vehicle washdown facilities, oily wastewater separators, potable water tanks, explosive storage facilities, borrow pits, Reverse Osmosis (RO) plant wastewater treatment plant and irrigation area.

Progressive clearing of native vegetation will be undertaken as required commencing Quarter 2 2022 and will be undertaken in accordance with the approved associated RGP Mining Proposal (Redcliffe 2022). The life of mine for the RGP is approximately 2 years (2024).

A GIS shapefile in GDA94 is provided with submission of this NVCP application.

4. ASSESSMENT OF CLEARING PRINCIPLES

The proposed clearing activities have been assessed against the ten clearing principles as defined in Schedule 5 of the Part V EP Act. This assessment is presented in Table 4. These principles aim to ensure that all potential impacts resulting from the removal of native vegetation can be assessed in an integrated way and applied to all lands throughout Western Australia. The principles address the four main environmental areas of biodiversity significance, land degradation, conservation estate and ground and surface water quality.

Table 4: Native Vegetation Clearing Principles

Number	Clearing Principle	Assessment
Biodiversity Significance		
A	Native vegetation should not be cleared if it 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 outside of the survey area. Assessed Outcome: Given the above, the proposed clearing is unlikely to have a significant impact on biodiversity at a local or regional level. Therefore, the proposed clearing is not likely to be at variance with this clearing principle.
B	Native vegetation should not be cleared if it comprises the whole or part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.	Two Threatened vertebrate species recorded in the survey, Malleefowl *Leipoa ocellata* and Chuditch *Dasyurus geoffroii* (both VU), are inferred to use parts of the study area intermittently for dispersal and foraging, but not to be breeding residents (Phoenix, 2021a). While several new and/or potential SRE taxa were recorded during the survey, the habitat within which these species were found is broadly represented on a regional and local level it is considered unlikely that these species are restricted to the study area (Phoenix 2021a). Assessed Outcome: Given the above, the proposed clearing is unlikely to have a significant impact on fauna habitat at a local or regional level. Therefore, the proposed clearing is not likely to be at variance with this clearing principle.
C	Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.	No Threatened flora species were recorded within the survey area. No Priority or otherwise significant flora were recorded within the survey area. Assessed Outcome: Given the above, the proposed clearing is unlikely to have a significant impact on rare flora at a local or regional level. Therefore, the proposed clearing is not likely to be at variance with this clearing 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.	There is no evidence of the survey area containing any TEC and the survey area is not located within an ESA. Assessed Outcome: Given the above, the proposed clearing is unlikely to have a significant impact on TECs. Therefore, the proposed clearing is not likely to be at variance with this clearing 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.	No significant remnant vegetation was identified within the survey area. The surrounding area is largely uncleared. Assessed Outcome: Given the above, the proposed clearing is unlikely to have a significant impact on remnant vegetation at a local or regional level. Therefore, the proposed clearing is not likely to be at variance with this clearing 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.	There are no major river systems in the vicinity of the proposed mining areas and any watercourses or drainages that do exist are ephemeral and only flow periodically, following significant rainfall. Dillon Creek is the main ephemeral creek in the project area, and it runs through tenement M37/1348, whilst creeks associated with this drainage system run through M37/1286. Clearing of vegetation in proximity to these ephemeral creeks will be minimised and where road crossings or

		other disturbances are unavoidable, surface water management measures will be implemented to minimise and prevent significant impacts to natural surface water flows and downstream habitats. Assessed Outcome: Given the above, the proposed clearing is unlikely to have a significant impact on watercourses or wetlands at a local or regional level. Therefore, the proposed clearing is not likely to be at variance with this clearing principle.
Land Degradation		
G	Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.	The proposed clearing of 250.3 hectares for the development of the RGP is not likely to cause appreciable further land degradation within the local or regional area. The area being utilised for the RGP has a long history of disturbance either from historic mining activities and pastoral activities across the region. Consequently, most, if not all, the landforms within the project area can be considered disturbed to various levels of impact (MBS 2021a). As a result, further disturbances due to planned mining activities are unlikely to cause significant further land degradation (MBS 2021a) (Appendix 2). Existing areas of disturbance (Nambi, Redcliffe, Mesa, Mertondale 5 and access tracks/roads), will be utilised where possible and in areas where clearing is necessary, surface water management measures (Appendix 6) will be employed. Some soils within the project area, within the Hub and to a lesser extent the GTS areas are likely to be susceptible to erosion given that they contain a fines content, dispersive clay and low gravel content. However, given the relatively flat topographic contours, sporadic and low rainfall and sparce vegetation coverage at these locations, it is unlikely that clearing in these areas will cause appreciable or significant land degradation. Assessed Outcome: Given the above, the proposed clearing is unlikely to have a significant impact on land degradation at a local or regional level. Therefore, the proposed clearing is not likely to be at variance with this clearing principle.
Conservation Estate		
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, adjacent or nearby to any conservation areas. There are no DBCA managed, or interest lands located within, adjacent or nearby to the survey area. The closest geoheritage site to the project area, the Lake Teague (Shoemaker Impact Structure) lies approximately 289 km to the north of the RGP. The closest nature reserves to the RGP are the Wanjarri, De La Poer Range and Yeo Lake reserves which are all between 130-246 km from the project boundaries. Assessed Outcome: Given the above, the proposed clearing is unlikely to have a significant impact on environmental values of any adjacent or nearby conservation area. Therefore, the proposed clearing is not likely to be at variance with this clearing principle.
Ground and Surface Water Quality		
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 only ephemeral watercourses or drainages in the project area. Standard surface management measures will be implemented within the RGP to surface water flows and quality. In particular, a creek diversion channel be established around the GTS open pit (Appendix 6). Clearing will not be interacting with groundwater. No GDE’s are identified within the immediate project area. The disturbance area is not with in a Public Drinking Water Source Area. Assessed Outcome: Given the above, the proposed clearing is unlikely to have a significant impact on the quality of surface or underground water on a local or regional level. Therefore, the proposed clearing is not likely to be at variance with this clearing principle.

J	Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding.	The areas proposed for clearing have relatively flat topographic contours. This along with sporadic and low rainfall, which is characteristic of the local area, as well as the generally high soil permeability characteristics indicated that it is unlikely that clearing will exacerbate or cause significant incidence of flooding. Although the inherent risk of flooding in this locality is low due to gentle topographic contours, where the soils have less favourable soil permeability characteristics (Hub and to a lesser extent GTS), measures will be taken to prevent the potential impacts of flooding and the pooling of surface water. Flood protection bunds are to be established for the Hub and GTS project areas to protect the mining areas and associated infrastructure and from localised flooding or water pooling impacts. Additionally natural surface water flows will be retained in these areas through management measures (Appendix 6). Assessed Outcome: Given the above, the proposed clearing is unlikely to cause, or exacerbate, the incidence of flooding. Therefore, the proposed clearing is not likely to be at variance with this clearing principle.

5. SUMMARY OF ASSESSMENT

The assessment of the clearing principles concludes that the clearing of 250.3 ha of native vegetation within a purpose permit area of 1,672.6 ha, is not likely to be at variance against any clearing principle.

6. MANAGEMENT COMMITMENTS

Environmental management commitments that will be undertaken during and after the completion of the project are summarised in Table 5.

Table 5: Management Commitments

Environment Aspect	Commitment No.	Commitment
Clearing and Topsoil Disturbance	Commitment 1	All clearing will be undertaken in accordance with a Native Vegetation Clearing Permit and the internal Ground Disturbance Permit.
	Commitment 2	Designated access routes and mining activities will be clearly delineated in the field.
	Commitment 3	Vehicles and other equipment will travel on designed access routes and mining infrastructure areas.
	Commitment 4	Disturbed areas will be rehabilitated progressively where possible and in accordance with the Mine Closure Plan.
Surface Water	Commitment 5	Access routes and mining infrastructure will avoid existing drainage lines where practicable.
	Commitment 6	Flood and surface water diversion bunds will be constructed around all vulnerable mine areas to prevent downstream sedimentation and impacts to surface and groundwater quality that may result from the proposed clearing.
	Commitment 7	Sediment control structures will be installed as necessary at locations where high sediment loads are anticipated or observed.
Groundwater	Commitment 8	Dewatering and groundwater quality monitoring will be undertaken in accordance with the DWER licence to operate.
Flora and Fauna	Commitment 9	No unapproved clearing of flora and vegetation will be undertaken.
	Commitment 10	Personnel will be required to adhere to speed limits and drive to road/weather conditions to minimise the risk of fauna injuries due to traffic.
	Commitment 11	All vehicles and other mobile equipment will be inspected to determine that they are free of weed seeds and soil prior to be permitted to operate on site.
Air Quality	Commitment 12	Vehicles and mobile plant will be maintained as per manufacturer specifications to ensure air emissions are minimised.
	Commitment 13	Unsealed surfaces will be watered as required to minimise the generation of dust.
	Commitment 14	During high winds, topsoil stripping and spreading activities will be restricted if dust cannot be adequately controlled.
Waste	Commitment 15	All waste generated from mining activities will either be recycled or disposed of to an approved landfill facility.
Hydrocarbons	Commitment 16	Hydrocarbons or other chemicals will be stored and handled as per the Safety Data Sheet in bunded areas.
	Commitment 17	Spill response kits will be available as required and selected all mining and construction personnel will be trained in spill response.
	Commitment 18	Vehicles and plant will be maintained as per manufacturer specifications to minimise the chance of leaks and breakdown related spills.
	Commitment 19	Any hydrocarbon contaminated soil will be removed and disposed of at the site bioremediation pad.
	Commitment 20	As required, any spills defined under Section 72 of the EP Act 1986 and Environmental Protection (Unauthorised Discharges) Regulations 2004 (WA) will be reported to regulatory authorities as required.

Environment Aspect	Commitment No.	Commitment
Fire	Commitment 21	During the induction process all personnel working in the area will be made aware of the risk of bushfires and the precautions necessary to minimise this hazard including knowledge of escape routes and correct disposal of cigarettes. All personnel will be trained in the use of available firefighting equipment and advised on the plan of action in case of a fire.
	Commitment 22	All vehicles and the fuel trailer will carry portable fire extinguishers. Larger machinery such as loaders and drill rigs will be fitted with a fire suppression deluge system if practical.
	Commitment 23	No hot works will be undertaken on Total Fire Ban days as declared by the Department of Fire and Emergency Services (DFES).
Heritage	Commitment 24	If an Aboriginal heritage site is identified, activities in the vicinity of the site will cease immediately, the provisions of the Aboriginal Heritage Act 1972 and the Aboriginal Cultural Heritage Act 2021, will be followed and the DPLH will be notified as required.
Workforce and Training	Commitment 25	All personnel to complete the site induction which outlines strategies to protect the environment.

7. REHABILITATION

Rehabilitation is the return of disturbed land to a safe, stable, productive, non-polluting and self-sustaining condition in consideration of beneficial uses of the land. Appropriate rehabilitation will ensure that the long-term impacts of mining in the area are minimised.

Rehabilitation will be undertaken in accordance with the RGP Mine Closure Plan and Redcliffe will comply with all tenement conditions.

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APPENDICES

APPENDIX 1: KIN MINING AUTHORISATION FOR DISTURBANCE OF GROUND ON M37/233

342 Scarborough Beach Rd,
Osborne Park
Western Australia 6017

1 November 2021

To Whom It May Concern:

RE: Authorisation for Disturbance of Ground on M37/233

Kin Mining NL holds 100% of the shares in Navigator Mining Pty Ltd. Navigator Mining Pty Ltd (Navigator) is the holder of M37/233. Navigator intends to enter into a Deed of Access Agreement with Redcliffe Project Pty Ltd (Redcliffe), holder of adjacent tenement M37/1276 and wholly owned subsidiary of Dacian Gold Limited (Dacian). Redcliffe plans to develop an open pit mine to extract the Golden Terrace South (GTS) gold deposit as part of its Redcliffe Gold Project.

Navigator acknowledges that Redcliffe will be lodging approval applications including, but not limited to:

1. Programs of Work (POWs), a Mining Proposal and Mine Closure Plan, under the provisions of the Mining Act 1978;
2. Native Vegetation Clearing Permits, Works Approvals and Licence applications under the provisions of the Environmental Protection Act 1986; and
3. Licence to Take Water under the Rights in Water and Irrigation Act 1914.

This letter serves as authority for Redcliffe, to submit all necessary approval applications relating to the GTS open pit development, inclusive of planned ground disturbance on M37/233 and to undertake such activities approved through the relevant legislative frameworks and in accordance with the Deed of Access Agreement between the parties.

Yours sincerely,

Andrew Munckton
Managing Director
Kin Mining NL
a.munckton@kinmining.com.au

APPENDIX 2: SOILS AND LANDFORM ASSESSMENT FOR THE RGP (MBS 2021A)

Redcliffe Gold Project - Soil and Landform Assessment

Prepared for:

Dacian Gold Limited

December 2021

Prepared by:

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REDCLIFFE GOLD PROJECT
SOIL AND LANDFORM ASSESSMENT

Distribution List:

Company	Contact name	Copies	Date
Dacian Gold Limited	Peter Dunstan Redcliffe Gold Project Manager	1	10 December 2021
RPM Global	Peter Smith Principal Environmental Advisor	1	10 December 2021

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Document Status	Prepared By	Authorised By	Date
Draft Report	Elliott Duncan	Michael North	25 November 2021
Final Report	Elliott Duncan	Michael North	10 December 2021

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1. INTRODUCTION

1.1 BACKGROUND

The Redcliffe Gold Project (RGP) is located approximately 45 to 60 km northeast of Leonora in the Goldfields region of Western Australia (Figure 1). Dacian Gold Limited (Dacian) is proposing to develop the RGP to supplement the Mt Morgans operations.

Gold was initially discovered in the area in 1898 leading to the development of the township of Mertondale in 1899. However, prospecting in the area was relatively short-lived with the town almost deserted by 1910. Gold production in the area, within the Mertondale Shear Zone, re-started in the 1980s and 1990s with an estimated 400,000 ounces of gold mined from historical pits and mines (Ralley 2010).

The RGP is typically split into three zones: Northern, Central and Southern zones:

- The Northern Zone has limited exploration compared to the Central and Southern Zones.
- The northern section of the Central Zone has abundant outcrop which allowed prospectors of the early 1900s to find gold. This led to the later mining of the historical Redcliffe and Mesa open pits by Dominion Mining in 1990 and Nambi open pits by Harbour Lights in 1991. The southern section of the Central Zone lies under transported and lateritic cover which has had limited previous exploration.
- The Southern Zone was extensively explored in the 1990s where shallow gold was detected. The Southern Zone includes several known deposits including Gold Terrace South (GTS) and Bindy.

Initial development of the RGP is expected to start in July 2022, with the initial development stages comprising three deposits:

- Nambi deposit extension - situated on tenement M37/1286 occupying an area of approximately 9.8 ha.
- Project Hub deposit - situated on tenement M37/1348, occupying an area of approximately 8.7 ha.
- GTS deposit - situated on tenement M37/1276 occupying an area of approximately 9.9 ha.

The development of the three deposits will be included in a single mining proposal (MP), expected to be submitted in the first quarter of 2022. In order to progress this project, Dacian requires a soil and landform assessment in order to understand the extent and characteristics of soils and landforms present within the project area. Information of this nature is important in mine development and closure planning as it provides:

- Information on the diversity, extent, and characteristics of landforms within the project area and highlights any areas of ecological, geological, or cultural importance.
- Details on the different soil types within the project area.
- An estimate of soil resources (volumes) available for use in project planning (construction/engineering purposes), rehabilitation, and project closure as required.
- An indication of soils which contain adverse characteristics when disturbed (i.e., acidic, saline, dispersive, phytotoxic, contaminated) and may be unsuitable for project planning or rehabilitation activities (including approximate volumes of this material).

1.2 SCOPE OF WORK

The scope of work performed by MBS Environmental (MBS) as a part of this assessment included:

- Liaising with Dacian to gain an understanding of the project layout, highlighting areas of proposed disturbance such as open pit voids, waste rock dumps, haul roads, access roads and other supporting infrastructure. There is no dedicated tailings storage facility (TSF) within the Redcliffe project area as ore will be processed and tailings stored at the nearby Mt Morgan's facility.

- Determining appropriate sampling locations for test pits and surface samples which intersect all proposed disturbance areas and land systems.
- Undertaking a review of regional and project land systems and landforms which included details on the major soil types within the project area.
- Based on the above, prepare a sample and analysis plan (SAP) which details the type of soil samples collected, the locations which they are to be collected from and the laboratory analyses required in order to meet DMIRS requirements.
- Liaising with Dacian geologists to implement soil (surface and subsoil) sampling as per the SAP, and to deliver the samples to the MBS office.
- Review of field data collected by Dacian and liaison where required.
- Ensuring that samples were sent from Dacian/Redcliffe to the MBS office and that sub-samples were selected and submitted to a National Association of Testing Authorities Australia (NATA) accredited laboratory which included preparation of all relevant Chain of Custody (CoC) documentation.
- Preparation of a soil and landform assessment report that included:
  - Descriptions of the natural landforms and soil types at the project site.
  - Assessment and identification of key physical and chemical characteristics of surface soils and subsoils.
  - Identification of soil types suitable for rehabilitation of mine waste landforms and other disturbed areas at mine closure.
  - Identification of potentially 'hostile' soils not suitable for project planning or rehabilitation activities (i.e., those that are acidic, saline, contaminated etc).
  - An indication of the volume of surface soils that may reasonably be harvested and stockpiled prior to mining.

Scale: 1:500000
Original Size: A4
Image: Copernicus Sentinel Data 2020
Grid: GDA94 / MGA zone 51
0 7.5 15 km

Dacian Gold
Redcliffe Gold Project

Figure 1

Project Location

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MBS ENVIRONMENTAL

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2. PROJECT DESCRIPTION

Dacian is proposing to develop and mine three pits, Nambi, Hub, and GTS (Figure 2), as per the initial stages of the RGP. Overall, the three pits will produce approximately 18.2 million tonnes of waste rock and 937,000 tonnes of ore, resulting in approximately 468.5 kg of gold at 0.5 g/t. Low grade ore contains between 0.5 and 0.7 g/t gold with high grade ore containing a minimum of 0.7 g/t gold.

Waste rock from each pit will be stockpiled within a waste rock dump located adjacent to each pit. The ore will be transported to Mt Morgans, located 20 km west of Laverton (Figure 1), for processing.

2.1 NAMBI DEPOSIT

The Nambi open pit, situated on tenement M37/1286, was previously mined by Harbour Lights in 1991. Ore was transported to St Barbara - Sons of Gwalia Harbour Lights operation for processing and waste rock was stockpiled to the east of the pit within the Nambi waste rock dump. No mining in the Nambi area has occurred since 1991.

Dacian is proposing a cut back of the existing Nambi open pit, extending the pit to the west to cover an area of 9.8 ha and increasing the depth from 60 m to 120 m.

The Nambi pit is expected to produce 6 million tonnes of waste rock and 318,000 tonnes of ore over a mine life of 12 to 15 months.

2.2 HUB DEPOSIT

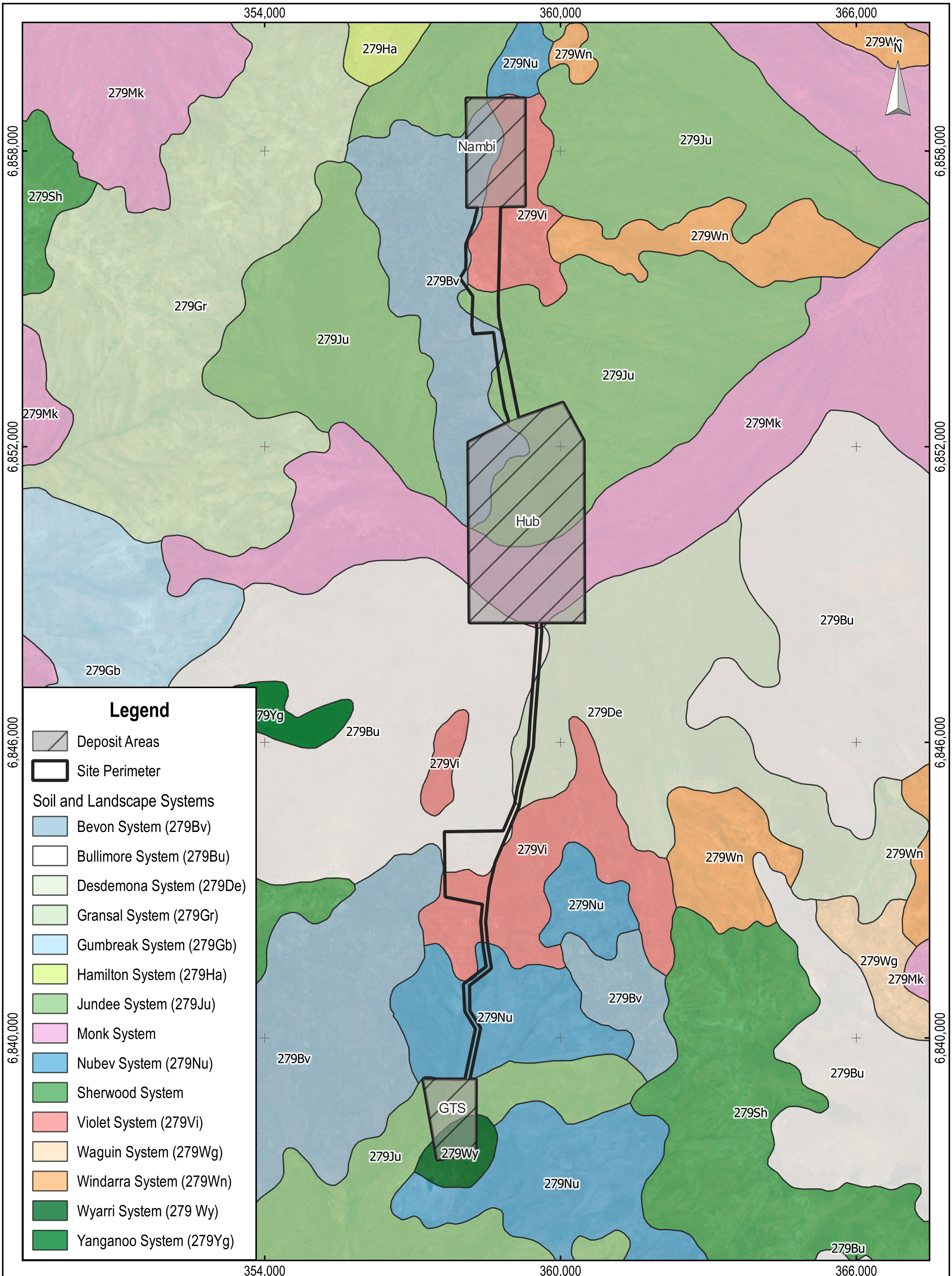
The Hub deposit is situated on tenement M37/1348, approximately 60 km northeast of Leonora, and is the central of the three deposits. Dacian is proposing to mine an open pit to a depth of 100 m over an area of 8.7 ha.

The Hub pit is expected to produce 7.4 million tonnes of waste rock and 209,000 tonnes of ore over a mine life of 12 to 16 months.

2.3 GTS DEPOSIT

The GTS deposit is situated on tenement M37/1276 and is the southern-most of the three deposits. Dacian is proposing to mine an open pit to a depth of 115 m over an area of 9.9 ha.

The GTS pit is expected to produce approximately 4.8 million tonnes of waste rock and 410,000 tonnes of ore over a mine life of 8 to 12 months.



Scale: 1: 100,000 Original Size: A4 Grid: GDA94 / MGA zone 51 0 1 2 km	Dacian Gold Redcliffe Gold Project	**Figure 2** **Layout of Disturbance Area and Land Systems**	Martinick Bosch Sell Pty Ltd 4 Cook St West Perth WA 6005 Australia t: +61 8 9226 3166 info@mbsenvironmental.com.au www.mbsenvironmental.com.au MBS ENVIRONMENTAL

W:\Dacian Gold\Redcliffe Gold Project\Soil Characterisation\GIS\Redcliff Gold Project_Soils.qgz 15/11/2021 F2 Disturbance Area and Land Systems

3. PROJECT ENVIRONMENT

3.1 CLIMATE

The climate of the area is characterised by low annual rainfall and a large temperature range, with evaporation exceeding rainfall annually (Johnson et al. 1999).

Climatic information for the project is collected from the nearest Bureau of Meteorology (BoM) meteorological site, Leonora Aero (site number: 12241). Temperatures can reach a maximum of 37°C in January and a minimum of 6°C in July (BoM 2021). The mean annual rainfall is 254 mm with majority of this rainfall recorded during January to March (BoM 2021).

3.2 REGIONAL GEOLOGY

Gold mineralisation is associated with the Archaean greenstones which generally occur in a north to south bearing in the Murchison and Eastern Goldfields (Ralley 2010).

The RGP is situated over a large portion of the Mertondale Shear Zone (MSZ). The MSZ trends north to south between the Keith-Kilkenny and Celia tectonic zones. The MSZ is the major source of gold within the RGP area. The MSZ is bound by strongly altered and mineralised fault systems; the Mertondale fault to the east and the Great Western fault system to the west (BMGS 2020)

An Archaean felsic volcanoclastic and sedimentary sequence is located to the west of the shear zone and Archaean predominantly mafic volcanics comprising basalt and dolerite are located to the east. The MSZ includes intrusions of felsic porphyries and Proterozoic dolerite dykes (BMGS 2020).

3.3 PROJECT GEOLOGY

3.3.1 Nambi Deposit

The Nambi gold deposit is hosted by a mafic volcanic sequence interbedded with thin graphitic schist units. This sequence has been intruded by felsic and granitoid dykes. Metamorphism in the area is lower to middle amphibolite facies with a characteristic mineral assemblage of amphibole and plagioclase.

The zone itself has a mylonitic fabric and an alteration assemblage of sericite-biotite-silica plus pyrite and pyrrhotite. The orientation of the ore zone is NNE-SSW and has a near vertical dip. Alteration adjacent to the main ore is restricted to thin bands of biotite, saussurite and silica with accessory pyrite-pyrrhotite (Harbour Lights 1991).

3.3.2 Hub Deposit

A package of northerly striking, folded, sub-vertical to steep east dipping felsic volcanics (rhyodacite), mafic, intermediate to felsic volcaniclastics and black shales comprise the Hub geological sequence. The deposit area has been intruded by both dolerite and lamprophyre dykes which brecciate and stope out the mineralised zones. A distinctive volcanic unit (rhyolite) is to the west of the shear, variably 5-20 m downhole (BMGS 2020).

Mineralisation at Hub is characterised by:

- Increased deformation.
- Increased pyrrhotite content (up to 15%).
- Crenulation fabric (defined by wispy, white late carbonate infill).

3.3.3 Golden Terrace South (GTS) Deposit

A poorly exposed south-plunging synclinal structure is reported to exist in the RGP area. The rocks are reported to be sub-vertical with steep dips to both east and west and strike between 320 and 340 degrees. Small subsidiary folds with a parallel plunge locally accompany a prominent lineation that dips 50 degrees southwards. Minor displacement is evident by several cross fault sets that strike approximately 45 and 100 degrees.

The dominant lithologies present are interbedded basaltic lavas and tuffs, tuffaceous sediments and carbonaceous (graphitic) shales, at times intruded by dolerite. All units have been metamorphosed to upper greenschist-lower amphibolites facies, which lead to the development of quartz-mica and quartz-chlorite mica schists from tuffs and sediments and fine grained amphibolites from basaltic volcanics. Original textures are well preserved in many tuffaceous lithologies (Ralley 2010).

3.4 HYDROLOGY

There are three broad, sub-parallel, south-easterly trending drainage systems, known as palaeodrainages, within the region (Johnson et al. 1999). The Carey and Raeside Palaeodrainages extend from a regional divide to the west and trend towards the Eucla Basin and the Minigwal Palaeodrainage rises from the northwest of the Cosmo Newberry Community and discharges into the Carey Palaeodrainage to the south of Lake Carey. These palaeodrainages tend to have low gradients and contain playa lakes, such as Lake Carey and Lake Way, which are normally dry and covered by mud or salt crusts. These playa lakes are typically fringed by sand and kopi dunes that restrict surface flow between lakes, however intense rainfall generally associated with cyclonic events can inundate these lakes (Johnson et al. 1999).

3.5 HYDROGEOLOGY AND GROUNDWATER QUALITY

Groundwater occurs within the major palaeodrainages and flows from the drainage divides towards the salt lakes and then downstream in the palaeochannels (Johnson et al. 1999). Rainfall maintains groundwater flows with discharge occurring mainly by evaporation in the playa lakes and some through-flow within the palaeochannels. The Eucla Basin, 350 km to the southeast, is the final point of outflow from the Carey and Raeside Palaeodrainages.

The RGP area is located in the upper reaches of the Station Creek catchment and regional groundwater flow is expected to be to the southwest towards the Station Creek palaeochannel and the Raeside regional palaeodrainage (Aquaterra 2010).

Groundwater quality in the RPG area is typically neutral to slightly alkaline and brackish-saline. Groundwater levels within the GTS pit are 15 mbgl to 20 mbgl (Aquaterra 2010). Mining is expected to extend below the groundwater table; therefore, pit lakes are expected to be formed after mine closure.

3.6 VEGETATION

Vegetation communities associated with different land systems and landforms within the project area are summarised below in Table 1 as outlined in Pringle et al. (1994).

Table 1: Vegetative Communities Associated with the Project Area

Land System	Landforms (% of land system)	Vegetation
Bevon (Bv)	Breakaways/ Footslopes (5%)	Scattered to moderately close generally non-saline low shrublands characterised by *Ptilotus obovatus* occasionally with *Eucalyptus 'nigrifunda'* or *E. lissophloia* trees. Variable scattered to moderately close halophytic low shrublands, occasionally with a tall shrub stratum dominated by *A. aneura* (mulga) and *Eucalyptus* in the south.
	Ridges (<1%)	Scattered to moderately close *A. aneura* tall shrublands.
	Hills (20%)	Scattered to moderately close *Acacia* (often *A. aneura)* tall shrublands.
	Low Rises (15%)	Scattered tall A. *aneura* shrublands.
	Stony Plains (40%)	Generally scattered *A. aneura* tall shrublands, occasionally scattered low bluebush shrublands, or *Eucalyptus lesouefii* (Goldfields blackbutt) woodlands in south on calcareous slopes.
	Lateritic Plains (15%)	Scattered A. *aneura* tall shrublands
	Drainage Tracts (5%)	Halophytic low shrublands, frequently with eucalypt trees in the south. Moderately close A. *aneura* tall shrublands.
Laverton (Lv)	Hills & Ridges (20%)	Scattered tall and mid shrublands, dominated by acacias and *Ptilotus obovatus* (cotton bush).
	Hillslopes (50%)	Scattered *Maireana sedifolia* (pearl bluebush) shrublands
	Stony Plains (25%)	Scattered *Acacia aneura* tall shrublands rarely with a halophytic understorey.
	Drainage Tracts (5%)	Moderately close *A. aneura* tall shrublands generally with few understorey shrubs.
Monk (Mk)	Stony Hardpan Plains (3%)	Scattered to very scattered *A. aneura* tall shrublands.
	Hardpan Plains (45%)	Generally scattered *A. aneura* tall shrublands, denser in groves.
	Loamy Tracts (40%)	Scattered *A. aneura* tall shrublands with wanderrie grasses.
	Drainage Tracts (9%)	Scattered to moderately close *A. aneura* tall shrublands.
	Sandy Banks (3%)	Scattered *A. aneura* tall shrublands with wanderrie grasses.
Jundee (Ju)	Stony Plains (15%)	Scattered to very scattered *A. aneura* tall shrublands
	Hardpan Plains (65%)	Scattered *A. aneura* tall shrublands, moderately closed *A aneura* tall shrublands in groves.
	Sandy Banks (5%)	Scattered *A. aneura* tall shrublands with wanderrie grasses, which are occasionally dominant.
	Loamy Plains (5%)	Scattered *A. aneura* tall shrublands with wanderrie grasses.
	Drainage Tracts (10%)	Scattered to close *A. aneura* tall shrublands.
Violet (Vi)	Low Rises (15%)	Scattered *A. aneura* tall shrublands.
	Lateritic Sandy Plains (20%)	Very scattered *A. aneura* tall shrublands with wanderrie grasses.

Land System	Landforms (% of land system)	Vegetation
	Stony Plains (35%)	Very scattered to scattered *A. aneura* tall shrublands or *Ptilotus* spp. Low shrublands.
	Hardpan Plains (20%)	Very scattered to scattered *A. aneura* tall shrublands occasional close *A. aneura* tall shrublands in groves.
	Drainage Tracts (10%)	Moderately close to close *A. aneura* tall shrublands or woodlands with very sparse understoreys.
Bullimore (Bu)	Sand Sheet (85%)	Hard spinifex hummock grasslands with generally very variable scattered tall shrubs and trees (*Acacia* spp. *Proteaceae* and *Eucalyptus* spp.), often with heath low shrubs.
	Sand Dunes (1%)	Very variable; dominated alternatively by spinifex, low myrtaceous heath or tall proteaceous shrubs, rarely by trees; heath component invariably prominent.
	Loamy Plains (10%)	Scattered to close *A. aneura* (mulga) shrublands, variably with spinifex and wanderrie grasses.
	Drainage Zones (2%)	Very variable: close *A. aneura* tall shrubs occasionally with heath shrubs, spinifex, or wanderrie grasses.
	Dissected Tracts (2%)	Very variable, low myrtaceous shrublands sometimes with *A. aneura* tall shrubs, or *Casuarina cristata* (black oak) trees in calcareous areas.
Desdemona (De)	Loamy Plains (80%)	Scattered to moderately close *Acacia aneura* (mulga) tall shrubs with wanderrie grasses.
	Sand Sheets (2%)	Scattered *Acacia* tall shrublands with wanderrie, *Amphipogon caricinus* (grey beard grass) and hummock grasses, and occasional heath shrubs.
	Hardpan Plains (7%)	Scattered tall *A. aneura* shrublands.
	Drainage Zones (3%)	Scattered to close *A. aneura* tall shrublands.
Wyarri (Wy)	Tors/Domes (50%)	Very scattered to scattered mixed shrublands with *Acacia quadrimarginea* (granite wattle) tall shrubs.
	Low Rises (15%)	Scattered mixed shrublands with *A. quadrimarginea* tall shrubs.
	Ridges (2%)	Scattered *Acacia aneura* (mulga) and *Acacia craspedocarpa* (hop mulga) tall shrublands.
	Footslopes (5%)	Scattered *A. quadrimarginea* tall shrublands.
	Gritty Surfaced Plains (10%)	Very scattered mixed shrublands with *A. aneura* and *A. quadrimarginea* tall shrubs.
	Stony Plains (10%)	Scattered *acacia* - *eremophila* shrublands.
	Hardpan Plains (5%)	Scattered *A. aneura* tall shrublands.
	Drainage Floors (5%)	Moderately close *A. aneura* shrublands occasionally with *eucalypt* overstoreys.
Sherwood (Sh)	Stony Plains (40%)	Scattered *Acacia* - *eremophila* shrublands. Occasionally scattered *Maireana* low shrublands.
	Gritty Surfaced Plains (15%	Very scattered *A. aneura* and *A. quadrimarginea* tall shrublands with wanderrie grasses.
	Lower Footslopes (10%)	Scattered halophytic low shrublands (*A. vesicaria* & *M. glomerifolia*)

Land System	Landforms (% of land system)	Vegetation
	Hardpan Plains (10%)	Scattered tall *A. aneura* shrublands.
	Drainage Tracts (10%)	Scattered halophytic low shrublands (*Atriplex* or *Frankenia*)
	Breakaways (8%)	Very scattered to scattered low shrublands (*Callitris collumellaris, Ptilotus obovatus, Frankenia* spp).
	Alluvial Plains (5%)	Scattered halophytic low shrublands or scattered *A. aneura* tall shrublands with a halophytic shrub understorey.
	Low Rises (2%)	Very scattered to scattered mixed shrublands (*A. quadrimarginea*)

4. LAND SYSTEMS AND LANDFORMS

4.1 LAND SYSTEMS AND SOILS

A desktop review of soil mapping units was undertaken using the Australian Soil Resources Information System (ASRIS) (CSIRO, 1991) and spatial data made available by the Department of Primary Industries and Regional Development (DPIRD, 2018) which shows the regional land system mapping units in relation to the indicative project disturbance envelope.

Seven land system units are present within the disturbance envelope (Figure 2). Characteristics of the units, including landforms and soil types are summarised in Table 2 as outlined in Pringle *et al,* (1994).

Table 2: Soil and Landform Units Within Project Disturbance Area

Land System	Geology	Landforms (% of land system)	Major Soil Types (% of land system)	Proposed Disturbance Areas Intersected
Bevon (Bv)	Tertiary limonite, minor Archaean greenstone and banded iron formation, extensive Quaternary colluvium and restricted areas of Quaternary alluvium and eluvium.	Breakaways/ Footslopes (5%) Ridges (<1%) Hills (20%) Low Rises (15%) Stony Plains (40%) Lateritic Plains (15%) Drainage Tracts (5%)	Red shallow loam (77%) Red brown hardpan shallow loam (15%) Red shallow sandy duplex (8%)	Nambi Pit Nambi WRD
Violet (Vi)	Archaean greenstone and basalt, Tertiary ferruginous duricrust and Quaternary sand, colluvium, eluvium, and minor cemented alluvium.	Low Rises (15%) Lateritic Sandy Plains (20%) Stony Plains (35%) Hardpan Plains (20%) Drainage Tracts (10%)	Red shallow loam (45%) Red deep sand (20%) Red shallow sandy duplex (10%) Red loamy earth (10%) Shallow gravel (10%) Red brown hardpan shallow loam (5%)	Nambi WRD Nambi ROM
Monk (Mk)	Cemented Quaternary alluvium and sand, derived mainly from granite.	Stony Hardpan Plains (3%) Hardpan Plains (45%) Loamy Tracts (40%) Drainage Tracts (9%) Sandy Banks (3%)	Red brown hardpan shallow loam (94%) Red loamy earth (6%)	Hub Infrastructure Area Hub Diversion Road

Land System	Geology	Landforms (% of land system)	Major Soil Types (% of land system)	Proposed Disturbance Areas Intersected
Jundee (Ju)	Cemented Quaternary alluvium derived mainly from greenstone uplands	Stony Plains (15%) Hardpan Plains (65%) Sandy Banks (5%) Loamy Plains (5%) Drainage Tracts (10%)	Red shallow loam (60%) Red loamy earth (30%) Red/brown non-cracking clay (5%) Red deep sand (5%)	Hub Pit Hub WRD Hub Infrastructure Area. GTS Pit GTS WRD
Bullimore (Bu)	Sand of Tertiary/Quaternary age, minor siliceous and ferruginous duricrusts, Archaean granite and Quaternary loam alluvium.	Sand Sheet (85%) Sand Dunes (1%) Loamy Plains (10%) Drainage Zones (2%) Dissected Tracts (2%)	Salt lake soil (60%) Red deep sandy duplex (25%) Red deep sand (10%) Red brown non-cracking clay (5%)	Reference system in case of future development
Desdemona (De)	Quaternary sand and loam with minor cemented alluvium; derived mainly from granitic rocks.	Loamy Plains (80%) Sand Sheets (2%) Hardpan Plains (7%) Drainage Zones (3%)	Red loamy earth (90%) Red brown hardpan shallow loam (7%) Red deep sandy duplex (3%)	Reference system in case of future development
Wyarri (Wy)	Archaean granite and minor Quaternary colluvium and alluvium.	Tors and Domes (50%) Low Rises (15%) Ridges (2%) Footslopes (5%) Gritty Surfaced Plains (10%) Hardpan Plains (5%) Drainage Floors (5%)	Stony soil (50%) Red shallow sand (25%) Red sandy earth (17%) Red brown hardpan shallow loam (5%) Red loamy earth (3%)	GTS WRD GTS ROM
Sherwood (Sh)	Archaean granite and gneiss, Quaternary colluvium, and alluvium.	Stony Plains (40%) Gritty Surfaced Plains (15%) Lower Footslopes (10%) Hardpan Plains (10%) Drainage Tracts (10%) Breakaways (8%) Alluvial Plains (5%) Low Rises (2%)	Red shallow sandy duplex (35%) Red shallow sand (31%) Red shallow loam (16%) Red brown hardpan shallow loam (10%) Red brown non-cracking clay (4%) Stony soil (4%)	Camp

4.2 LANDFORMS

Landforms can be described as "The distinctive, recognisable physical features of the earth's surface having a characteristic shape produced by natural processes. A landform is defined by the combination of its geology (composition) and morphology (form)" (EPA 2018).

The following sections describe the regional landform context of the RGP area as well as the landforms identified within the RGP are located and an assessment of their potential significance (refer Section 4.2.3).

4.2.1 Regional Landform Context

The RGP is located within the Murchison Biodiversity Region. The landscape of the Murchison bioregion comprises low hills, mesas of duricrust separated by flat colluvium and alluvial plains (Commonwealth Government, 2008). The project lies within the Eastern Murchison which 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 (Botanica 2019).

Common landforms within the greater project area include:

- Hills and ridges on greenstone, granite, basalts.
- Breakaways and lower plains.
- Erosional surfaces of low relief (<20 m).
- Hardpan wash plains.
- Deep coarse sand plains.
- Saline plains.
- Calcareous depositional plains.
- Salt lakes.

In addition, these major landmarks are present in the larger project area

- Mt Clifton (557 mAHD) which lies approximately 9 km west of tenement M37/1286.
- Monument Hill (545 mAHD) which lies approximately 30.4 km Southeast of tenement M37/1276.
- Charlie borefield which lies approximately 17 km northeast of tenement M37/1286.
- Roy-Valais Borefield which lies approximately 35 km east of tenement M37/1348.
- Lake Irwin lies approximately 38 km to the northeast of tenement M37/1286.
- Lake Carey which lies approximately 65 km to the southeast of tenement M37/1276

4.2.2 Project Area Landforms

Based on aerial photography and use of DMIRS GeoVIEW database (DMIRS 2021), the following landforms have been identified in the project area:

- Irregular low ironstone hills with stony lower slopes supporting mulga shrublands.
- Extensive sandplains supporting spinifex hummock grasslands.
- Extensive plains with deep sandy or loamy soils, supporting mulga and wanderrie grasses.

- Hardpan plains with ironstone gravel mantles, supporting mulga shrublands.
- Hardpan plains with occasional sandy banks, supporting mulga tall shrublands and wanderrie grasses.
- Undulating stony and gravelly plains and low rises, supporting mulga shrublands.
- Granite domes, hills and tors with gritty-surfaced plains supporting mulga and granite wattle shrublands.
- Granite breakaways and extensive granitic plains, with mulga shrublands and minor halophytic shrublands.

In addition, two other major landmarks exist within the project area

- Dillon Creek runs through tenement M37/1348, whilst creeks associated with this drainage system run through M37/1286.
- Mt Redcliffe (553 mAHD) is within tenement M37/1286.

4.2.3 Assessment of Landform Significance

From a review of aerial photography and use of DMIRS GeoVIEW database (DMIRS 2021) the landform types within the RGP are thus considered to be extensively represented within the region. It is also noted that the landforms identified within the RGP are well represented overall at the regional level and therefore ecological impacts from landform disturbance are not expected to be significant.

Landforms with significant scientific or evolutionary values in WA are identified as geoheritage sites or reserves. A State register of all geoheritage sites and reserves is managed by the Executive Director of the Geological Survey of Western Australia (GSWA) to assist in managing, preserving, and protecting exceptional geological features. Geoheritage focuses on the diversity of minerals, rocks, fossils, and features that indicate the origin and/or alteration of minerals, rocks, and fossils. It also includes landforms and other geomorphological features that illustrate the effects of present and past effects of climate and earth forces (McBriar 1995 as cited in Brocx and Semeniuk 2007). There are no known scientific or evolutionary values associated with the landforms within the project area. The closest geoheritage site to the EGP, the Lake Teague (Shoemaker Impact Structure) - lies approximately 289 km to the north. It is unlikely that landforms within the project area would be considered to be geoheritage sites, given they are not unique or restricted to this area. Similarly, the closest nature reserves to the RGP are the Wanjarri, De La Poer Range and Yeo Lake reserves which are all between 130-246 km from the project boundaries. Any disturbances from the project are thus unlikely to have any impact on the integrity of these reserves.

5. DETAILED FIELD INVESTIGATION

5.1 SAMPLING LOCATIONS

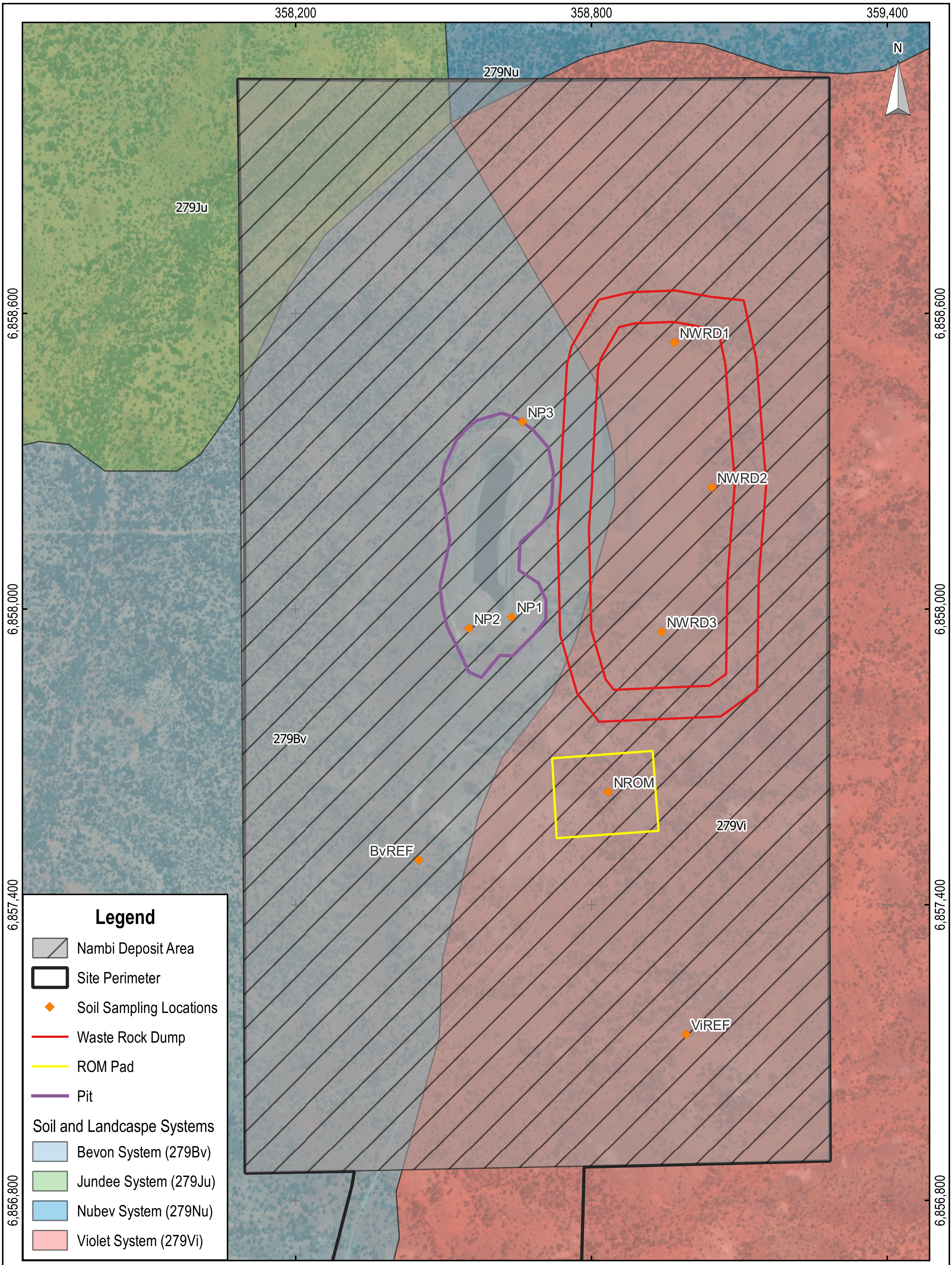
Approximate sampling locations were determined for field sampling using available soil and landform data in conjunction with the proposed site layout. In areas in which soil excavation is likely to be extensive during mine development (e.g., open pits, WRD) an excavator was used in order for topsoil and subsoil horizons to be exposed, described, and sampled. In areas of lesser disturbance (e.g., camps, wastewater treatment plants, solar arrays) surface topsoil samples were collected via manual excavation (digging or hand augering). It is noted that the number of soil samples is directly dependant on the nature of the deposit and the extent of soil resources on site.

Based on the regional soil information and proposed site layout (as of July 2021 and shown in Figure 2), a total of 42 sample locations were identified, 20 of which will be excavated to sample surface and subsoils, and 22 of which are for sampling topsoil only. In total 62 samples were collected which included 42 surface and 20 subsoil samples which are detailed in (Table 3) and summarised in Figure 3, Figure 4, Figure 5, and Figure 6 for each development area.

Table 3: Soil Sampling Locations

Sample Code	Mine Activity Area	Disturbance Area	Easting	Northing	Soil and Landform Unit	Samples Collected
BvREF	Nambi	Reference	358437.4	6857495.5	Bevon	Surface Soil
NP1		Pit	358642.6	6857965.5		Surface Soil + Subsoils
NP2			358547.9	6857960.0		
NP3			358661.6	6858366.3		
NWRD1		WRD	358974.0	6858539.9	Violet	
NWRD2			358043.8	6858248.2		
NWRD3			358953.6	6857935.9		
NROM		ROM	358830.2	6857624.9		Surface Soil
ViREF		Reference	358983.2	6857126.3		
HDR1	Hub	Haul Road	359940.9	6852275.9	Jundee	
HDR2			360123.6	6850804.7		
HDR3			359975.5	6850029.6	Monk	
HDR4			359659.5	6849338.5		
HP1		Pit	359358.4	6850942.9	Jundee	Surface Soil + Subsoils
HP2			359447.3	6851115.7		
HP3			359348.5	6850957.8		
HWRD1		WRD	359555.9	6851411.9		
HWRD2			359768.1	6851268.8		
HWRD3			359827.4	6851071.3		
HWRD4			359699.0	6850849.1		
HIA1		Infrastructure Area	359516.4	6850612.2		Surface Soil
HIA2			359832.3	6850498.6		

Sample Code	Mine Activity Area	Disturbance Area	Easting	Northing	Soil and Landform Unit	Samples Collected
HIA3			359600.3	6850296.2		
HIA4			359521.3	6849970.4	Monk	
JuREF		Reference	358805.5	6850444.3	Jundee	
BuREF			358422.1	6848627.6	Bullimore	
DeREF			360344.1	6848581.5	Desdemona	
CAMP1		Camp	359223.9	6843026.0	Sherwood	
CAMP2			359400.3	6842972.9		
CAMP3			358989.5	6842902.7		
CAMP4			359005.4	6843010.5		
CAMP5			359251.2	6842865.2		
CAMP6			358844.5	6842942.3		
GTS P1	GTS	Pit	357396.8	6838314.7	Jundee	Surface Soil + Subsoils
GTS P2			357475.8	6838415.1		
GTS P3			357594.3	6838219.2		
GTS WRD1		WRD	357809.9	6838856.1		
GTS WRD2			357837.9	6838635.6		
GTS WRD3			357862.6	6838429.9		
GTS WRD4			357903.7	6838258.7	Wyarri	
GTS ROM		ROM	357772.0	6838123.8		Surface Soil
WyREF		Reference	358119.3	6837970.8		



Scale: 1: 10,000
Original Size: A4

Grid: GDA94 / MGA zone 51
0 100 200 m

Dacian Gold
Redcliffe Gold Project

Figure 3

Soil Sampling Locations Within the Nambi Deposit

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MBS ENVIRONMENTAL

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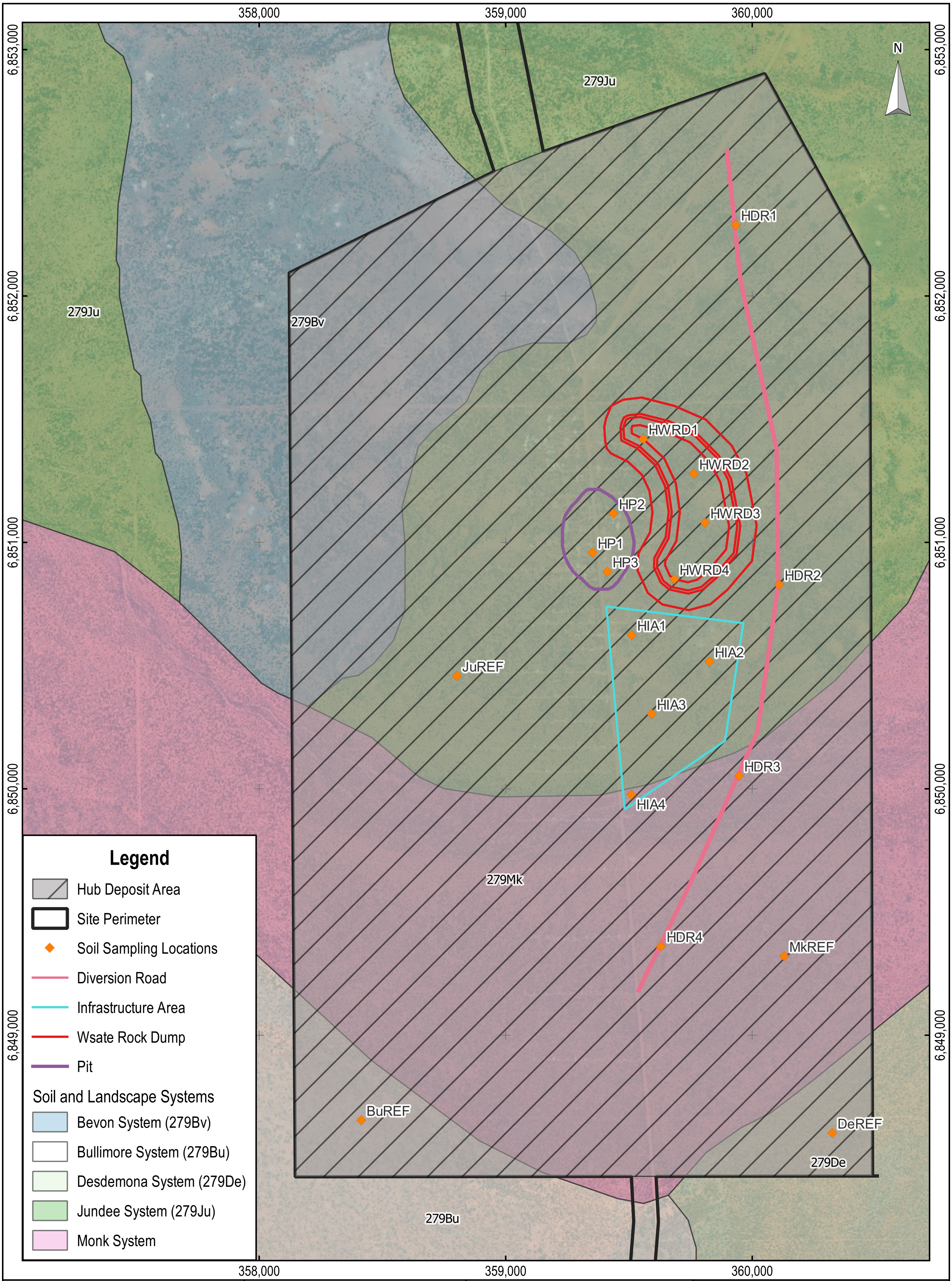

Scale: 1: 20,000
Original Size: A4

Grid: GDA94 / MGA zone 51

0 250 500 m

Dacian Gold
Redcliffe Gold Project

Figure 4

Soil Sampling Locations Within the Hub Deposit

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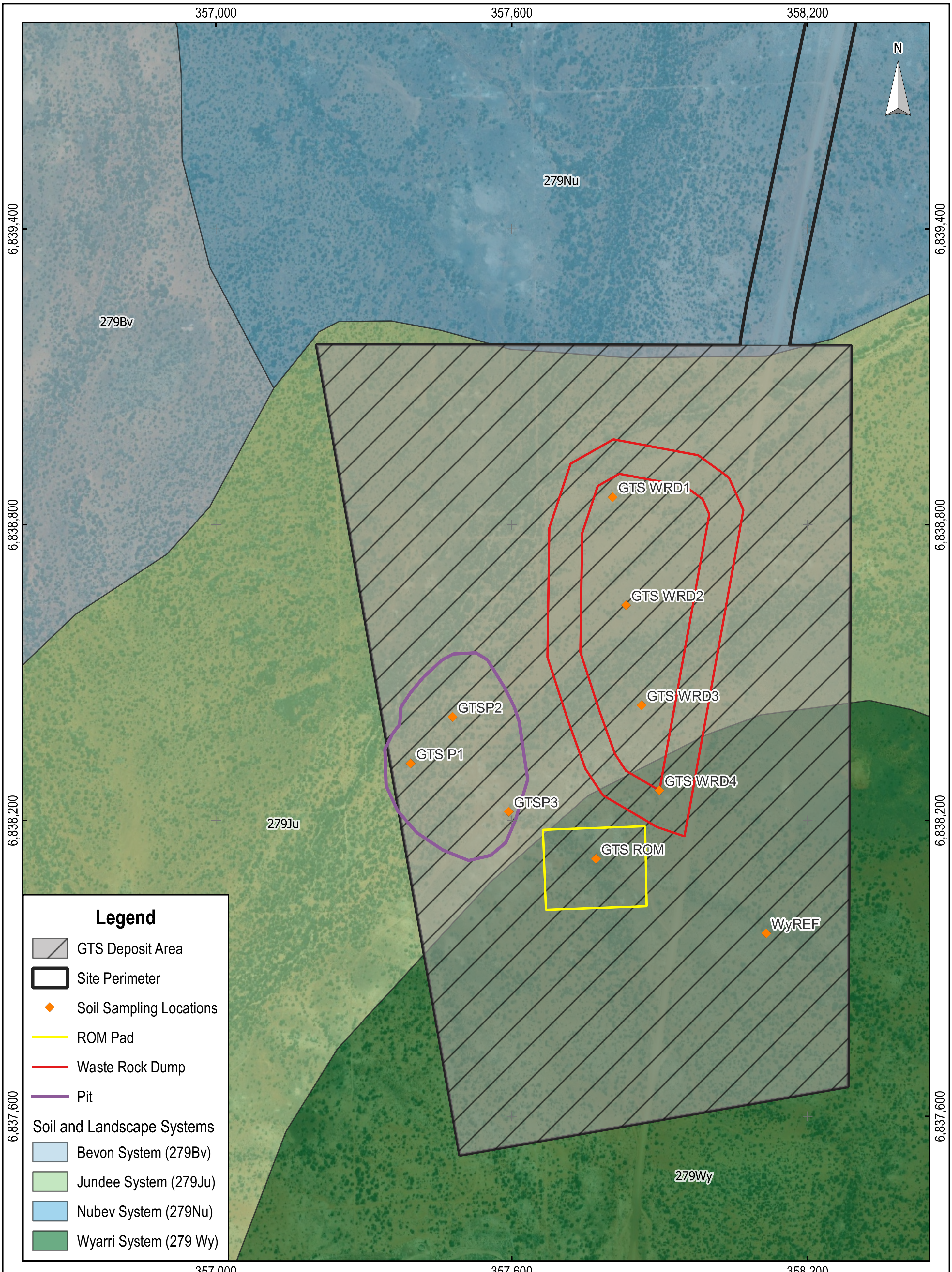

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Original Size: A4

Grid: GDA94 / MGA zone 51

0 100 200 m

Dacian Gold
Redcliffe Gold Project

Figure 5

Soil Sampling Locations Within the GTS Deposit

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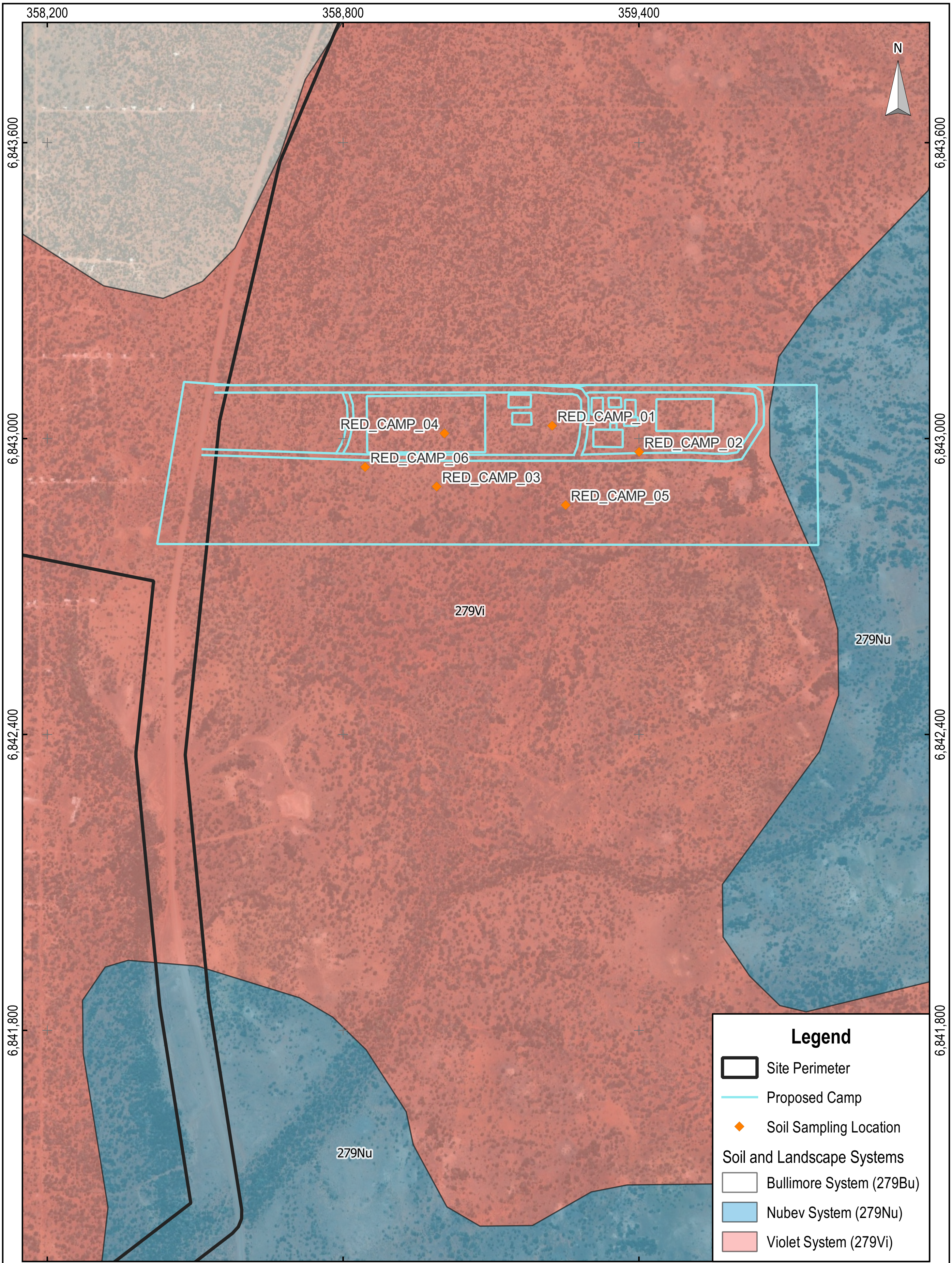


Scale: 1: 10,000 Original Size: A4 Grid: GDA94 / MGA zone 51 0 100 200 m	Dacian Gold Redcliffe Gold Project	**Figure 6** **Location of Proposed Mine Camp and Soil Sampling Locations**	Martinick Bosch Sell Pty Ltd 4 Cook St West Perth WA 6005 Australia t: +61 8 9226 3166 info@mbsenvironmental.com.au www.mbsenvironmental.com.au MBS ENVIRONMENTAL

\\mbssvr\working\Dacian Gold\Redcliffe Gold Project\Soil Characterisation\GIS\Redcliff Gold Project_Soils.qgz 03/12/2021 F6 Mine Camp and Soil Samples

5.2 SOIL PROFILE CHARACTERISATION

In order to ensure an appropriate characterisation of topsoil and subsoil resources within the disturbance area, soil profiles were logged at each of the sampling locations. Test pits were generated using excavators prior to field sampling taking place, whereby soils were removed from the profile in 200-250 mm deep layers, with the removed soil placed in separate piles to ensure changes in characteristics could be documented accurately.

Soil profiles were logged using the MBS template (Appendix 2) which records the following details of both the site and soil sample:

- Sample location - including coordinates (from a Global Positioning Device (GPS)) and characteristics of the proposed disturbance (i.e., pit, WRD, camp etc).
- Vegetation and landscape characteristics (including slope and elevation).
- Details of soil characteristics (i.e., texture, colour, gravel content) throughout the profile.
- Sample ID numbers, and photographic records of exposed soil profiles, collected soil samples, and the surrounding environment (i.e., vegetation and landscape).

For each trench or test pit that was evaluated, the profile by depth was classified and paired with a description of the dominant soil type based off the descriptions in Schoknecht & Pathan, 2013). The characteristics of soils can change throughout the profile and thus profiles are described across different horizons (layers) as follows:

- 'O Horizons'. Partly decomposed organic matter accumulated at the surface of the topsoil and overlies the A horizon. O-horizons are noted, when present, but not generally sampled.
- 'A Horizons': topsoil or first horizon. Can also be sub-classified (A1, A2, etc.) if multiple types of different soils occur within the same horizon. Soils in the A horizon are typically enriched in organic matter content (plant debris and humus) and more coarse texture (less clay) compared to underlying horizons.
- 'B Horizons': second horizon (subsoil). Clay, soluble salts, gravel and/or iron staining are commonly found in this horizon as a result of illuviation. It is common for more than one B horizon to be present – these are sequentially identified as B1, B2, etc. when present.
- 'C Horizons': third horizon (substratum). Underlies horizon B before fresh bedrock is found. Typically, characteristic of weathered bedrock (saprock). Depth to C horizon if found should be noted but does not require sampling.
- 'E Horizons'. If present, this is a distinctive layer (usually pale/white) formed between A and B horizons as a result of heavy leaching, leaving only resistant minerals behind (i.e., quartz).
- 'R Layer'. Hard bedrock.

Along with the soil profile classification and description, photographs were taken and included in the log:

- One photograph of the bagged and labelled soil sample(s) for the location to help indicate the sequence of photos by location.
- One photograph of the soil profile (e.g., Plate 1).
- At least one photograph of the surrounding landscape and vegetation.
- Site and field profile descriptions were recorded as per the Australian Soil and Land Survey Handbook (McDonald and Isbell 2009) with the following recorded for all samples:
  - Horizon depth and boundary type (transitional or abrupt).
  - Soil colour (grey, grey-brown, dark brown, red-brown, yellow-brown, yellow, etc.).
  - Field texture description (e.g., sand, light clay, gravelly loam, silty gravel).
  - Moisture content (dry, damp, moist or saturated).

- Presence, depth, and types of plant roots (fine, medium, coarse).
- Presence and characteristics of coarse fragments such as pisolitic gravels, rock fragments, and charcoal (proportions of total matrix, rounded or angular, composition/possible source of fragments).
- Presence or absence of pedogenic features (terrace gravels, mottles, hardpans – silcrete, calcrete, ferricrete, nodular calcrete, ferruginous pisoliths, etc).
- Underlying bedrock or saprock geology, where observable.

Plate 1: Example of Soil Profile Photograph

5.3 LABORATORY TESTS

A laboratory analysis program was undertaken by a NATA accredited laboratory to characterise physical and chemical properties of the soils to assess any risks associated with the disturbance of soils (i.e., acidity; metal/metalloid contamination; susceptibility to erosion, etc) and their suitability for use as cover materials for rehabilitation. For this reason, the test program focused on parameters relating to physical stability, plant nutrition, and contamination.

The following tests were undertaken by ChemCentre (Bentley, Western Australia), generally using in-house modifications of standard soil tests described by Rayment and Lyons (2011):

- pH and electrical conductivity (EC).
- Exchangeable cations (calcium, sodium, potassium, and sodium) and exchangeable sodium percentage (ESP%) and base saturation percentage (BS%). Exchangeable acidic cations (aluminium and manganese) were also measured on acidic soils with pH values below 6.5.
- Organic carbon, total nitrogen, total phosphorus, and phosphorus retention index (PRI).
- Particle size (sand, silt, clay, and gravel contents).
- Potential for clay dispersion (Emerson Class, AS 1289 3.8.1 2006).
- Nutrients and plant available heavy metals (Mehlich-3 extract, Mehlich 1984).
- Aqua-regia digestible concentrations of eight metals and metalloids to establish a baseline for future contaminated site assessments in accordance with NEPC (2013) guidelines.

5.4 INTERPRETATION OF RESULTS

The following sources of information were used to assess the significance of laboratory test results:

- Soil Analysis: An Interpretation Manual (Peverill *et al*. 1999).
- Interpreting Soil Test Results. What do all the numbers mean? (Hazelton and Murphy 2007).

- Soil Groups of Western Australia. In Resource Management Technical Report 380, Soil Physical Measurement and Interpretation for Land Evaluation, Australian Soil and Land Survey Handbooks Series 5 (4th ed). DAFWA, Perth (Schoknecht and Pathan 2013).
- Soil Guide. A handbook for understanding and managing agricultural soils. DAFWA Bulletin 4343 (DAFWA 1998).
- Soil-Landscapes of Western Australia's Rangelands and Arid Interior. Resource Management Technical Report 313 (Tille 2006).

A summary of the information sources and ratings tables used for this assessment is presented in Appendix 1.

6. SOIL PROFILE DESCRIPTIONS

Test pit photographs, soil profile descriptions, laboratory sample details and general descriptions for each soil test pit and sampling location are presented in Appendix 2. The main soil types present in the RGP included: Red brown hardpan shallow loams (DAFWA Soil Group 523), Red shallow loams (DAFWA Soil Group 522), red loamy earths (DAFWA Soil Group 544) and red sands/duplexes (DAFWA Soil Groups 405/406/423/445). The distribution of difference soil types across the project area is summarised in Figure 7.

6.1.1 Red Loamy Earth (DAFWA Soil Group 544)

Red loamy earths (along with red shallow loams) were the most common soil types identified during the profiling of test pits from across the RGP. These soils were predominantly located within the Hub and to a lesser extent the GTS development areas, predominantly in the Jundee and Wyarri land systems (Figure 7). These soils typically contained silty to silty-clayey sands overlying laterite which would be present at a depth of anywhere from 35 cm to 50 cm in the profile. These soils typically housed scattered tree/shrub communities and were typically found in relatively flat environments (Plate 2).

Plate 2: Example of Red Loamy Earth (DAFWA Soil Group 544) - Hub Pit 1

6.1.2 Red Shallow Loam (DAFWA Soil Group 522)

Red shallow loams (DAFWA Soil Group 522) were also very common soils within the RGP. These soils were predominantly found within the Nambi development area, within the Bevon and Violet land systems (Figure 7). These soils are typically very shallow and contain red to red brown sandy loams to a depth of around 20 - 45cm which overlies Indurated (hardpan) or gravelly clay material. These soils were found in flat to gentling sloping environments at higher elevations than in other areas (Plate 3).

Plate 3: Example of Red Shallow Loam (DAFWA Soil Group 522) - Nambi Pit 2

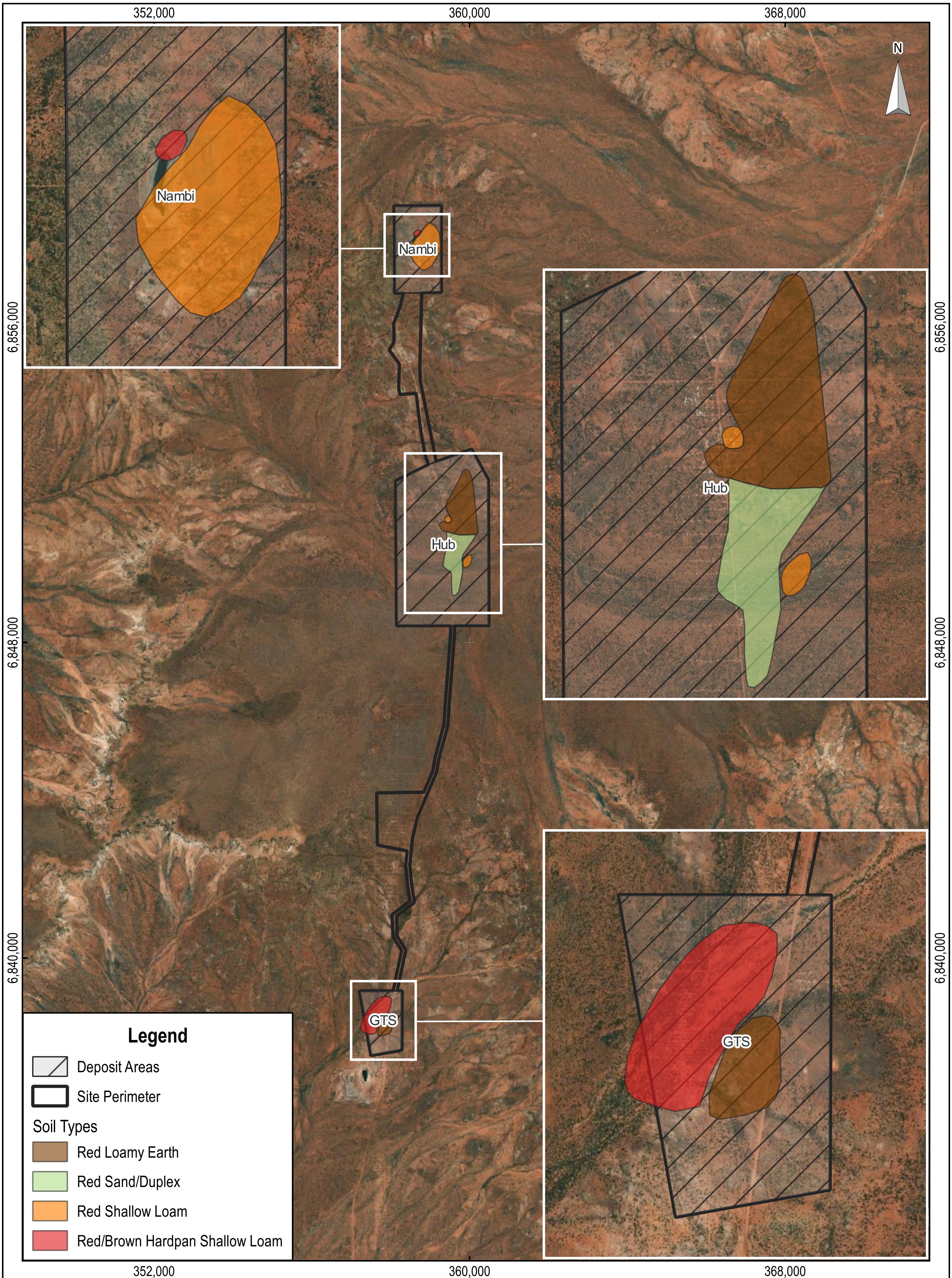
6.1.3 Red Brown Hardpan Shallow Loam (DAFWA Soil Group 523)

Red brown hardpan shallow loam soils were the dominant soil type present in the GTS development area (Figure 7). These soils share many similarities with the red shallow loams outlined above (Section 6.1.2), with the major difference being the presence of a red-brown hardpan layer at approximately 30 cm which was overlain by a red-brown silty sand (Plate 4). These soils were typically present in flat environments and often contained dense surface gravel and supported dense to scattered vegetative communities.

Plate 4: Example of Red-brown Hardpan Shallow Loam (DAFWA Soil Group 523) - GTS Pit 1

6.1.4 Red Sands/Duplexes (DAFWA Soil Groups 405/406/423/445)

Red sands or duplexes are likely to be a minor soil type within the hub development area. Selected surface soils in the Hub Infrastructure Area (HIA) were classed as red sands (HIA1/HIA4). Profiling of these soils was not performed which makes it impossible to further classify these soils with regards to depth and whether they are deep sands or duplex soils.



Scale: 1: 125,000
Original Size: A4

Grid: GDA94 / MGA zone 51
0 1 2 km

Dacian Gold
Redcliffe Gold Project

Figure 7

Map of Dominant Soil Types Across the Redcliffe Gold Project

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7. PHYSICAL PROPERTIES

7.1 GRAVEL CONTENT

The average gravel content by proposed disturbance area is presented below in Table 4 and in detail in Appendix 3 and Appendix 4.

Table 4: Gravel Content of Redcliffe Soils

Disturbance Areas	Sample Type	Gravel Content % (>2 mm)		
		Average	Minimum	Maximum
Camp	Surface	26	6	54
GTS Pit	Surface	21	10	35
	Subsoil	32	17	47
GTS WRD	Surface	15	5	25
	Subsoil	47	27	69
GTS ROM*	Surface	14	-	-
Hub Pit	Surface	22	12	33
	Subsoil	45	38	58
Hub WRD	Surface	22	15	30
	Subsoil	38	16	60
Hub Haul Road	Surface	14	4	24
Hub Infrastructure	Surface	20	3	34
Nambi Pit	Surface	48	44	52
	Subsoil	57	48	64
Nambi WRD	Surface	22	16	34
	Subsoil	44	19	58
Nambi ROM*	Surface	4	-	-
Wyarri Reference*	Surface	25	-	-
Jundee Reference*	Surface	17	-	-
Bullimore Reference*	Surface	3	-	-
Desdemona Reference*	Surface	5	-	-
Bevon Reference*	Surface	27	-	-
Violet Reference*	Surface	9	-	-

*Note: Values with a * represent single samples from a specific proposed disturbance area.*

The following key points are noted:

- Across all samples gravel contents ranged from 3% to 69%.
- Generally, the areas that contained the highest gravel contents was the proposed Nambi pit area in which all samples were between 44% to 64%.
- Across most of the remaining proposed disturbance areas average gravel contents were between 14%-26% in surface soils and between 32%-48% in subsoils.

- The majority of the reference samples contained gravel contents below 17%.

7.2 PARTICLE SIZE DISTRIBUTION

The textural classification of selected soil samples (<2 mm fraction) is presented below in Table 5 and in detail in Appendix 3 and Appendix 4.

Table 5: Particle Size Distribution of Selected Samples

Sample	<2 mm Soil Fraction			Texture
	Sand %	Silt %	Clay %	
Surface Soils				
GTS P3	76	10	14	Sandy Loam
GTS WRD1	86	8	6	Loamy Sand
GTS WRD4	63	14	23	Sandy Clay Loam
HDR1	61.5	10	28.5	Sandy Clay Loam
HIA1	81.5	5	13.5	Sandy Loam
HP3	41	32.5	26.5	Loam
HWRD1	68	8	24	Sandy Clay Loam
NP2	78	11	11	Sandy Loam
NP3	65	22	13	Sandy Loam
NWRD1	83.5	4.5	12	Loamy Sand
NWRD3	76	7	17	Sandy Loam
Subsoils				
GTS P3	75	12	13	Sandy Loam
GTS WRD1	82	11.5	7	Loamy Sand
GTS WRD4	74	11.5	14.5	Sandy Loam
HP3	70	11	19	Sandy Loam
HWRD1	60	11.5	28.5	Sandy Clay Loam
NP2	77	13	10	Sandy Loam
NP3	75	13	12	Sandy Loam
NWRD1	83	10	7	Loamy Sand
NWRD3	83	10	7	Loamy Sand

The following key points are noted:

- There was a large degree of variability in the textural classification of surface soils within the RGP.
- The following samples - GTS WRD4, HDR1, HWRD1 and HP3 were classed as sandy clay loams or loams and contained relatively high clay contents between 23-29% and in the case of sample HP3 a high silt content of 32.5%.
- The remaining surface soils were classed as sandy loams or loamy sands which are more typical of soils present within the region.

- The majority of subsoils were classed as sandy loams or loamy sands including GTS WRD4 and HP3 which were classed as sandy clay loam and loam respectively.
- Sample HWRD1 was the only instance in which surface and subsoils were both classified as a sandy clay loam with both samples containing clay contents between 24% and 28.5%.

7.3 EMERSON CLASS

Data for Emerson Class number which is used to estimate the likelihood of clay dispersion under different environmental conditions is presented in Table 6 and in detail in Appendix 3 and Appendix 4.

Table 6: Emerson Class Data for Selected Redcliffe Soils

Sample	Soil Type	Emerson Class	Classification
GTS P1	Surface	1	Dispersive
	Subsoil	1	Dispersive
GTS P2	Surface	1	Dispersive
	Subsoil	1	Dispersive
GTS WRD2	Surface	2	Dispersive
	Subsoil	4	Non-Dispersive
GTS WRD4	Surface	2	Dispersive
	Subsoil	3	Potentially Dispersive
H P1	Surface	2	Dispersive
	Subsoil	2	Dispersive
H P2	Surface	2	Dispersive
	Subsoil	2	Dispersive
H WRD2	Surface	2	Dispersive
	Subsoil	2	Dispersive
H WRD4	Surface	1	Dispersive
	Subsoil	2	Dispersive
N P1	Surface	3	Potentially Dispersive
	Subsoil	3	Potentially Dispersive
N P2	Surface	2	Dispersive
	Subsoil	3	Potentially Dispersive
N WRD2	Surface	3	Potentially Dispersive
	Subsoil	4	Non-Dispersive
N WRD3	Surface	2	Dispersive
	Subsoil	4	Non-Dispersive

The following key points are noted:

- Surface and subsoils from the GTS pit had an Emerson Class number of 1 and are thus highly dispersive.
- Surface soils from the GTS WRD were also considered dispersive (Emerson Class 2), however, subsoils were unlikely to be spontaneously dispersive (Emerson Class 3-4).

- All soils (surface and subsoils) from the Hub area (pits and WRD) were classed as spontaneously dispersive i.e., Emerson Class 1-2.
- Surface samples from NP2 and NWRD3 were considered spontaneously dispersive (Emerson Class 2), however, the remaining soils in the area were less likely to be dispersive (Emerson Class 3-4).

8. CHEMICAL PROPERTIES

8.1 pH AND SALINITY

Data for soil pH and salinity is presented below in Table 7 and in detail in Appendix 3 and Appendix 4
.

Table 7: pH and EC (Salinity) Data for Selected Soils

Disturbance Area	Soil Type	pH			EC (mS/cm)		
		Average	Minimum	Maximum	Average	Minimum	Maximum
Camp	Surface	4.8	4.4	5.4	3	1	4
GTS Pit	Surface	7.1	6.7	7.5	6	2	11
	Subsoil	7.5	6.6	8.7	16	<1	42
GTS WRD	Surface	6.1	5.5	6.6	8	1	23
	Subsoil	7.9	6.3	8.9	133	7	420
GTS ROM*	Surface	6.6	-	-	2	-	-
Hub Pit	Surface	4.9	4.7	5.0	2	2	3
	Subsoil	5.4	5.2	5.5	3	1	4
Hub WRD	Surface	5.3	4.7	6.3	4	2	8
	Subsoil	6.1	4.9	7.4	3	2	5
Hub Haul Road	Surface	4.8	4.3	5.5	3	2	4
Hub Infrastructure	Surface	5.4	4.7	6.2	5	1	11
Nambi Pit	Surface	7.9	7.7	8.1	13	3	33
	Subsoil	7.4	6.9	7.8	55	4	150
Nambi WRD	Surface	6.6	6.3	7.0	9	2	20
	Subsoil	8.5	8.0	8.9	40	9	79
Nambi ROM*	Surface	5.7	-	-	2	-	-
Wyarri Reference*	Surface	6.6	-	-	68	-	-
Jundee Reference*	Surface	4.6	-	-	3	-	-
Bullimore Reference*	Surface	5.7	-	-	5	-	-
Desdemona Reference*	Surface	4.7	-	-	6	-	-
Bevon Reference*	Surface	6.3	-	-	2	-	-
Violet Reference*	Surface	5.8	-	-	2	-	-

*Note: Values with a * represent single samples from a specific proposed disturbance ore reference area.*

The following key points are noted:

- Across the project area soil pH ranged from 4.3 - 8.9.

- Generally, the most acidic soils were located within the Hub development area and in the proposed camp area in which some soils were recorded as having pH values of <4.5.
- In the Hub area soil acidity decreased with depth with subsoils within the pit and WRD area on average containing pH values 0.5 - 0.8 units higher.
- Soil pH in the GTS and Nambi areas were largely circum neutral to alkaline. Within the GTS pit and WRD and the Nambi WRD areas subsoils were considerably more alkaline than surface soils, whereas the opposite was true in the Nambi pit area.
- The pH of reference (surface) soil samples ranged from 4.6 - 6.6 across the different land-systems.
- EC values ranged from <1 mS/m to 420 mS/m across the project area.
- The majority of samples contained EC values of <15 mS/m which classes these soils as non-saline.
- Four samples representing soils from the GTS WRD, Nambi WRD areas and the Wyarri reference soil contained EC values between 42 mS/m - 79 mS/m which are considered moderate to high salinities.
- A subsoil pit from the GTS WRD had an EC value of 420 mS/m whilst a subsoil from the Nambi pit had a value of 150 mS/m which are both classified as extremely saline soils.

8.2 CATION EXCHANGE CAPACITY

Characteristics of cation exchange capacity (cmol(+)/kg) and ESP for selected soils are presented below and in detail in Table 8.

Table 8: Average Cation Exchange Characteristics of Redcliffe Soils

Disturbance Areas	Soil Type	Exchangeable - cmol(+)/kg							%	
		Ca	K	Mg	Na	Al	Mn	ECEC	BS	ESP
GTS Pit	Surface	2.1	0.4	0.8	0.2	N. D	N. D	3.5	N/A	5
	Subsoil	3.6	0.2	2.9	0.4	N. D	N. D	7.0	N/A	5
GTS WRD	Surface	2.0	0.5	1.0	0.1	0.1	0.04	3.7	96	2
	Subsoil	11.0	1.3	3.1	1.7	0.1	0.02	16.8	99	9
GTS ROM	Surface	2.6	0.6	0.6	0.03	N. D	N. D	3.9	N/A	1
Hub Pit	Surface	0.6	0.2	0.3	0.02	0.8	0.04	1.9	58	10
	Subsoil	3.4	0.4	1.9	0.4	0.6	0.2	6.8	87	6
Hub WRD	Surface	2.4	0.5	1.2	0.1	0.2	0.03	4.4	92	3
	Subsoil	5.8	0.8	3.8	1.0	N. D	N. D	11.3	N/A	3
Hub Haul Road	Surface	1.7	0.3	0.7	0.04	0.2	0.03	3.0	92	8
Hub Infrastructure	Surface	2.3	0.4	1.4	0.1	0.1	<0.02	4.2	98	7
Nambi Pit	Surface	6.1	0.3	3.7	0.3	N. D	N. D	10.3	N/A	2
	Subsoil	11.0	0.1	8.0	1.2	N. D	N. D	20.7	N/A	6
Nambi WRD	Surface	5.6	0.8	1.1	0.1	0.1	0.1	7.6	98	2
	Subsoil	9.0	0.7	1.3	0.3	N. D	N. D	11.3	N/A	3
Nambi ROM	Surface	2.6	0.6	1.1	0.1	0.1	0.02	4.5	97	2
Bullimore Reference	Surface	2.2	0.3	1.2	0.3	0.1	0.03	4.1	97	3
Desdemona Reference	Surface	1.0	0.4	0.4	0.1	0.3	0.1	2.2	86	8
Low		<5	<0.5	<1	<0.3	<0.1	<0.02	<5	<20	<6
Moderate/Typical		5-10	0.5-2	1-5	0.3-1	0.1-1.0	0.02-1.0	5-15	20-60	6-15
High		>10	>2	>5	>1	>1.0	>1	>15	>60	>15

*Note: Values with a * represent the geometric mean of multiple samples from the same disturbance area*
N.D = Not Determined, N/A = Not Applicable

The following key observations are noted:

- Effective Cation Exchange Capacity (ECEC, calculated as the sum of individual cation concentrations) values ranged from 1.9 cmol(+)/kg to 20.7 cmol(+)/kg across the project area. The majority of samples were considered to contain ECEC values that were in the low to typical range with respect to WA soils.
- Subsoil samples from the GTS WRD and Nambi pit were the only instances of soils adjudged to contain an high ECEC.
- These soils contained elevated exchangeable calcium and sodium concentrations, whilst Nambi pit samples also contained elevated exchangeable magnesium concentrations. Elevated exchangeable sodium concentrations were also present in selected Hub WRD samples. Exchangeable concentrations of base

cations (calcium, potassium, magnesium, and sodium) in all remaining samples were classed as low to typical.

- Exchangeable sodium percentages (ESP%) were <13.1% in all samples which classed all soils as having low to moderate sodicity.
- Exchangeable concentrations of acidic cations such as aluminium and manganese were classed as low to moderate in all samples. Base saturation percentages (BS%) were typically >86% indicating little risks regarding the presence of aluminium and/or manganese toxicity on these soils.
- One surface sample from the proposed Hub pit (HP1) contained an elevated exchangeable aluminium concentration of 1 cmol(+)/kg and a low to moderate BS of 42%. This soil was also strongly acidic (pH 4.7) and is therefore the most likely example of a soil in which acidity and/or aluminium toxicity may reduce the growth of vegetation.

8.3 Organic Carbon, Total Nitrogen & Bioavailable Nutrients

8.3.1 Organic Carbon and Total Nitrogen

Results for organic carbon and total nitrogen concentrations in selected soils are presented in Table 9 and in detail in Appendix 2.

Table 9: Average Organic Carbon, Total Nitrogen and Phosphorus Retention Index (PRI) Concentrations in Selected Surface Soils

Disturbance Area	No of Samples	Organic C (%)	Total N (%)	C: N	PRI (mL/g)	Total P (mg/kg)
Camp	4	0.31	0.03	11	47	128
GTS Pit	2	0.48	0.04	11	N. D	N. D
GTS WRD	2	0.36	0.04	9	N. D	N. D
Hub Pit	2	0.37	0.04	10	N. D	N. D
Hub WRD	2	0.36	0.03	12	N. D	N. D
Nambi Pit	2	0.16	0.02	8	N. D	N. D
Nambi WRD	2	0.35	0.04	10	N. D	N. D
Hub Haul Road	1	0.31	0.03	9	N. D	N. D
Hub Infrastructure	1	0.28	0.03	8	N. D	N. D
Low		<0.5	<0.05	<10	0-2	N/G
Med		0.5-1.5	0.05-0.3	10 - 16	2-20	N/G
High		>1.5	>0.3	>16	20-100	N/G

Major observations included:

- The vast majority of soils contained organic carbon and total nitrogen concentrations were low by Western Australian standards.

- Carbon to nitrogen ratios (C:N) were also low to moderate by WA standards and thus if organic materials were applied to these soils would likely be a temporary mineral nitrogen surplus as the carbon is utilised by microorganisms.
- The areas designated for the potential camp all contained PRI values between 39-54 mL/g. PRI is a measure of the ability of soils to adsorb phosphate on surfaces. The PRI values observed here classify these soils as having a high phosphate adsorption capacity.
- On this basis, the eutrophication risk is classified as Category D according to DOW guidelines (DOW, 2008).

8.3.2 Bioavailable Nutrients and Trace Elements

Results for a suite of Mehlich-3 extractable nutrients and trace elements in selected Redcliffe soils are presented in Table 10 and in detail in Appendix 3.

Table 10: Concentrations of Mehlich Extractable Nutrients and Trace Elements in Selected Samples

Disturbance Areas	No of Samples	Mehlich-3 Extractable Concentrations (mg/kg)												
		B	Ca	Co	Cu	Fe	K	Mg	Mn	Mo	Ni	P	S	Zn
GTS Pit	2	0.4	610	1.4	1.2	58	234	118	82	<0.01	0.7	8	7	3
GTS WRD	2	<0.1	365	1.1	1.2	39	245	125	45	<0.01	0.8	7	6	1.2
Hub Pit	2	<0.1	145	1.1	0.9	34	125	38	41	<0.01	0.2	3	17	0.3
Hub WRD	2	<0.1	107	0.2	0.9	39	137	39	16	<0.01	0.2	4	22	1.9
Nambi Pit	2	<0.1	2200	2.0	2.2	69	180	555	46	<0.01	0.7	4	88	1.5
Nambi WRD	2	0.6	770	1.9	1.3	37	255	125	55	<0.01	0.6	5	6	1.0
Hub Haul Road	1	0.4	390	1.0	1.4	55	280	130	44	<0.01	0.3	2	4	0.9
Hub Infrastructure	1	<0.1	140	0.3	0.9	27	200	43	19	<0.01	<0.1	2	32	0.3
Low		<0.1	<50	<1	<0.1	<10	<10	<20	<5	<0.01	<1	<2	<5	<0.2
Moderate/Typical		0.1-2	50-5000	1-60	0.1-5	10-200	10-300	20-2000	5-100	0.01 - 0.05	1-20	2-10	5-200	0.2-5
Elevated		>2	>5000	>60	>5	>200	>300	>2000	>100	>0.05	>20	>10	>200	>5

Major observations are as follows:

- Bioavailable concentrations of calcium, copper, iron, potassium, magnesium, manganese, phosphorus, sulfur, and zinc were generally considered typical of concentrations found in unfertilised Western Australian soils.
- Bioavailable concentrations of elements such as boron, cobalt, molybdenum, and nickel were, however, generally considered low in most of the soils assessed here compared with other undisturbed WA surface soils.
- Examples of bioavailable concentrations that were considered 'elevated' were extremely rare. The only examples were two soils (GTS P3 and NWRD2) which contained elevated bioavailable potassium concentrations (330-380 mg/kg).

8.4 METALS AND METALLOIDS

8.4.1 Aqua Regia Digest Totals

In order to establish site-specific background concentrations of selected metals and metalloids, aqua regia digests were performed on selected soils as outlined in Table 11 , Appendix 3 and Appendix 4.

Concentrations were compared to two the Department of Environment and Conservation (DEC) soil investigation guidelines (DEC 2010), the National Environmental Protection Council (NEPC) 2013 guidelines (NEPC, 2013) and also the global average elemental concentrations for soils (maximum concentrations).

Table 11: Aqua-Regia Digestible Metal and Metalloid Concentrations in Selected Samples

Sample IDs	Aqua-Regia Digestible (mg/kg)											
	Ag	As	Cd	Cr	Cu	Hg	Mn	Ni	Pb	Sb	Se	Zn
GTS Pit 3	<0.05	4.8	0.05	160	24	<0.02	270	23	6.8	0.13	0.6	31
GTS WRD4	<0.05	4.0	<0.05	130	23	<0.02	210	26	7.5	0.09	0.5	32
Hub Pit 2	<0.05	4.5	<0.05	220	21	<0.02	290	18	8.8	0.09	0.9	20
Hub WRD 1	<0.05	4.2	<0.05	230	32	<0.02	230	24	8.7	0.08	1.1	31
Nambi Pit 2	<0.05	3.1	<0.05	91	52	<0.02	290	30	3	<0.05	0.5	44
Nambi WRD2	<0.05	3.4	0.05	130	33	<0.02	390	32	6.9	0.07	0.9	40
Hub Haul Road 3	<0.05	3.4	<0.05	130	21	<0.02	270	13	7.3	0.08	0.6	23
Hub Infrastructure Area 3	<0.05	4.9	<0.05	220	21	<0.02	140	13	9.2	0.07	1.0	18
Bevon Reference	<0.05	2.7	<0.05	110	43	<0.02	350	23	4.9	<0.05	0.6	37
Bullimore Reference	<0.05	3.9	<0.05	120	11	<0.02	140	12	6.6	0.07	0.5	13
Desdemona Reference	<0.05	4.5	<0.05	220	19	<0.02	130	20	9.1	<0.05	0.7	27
Jundee Reference	<0.05	5.5	<0.05	170	18	<0.02	140	15	11	<0.05	0.9	23
Violet Reference	<0.05	3.9	0.06	150	34	<0.02	440	29	7.1	0.07	0.6	33
Wyarri Reference	<0.05	3.7	<0.05	160	32	<0.02	280	34	8.2	0.1	0.5	53
DEC 2010	N/G	20	3	400	100	1	N/G	60	600	N/G	N/G	200
NEPM (2013)	N/G	100	N/G	470	150	N/G	N/G	80	1100	N/G	N/G	200

All metals and metalloids were present in concentrations that are below relevant EIL's.

8.4.2 Bioavailable Contaminants

Results for a suite of Mehlich-3 extractable potential contaminants in selected soils are presented in Table 12 and in detail in Appendix 3.

Table 12: Average Concentrations of Mehlich-3 Extractable Trace Elements and Contaminants in Selected Samples

Disturbance Area	Number of Samples	Mehlich 3 Extractable (mg/kg)			
		As	Cd	Pb	Se
GTS Pit	2	<0.1	0.05	0.6	<0.1
GTS WRD	2	0.1	0.05	0.6	<0.1
Hub Pit	2	0.2	0.03	0.6	<0.1
Hub WRD	2	0.1	0.03	0.6	<0.1
Nambi Pit	2	<0.1	0.05	0.2	<0.1
Nambi WRD	2	<0.1	0.05	0.5	<0.1
Hub Haul Road	1	<0.1	0.04	0.5	<0.1
Hub Infrastructure	1	<0.1	0.03	0.5	<0.1
Elevated		>5	>1	>35	>1.5

Major observations are as follows:

- All samples contained bioavailable concentrations of arsenic, cadmium, lead and selenium that were well below concentrations that are considered 'elevated'.

9. SUMMARY AND MANAGEMENT IMPLICATIONS

9.1 LANDFORMS

- The following landforms were identified within the RGP and were also common throughout the larger region:
  - Irregular low ironstone hills with stony lower slopes supporting mulga shrublands.
  - Extensive sandplains supporting spinifex hummock grasslands.
  - Extensive plains with deep sandy or loamy soils, supporting mulga and wanderrie grasses.
  - Hardpan plains with ironstone gravel mantles, supporting mulga shrublands.
  - Hardpan plains with occasional sandy banks, supporting mulga tall shrublands and wanderrie grasses.
  - Undulating stony and gravelly plains and low rises, supporting mulga shrublands.
  - Granite domes, hills and tors with gritty-surfaced plains supporting mulga and granite wattle shrublands.
  - Granite breakaways and extensive granitic plains, with mulga shrublands and minor halophytic shrublands.
- In addition, the following landmarks were identified within the project area:
  - Dillon Creek runs through tenement M37/1348, whilst creeks associated with this drainage system run through M37/1286.
  - Mt Redcliffe (553 mAHD) is within tenement M37/1286.
- There are no known scientific or evolutionary values associated with the landforms within the project area.
  - The closest geoheritage site to the project area, the Lake Teague (Shoemaker Impact Structure) - Lies approximately 289 km to the north of the RGP.
  - The closest nature reserves to the RGP are the Wanjarri, De La Poer Range and Yeo Lake reserves which are all between 130-246 km from the project boundaries.

9.2 PHYSICAL PROPERTIES OF PROJECT SOILS

Major findings related to the physical properties of Redcliffe soils are outlined below:

- The dominant soil types within the project area were red loamy earths (DAFWA Soil Group 544), red shallow loams (DAFWA Soil Group 522) and red-brown hardpan shallow loams (DAFWA Soil Group 523).
- Red loamy earths were the dominant soils in the Hub development area, red shallow loams were more common in the Nambi area, whilst red-brown hardpan shallow loams were most common in the GTS area (Figure 7).
- The red shallow loams from the Nambi area typically contained relatively high gravel contents (44% - 64%), limited fines contents (11% clay, 11% silt) and were generally unlikely to be highly dispersive (majority Emerson Class 3-4).
- The red loamy earths from the Hub development area contained lower gravel contents (14% - 45%), higher fines contents (23% clay, 13% silt in the <2 mm fraction) and were considered to be spontaneously dispersive (Emerson Class 1-2).
- The red-brown hardpan shallow loams from the GTS area contained similar gravel contents (14% - 47%) to soils in the Hub area. These soils contained limited fines contents (13% clay, 11% silt in the <2 mm fraction) and were generally considered to be spontaneously dispersive (Emerson Class 1-2).
- Soils from the Hub development area in particular appear the most prone to erosion on sloping surfaces due to the combination of relatively abundant dispersive clay/silt materials and relatively low gravel contents.

- Conversely, soils from the Nambi area appear to be the most useful in rehabilitating sloping surfaces as they have low fines contents, low dispersivity and relatively high gravel contents.

9.3 CHEMICAL PROPERTIES OF PROJECT SOILS

Major findings related to the chemical properties of Redcliffe soils are outlined below:

- The red shallow loams from the Nambi area were:
  - Circum neutral to alkaline (pH 6.3 - 8.9), with pit samples becoming more acidic with depth and WRD samples more alkaline with depth.
  - Moderate to highly saline (<150 mS/m) with salinity increasing with depth.
  - Unlikely to be sodic (ESP <6%) and contained moderate to high exchangeable cation concentrations.
  - Very low concentrations of extractable micronutrients such as cobalt, molybdenum and nickel plus low organic carbon and total nitrogen concentrations.
  - Unlikely to contain elevated concentrations of metals and/or metalloids considered to be environmental contaminants.
- The red loamy earths from the Hub area were:
  - Generally acidic (pH 4.3 - 7.4), with samples becoming more alkaline with depth.
  - Non-saline (<11 mS/m).
  - Low to moderately sodicity (ESP 2 - 10%) and also contained low to moderate exchangeable cation concentrations.
  - Unlikely to express aluminium or manganese toxicity due to high base saturation percentages of >87%.
  - Very low concentrations of extractable micronutrients such as boron, cobalt, molybdenum, or nickel plus soils contained low organic carbon and total nitrogen concentrations.
  - Unlikely to contain elevated concentrations of metals and/or metalloids considered to be environmental contaminants.
- The red-brown hardpan shallow loams from the GTS area were:
  - Slightly acidic to slightly alkaline (pH 5.5 - 8.7) with soils becoming more alkaline with depth and likely underlain by calcrete.
  - Extremely saline in subsoils (<420 mS/m) and non-saline in surface soils (<23 mS/m).
  - Unlikely to be either sodic (ESP <9%) or express aluminium/manganese toxicity (BS >99%), and also contained moderate to high exchangeable cation concentrations.
  - Very low concentrations of extractable micronutrients such as boron, cobalt, molybdenum, and nickel plus soils contained low organic carbon and total nitrogen concentrations.
  - Unlikely to contain elevated concentrations of metals and/or metalloids considered to be environmental contaminants.
- Overall, the majority of surface soils assessed here will be largely suitable for rehabilitative purposes. Major findings in the context of soil chemistry include:
  - pH in the Nambi and GTS being of no concern. Surface soils (0-10 cm) in the Hub area are highly acidic, however, given the subsoils (>10 cm) are more alkaline, the blending of material during excavation and stockpiling should alleviate any concerns regarding its ability to support vegetative growth.
  - Surface soils (0-10 cm) are generally non-saline, however, subsoils, particularly in the Nambi and GTS areas contain pockets of extremely saline material which may be hostile to vegetation.
  - The risks of sodicity and aluminium/manganese toxicity are rated as low in all areas.

  - Most surface soils contain low concentrations of extractable micronutrients such as boron, cobalt, molybdenum, and nickel plus contain low organic carbon and total nitrogen concentrations. It is uncertain whether these concentrations indicate deficiencies that may limit the potential for vegetation to recolonise and thus rehabilitate the landscape, although the use of fertilisers should eliminate any nutrient deficiencies. Excessive fertiliser use may, however, encourage weed growth and also lead to plant densities that are not sustainable during periods of drought.
  - No soils contained total or bioavailable concentrations of metals and/or metalloids that are considered possible environmental contaminants.
- In addition, soils from the area designated to be the camp area (within the Sherwood land system) contained PRI values between 39-54 mL/g. PRI is a measure of the ability of soils to adsorb soluble phosphate on surfaces, which in a practical sense details the extent to which soluble phosphate is likely to move within soils. This measurement is often taken for soils in areas designated to become mine villages or camps as a result of wastewater disposal requirements. The PRI values for the camp soils are considered high which supports the placement of the camp within this area. This classes the area for the proposed waste water irrigation field as Category D according to DOW guidelines (DOW, 2008).

9.4 IMPLICATIONS FOR SOIL MANAGEMENT

9.4.1 Landform Disturbance

The area being utilised for the RGP has had a long history of disturbance either from historic mining activities (Nambi) with pastoral activities across the region (Hub and GTS). Consequently, most if not all the landforms within the project area can be considered disturbed in an ecological context and as a result further disturbances as a result of planned mining activities are unlikely to be ecologically significant. In addition, reviews of aerial photography and use of DMIRS GeoVIEW database (DMIRS 2021) demonstrated that the common landforms within the project area were well represented at the regional scale. As a consequence, any disturbances to landforms within the RGP are almost certain to be insignificant at the regional scale.

9.4.2 Soil Harvesting, Storage and Use in Mine Rehabilitation

The purpose of soil harvesting is to ensure that there are sufficient volumes of topsoil and, if required, subsoil of suitable quality for rehabilitation of disturbed areas at mine closure or for progressive rehabilitation. The dominant soils in the three areas of the RGP differ, however, in general they can all be utilised in project planning (construction/engineering purposes) and project closure rehabilitation to some extent as outlined in Table 13.

Table 13: Details and Rehabilitation Potential of Surface and Subsoils From Across the Redcliffe Gold Project

Characteristic	Hub		Nambi		GTS	
	Surface	Subsoil	Surface	Subsoil	Surface	Subsoil
Dominant Type	Red Loamy Earths		Red Shallow Loams		Red-Brown Hardpan Shallow Loams	
Texture	Sand clay loams/loams	Sandy clay loams/sandy loams	Sandy loams	Sandy loams	Sandy clay loams/sandy loams	Sandy Loams
Maximum harvestable depth	10 cm	<50 cm	10 cm	<30 cm	10 cm	<50 cm
Physical status	High erosion risk - abundant 'fines', high dispersivity, low gravel		Low erosion risk - low 'fines', low dispersivity, high gravel		Moderate erosion risk - low 'fines', high dispersivity, low gravel	
pH status	Strongly acidic	Acidic	Circum neutral - alkaline	Alkaline	Circum neutral	Alkaline
Salinity status	Non-saline	Non-saline	Non-saline	Moderate/high salinity	Non-saline	High/extreme salinity
Aluminium, manganese toxicity	Moderate risk (to acid sensitive species)	Low risk	Low risk	Low risk	Low risk	Low risk
Nutritional status	Low C, N + B, Co, Mn, and Ni	Not Assessed	Low C, N + Co, Mn, and Ni deficient	Not Assessed	Low C, N + B, Co, Mn, and Ni deficient	Not Assessed
Contaminant status	No risk	Not Assessed	No risk	Not Assessed	No risk	Not Assessed
Potential use in/on	Vegetative rehabilitation Flat surfaces Clay source	Vegetative rehabilitation Flat surfaces Clay source Laterite/hardpan source	Vegetative and structural rehabilitation Flat and sloping surfaces	Structural rehabilitation Flat and sloping surfaces Laterite/hardpan source	Vegetative rehabilitation Flat surfaces	Laterite/hardpan source
Avoid use in/on	Sloping surfaces - erosion prone. Areas with acid-susceptible vegetation	Sloping surfaces - erosion prone. Areas with acid-susceptible vegetation	N/A	Vegetative rehabilitation - high salinity	Sloping surfaces - erosion prone	Sloping surfaces - erosion prone Vegetative rehabilitation - Extreme salinity
Estimated harvestable volumes (m^3) (Maximum)*	98,400	393,600	62,800	125,600	42,700	170,800
Harvestable Clay Volumes (m^3) (Maximum)*	22,632	94,464	N/A	N/A	N/A	N/A

** Estimated soil/clay volumes are based on the maximum available resources present on site i.e., harvesting the entire soil profile from a planned disturbance area.*

9.4.2.1 Surface Soils

Generally surface soils from across the RGP have the potential to be used in post closure rehabilitation, predominantly as a medium for vegetative recolonisation of mine landforms. This is largely due to these soils being:

- Non-saline.
- Unlikely to exhibit aluminium or manganese toxicity.
- Unlikely to contain elevated concentrations of total or bioavailable contaminants.

Surface soils from all three areas are potentially deficient in trace elements such as boron, cobalt, manganese, and nickel, however, it is uncertain as to how significant this will be in the context of limiting the growth of vegetation and in addition any issues could be rectified via the careful use of fertilisers.

Soils from the Hub area are strongly acidic (pH <5) which has the potential to limit the growth of non-acid tolerant plant species. This can also be rectified easily via the application of agricultural lime to increase soil pH or via the blending of surface soils with some subsoil material or soils from other areas which have a higher pH.

Surface soils from the Hub area and the GTS area to a lesser extent are likely to be susceptible to erosion given they contain a relatively high 'fines' content, dispersive clay materials and low gravel contents. It is therefore recommended that these soils are not used on sloping surfaces. Surface soils from Nambi area do not share these properties and can therefore be used in rehabilitation on both flat and sloping surfaces as required.

The GTS area contains the highest proportion of potentially acid forming (PAF) waste rock, and it is therefore possible that greater volumes of soil may need to be harvested from this area if there is insufficient non-acid forming (NAF) rock to cover all PAF material to a minimum depth of 5-10m.

Finally, surface soils from the Hub area contain relatively high clay contents (up to 30% by mass) and thus represent a significant clay source that could potentially be harvested and used in mining operations (Table 13), such as anti-seepage layers for waste landforms such as TSFs and WRDs.

9.4.2.2 Subsoils

Subsoils within the RGP have a number of characteristics that are useful for rehabilitation and/or mine planning activities. All three areas contain laterite/hardpan/calcrete materials at a depth of within 50 cm which are useful materials for stabilising waste landforms and can be used to generate rock mulch to support vegetative growth if required. In this assessment the extent of the laterite/hardpan layer below the soil profile was not determined and thus calculating the available laterite/hardpan/calcrete resources available is beyond the scope of this assessment.

Subsoils from the Hub area share similar characteristics with those in surface soils and can therefore be used to promote vegetative rehabilitation on flat surfaces and as a potential (subject to geotechnical testing) source of clay materials (Table 13).

Subsoils from Nambi typically contain a high gravel content and a low proportion of dispersive clay/silt materials making them suitable as a cover material on sloping surfaces. There is a risk of subsoils from Nambi being saline, which has the potential to limit the success of vegetative growth on rehabilitated surfaces. This could, however, be alleviated by the blending with non-saline or rock mulch cover material.

Subsoils from the GTS area are, however, unlikely to be extensively utilised in rehabilitation given they are extremely saline, have a low gravel content and contain dispersive clay/silt materials.

Surface soils and harvested laterite/hardpan should be managed in accordance with the *Statutory Guidelines for Mining Proposals in Western Australia* (DMIRS 2020) and constructed to a maximum height of two metres. Harvesting of dry soil should not be undertaken during windy conditions as the sandy soil has potential to generate significant volumes of dust.

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APPENDICES

APPENDIX 1: SOIL ASSESSMENT METHODOLOGY

1. INTRODUCTION

1.1 SOIL TEST METHODOLOGY

Understanding the physical, chemical and biological properties of soils is dependent on the ability of scientists and land managers to critically evaluate and assess data provided by meaningful soil tests. A multitude of different soil tests, often intended to measure the same soil quality parameter, have been developed over many years for various reasons, including:

- Characterisation of the diversity of soil types around the world with widely different physical and chemical properties.
- Cost - market forces by land managers, especially farmers, have driven development of soil tests that are simple, rapid and cheap to form, even though technically superior procedures exist.
- Speed of assessment: Rapid advances in laboratory automation, technical capabilities of modern instruments and data management systems.
- Increasing demands to deal with emerging issues of natural resource management including sustainability issues, environmental protection, soil health and food safety.

Unlike water and geological analysis, total elemental composition of soils generally provides will little predictive capacity for assessing the ability of soil to provide necessary levels of nutrients for good plant growth. For this reason, different soil tests for specific nutrients have been developed using extracting solutions that mimic the role of plant roots for taking up nutrients from soil.

In recent times, there have been attempts by various organisations to standardise laboratory methods throughout Australia. Most government and commercial soil testing laboratories in Australia now use standard methods, or validated variations derived from the following sources:

- Chemical analysis for agriculture and land management: Soil Chemical Methods – Australian (Rayment and Lyons 2011).
- Environmental assessment: NEPC. 2013. National Environment Protection (Assessment of Site Contamination) Measure. Guideline on Laboratory Analysis of Potentially Contaminated Soil. Schedule B3. National Environment Protection Council.
- Physical and engineering properties of soil: Australian Standard AS 1289.0-2000.

MBS Environmental provides soil characterisation assessments, mainly for the mining industry in WA and other Australian states, to inform pre-feasibility studies, mining proposals and closure planning to meet regulators' requirements. Soil test data and interpretation is provided to meet the following objectives:

- Properties of regional and project areas soils in terms of:
  - Physicochemical attributes including acidity, alkalinity, salinity, sodicity, texture, fertility and structural stability.
  - An indication of the volumes of suitable topsoils and subsoils that can be harvested and stockpiled for rehabilitation activities.
  - Ability to assimilate potential environmental contaminants such as hydrocarbons, metals, metalloids, nutrients, salts, acidity and pathogens.
- Achieving acceptable mine closure outcomes to provide a land surface that is:
  - Structurally stable and safe.
  - Non-polluting (surface water run-off, groundwater and air quality).
  - Compatible with post-mineral land use requirements.

Note that MBS Environmental does not offer geophysical and geotechnical soil assessment for engineering purposes such as constructions of roads, structures and water storages.

1.2 INFORMATION SOURCES

Interpretation of laboratory and field soil testing results and observations requires not only accurate data, but also a "Decision Support System" that provides meaningful predictions of soil properties and behaviour. A reliable Decision Support System needs to be:

- Developed and validated for local conditions including soil types, climate and land use.
- Able to predict soil constraints that may limit productivity and health of vegetation including:
  - Crop plants for agricultural land use on different soil types and environmental settings.
  - Pasture and feed value for pastoral land use.
  - Native plants for rehabilitation of degraded or disturbed areas, especially for WA plant species that are specially adapted to low nutrient and poorly structured soils.
- Able to quantify the risk of ecological and human health impacts for a specific location relating to:
  - Heavy metals and metalloids.
  - Nutrient runoff and leaching.
  - Petroleum hydrocarbons.
  - Agro-chemicals including insecticides and herbicides.

There is an enormous volume of interpretative soil test information available in response to the diversity of soil test methods and differences in soil types throughout the world. However, it is important that the information used be validated against local conditions and for this reason, much of the information published by reputable authorities in overseas countries is not applicable to Australian conditions.

The following sources of information are used by MBS Environmental to assess the significance of laboratory test results:

- Soil Analysis: An Interpretation Manual (Peverill *et al.* 1999). This reference was compiled by specialists from CSIRO and State Government agricultural research agencies. It is biased towards agricultural production, mainly in the eastern states, although it does reference large volumes of research provided by WA researchers between 1960 and 1998.
- Interpreting Soil Test Results. What do all the numbers mean? (Hazelton and Murphy 2007). This document was written specifically for officers in the former Soil Conservation Service of NSW, but is now used widely by soil professionals in other Australian States.
- Soil Guide. A handbook for understanding and managing agricultural soils. DAFWA Bulletin 4343 (DAFWA 2001). This document was prepared specifically for WA agricultural land use.
- Land Evaluation Standards for Land Resource Mapping (assessing land qualities and determining land capability in south-western Australia). DAFWA Resource Management Technical Report 298 (DAFWA 2005). This report describes the standard method for attributing and evaluating conventional land resource survey maps in the south-west agriculture region of Western Australia so that strategic decisions about the management, development and conservation of land resources can be based on the best information available.
- Understanding soil analysis data. DAFWA Resource Management Technical Report 327 (DAFWA 2008). The aim of this report is to help people who are interested in soil science, but are not specialists in this area, to better understand soil analysis reports in particular, and soil data in general.
- Soilquality.org.au website, with contributions from the University of Western Australia, DAFWA, Wheatbelt Natural Resource Management, Grains Research & Development Corporation, South Coast Natural Resource Management and the Grower Group Alliance.

MBS Environmental also draws upon the author's experience from coordinating physical and chemical laboratory analysis for DAFWA and DPaw soil and biological surveys conducted between 1988 and 2008. These include:

- Reference soils of south-western Australia (McArthur 1991). This publication presents soil profile descriptions and laboratory analysis of samples from the O, A and B soil horizons from 161 locations between Geraldton and Esperance in south-western Australia.
- Laboratory soil test results for about 10,000 soil samples from soil surveys of WA conducted by DAFWA between 1989 and 2007. Details of these surveys are presented in DAFWA Resource Management Technical Report 280, Soil-Landscape Mapping in South-Western Australia, Overview of methodology and outputs (DAFWA 2004).
- Soil analysis data to support the following biological surveys conducted by the Department of Parks and Wildlife (DPaW):
  - Pilbara region biological survey, 2002-2007 (George *et al*. 2009).
  - Floristic surveys of the banded iron formation ranges of the Yilgarn, 2005 to 2008 (Meissner and Caruso, 2008).
  - Wetland flora and vegetation of the WA wheatbelt, 2004.

2. PHYSICAL PROPERTIES

2.1 PARTICLE SIZE AND TEXTURE

2.1.1 Field Measurements

Soil texture describes the proportions of sand, silt and clay particles; the particle size distribution. Sands are mineral particles with an effective diameter between 0.02 and 2 mm, silt from 0.002 to 0.02 mm and clay less than 0.002 mm.

The field (or hand texture) of soil can be assigned by describing the behaviour of a sample of field sieved (<2 mm) soil when moistened to field capacity and kneaded into a ball or bolus and then pressed out between the thumb and forefinger to form a ribbon (bolus) (McDonald *et al.* 1990). The behaviour of the soil during bolus formation and the length of the ribbon define the field texture grade, as summarised in Table A1-1.

Table A1-1: Field Texture Grades

Texture Grade	Behaviour of Moist Bolus	Approximate Clay Content
Sand	Nil to very slight coherence; cannot be moulded; single sand grains adhere to fingers	<5%
Loamy sand	Slight coherence; can be sheared between thumb and forefinger to give a small ribbon (~5 mm)	About 5%
Clayey sand	Slight coherence; sticky when wet; many sand grains stick to fingers, discolours fingers with stain; ribbon 5 to 15 mm	5-10%
Sandy loam	Coherent bolus but very gritty; dominant sand grains of medium size and readily visible; ribbon of 15 to 25 mm	10-20%
Loam	Bolus coherent and spongy; no obvious grittiness or silkiness; ribbon about 25 mm	About 25%
Sandy clay loam	Strongly coherent bolus; sandy to touch; ribbon of 25 to 40 mm	20-30%
Clay loam	Coherent plastic bolus; smooth to manipulate; ribbon of 40 to 50 mm	30-35%
Clay loam, sandy	Coherent plastic bolus; sand grains visible in finer matrix; ribbon of 40 to 50 mm	30-35%
Light clay	Plastic bolus; smooth to touch; slight resistance to shearing; ribbon of 50 to 75 mm	35-40%
Light medium clay	Ribbon of about 75 mm; slight to moderate resistance to ribboning shear	40-45%
Medium clay	Smooth plastic bolus; can be moulded into rods without fracture; moderate resistance to ribboning shear; ribbons 75 mm of longer	45-55%
Medium heavy clay	Ribbons of 75 mm or longer; moderate to firm resistance to ribboning shear	≥50%
Heavy clay	Extremely plastic; firm resistance to ribboning shear; ribbons of 75 mm or longer	≥50%

2.1.2 Laboratory Measurements

Soil texture assessment can be undertaken by two distinct laboratory methodologies:

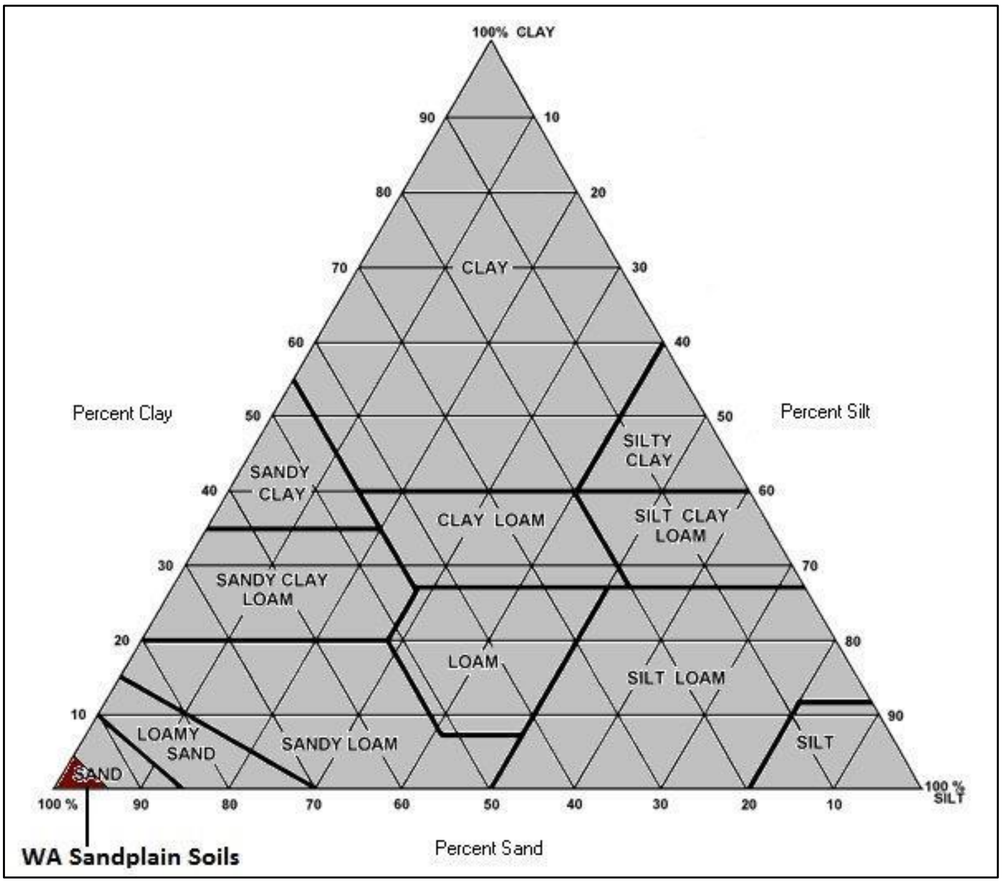
- Particle size determination. This method involves determination of the relative proportions of and, silt and clay sized particles, usually by a combination of sedimentation (hydrometer measurements) and sieving, and classifying the sol texture using the "soil texture triangle" (Figure 1). The method is preferred by land capability and land management professionals.
- Atterberg limits. This methodology, favoured by engineers, classifies soil on the basis of measurements for:
  - Plastic limit, defined as the amount of water added to dry soil to reach a plastic state.
  - Liquid limit, defined as the amount of water added to dry soil to reach a fluid state.
  - Plasticity Index, defined as the difference between the liquid limit (% by weight, dry soil basis) and plastic limit ((% by weight, dry soil basis).

In most cases, field texture grades align well with laboratory based classifications. Poor correlation is occasionally observed for unusual soil types, especially highly saline soils and compacted ferruginous soils (plinthites).

Soil texture information based on laboratory particle size measurements is often used to predict other soil physical characteristics such as hydraulic permeability and water holding capacity (DAFWA 2004). Although laboratory tests are available for direct measurement of these properties, the methodology is comparatively expensive and requires specific sample collection and preservation techniques.

The southwest and arid interior of WA is represented by vast tracts of sandplain, especially dune fields in the Great Sandy and Great Victoria Deserts and coastal plains between Geraldton and Esperance. The sandy nature of these soils in indicated in Figure 1.

Figure 1: Soil Texture Triangle



2.2 DISPERSION POTENTIAL

The structural stability of loams and clay soils can be assessed by a simple field test referred to as the Emerson aggregate test (AS 1289 C8.1 1980). The test involves observation of the behaviour of natural soil aggregates (peds) and subsamples of soil remoulded at field capacity when placed in deionised water. Poorly structured soils, often containing sodic clays (Section 3.3), exhibit low strength when wet, resulting in rapid slaking of aggregates and dispersion of fine clays, resulting in a cloudy halo when placed in deionised water.

The Emerson Aggregate Test provides an Emerson class number ranging from 1 to 8, with Emerson class number 1 indicating soils with weak structure and high potential for clay dispersion, while Emerson class number 8 indicating soils that do not slake, swell or disperse when placed in water. Soil aggregates that slake and disperse readily (Emerson class numbers 1, 2 and 3) indicate weak structure that is easily disrupted by raindrop impact or mechanical disturbance and therefore prone to water erosion, especially on sloping landforms.

The Emerson aggregate test requires submission of a field sample in which natural aggregates have been preserved and not destroyed by crushing and grinding. For this reason, samples provided by reverse circulation drilling are not suitable.

Description of Emersion class numbers are presented in Table A1:2.

Table A1:2: Emerson Aggregate Test Class Numbers

Class Number	Description
Class 1	Dry aggregates slake and completely disperse within several hours.
Class 2	Dry aggregates slake and partly disperse after 24 hours.
Class 3a	Dry aggregates slake but do not disperse. Remoulded soil disperses completely.
Class 3b	Dry aggregates slake but do not disperse. Remoulded soil partly disperses.
Class 4	Dry aggregates slake but do not disperse. Remoulded soil does not disperse. Soil contains free carbonate minerals and / or gypsum.
Class 5	Dry aggregates slake but do not disperse. Remoulded soil does not disperse. No carbonates or gypsum present. 1:5 suspension in water remains dispersed
Class 6	Dry aggregates slake but do not disperse. Remoulded soil does not disperse. No carbonates or gypsum present. 1:5 suspension in water flocculates.
Class 7	Dry aggregates do not slake. Aggregates swell.
Class 8	Dry aggregates do not slake. Aggregates do not swell.

2.3 SOIL WATER RELATIONSHIPS

Physical characteristics of soil, especially drainage and water storage, play critically important roles in the ability of soils to support sustainable plant growth. Well drained soils with low water holding capacity, such as those with deep sandy profiles, retain relatively little water from rainfall, and therefore require a deep profile to support plant growth. Conversely, poorly drained clay soils are subject to water-logging as a consequence of very slow infiltration rates. Many plant species perform poorly in water-logged soils as a consequence of low oxygen availability, or high risk of fungal disease (especially *Phytophora*).

Providing meaningful laboratory results for hydraulic conductivity and water holding capacity in the laboratory is complicated by the nature of the sample submitted for analysis. These tests require an undisturbed core sample to reflect physical characteristics of soil in its natural environment. Other physical and chemical soil tests are usually conducted on a homogenised sample that has been crushed and sieved to break down natural structure and allow removal of coarse fragments. The inherent structure of undisturbed soil, which comprises various micro, meso and macropores determines drainage and water storage characteristics. During a mining project, soil required for waste landform rehabilitation is disturbed at regular intervals by processes including compaction, vegetation clearing, soil harvesting, stockpiling, re-spreading, blending with waste rock and contour ripping – all of which changes these physical soil characteristics.

MBS Environmental does not recommend laboratory testing for these soil properties for reason discussed above (and high costs). Useful information relating to assessment of these soil properties is better provided by field observations by an experienced soil scientist, and by correlation with more easily measured soil properties such as particle size distribution.

2.3.1 Hydraulic Permeability

The rate at which the water moves through a soil profile depends on the soil's permeability (the ease with which water can be transmitted). The permeability of a soil to water is described by its hydraulic conductivity (K), which is usually measured on an intact soil core sample to reflect field conditions. Darcy's Law combines the effects of gradient and hydraulic conductivity to calculate the quantity of water (flux) flowing in a saturated system:

$$\text{Flux rate in a saturated system (mm/h)} = -K_s * (\Delta\psi/\Delta z)$$

where K_s is the saturated hydraulic conductivity,
$\Delta\psi$ is the change in matric potential, and
Δz is the change in distance.

Hydraulic conductivity is highest in soils with a porous structure and where the pores are interconnected (i.e. coarse sands, gravels and structured loam and clay soils). Common values for K_s for soils of different texture are presented in Table A1-3. In general, K_s values greater than 1×10^{-6} m/sec (0.1 m/day) represent freely draining conditions, while soils where K_s is less than 1×10^{-9} (0.0001 m/day) are almost impermeable.

Table A1-3: K_s Values of Soils of Different Texture Classes

Texture / Soil Type	K_s (m/sec)
Gravel	10^{-2} to 10^{-3}
Coarse sand	10^{-3}
Medium sand	10^{-4}
Fine sand	10^{-5}
Loam	10^{-5} to 10^{-6}
Clay soils	10^{-6} to 10^{-7}
Compacted clays	10^{-7} to 10^{-12}

Provided soils are well graded, contain mainly spherical particles and Low Activity Clays (LAC) clay minerals, it is possible to estimate the K_s of compacted soil using Hazen's formula, which states that K_s (m/s) is related to the 10th percentile particle diameter (d_{10} expressed as mm) by the equation:

$K_s = C (d_{10})^2$, where C is a constant between 0.4 and 1.2 (typically 1.0).

2.3.2 Water Holding Capacity

Pore space is that fraction of the soil with potential to be occupied by air and/or water. The *matric potential* (ψ) is the potential produced by capillary and surface forces, or alternatively, the suction pressure by which water is held by the soil. Most soil water is stored in capillaries (or pores) of varying diameter and connectivity. Water stored in very fine (micro) capillaries requires a very high suction force to drain the water. For this reason, water stored in these pores may not be available for plant uptake. On the other hand, water stored in large diameter pores may drain from the soil profile by gravitational forces, and therefore drains beyond the root zone before it can be accessed by plant roots. The amount of water stored in "mesopores", i.e. water that is not tightly by bound in soil, but does not drain rapidly, is termed "Available Water capacity" (AWC).

AWC is defined as the difference between the upper storage limit (USL) and lower storage limit (LSL) per unit depth (v/v) or mass (w/w). AWC is a capacity measure (e.g. 200 mm/m) while *available water* (or available water storage) is a mass or volume measure related to water extraction by plants or to a specified depth (e.g. 75 mm to a depth of 0.5 m). Values of AWC range from 20 mm/m in very coarse sands to more than 250 mm/m in finer textured soils, with the typical range being 50 to 150 mm/m for WA soils. Typical values for soils of different texture classes are presented in Table A1-4 (adapted from DAFWA 2001).

Table A1-4: AWC Values of Soils of Different Texture Classes

Texture / Soil Type	Clay Content (%)	Sand Size Fraction	AWC (mm/m)
Sand	<5	Coarse	~20
		Medium	30-50
		Fine	50-70
Loamy/clayey sands	5-10	Coarse	50-60
		Medium	60-90
		Fine	80-100
Sandy loam	15-20	Coarse	50-220
		Medium	60-170
		Fine	140-220
Light sandy clay loam	15-20	Coarse	50-150
		Medium	90-220
		Fine	100-180
Loam	25	-	100-240
Sandy clay loam	20-30	-	100-190
Clay loam	30-35	-	100-210
Sandy clay	35-40	-	80-150
Clay (non-cracking)	>35	-	90-140
Clay (cracking)	>35	-	~210

3. CHEMICAL PROPERTIES

3.1 PH

As with many measurements on soil, pH values vary with the procedure used. Being a solution measurement, pH of dry soil is effectively meaningless. Soil pH estimates are undertaken in the laboratory by shaking a sample of dry, sieved soil with a standard volume of either deionised water or a dilute salt solution, followed by pH measurement with a calibrated pH meter. pH measurements using deionised water at a sample : solution ratio of 1:5 are widely used for land capability assessment, while use of 0.01 M calcium chloride as the equilibrating solution is preferred for agricultural purposes as this method has been shown by researchers as a superior indicator of phytotoxicity of soil.

The soil pH rating Table adopted for use by MBS Environmental is presented in Table A1-5. The rating table applies to measurements using the 1:5 deionised water extraction method.

Table A1-5: Soil pH Rating Table

pH Range	Rating
1.8 - 3.4	Ultra acid
3.5 - 4.4	Extremely acid
4.5 - 5.0	Very strongly acid
5.1 - 5.5	Strongly acid
5.6 - 6.0	Moderately acid
6.1 - 6.5	Slightly acid
6.6 - 7.3	Circum-neutral
7.4 - 7.8	Slightly alkaline
7.9 - 8.4	Moderately alkaline
8.5 - 9.0	Strongly alkaline
9.1 - 10	Very strongly alkaline
>10	Ultra alkaline

From Rayment and Lyons (2011), adapted from Bruce and Rayment 1982 and USDA 2004.

3.2 ELECTRICAL CONDUCTIVITY AND SALINITY

Measurement of electrical conductivity (EC) of recovered soil porewater, or more commonly either porewater recovered after wetting the sample to saturation or using the 1:5 soil:water extract from pH measurement. EC of the saturation extract is referred to as ECe, while EC of the 1:5 soil:water extract is referred to as EC (1:5).

ECe is considered to be the superior indication of salinity; values of <200 mS/m indicate very low salinity, while values >1,600 indicate high salinity, regardless of the soil type. However, measurement of ECe involves a labour intensive test method and therefore not commonly requested. Salinity risk assessment based on EC (1:5) measurements need to consider the soil type. Table A1-6 presents soil salinity rating classes used by MBS Environmental for sand, loam and clay soil types.

Table A1-6: Salinity Rating Table

Soil Type	Salinity Rating Based on EC (1:5) (mS/m)				
	Nil	Slight	Moderate	High	Extreme
Sand	0 – 15	15 - 25	25 – 50	50 – 100	>100
Loam	0 – 20	20 – 35	35 – 70	70 – 150	>150
Clay	0 - 25	25 - 50	50 - 100	100 - 200	>200

3.3 EXCHANGEABLE CATIONS

The ability of soil to behave as a cation exchange material has been known for more than a century. The major soil cations fall into two distinct groups:

- Basic soil cations comprising Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}.
- Acidic cations comprising H^{+}, Al^{3+} and Mn^{2+}. The sum of these cations is referred to as either “exchangeable” or “titratable” acidity.

At a fixed pH, the sum of all soil cations (when expressed in units of centimoles of positive charge per kilogram, cmol(+)/kg) is constant. This value is referred to as the Cation Exchange Capacity (CEC), which is measured at either pH 7 for circum-neutral soils or pH 8.5 for soils containing free calcium carbonate.

The main soil components contributing to CEC are organic matter and clay minerals. CEC values typically range from <2 cmol(+)/kg) for highly weathered siliceous sands, to 10 cmol(+)/kg) for clay loam soils containing kaolinite as the dominant clay mineral, to greater than 50 cmol(+)/kg) for soils containing clay minerals belonging to the smectite (montmorillonite) or illite group. CEC is an important property for productive agricultural soils as it plays a major role in retention of essential plant nutrients and influencing the physical structure of clay rich soil types.

While most laboratories provide cost-effective methods for measuring soil CEC, it is more common to measure the individual soil cations after extraction with ammonium chloride solution (at either pH 7 or pH 8.5). These procedures are effective at extracting the basic soil cations, but the acidic soil cations are not extracted. For circum-neutral and alkaline soil types, the sum of the concentrations of basic soil cations is very close to the measured CEC. In such cases, the sum of the basic soil cations (expressed in units of cmol(+)/kg)) is referred to as Effective CEC (ECEC).

For acidic soils, the contribution of the acidic soil cations becomes increasingly significant. In such cases, ECEC calculation requires inclusion of the ‘exchangeable acidity” component. Alternatively, use of unbuffered 0.1 M barium chloride as the cation displacing extractant allows for measurement of extraction aluminium and manganese, in addition to the basic soil cations. Although exchangeable hydrogen has not been measured, this sum of the basic cations plus exchangeable aluminium and manganese provides an acceptable estimate of ECEC.

The relative proportions of the four basic cations play a major role on the structure of clay rich soil type. Calcium, magnesium and potassium are essential plant nutrients and contribute to good soil structure by allowing effective exchange of air and water into the soil matrix during both wetting and drying cycles. Exchangeable sodium, however, is not conducive to good soil structure and sodium rich (sodic) clays are prone to spontaneous dispersion (Section 2.2), resulting in hard-setting soils when dry and highly erodible soils when saturated.

The acidic soil cations are also undesirable components of a healthy soil, particularly the aluminium component as soluble aluminium is phytotoxic to plants. Elevated concentrations of soluble manganese, which is associated with high concentrations of exchangeable manganese in acidic soils, may also be phytotoxic.

Two important derived parameters from exchangeable cation soil measurements are Base Saturation Percentage (BS%) and Exchangeable Sodium Percentage (ESP). BS% is the sum of the basic soil cations divided by the measured CEC (or ECEC if exchangeable acidity has been measured) and expressed as a percentage. Circum-neutral and alkaline soils have very high BS% values, while acidic soils may have much lower BS% values. BS% provides a better indication of potential soil acidity problems than pH measurements. For example, a soil with a pH of 4.5 and BS% of 30% is likely to be toxic to plants, while a soil with pH of 4.5 and BS% of 80% may not be toxic.

ESP is the exchangeable sodium concentration divided by the measured CEC (or ECEC for circum-neutral and alkaline soils) and expressed as a percentage. ESP values as low as 6% can be responsible for poor structure. ESP values greater than 6% identify sodic soils (Northcote and Skene 1972), which are highly susceptible to structural degradation and erosion.

Table A1-7: Ratings for Exchangeable Cations and Related Parameters

Parameter	Units	Rating		
		Low	Medium	High
CEC	cmol(+)/kg	<5	5 - 15	>15
Calcium	cmol(+)/kg	<5	5 - 10	>10
Magnesium	cmol(+)/kg	<1	1 - 5	>5
Sodium	cmol(+)/kg	<0.3	0.3 – 1.0	>1.0
Potassium	cmol(+)/kg	<0.5	0.5 -2.0	>2.0
Aluminium	cmol(+)/kg	<0.1	0.1 – 1.0	>1.0
Manganese	cmol(+)/kg	<0.02	0.02 – 1.0	>1.0
BS%	%	<20	20 - 60	>60
ESP	%	<6 (non-sodic)	6 – 15 (moderately sodic)	>15 (highly sodic)

Adapted from DAFWA 2004.

3.4 ORGANIC CARBON AND SOIL NITROGEN

Soil organic matter is a critical component of a healthy soil. It plays a major role in maintaining good soil structure, retaining moisture and nutrients and a source of food and energy for soil microbial activity.

Soil organic matter contains 45% to 55% carbon, with most of the balance being oxygen, hydrogen and nitrogen, with lower but still important concentrations of phosphorus and sulfur. There are two reliable laboratory methods for measuring soil organic carbon, which is a very good indicator of soil organic matter content:

- Wet oxidation, with the Walkley and Black method (Walkley and Black 1934) being the most common variation.
- Combustion, occasionally referred to as LECO® Total Organic Carbon.

By international standards, WA soils contain low concentrations of organic carbon. Organic carbon content is dependent upon soil texture and climate, with sandy soils and soil from tropical northern WA and arid central WA containing lower carbon contents (typically <1% in topsoil) compared to clay and loam soils from the temperature southwest corner of WA.

Soil organic matter is also responsible for most of the total nitrogen content of soil, with the remainder (typically <5% of total nitrogen) being in the mineral ammonium (NH_4^+) and nitrate (NO_3^-) forms. Mineralisation of soil organic matter by microbial activity can convert some of this organic nitrogen into mineral nitrogen, which is then available for uptake by plants. However, the amount of nitrogen that can be released by mineralisation is variable and determined largely by the ratio of organic carbon to nitrogen (C/N ratio). For soils with low C/N ratios, mineralisation of soil organic matter releases substantial amounts of mineral nitrogen. Alternatively, microbes breaking down carbon rich soil organic matter require more nitrogen than is available from organic matter, resulting in removal of mineral forms of nitrogen naturally present in soil. This is known as "nitrogen drawdown" and is common when carbon rich woody mulch or leaf litter is added to soil as a soil conditioner or water retentive mulch. Ratings descriptions for organic carbon, total nitrogen and C/N ratio are presented in Table A1-8.

Table A1-8: Ratings Table for Organic Carbon, Total Nitrogen and C/N Ratio

Parameter	Rating		
	Low	Medium	High
Organic carbon, A1 horizon, northern and eastern WA	<0.5%	0.5 – 1.5%	>1.5%
Organic carbon, A2 and B horizon, northern and eastern WA	<0.05%	0.05 – 0.3%	>0.3%
Organic carbon, A1 horizon, southwest WA	<1%	1 – 2%	>2%
Organic carbon, A2 and B horizon, southwest WA	<0.1%	0.1 – 0.5%	>0.5%
Total nitrogen, A1 horizon, northern and eastern WA	<0.05%	0.05 – 0.3%	>0.3%
Total nitrogen, A1 horizon, southwest WA	<0.1	0.1 – 0.5%	>0.5%
Total nitrogen, A2 and B horizons	Generally not measured		
C/N ratio	<10	10 - 16	>16

Adapted from DAFWA 2004.

3.5 BIOAVAILABLE NUTRIENTS

Soil testing is widely used for diagnosing potential nutrient deficiencies and imbalances in soils used for agriculture. Large fertiliser companies often provide cost-effective soil testing packages that provide fertiliser recommendations based on soil test results.

The decision support systems required for provision of reliable fertiliser recommendations based on soil test require a large volume of calibration data based on field trials conducted over many years for different crop plants and on different soil types. The soil tests used also vary for different nutrients as summarised below:

- Phosphorus and potassium use 0.5 M sodium bicarbonate.
- Sulfur uses 0.25 M potassium chloride.
- Boron uses extraction with hot 0.01 M calcium chloride solution.
- Multi-element test for micro-nutrients (Cu, Fe, Mn and Zn) uses 0.005 M DTPA solution.

With the exception of phosphorus (Handreck 1997a and 1997b), there is very little published information available that relates nutrient soil test results with the health of Australian native plants. Also, native plant establishment on disturbed WA soil types is considered to be limited mainly of constraints such as low water holding capacity, salinity or elevated acidity/alkalinity rather than nutrient deficiencies or imbalances. Even in circumstances where nutrient deficiency has been identified as a potential limitation for rehabilitating disturbed sites with WA native plants, land managers are often reluctant to apply additional nutrients in the form of organic or chemical fertilisers on the potential for promoting weed establishment.

MBS Environmental has adopted the Mehlich 3 multi-element soil test methodology (Mehlich 1984) as a cost-effective alternative method to the suite of nutrient soil tests listed above to assess mine site soils for potential nutrient deficiencies, toxicity or imbalance that may affect revegetation outcomes. Concentrations assigned to low, typical and elevated ranges presented in Table A1-9 were derived from the following information:

- Correlations between calibrated single nutrient soil test values (specific for each nutrient) and plant response, typically crop plants under glasshouse or controlled field experiments (Peverill et al. 1999).
- Correlations between Mehlich 3 and calibrated single nutrient soil test results (Walton and Allen 2004). Most of the single nutrient tests correlate well the Mehlich 3 test for acidic, neutral and slightly alkaline (but non-calcareous) WA soil types.
- Results for surface samples analysed from DAFWA and DPaW soil surveys (Section 1.2) and previous mine site surveys conducted by MBS Environmental.

The "Low" rating corresponds approximately to the lowest fifth percentile of unfertilised WA surface soil types and indicates conditions that may result in deficiency to plants not adapted to very low nutrient concentrations in soils. These soil types are often highly weathered siliceous sands in moderate to high rainfall areas in the southwest of WA.

The "Elevated" rating corresponds approximately to the 95th percentile of unfertilised WA surface soil types and may indicate conditions resulting in either nutrient imbalances or toxicities to plant not adapted to high nutrient (especially micronutrients such as boron) concentrations.

Table A1-9: Ratings Table for Bio-available Nutrients (mg/kg), Mehlich 3 Test

Nutrient	Rating		
	Low	Typical Range	Elevated
Phosphorus	<2	2 - 10	>10
Potassium	<10	10 - 300	>300
Calcium	<50	50 – 5,000	>5,000
Magnesium	<20	20 – 2,000	>2,000
Sulfur	<5	5 - 200	>200
Boron	<0.1	0.1 - 2	>2
Copper	<0.1	0.1 - 5	>5
Iron	<10	10 – 200	>200
Manganese	<5	5 - 100	>100
Molybdenum	<0.01	0.01 – 0.05	>0.05
Zinc	<0.2	0.2 - 5	>5

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APPENDIX 2: SOIL PROFILE DESCRIPTIONS

Sample Location and Details						
Site	NP1	**GPS Coordinates**	51	358642.6	mE	Page 1 of 36
				6857965.5	mN	
Locality	Pit	**Date**	26-Aug-21		**Time**	Not Provided

Vegetation and Landscape	
Slope & Elevation	540m, flat
Vegetation	Cleared
Landscape	Disturbed, cleared pad

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Brown red loose-silty sand
10-20cm	Brown red gravelly sand over hardpan
Sample Register	NP1 0-10cm, NP1 10-20cm

Photographs

Photo 1:

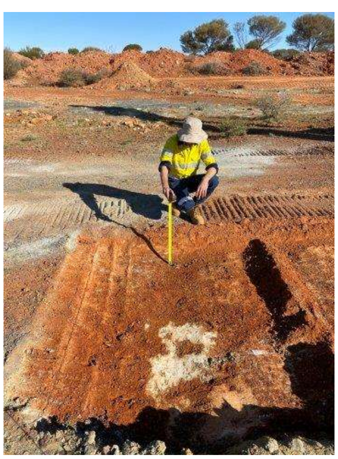

Photo 2:

Sample Location and Details							
Site	NP2	**GPS Coordinates**	51	358586	mE	Page 2 of 36
				6857960	mN	
Locality	Pit	**Date**	26-Aug-21		**Time**	Not Provided

Vegetation and Landscape	
Slope & Elevation	541m, flat
Vegetation	Cleared
Landscape	Disturbed, cleared pad

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Brown red loose-gravel silt
10-20cm	Brown loose-gravel silt
Sample Register	NP2 0-10cm, NP2 10-20cm

Photographs

Photo 1:

Photo 2:

Sample Location and Details						
Site	NP3	**GPS Coordinates**	51	358667	mE	Page 3 of 36
				6858359	mN	
Locality	Pit	**Date**	26-Aug-21		**Time**	Not Provided

Vegetation and Landscape	
Slope & Elevation	547m, flat
Vegetation	Shrub - scarce
Landscape	Disturbed woody debris. Moved away from built up pad

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Pink-brown loose-gravel silt
10-20cm	Brown red loose-gravel silt
Sample Register	NP3 0-10cm, NP3 10-20cm

Photographs

Photo 1:

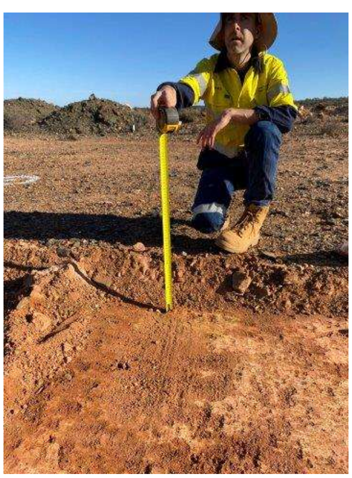

Photo 2:

Sample Location and Details							
Site	NWRD1	**GPS Coordinates**	51	358974	mE	Page 4 of 36
				6858540	mN	
Locality	WRD	**Date**	26-Aug-21		**Time**	Not Provided

Vegetation and Landscape	
Slope & Elevation	531m, flat
Vegetation	Trees-shrub wildflowers
Landscape	On minor track and adjacent to creek

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Brown-red silty-sand gravel
10-45cm	Brown-red loose- gravel silty sand over bedrock/calcrete
Sample Register	NWRD1 0-10cm, NWRD1 10-45cm

Photographs

Photo 1:

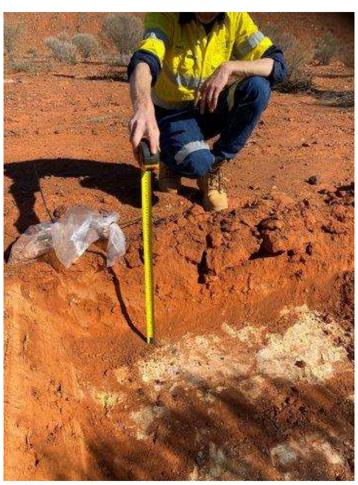

Photo 2:

Sample Location and Details						
Site	NWRD2	**GPS Coordinates**	51	359044	mE	Page 5 of 36
				6858248	mN	
Locality	WRD	**Date**	26-Aug-21		**Time**	Not Provided

Vegetation and Landscape	
Slope & Elevation	547m, flat
Vegetation	Shrub - scarce
Landscape	Ironstone-float on surface

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Pink-brown loose-gravel silt
Sample Register	NWRD2 0-10 cm, NWRD2 10-40cm

Photographs

Photo 1:

Photo 2:

Sample Location and Details						
Site	NWRD3	**GPS Coordinates**	51	358953.6	mE	Page 6 of 36
				6857936	mN	
Locality	WRD	**Date**	26-Aug-21	**Time**	Not Provided	

Vegetation and Landscape	
Slope & Elevation	539m, slight slope
Vegetation	Trees/scrub -scarce
Landscape	Ironstone-float on surface

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Gravelly-silt
10-30cm	Loose silty sand
Sample Register	NWRD3 0-10 cm, NWRD3 10-30cm

Photographs

Photo 1:

Photo 2:

Sample Location and Details							
Site	HP1	**GPS Coordinates**	51	359358.4	mE		Page 7 of 36
				6850943	mN		
Locality	Pit	**Date**	26-Aug-21		**Time**		Not Provided

Vegetation and Landscape	
Slope & Elevation	501m, flat
Vegetation	Tree/shrub - scarce
Landscape	Sparse rock float/woody debris/ disturbed surrounding area

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Loose- silty sand
10-38cm	Gravelly sand -laterite
Sample Register	HP1 0-10 cm, HP1 10-38 cm

Photographs

Photo 1:

Photo 2:

Sample Location and Details							
Site	HP2	**GPS Coordinates**	51	359447.3	mE	
				6851116	mN	
Locality	Pit	**Date**	26-Aug-21		**Time**	Not Provided

Vegetation and Landscape	
Slope & Elevation	501m, flat
Vegetation	tree/shrub - scattered
Landscape	Sparse rock floats/ woody debris/ flowering bush

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Loose Silty Sand
10-50cm	Silty sand - laterite
Sample Register	HP2 0-10 cm, HP2 10-50 cm

Photographs

Photo 1:

Photo 2:

Sample Location and Details							
Site	HP3	**GPS Coordinates**	51	359348.5	mE	Page 9 of 36
				6850958	mN	
Locality	Pit	**Date**	26-Aug-21		**Time**	Not Provided

Vegetation and Landscape	
Slope & Elevation	532m, flat
Vegetation	Trees/shrub - scattered
Landscape	Disturbed/cleared land/ on existing track

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Brown-red gravelly-silt
Sample Register	HP3 0-10 cm, HP3 10-25 cm

Photographs

Photo 1:

Photo 2:

Sample Location and Details							
Site	HWRD1	**GPS Coordinates**	51	359555.9	mE	Page 10 of 36	
				6851412	mN		
Locality	WRD	**Date**	26-Aug-21		**Time**	Not Provided	

Vegetation and Landscape	
Slope & Elevation	499m
Vegetation	Tree/shrub - scattered
Landscape	Angular quartz-ironstone float/disturbed

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Loose- silty sand
10-40cm	Silty sand - laterite
Sample Register	HWRD1 0-10 cm, HWRD1 10-40 cm

Photographs

Photo 1:

Photo 2:

Sample Location and Details							
Site	HWRD2	**GPS Coordinates**	51	359768.1	mE	Page 11 of 36	
				6851269	mN		
Locality	WRD	**Date**	26-Aug-21		**Time**	Not Provided	

Vegetation and Landscape	
Slope & Elevation	499m
Vegetation	Tree/shrub - scarce
Landscape	Angular quartz-ironstone float/woody debris

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Loose- silty sand- gravel
10-50cm	Gravelly sand -laterite
Sample Register	HWRD2 0-10 cm, HWRD2 10-50 cm

Photographs

Photo 1:

Photo 2:

Sample Location and Details							
Site	HWRD3	**GPS Coordinates**	51	359827.4	mE	Page 12 of 36
				6851071	mN	
Locality	WRD	**Date**	26-Aug-21		**Time**	Not Provided

Vegetation and Landscape	
Slope & Elevation	496m
Vegetation	Tree/shrub - scarce - scattered
Landscape	Abundant quartz-ironstone float/ hard ground

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Loose- silty sand
10-25cm	Sandy-mottled/minor bleaching -laterite
Sample Register	HWRD3 0-10 cm, HWRD3 10-25 cm

Photographs

Photo 1:

Photo 2:

Sample Location and Details							
Site	HWRD4	**GPS Coordinates**	51	359699	mE	
				6850849	mN	
Locality	WRD	**Date**	26-Aug-21		**Time**	Not Provided

Vegetation and Landscape	
Slope & Elevation	504m
Vegetation	Tree/shrub - scarce
Landscape	Abundant quartz-ironstone float

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Loose- silty sand
10-35cm	Silty sand - laterite
Sample Register	HWRD4 0-10 cm, HWRD4 10-35 cm

Photographs

Photo 1:

Photo 2:

Sample Location and Details						
Site	GTS P1	**GPS Coordinates**	51	357372	mE	Page 14 of 36
				6838210	mN	
Locality	Pit	**Date**	26-Aug-21		**Time**	Not Provided

Vegetation and Landscape	
Slope & Elevation	485m
Vegetation	Tree/shrub - dense
Landscape	Moved location out of creek line. Access difficult due to vegetation

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Loose- silty sand
10-35cm	Loose-silty sand
Sample Register	GTS P1 0-10 cm, GTS P1 10-35 cm

Photographs

Photo 1:

Photo 2:

Sample Location and Details

Site	GTS P2	**GPS Coordinates**	51	357476	mE	Page 15 of 36
				6838415	mN	
Locality	Pit	**Date**	26-Aug-21		**Time**	Not Provided

Vegetation and Landscape

Slope & Elevation	491m, slight slope
Vegetation	Tree/shrub
Landscape	Close to creek line

Soil / Soil Profile Annotation

Profile	Description
0-10cm	Sandy silt
10-25cm	Gravelly-silt
Sample Register	GTS P2 0-10 cm, GTS P2 10-25 cm

Photographs

Photo 1:

Photo 2:

Sample Location and Details							
Site	GTS P3	**GPS Coordinates**	51	357594	mE	Page 16 of 36	
				6838219	mN		
Locality	Pit	**Date**	26-Aug-21		**Time**	Not Provided	

Vegetation and Landscape	
Slope & Elevation	486m, flat
Vegetation	Tree/shrub
Landscape	Close to creek line

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Silty-sand
10-50cm	Gravelly-silt
Sample Register	GTS P3 0-10 cm, GTS P3 10-50 cm

Photographs

Photo 1:

Photo 2:

<table>
<tr><th colspan="7">Sample Location and Details</th></tr>
<tr><td rowspan="2">Site</td><td rowspan="2">GTS WRD1</td><td rowspan="2">GPS Coordinates</td><td rowspan="2">51</td><td>357810</td><td>mE</td><td rowspan="2">Page 17 of 36</td></tr>
<tr><td>6838856</td><td>mN</td></tr>
<tr><td>Locality</td><td>WRD</td><td>Date</td><td colspan="2">26-Aug-21</td><td>Time</td><td>Not Provided</td></tr>
</table>

Vegetation and Landscape	
Slope & Elevation	497m, flat
Vegetation	Tree/shrub - scattered
Landscape	Close to creek line

Soil / Soil Profile Annotation

Profile	Description
0-10cm	Silty-sand
10-40cm	Gravelly-silt over calcrete
Sample Register	GTS WRD1 0-10 cm, GTS WRD1 10-40 cm

Photographs

Photo 1:

Photo 2:

Sample Location and Details							
Site	GTS WRD2	**GPS Coordinates**	51	357838	mE	Page 18 of 36
				6838636	mN	
Locality	WRD	**Date**	26-Aug-21		**Time**	Not Provided

Vegetation and Landscape	
Slope & Elevation	496m, flat
Vegetation	Tree/shrub - sparse
Landscape	Quartz-ironstone float

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Gravelly sandy-silt
10-45cm	Gravelly-silt
Sample Register	GTS WRD2 0-10 cm, GTS WRD2 10-45 cm

Photographs

Photo 1:

Photo 2:

Sample Location and Details						
Site	GTS WRD3	**GPS Coordinates**	51	357863	mE	Page 19 of 36
				6838430	mN	
Locality	WRD	**Date**	26-Aug-21		**Time**	Not Provided

Vegetation and Landscape	
Slope & Elevation	501m, flat
Vegetation	Tree/shrub - sparse
Landscape	Quartz-ironstone float

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Gravelly-silt
10-55cm	Gravelly-silt
Sample Register	GTS WRD3 0-10 cm, GTS WRD3 10-55 cm

Photographs

Photo 1:

Photo 2:

Sample Location and Details						
Site	GTS WRD4	**GPS Coordinates**	51	357904	mE	Page 20 of 36
				6838259	mN	
Locality	WRD	**Date**	26-Aug-21		**Time**	Not Provided

Vegetation and Landscape	
Slope & Elevation	488m, flat
Vegetation	Tree/shrub - sparse
Landscape	

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Silty-sand
10-20cm	Silty-gravel
Sample Register	GTS WRD4 0-10 cm, GTS WRD4 10-20 cm

Photographs

Photo 1:

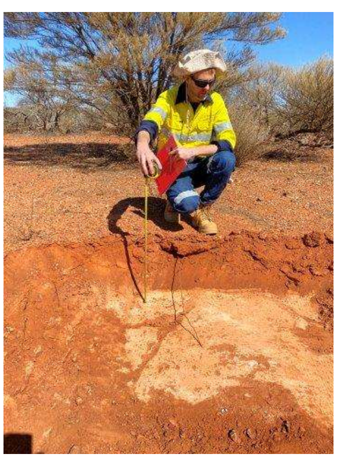

Photo 2:

Sample Location and Details							
Site	NROM	**GPS Coordinates**	51	358830	mE	Page 21 of 36
				6857625	mN	
Locality	ROM	**Date**	18-Jul-21		**Time**	Not Provided

Vegetation and Landscape	
Slope & Elevation	511m, flat
Vegetation	Dense
Landscape	Drainage system, rock fragments woody debris with some termite activity

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Red brown silty sand, drainage system
Sample Register	NROM

Photographs

Photo 1:

Photo 2:

Sample Location and Details							
Site	GTS ROM	**GPS Coordinates**	51	357772	mE		
				6838124	mN		
Locality	ROM	**Date**	18-Jul-21	**Time**		Not Provided	

Vegetation and Landscape	
Slope & Elevation	486m, flat
Vegetation	Groves
Landscape	Wood debris, edge of quartz float and next to creek (drainage system)

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Red brown clayey sand
Sample Register	GTS ROM

Photographs

Photo 1:

Photo 2:

<table>
<tr><th colspan="7">Sample Location and Details</th></tr>
<tr><td rowspan="2">Site</td><td rowspan="2">HDR1</td><td rowspan="2">GPS Coordinates</td><td rowspan="2">51</td><td>359941</td><td>mE</td><td rowspan="2"></td></tr>
<tr><td>6852276</td><td>mN</td></tr>
<tr><td>Locality</td><td>Diversion Road</td><td>Date</td><td colspan="2">18-Jul-21</td><td>Time</td><td>Not Provided</td></tr>
<tr><th colspan="7">Vegetation and Landscape</th></tr>
<tr><td colspan="2">Slope & Elevation</td><td colspan="5">495m, flat</td></tr>
<tr><td colspan="2">Vegetation</td><td colspan="5">Groves</td></tr>
<tr><td colspan="2">Landscape</td><td colspan="5">Quartz + ironstone scree, with grass tufts in woodlands, termite mounds and animal diggings</td></tr>
<tr><th colspan="7">Soil / Soil Profile Annotation</th></tr>
<tr><td colspan="2">Profile</td><td colspan="5">Description</td></tr>
<tr><td colspan="2">0-10cm</td><td colspan="5">Red brown silty clayey sand</td></tr>
<tr><td colspan="2"></td><td colspan="5"></td></tr>
<tr><td colspan="2"></td><td colspan="5"></td></tr>
<tr><td colspan="2"></td><td colspan="5"></td></tr>
<tr><td colspan="2"></td><td colspan="5"></td></tr>
<tr><td colspan="2">Sample Register</td><td colspan="5">HDR1</td></tr>
<tr><th colspan="7">Photographs</th></tr>
<tr><td colspan="4">Photo 1:</td><td colspan="3">Photo 2:</td></tr>
</table>

Sample Location and Details

Site	HDR2	**GPS Coordinates**	51	360124	mE	Page 24 of 36
				6850805	mN	
Locality	Diversion Road	**Date**	18-Jul-21		**Time**	Not Provided

Vegetation and Landscape

Slope & Elevation	495m, flat
Vegetation	Groves
Landscape	Magnetic Fe nodules (<10mm,>2mm), termites and low trees and shrubs

Soil / Soil Profile Annotation

Profile	Description
0-10cm	Red brown silty clayey sand
Sample Register	HDR2

Photographs

Photo 1: **Photo 2:**

<table>
<tr><th colspan="7">Sample Location and Details</th></tr>
<tr><td rowspan="2">Site</td><td rowspan="2">HDR3</td><td rowspan="2">GPS Coordinates</td><td rowspan="2">51</td><td>359976</td><td>mE</td><td rowspan="2">Page 25 of 36</td></tr>
<tr><td>6850030</td><td>mN</td></tr>
<tr><td>Locality</td><td>Diversion Road</td><td>Date</td><td colspan="2">18-Jul-21</td><td>Time</td><td>Not Provided</td></tr>
<tr><th colspan="7">Vegetation and Landscape</th></tr>
<tr><td colspan="2">Slope & Elevation</td><td colspan="5">499m, flat</td></tr>
<tr><td colspan="2">Vegetation</td><td colspan="5">Groves</td></tr>
<tr><td colspan="2">Landscape</td><td colspan="5">Leaf litter, woody debris, flood plain</td></tr>
<tr><th colspan="7">Soil / Soil Profile Annotation</th></tr>
<tr><td colspan="2">Profile</td><td colspan="5">Description</td></tr>
<tr><td colspan="2">0-10cm</td><td colspan="5">Red brown silty sand</td></tr>
<tr><td colspan="2"></td><td colspan="5"></td></tr>
<tr><td colspan="2"></td><td colspan="5"></td></tr>
<tr><td colspan="2"></td><td colspan="5"></td></tr>
<tr><td colspan="2">Sample Register</td><td colspan="5">HDR3</td></tr>
<tr><th colspan="7">Photographs</th></tr>
<tr><td colspan="4">Photo 1:</td><td colspan="3">Photo 2:</td></tr>
</table>

<table>
<tr><th colspan="7">Sample Location and Details</th></tr>
<tr><td rowspan="2">Site</td><td rowspan="2">HDR4</td><td rowspan="2">GPS Coordinates</td><td rowspan="2">51</td><td>359660</td><td>mE</td><td rowspan="2"></td></tr>
<tr><td>6849339</td><td>mN</td></tr>
<tr><td>Locality</td><td>Diversion Road</td><td>Date</td><td colspan="2">18-Jul-21</td><td>Time</td><td>Not Provided</td></tr>
</table>

Vegetation and Landscape	
Slope & Elevation	496m, flat
Vegetation	Dense
Landscape	Wood debris, leaf litter

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Red brown clayey sand, wood debris, leaf litter
Sample Register	HDR4

Photographs

Photo 1:

Photo 2:

<table>
<tr><th colspan="7">Sample Location and Details</th></tr>
<tr><td rowspan="2">Site</td><td rowspan="2">HIA1</td><td rowspan="2">GPS Coordinates</td><td rowspan="2">51</td><td>359516</td><td>mE</td><td rowspan="2">Page 27 of 36</td></tr>
<tr><td>6850612</td><td>mN</td></tr>
<tr><td>Locality</td><td>Infrastructure Area</td><td>Date</td><td colspan="2">18-Jul-21</td><td>Time</td><td>Not Provided</td></tr>
</table>

Vegetation and Landscape	
Slope & Elevation	501m, flat
Vegetation	Low trees sparse - low shrubs mod dense
Landscape	Quartz + ironstone with ~5mm rounded clasts (mature system)

Soil / Soil Profile Annotation

Profile	Description
0-10cm	Red brown fine subrounded clasts in sand (pooly sorted)
Sample Register	HIA1

Photographs

Photo 1: **Photo 2:**

<table>
<tr><th colspan="7">Sample Location and Details</th></tr>
<tr><td rowspan="2">Site</td><td rowspan="2">HIA2</td><td rowspan="2">GPS Coordinates</td><td rowspan="2">51</td><td>359832</td><td>mE</td><td rowspan="2"></td></tr>
<tr><td>6850499</td><td>mN</td></tr>
<tr><td>Locality</td><td>Infrastructure Area</td><td>Date</td><td colspan="2">18-Jul-21</td><td>Time</td><td>Not Provided</td></tr>
<tr><th colspan="7">Vegetation and Landscape</th></tr>
<tr><td colspan="2">Slope & Elevation</td><td colspan="5">498m, flat</td></tr>
<tr><td colspan="2">Vegetation</td><td colspan="5">Scattered</td></tr>
<tr><td colspan="2">Landscape</td><td colspan="5">Thin duricrust, Fe/qz scree, qz fragments, woody debris</td></tr>
<tr><th colspan="7">Soil / Soil Profile Annotation</th></tr>
<tr><td colspan="2">Profile</td><td colspan="5">Description</td></tr>
<tr><td colspan="2">0-10cm</td><td colspan="5">Red brown gravelly clayey sand</td></tr>
<tr><td colspan="2"></td><td colspan="5"></td></tr>
<tr><td colspan="2"></td><td colspan="5"></td></tr>
<tr><td colspan="2"></td><td colspan="5"></td></tr>
<tr><td colspan="2">Sample Register</td><td colspan="5">HIA2</td></tr>
<tr><th colspan="7">Photographs</th></tr>
<tr><td colspan="4">Photo 1:</td><td colspan="3">Photo 2:</td></tr>
</table>

<table>
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<tr><td>6850296</td><td>mN</td></tr>
<tr><td>Locality</td><td>Infrastructure Area</td><td>Date</td><td colspan="2">18-Jul-21</td><td>Time</td><td>Not Provided</td></tr>
<tr><th colspan="7">Vegetation and Landscape</th></tr>
<tr><td colspan="2">Slope & Elevation</td><td colspan="5">499m, flat</td></tr>
<tr><td colspan="2">Vegetation</td><td colspan="5">Groves</td></tr>
<tr><td colspan="2">Landscape</td><td colspan="5">Thin duricrust, leaf litter minor grass tuffs, mounded ant nest with leaf litter aligned</td></tr>
<tr><th colspan="7">Soil / Soil Profile Annotation</th></tr>
<tr><td colspan="2">Profile</td><td colspan="5">Description</td></tr>
<tr><td colspan="2">0-10cm</td><td colspan="5">Red brown clayey sand</td></tr>
<tr><td colspan="2"></td><td colspan="5"></td></tr>
<tr><td colspan="2"></td><td colspan="5"></td></tr>
<tr><td colspan="2"></td><td colspan="5"></td></tr>
<tr><td colspan="2">Sample Register</td><td colspan="5">HIA3</td></tr>
<tr><th colspan="7">Photographs</th></tr>
<tr><td colspan="4">Photo 1:</td><td colspan="3">Photo 2:</td></tr>
</table>

Sample Location and Details							
Site	HIA4	**GPS Coordinates**	51	359521	mE		Page 30 of 36
				6849970	mN		
Locality	Infrastructure Area	**Date**	18-Jul-21		**Time**		Not Provided

Vegetation and Landscape	
Slope & Elevation	501m, flat
Vegetation	Dense
Landscape	Adjacent creek, rock and flow debris, moved sampling area ~3m north to be out of actual creek bed

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Brown silty sand
Sample Register	HIA4

Photographs

Photo 1:

Photo 2:

Sample Location and Details							
Site	BvREF	**GPS Coordinates**	51	358643	mE	Page 31 of 36	
				6857966	mN		
Locality	Reference	**Date**	18-Jul-21		**Time**	Not Provided	

Vegetation and Landscape	
Slope & Elevation	524m, slope
Vegetation	Dense
Landscape	Base of terraces, rocky and channelled, wood debris, sloping east

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Brown silty clayey sand (with clasts)
Sample Register	BvREF

Photographs	
Photo 1:	**Photo 2:**

<table>
<tr><th colspan="8">Sample Location and Details</th></tr>
<tr><td rowspan="2">Site</td><td rowspan="2">ViREF</td><td rowspan="2">GPS Coordinates</td><td rowspan="2">51</td><td>358983</td><td>mE</td><td rowspan="2" colspan="2">Page 32 of 36</td></tr>
<tr><td>6857126</td><td>mN</td></tr>
<tr><td>Locality</td><td>Reference</td><td>Date</td><td colspan="2">18-Jul-21</td><td>Time</td><td colspan="2">Not Provided</td></tr>
<tr><th colspan="8">Vegetation and Landscape</th></tr>
<tr><td colspan="2">Slope & Elevation</td><td colspan="6">511m, slight slope</td></tr>
<tr><td colspan="2">Vegetation</td><td colspan="6">Sparse</td></tr>
<tr><td colspan="2">Landscape</td><td colspan="6">Edge of angular quartz float with polished Fe rounded to subrounded nodules, slight slope to the west</td></tr>
<tr><th colspan="8">Soil / Soil Profile Annotation</th></tr>
<tr><td colspan="2">Profile</td><td colspan="6">Description</td></tr>
<tr><td colspan="2">0-10cm</td><td colspan="6">Red brown silty clayey sand</td></tr>
<tr><td colspan="2"></td><td colspan="6"></td></tr>
<tr><td colspan="2"></td><td colspan="6"></td></tr>
<tr><td colspan="2"></td><td colspan="6"></td></tr>
<tr><td colspan="2"></td><td colspan="6"></td></tr>
<tr><td colspan="2">Sample Register</td><td colspan="6">ViREF</td></tr>
<tr><th colspan="8">Photographs</th></tr>
<tr><td colspan="4">Photo 1:</td><td colspan="4">Photo 2:</td></tr>
</table>

Sample Location and Details							
Site	JuREF	**GPS Coordinates**	51	358806	mE	
				6850444	mN	
Locality	Reference	**Date**	18-Jul-21		**Time**	Not Provided

Vegetation and Landscape	
Slope & Elevation	501m, flat
Vegetation	Dense
Landscape	Thin duricrust, sub-rounded (~2-5mm) clasts within sample, woody debris and leaf litter around sampling area

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Red brown clayey sand
Sample Register	JuREF

Photographs

Photo 1:

Photo 2:

Sample Location and Details						
Site	BuREF	**GPS Coordinates**	51	358422	mE	Page 34 of 36
				6848628	mN	
Locality	Reference	**Date**	18-Jul-21	**Time**		Not Provided

Vegetation and Landscape	
Slope & Elevation	497m, flat
Vegetation	Dense
Landscape	Spinafex and dense low shrubs with sparse trees, patchy moderately sorted gravelly sand on top of mod thick duricrust into hardpan.

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Red brown sandy clay
Sample Register	BuREF

Photographs

Photo 1:

Photo 2:

<table>
<tr><th colspan="8">Sample Location and Details</th></tr>
<tr><td rowspan="2">Site</td><td rowspan="2">DeREF</td><td rowspan="2">GPS Coordinates</td><td rowspan="2">51</td><td>360344</td><td>mE</td><td rowspan="2" colspan="2"></td></tr>
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<tr><th colspan="8">Vegetation and Landscape</th></tr>
<tr><td colspan="2">Slope & Elevation</td><td colspan="6">495m, flat</td></tr>
<tr><td colspan="2">Vegetation</td><td colspan="6">Dense</td></tr>
<tr><td colspan="2">Landscape</td><td colspan="6">Leaf litter, wood debris, grass tussocks and animal burrows</td></tr>
<tr><th colspan="8">Soil / Soil Profile Annotation</th></tr>
<tr><td colspan="2">Profile</td><td colspan="6">Description</td></tr>
<tr><td colspan="2">0-10cm</td><td colspan="6">Brown silty clay sand</td></tr>
<tr><td colspan="2"></td><td colspan="6"></td></tr>
<tr><td colspan="2"></td><td colspan="6"></td></tr>
<tr><td colspan="2"></td><td colspan="6"></td></tr>
<tr><td colspan="2">Sample Register</td><td colspan="6">DeREF</td></tr>
<tr><th colspan="8">Photographs</th></tr>
<tr><td colspan="4">Photo 1:</td><td colspan="4">Photo 2:</td></tr>
</table>

Sample Location and Details						
Site	WyREF	**GPS Coordinates**	51	358119	mE	Page 36 of 36
				6837971	mN	
Locality	Reference	**Date**	18-Jul-21		**Time**	Not Provided

Vegetation and Landscape	
Slope & Elevation	490m, slight slope
Vegetation	Sparse trees - scattered bluebush
Landscape	Base of small rise with abundant quartz float and lithic clasts over mound area, duricrust, possible cryptogamic crust.

Soil / Soil Profile Annotation	
Profile	Description
0-10cm	Red brown sandy clay
Sample Register	WyREF

Photographs

Photo 1:

Photo 2:

APPENDIX 3: COLLATED ANALYTICAL RESULTS

Table A1 - Gravel Content, Texture and Emerson Class

Area	Sample ID	Type	Stones	Sand	Silt	Clay	Emerson Class
			%				1-6
Camp	Res_Camp_01	Surface	32				
Camp	Res_Camp_02	Surface	54				
Camp	Res_Camp_03	Surface	6				
Camp	Res_Camp_04	Surface	17				
Camp	Res_Camp_05	Surface	14				
Camp	Res_Camp_06	Surface	32				
GTS	GTSP1B	Subsoil	47				1
GTS	GTSP2B	Subsoil	17				1
GTS	GTSP3B	Subsoil	33	75	12	13	
GTS	GTSP1A	Surface	10				1
GTS	GTSP2A	Surface	35				1
GTS	GTSP3A	Surface	18	76	10	14	
GTS	GTSWRD1B	Subsoil	27	82	11.5	7.5	
GTS	GTSWRD2B	Subsoil	61				4
GTS	GTSWRD3B	Subsoil	69				
GTS	GTSWRD4B	Subsoil	33	74	11.5	14.5	3
GTS	GTSWRD1A	Surface	5	86	8	6	
GTS	GTSWRD2A	Surface	11				2
GTS	GTSWRD3A	Surface	25				
GTS	GTSWRD4A	Surface	18	63	14	23	2
GTS	GTS ROM	Surface	14				
Hub	HDR 1	Surface	4	61.5	10	28.5	
Hub	HDR 2	Surface	24				
Hub	HDR 3	Surface	17				
Hub	HDR 4	Surface	10				
Hub	HIA 1	Surface	27	81.5	5	13.5	
Hub	HIA 2	Surface	34				
Hub	HIA 3	Surface	16				
Hub	HIA 4	Surface	3				
Hub	HP1B	Subsoil	58				2
Hub	HP2B	Subsoil	40				2
Hub	HP3B	Subsoil	38	70	11	19	
Hub	HP1A	Surface	33				2
Hub	HP2A	Surface	22				2
Hub	HP3A	Surface	12	41	32.5	26.5	
Hub	HWRD1B	Surface	16	60	11.5	28.5	
Hub	HWRD2B	Surface	40				2
Hub	HWRD3B	Surface	36				
Hub	HWRD4B	Surface	60				2
Hub	HWRD1A	Surface	15	68	8	24	
Hub	HWRD2A	Surface	18				2
Hub	HWRD3A	Surface	30				
Hub	HWRD4A	Surface	28				1
Nambi	NP1B	Subsoil	60				3
Nambi	NP2B	Subsoil	64	77	13	10	3
Nambi	NP3B	Subsoil	48	75	13	12	
Nambi	NP1A	Surface	48				3

Table A1 - Gravel Content, Texture and Emerson Class

Area	Sample ID	Type	Stones	Sand	Silt	Clay	Emerson Class
Nambi	NP2A	Surface	44	78	11	11	2
Nambi	NP3A	Surface	52	65	22	13	
Nambi	NWRD1B	Subsoil	55	83	10	7	
Nambi	NWRD2B	Subsoil	19				4
Nambi	NWRD3B	Subsoil	58	83	10	7	4
Nambi	NWRD1A	Surface	16	83.5	4.5	12	
Nambi	NWRD2A	Surface	16				3
Nambi	NWRD3A	Surface	34	76	7	17	2
Reference	Bv REF	Surface	27				
Reference	De REF	Surface	5				
Reference	Ju REF	Surface	17				
Reference	Vi REF	Surface	9				
Reference	N ROM	Surface	4				
Reference	Bu REF	Surface	3				
Reference	Wy REF	Surface	25				

Table A2 - pH and EC

Area	Sample ID	Type	EC	pH
			mS/m	SU
Camp	Res_Camp_01	Surface	3	4.9
Camp	Res_Camp_02	Surface	1	5.4
Camp	Res_Camp_03	Surface	3	4.8
Camp	Res_Camp_04	Surface	4	4.4
Camp	Res_Camp_05	Surface	3	4.7
Camp	Res_Camp_06	Surface	2	4.5
GTS	GTSP1B	Subsoil	<1	6.6
GTS	GTSP2B	Subsoil	4	7.1
GTS	GTSP3B	Subsoil	42	8.7
GTS	GTSP1A	Surface	5	7.5
GTS	GTSP2A	Surface	2	6.7
GTS	GTSP3A	Surface	11	7
GTS	GTSWRD1B	Subsoil	88	8.4
GTS	GTSWRD2B	Subsoil	18	8.9
GTS	GTSWRD3B	Subsoil	420	8
GTS	GTSWRD4B	Subsoil	7	6.3
GTS	GTSWRD1A	Surface	2	6.2
GTS	GTSWRD2A	Surface	1	5.5
GTS	GTSWRD3A	Surface	23	6.6
GTS	GTSWRD4A	Surface	4	5.9
GTS	GTS ROM	Surface	2	6.6
Hub	HDR 1	Surface	4	4.6
Hub	HDR 2	Surface	3	4.9
Hub	HDR 3	Surface	2	5.5
Hub	HDR 4	Surface	2	4.3
Hub	HIA 1	Surface	1	4.9
Hub	HIA 2	Surface	2	5.6
Hub	HIA 3	Surface	11	4.7
Hub	HIA 4	Surface	4	6.2
Hub	HP1B	Subsoil	3	5.2
Hub	HP2B	Subsoil	4	5.5
Hub	HP3B	Subsoil	1	5.5
Hub	HP1A	Surface	2	4.7
Hub	HP2A	Surface	2	5
Hub	HP3A	Surface	3	5
Hub	HWRD1B	Subsoil	3	4.9
Hub	HWRD2B	Subsoil	2	7.4
Hub	HWRD3B	Subsoil	3	5.1
Hub	HWRD4B	Subsoil	5	6.8
Hub	HWRD1A	Surface	3	4.7
Hub	HWRD2A	Surface	8	6.3
Hub	HWRD3A	Surface	3	5
Hub	HWRD4A	Surface	2	5
Nambi	NP1B	Subsoil	12	7.4
Nambi	NP2B	Subsoil	4	7.8
Nambi	NP3B	Subsoil	150	6.9
Nambi	NP1A	Surface	4	8
Nambi	NP2A	Surface	3	7.7

Table A2 - pH and EC

Area	Sample ID	Type	EC	pH
			mS/m	SU
Nambi	NP3A	Surface	33	8.1
Nambi	NWRD1B	Subsoil	31	8.5
Nambi	NWRD2B	Subsoil	79	8
Nambi	NWRD3B	Subsoil	9	8.9
Nambi	NWRD1A	Surface	2	6.4
Nambi	NWRD2A	Surface	20	6.3
Nambi	NWRD3A	Surface	6	7
Nambi	N ROM	Surface	2	5.7
Reference	Bv REF	Surface	2	6.3
Reference	De REF	Surface	6	4.7
Reference	Ju REF	Surface	3	4.6
Reference	Vi REF	Surface	2	5.8
Reference	Bu REF	Surface	5	5.7
Reference	Wy REF	Surface	68	6.6

Table A3 - Cation Exchange Capacity

Area	Sample ID	Type	Ca	K	Mg	Na	Al	Mn	ECEC	BS	ESP
			cmol(+)/kg							%	
Reference	Bu REF	Surface	2.2	0.27	1.2	0.26	0.11	0.03	4.07	96.6	6.5
Reference	De REF	Surface	0.98	0.38	0.43	0.07	0.25	0.05	2.16	86.1	3.2
GTS	GTS ROM	Surface	2.6	0.63	0.62	0.03	N/A	N/A	3.88	N/A	0.8
GTS	GTSP1A	Surface	2.4	0.59	0.93	0.32	N/A	N/A	4.24	N/A	7.6
GTS	GTSP1B	Subsoil	2	0.16	1.2	0.14	N/A	N/A	3.5	N/A	4
GTS	GTSP2A	Surface	1.7	0.25	0.75	0.05	N/A	N/A	2.75	N/A	1.8
GTS	GTSP2B	Subsoil	5.1	0.26	4.5	0.72	N/A	N/A	10.58	N/A	6.8
GTS	GTSWRD2A	Surface	1.5	0.45	1.1	0.03	0.14	0.04	3.26	94.5	1.2
GTS	GTSWRD2B	Subsoil	13	1.8	4.6	2.9	N/A	N/A	22.3		13.1
GTS	GTSWRD4A	Surface	2.4	0.6	0.85	0.11	0.09	0.04	4.09	96.8	2.7
GTS	GTSWRD4B	Subsoil	8.4	0.76	1.5	0.52	0.08	0.02	11.28	99.1	4.6
Hub	HDR 2	Surface	1.7	0.27	0.71	0.04	0.2	0.03	2.95	92.2	1.5
Hub	HIA 2	Surface	2.3	0.36	1.4	0.08	0.09	<0.02	4.23	97.9	1.8
Hub	HP1A	Surface	0.37	0.21	0.18	<0.02	1	0.03	1.79	42.5	0.6
Hub	HP1B	Subsoil	1.5	0.16	2.1	0.56	0.97	0.17	5.46	79.1	10.5
Hub	HP2A	Surface	0.88	0.26	0.33	0.02	0.51	0.04	2.04	73.0	1
Hub	HP2B	Subsoil	5.2	0.72	1.7	0.22	0.24	0.12	8.2	95.6	2.7
Hub	HWRD2A	Surface	3.8	0.63	1.7	0.09	0.09	0.03	6.34	98.1	1.5
Hub	HWRD2B	Subsoil	5.4	0.66	2.8	0.29	N/A	N/A	9.15	N/A	3.2
Hub	HWRD4A	Surface	1	0.28	0.66	0.07	0.31	0.03	2.35	85.5	2.9
Hub	HWRD4B	Subsoil	6.2	0.83	4.8	1.6	N/A	N/A	13.43	N/A	11.9
Nambi	N ROM	Surface	2.6	0.56	1.1	0.08	0.13	0.02	4.49	96.7	1.7
Nambi	NP1A	Surface	6	0.26	3.1	0.34	N/A	N/A	9.7	N/A	1.9
Nambi	NP1B	Subsoil	9.8	0.13	8.3	1.7	N/A	N/A	19.93	N/A	8.5
Nambi	NP2A	Surface	6.1	0.36	4.2	0.25	N/A	N/A	10.91	N/A	2.3
Nambi	NP2B	Subsoil	13	0.12	7.6	0.71	N/A	N/A	21.43	N/A	3.3
Nambi	NWRD2A	Surface	7	0.82	1.2	0.15	0.08	0.07	9.32	98.4	1.6
Nambi	NWRD2B	Subsoil	13	1	2.1	0.31	N/A	N/A	16.41	N/A	1.9
Nambi	NWRD3A	Surface	4.1	0.79	0.9	0.11	N/A	N/A	5.9	N/A	1.9
Nambi	NWRD3B	Subsoil	5	0.46	0.48	0.2	N/A	N/A	6.14	N/A	3.2
Low			<5	<0.5	<1	<0.3	<0.1	<0.02	<5	<20	<6
Med			5-10	0.5-2	1-5	0.3-1	0.1-1.0	0.02-1.0	5-15	20-60	6-15
High			>10	>2	>5	>1	>1.0	>1	>15	>60	>15

Table A4 - Bioavailable Nutrients and Trace Elements

Area	Sample ID	Type	OrgC	N	C:N	P Retention Index	Total P	Al	B
			%		Ratio	mL/g	mg/kg	mg/kg	mg/kg
Camp	Res_Camp_02	Surface	0.35	0.029	12	54	130	N.D	N.D
Camp	Res_Camp_03	Surface	0.13	0.019	7	44	130	N.D	N.D
Camp	Res_Camp_04	Surface	0.4	0.032	13	39	120	N.D	N.D
Camp	Res_Camp_05	Surface	0.35	0.031	11	52	130	N.D	N.D
GTS	GTSP2A	Surface	0.15	0.016	9	N.D	N.D	220	<0.1
GTS	GTSP3A	Surface	0.81	0.068	12	N.D	N.D	360	0.7
GTS	GTSWRD2A	Surface	0.22	0.028	8	N.D	N.D	490	<0.1
GTS	GTSWRD4A	Surface	0.5	0.049	10	N.D	N.D	450	0.1
Hub	HDR 3	Surface	0.31	0.034	9	N.D	N.D	440	<0.1
Hub	HIA 3	Surface	0.28	0.033	8	N.D	N.D	360	<0.1
Hub	HP2A	Surface	0.24	0.027	9	N.D	N.D	460	<0.1
Hub	HP3A	Surface	0.5	0.045	11	N.D	N.D	550	<0.1
Hub	HWRD1A	Surface	0.34	0.028	12	N.D	N.D	>550	<0.1
Hub	HWRD3A	Surface	0.37	0.034	11	N.D	N.D	390	<0.1
Nambi	NP2A	Surface	0.14	0.019	7	N.D	N.D	380	0.1
Nambi	NP3A	Surface	0.17	0.022	8	N.D	N.D	400	1
Nambi	NWRD1A	Surface	0.3	0.028	11	N.D	N.D	320	0.2
Nambi	NWRD2A	Surface	0.4	0.044	9	N.D	N.D	420	0.5
Low			<0.5	<0.05	<10	0-2	N/A	N/A	<0.1
Med			0.5-1.5	0.05-0.3	10 - 16	2-20	N/A	N/A	0.1-2
High			>1.5	>0.3	>16	20-100	N/A	>550	>2

Table A4 - Bioavailable Nutrients and Trace Elements

Area	Sample ID	Type	Ca	Co	Cu	Fe	K	Mg	Mn
			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Camp	Res_Camp_02	Surface	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Camp	Res_Camp_03	Surface	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Camp	Res_Camp_04	Surface	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Camp	Res_Camp_05	Surface	N.D	N.D	N.D	N.D	N.D	N.D	N.D
GTS	GTSP2A	Surface	350	0.92	0.9	65	88	95	33
GTS	GTSP3A	Surface	870	1.9	1.5	50	380	140	130
GTS	GTSWRD2A	Surface	280	1.2	1.4	41	200	140	53
GTS	GTSWRD4A	Surface	450	1	1.1	37	290	110	37
Hub	HDR 3	Surface	390	0.96	1.4	55	280	130	44
Hub	HIA 3	Surface	140	0.31	0.9	27	200	43	19
Hub	HP2A	Surface	160	1.4	0.8	38	110	38	48
Hub	HP3A	Surface	130	0.84	1	29	140	37	33
Hub	HWRD1A	Surface	63	0.16	1	34	94	23	8.2
Hub	HWRD3A	Surface	150	0.33	0.7	44	180	55	23
Nambi	NP2A	Surface	1300	2.8	1.8	67	140	560	72
Nambi	NP3A	Surface	3100	1.2	2.5	71	220	550	20
Nambi	NWRD1A	Surface	340	1.4	0.9	34	180	110	43
Nambi	NWRD2A	Surface	1200	2.4	1.7	39	330	140	67
Low			<50	<2	<0.1	<10	<10	<20	<5
Med			50-5000	2-60	0.1-5	10-200	10-300	20-2000	5-100
High			>5000	>60	>5	>200	>300	>2000	>100

Table A4 - Bioavailable Nutrients and Trace Elements

Area	Sample ID	Type	Mo	Na	Ni	P	S	Zn	Cd	As	Pb
			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Camp	Res_Camp_02	Surface	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Camp	Res_Camp_03	Surface	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Camp	Res_Camp_04	Surface	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Camp	Res_Camp_05	Surface	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
GTS	GTSP2A	Surface	<0.01	4	0.6	2	2	0.6	0.03	<0.1	0.2
GTS	GTSP3A	Surface	0.01	77	0.8	14	11	4.6	0.06	<0.1	0.9
GTS	GTSWRD2A	Surface	<0.01	4	0.5	5	5	0.9	0.05	0.1	0.4
GTS	GTSWRD4A	Surface	<0.01	21	1.2	9	6	1.4	0.05	0.1	0.7
Hub	HDR 3	Surface	<0.01	1	0.3	2	4	0.9	0.04	<0.1	0.5
Hub	HIA 3	Surface	<0.01	25	<0.1	2	32	0.3	0.03	<0.1	0.5
Hub	HP2A	Surface	<0.01	<1	0.2	3	20	0.4	0.03	0.2	0.6
Hub	HP3A	Surface	<0.01	<1	0.1	3	13	0.2	0.03	0.2	0.6
Hub	HWRD1A	Surface	<0.01	<1	<0.1	3	35	3.2	0.03	0.1	0.6
Hub	HWRD3A	Surface	<0.01	6	0.4	5	9	0.5	0.03	0.1	0.5
Nambi	NP2A	Surface	<0.01	36	1.0	3	5	1.3	0.05	0.1	0.2
Nambi	NP3A	Surface	<0.01	110	0.3	4	170	1.6	0.05	<0.1	0.2
Nambi	NWRD1A	Surface	<0.01	10	0.3	3	3	0.9	0.03	<0.1	0.4
Nambi	NWRD2A	Surface	<0.01	27	0.8	6	8	1.1	0.06	0.1	0.5
Low			<0.01	N/A	<1	<2	<5	<0.2	N/A	N/A	N/A
Med			0.01 - 0.05	N/A	1-20	2-10	5-200	0.2-5	N/A	N/A	N/A
High			>0.05	>180	>20	>10	>200	>5	>1	>5	>35

Table A4 - Bioavailable Nutrients and Trace Elements

Area	Sample ID	Type	Se
			mg/kg
Camp	Res_Camp_02	Surface	N.D
Camp	Res_Camp_03	Surface	N.D
Camp	Res_Camp_04	Surface	N.D
Camp	Res_Camp_05	Surface	N.D
GTS	GTSP2A	Surface	<0.1
GTS	GTSP3A	Surface	<0.1
GTS	GTSWRD2A	Surface	<0.1
GTS	GTSWRD4A	Surface	<0.1
Hub	HDR 3	Surface	<0.1
Hub	HIA 3	Surface	<0.1
Hub	HP2A	Surface	<0.1
Hub	HP3A	Surface	<0.1
Hub	HWRD1A	Surface	<0.1
Hub	HWRD3A	Surface	<0.1
Nambi	NP2A	Surface	<0.1
Nambi	NP3A	Surface	<0.1
Nambi	NWRD1A	Surface	<0.1
Nambi	NWRD2A	Surface	<0.1
Low			N/A
Med			N/A
High			>1.5

Table A5 - Aqua Regia Digestible Metals and Metalloids

Area	Sample ID	Type	Ag	As	Cd	Cr	Cu	Hg	Mn	Ni
			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Reference	Wy REF	Surface	<0.05	3.7	<0.05	160	32	<0.02	280	34
Reference	Bu REF	Surface	<0.05	3.9	<0.05	120	11	<0.02	140	12
Reference	De REF	Surface	<0.05	4.5	<0.05	220	19	<0.02	130	20
Reference	Ju REF	Surface	<0.05	5.5	<0.05	170	18	<0.02	140	15
Reference	Bv REF	Surface	<0.05	2.7	<0.05	110	43	<0.02	350	23
Reference	Vi REF	Surface	<0.05	3.9	0.06	150	34	<0.02	440	29
GTS	GTSP3A	Surface	<0.05	4.8	0.05	160	24	<0.02	270	23
GTS	GTSWRD4A	Surface	<0.05	4	<0.05	130	23	<0.02	210	26
Hub	HDR 3	Surface	<0.05	3.4	<0.05	130	21	<0.02	270	13
Hub	HIA 3	Surface	<0.05	4.9	<0.05	220	21	<0.02	140	13
Hub	HP2A	Surface	<0.05	4.5	<0.05	220	21	<0.02	290	18
Hub	HWRD1A	Surface	<0.05	4.2	<0.05	230	32	<0.02	230	24
Nambi	NP2A	Surface	<0.05	3.1	<0.05	91	52	<0.02	290	30
Nambi	NWRD2A	Surface	<0.05	3.4	0.05	130	33	<0.02	390	32
Ecological investigation Levels (DEC 2010)			N/G	20	3	400	100	1	N/G	60
NEPM (2013)			N/G	100	N/G	470	150	N/G	N/G	80
Maximum Average abundance soils			0.1	50	1	1000	100	0.03	850	500

Table A5 - Aqua Regia Digestible Metals and Metalloids

Area	Sample ID	Type	Pb	Sb	Se	Zn
			mg/kg	mg/kg	mg/kg	mg/kg
Reference	Wy REF	Surface	8.2	0.1	0.53	53
Reference	Bu REF	Surface	6.6	0.07	0.47	13
Reference	De REF	Surface	9.1	<0.05	0.68	27
Reference	Ju REF	Surface	11	<0.05	0.93	23
Reference	Bv REF	Surface	4.9	<0.05	0.61	37
Reference	Vi REF	Surface	7.1	0.07	0.56	33
GTS	GTSP3A	Surface	6.8	0.13	0.63	31
GTS	GTSWRD4A	Surface	7.5	0.09	0.53	32
Hub	HDR 3	Surface	7.3	0.08	0.59	23
Hub	HIA 3	Surface	9.2	0.07	1	18
Hub	HP2A	Surface	8.8	0.09	0.88	20
Hub	HWRD1A	Surface	8.7	0.08	1.1	31
Nambi	NP2A	Surface	3	<0.05	0.54	44
Nambi	NWRD2A	Surface	6.9	0.07	0.88	40
Ecological investigation Levels (DEC 2010)			600	N/G	N/G	200
NEPM (2013)			1100	N/G	N/G	360
Maximum Average abundance soils			200	5	0.2	300

APPENDIX 4: LABORATORY REPORTS

ChemCentre
Scientific Services Division
Report of Examination

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www.chemcentre.wa.gov.au
ABN 40 991 885 705

Purchase Order: DGMSRA
Your Reference:
ChemCentre Reference: 21S1215 R0

MBS Environmental
4 Cook St
West Perth WA 6005

Attention: Elliott Duncan

Final Report on 6 samples of soil received on 20/09/2021

LAB ID	Client ID and Description
21S1215 / 001	Res_Caamp_01
21S1215 / 002	Res_Caamp_02
21S1215 / 003	Res_Caamp_03
21S1215 / 004	Res_Caamp_04
21S1215 / 005	Res_Caamp_05
21S1215 / 006	Res_Caamp_06

Analyte		**Stones**	**EC**	**pH**	**OrgC**	**N**	**P**
Method		(>2mm)	(1:5)	(H2O)	(W/B)	(total)	PRI
Unit		%	mS/m		%	%	mL/g
Lab ID	**Client ID**						
21S1215/001	Res_Caamp_01	31.8	3	4.9			
21S1215/002	Res_Caamp_02	53.9	1	5.4	0.35	0.029	54
21S1215/003	Res_Caamp_03	5.5	3	4.8	0.13	0.019	44
21S1215/004	Res_Caamp_04	17.2	4	4.4	0.40	0.032	39
21S1215/005	Res_Caamp_05	13.9	3	4.7	0.35	0.031	52
21S1215/006	Res_Caamp_06	31.6	2	4.5			

Analyte		**P**
Method		(totals)
Unit		mg/kg
Lab ID	**Client ID**	
21S1215/002	Res_Caamp_02	130
21S1215/003	Res_Caamp_03	130
21S1215/004	Res_Caamp_04	120
21S1215/005	Res_Caamp_05	130

Analyte	Method	Description
Stones	(>2mm)	Stones - sieved particles greater than 2 mm (sample preparation method manual 3.3.2)
EC	(1:5)	Electrical conductivity of 1:5 soil extract at 25 C by in-house method S02
pH	(H2O)	pH of 1:5 soil extract in water by in-house method S01
N	(total)	Nitrogen N, total by method S10
P	(totals)	Phosphorus,P Total by method S14
OrgC	(W/B)	Organic Carbon C, Walkley and Black method S09.
P	PRI	Phosphorus Retention Index by method S15

Results are based on a air-dry (40C) , < 2 mm basis. Stones (>2mm) if present are reported on an air dry whole sample basis.The results apply only to samples as received. This report may only be reproduced in full.

Unless otherwise advised, the samples in this job will be disposed of after a holding period of 30 days from the report date shown below.

Phosphorus Retention Index (PRI) is a measure of the ability of soil to retain or leach applied phosphate.

PRI is defined as the ratio P ads : P eq where P ads is the amount of phosphorus adsorbed by soil (µg P/g soil) .

The phosphorus fixation properties of soil may be described by the following PRI values:

PRI

negative	desorbing (P leaching)
0 - 2	weakly adsorbing
2 - 20	moderately adsorbing
20 - 100	strongly adsorbing
>100	very strongly adsorbing

B. Price

Barry Price
Snr Chemist & Research Officer
Scientific Services Division
18-Oct-2021

ChemCentre

Scientific Services Division

Report of Examination

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Purchase Order: DGMRSA
Your Reference:
ChemCentre Reference: 21S1027 R0

MBS Environmental
4 Cook St
West Perth WA 6005

Attention: Elliott Duncan

Final Report on 50 samples of soil received on 07/09/2021

LAB ID	Client ID and Description
21S1027 / 001	HP1A 0 - 0.1
21S1027 / 002	HP1B 0.1 - 0.38
21S1027 / 003	HP2A 0 - 0.1
21S1027 / 004	HP2B 0.1 - 0.25
21S1027 / 005	HP3A 0 - 0.1
21S1027 / 006	HP3B 0.1 - 0.5
21S1027 / 007	HWRD1A 0 - 0.1
21S1027 / 008	HWRD1B 0.1 - 0.4
21S1027 / 009	HWRD2A 0 - 0.1
21S1027 / 010	HWRD2B 0.1 - 0.5
21S1027 / 011	HWRD3A 0 - 0.1
21S1027 / 012	HWRD3B 0.1 - 0.25
21S1027 / 013	HWRD4A 0 - 0.1
21S1027 / 014	HWRD4B 0.1 - 0.35
21S1027 / 015	NP1A 0 - 0.1
21S1027 / 016	NP1B 0.1 - 0.2
21S1027 / 017	NP2A 0 - 0.1
21S1027 / 018	NP2B 0.1 - 0.2
21S1027 / 019	NP3A 0 - 0.1
21S1027 / 020	NP3B 0.1 - 0.2
21S1027 / 021	NWRD1A 0 - 0.1
21S1027 / 022	NWRD1B 0.1 - 0.4
21S1027 / 023	NWRD2A 0 - 0.1
21S1027 / 024	NWRD2B 0.1 - 0.4
21S1027 / 025	NWRD3A 0 - 0.1
21S1027 / 026	NWRD3B 0.1 - 0.4
21S1027 / 027	GTSP1A 0 - 0.1
21S1027 / 028	GTSP1B 0.1 - 0.35
21S1027 / 029	GTSP2A 0 - 0.1
21S1027 / 030	GTSP2B 0.1 - 0.25
21S1027 / 031	GTSP3A 0 - 0.1
21S1027 / 032	GTSP3B 0.1 - 0.5
21S1027 / 033	GTSWRD1A 0 - 0.1
21S1027 / 034	GTSWRD1B 0.1 - 0.4
21S1027 / 035	GTSWRD2A 0 - 0.1
21S1027 / 036	GTSWRD2B 0.1 - 0.45

LAB ID	Client ID and Description
21S1027 / 037	GTSWRD3A 0 - 0.1
21S1027 / 038	GTSWRD3B 0.1 - 0.55
21S1027 / 039	GTSWRD4A 0 - 0.1
21S1027 / 040	GTSWRD4B 0.1 - 0.2
21S1027 / 042	De REF 0 - 0.1
21S1027 / 045	N ROM 0 - 0.1
21S1027 / 046	Bu REF 0 - 0.1
21S1027 / 048	GTS ROM 0 - 0.1
21S1027 / 049	HIA 1 0 - 0.1
21S1027 / 050	HIA 2 0 - 0.1
21S1027 / 051	HIA 3 0 - 0.1
21S1027 / 053	HDR 1 0 - 0.1
21S1027 / 054	HDR 2 0 - 0.1
21S1027 / 055	HDR 3 0 - 0.1

Analyte		Ag	As	Cd	Co	Co	Cr
Method		iMET2SAMS	iMET2SAMS	iMET2SAMS	iMET2SAICP	iMET2SAMS	iMET2SAICP
Unit		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Lab ID	Client ID						
21S1027/003	HP2A	<0.05	4.5	<0.05		7.5	220
21S1027/007	HWRD1A	<0.05	4.2	<0.05		10	230
21S1027/017	NP2A	<0.05	3.1	<0.05	16		91
21S1027/023	NWRD2A	<0.05	3.4	0.05	17		130
21S1027/031	GTSP3A	<0.05	4.8	0.05		6.8	160
21S1027/039	GTSWRD4A	<0.05	4.0	<0.05		7.9	130
21S1027/051	HIA 3	<0.05	4.9	<0.05		4.5	220
21S1027/055	HDR 3	<0.05	3.4	<0.05		6.5	130

Analyte		Cu	Hg	Mn	Ni	Ni	Pb
Method		iMET2SAICP	iMET2SAMS	iMET2SAICP	iMET2SAICP	iMET2SAMS	iMET2SAMS
Unit		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Lab ID	Client ID						
21S1027/003	HP2A	21	<0.02	290	18		8.8
21S1027/007	HWRD1A	32	<0.02	230	24		8.7
21S1027/017	NP2A	52	<0.02	290	30		3.0
21S1027/023	NWRD2A	33	<0.02	390	32		6.9
21S1027/031	GTSP3A	24	<0.02	270	23		6.8
21S1027/039	GTSWRD4A	23	<0.02	210	26		7.5
21S1027/051	HIA 3	21	<0.02	140		13	9.2
21S1027/055	HDR 3	21	<0.02	270		13	7.3

Analyte		Sb	Se	Stones	Zn	EC	pH
Method		iMET2SAMS	iMET2SAMS	(>2mm)	iMET2SAMS	(1:5)	(H2O)
Unit		mg/kg	mg/kg	%	mg/kg	mS/m	
Lab ID	Client ID						
21S1027/001	HP1A			32.7		2	4.7
21S1027/002	HP1B			57.8		3	5.2
21S1027/003	HP2A	0.09	0.88	21.7	20	2	5.0
21S1027/004	HP2B			39.5		4	5.5
21S1027/005	HP3A			12.3		3	5.0
21S1027/006	HP3B			37.8		1	5.5
21S1027/007	HWRD1A	0.08	1.1	14.5	31	3	4.7
21S1027/008	HWRD1B			15.6		3	4.9
21S1027/009	HWRD2A			18.0		8	6.3
21S1027/010	HWRD2B			40.4		2	7.4
21S1027/011	HWRD3A			29.5		3	5.0
21S1027/012	HWRD3B			35.7		3	5.1
21S1027/013	HWRD4A			27.6		2	5.0
21S1027/014	HWRD4B			59.8		5	6.8
21S1027/015	NP1A			48.2		4	8.0
21S1027/016	NP1B			59.7		12	7.4
21S1027/017	NP2A	<0.05	0.54	44.3	44	3	7.7
21S1027/018	NP2B			64.2		4	7.8
21S1027/019	NP3A			51.5		33	8.1
21S1027/020	NP3B			48.0		150	6.9
21S1027/021	NWRD1A			16.1		2	6.4
21S1027/022	NWRD1B			55.4		31	8.5
21S1027/023	NWRD2A	0.07	0.88	15.5	40	20	6.3

Analyte Method Unit Lab ID	Client ID	Sb iMET2SAMS mg/kg	Se iMET2SAMS mg/kg	Stones (>2mm) %	Zn iMET2SAMS mg/kg	EC (1:5) mS/m	pH (H2O)
21S1027/024	NWRD2B			19.4		79	8.0
21S1027/025	NWRD3A			33.8		6	7.0
21S1027/026	NWRD3B			57.6		9	8.9
21S1027/027	GTSP1A			10.2		5	7.5
21S1027/028	GTSP1B			47.0		<1	6.6
21S1027/029	GTSP2A			34.6		2	6.7
21S1027/030	GTSP2B			16.8		4	7.1
21S1027/031	GTSP3A	0.13	0.63	17.9	31	11	7.0
21S1027/032	GTSP3B			33.0		42	8.7
21S1027/033	GTSWRD1A			5.2		2	6.2
21S1027/034	GTSWRD1B			27.2		88	8.4
21S1027/035	GTSWRD2A			10.9		1	5.5
21S1027/036	GTSWRD2B			61.0		18	8.9
21S1027/037	GTSWRD3A			24.8		23	6.6
21S1027/038	GTSWRD3B			68.5		420	8.0
21S1027/039	GTSWRD4A	0.09	0.53	17.5	32	4	5.9
21S1027/040	GTSWRD4B			32.9		7	6.3
21S1027/051	HIA 3	0.07	1.0		18		
21S1027/055	HDR 3	0.08	0.59		23		

Analyte Method Unit Lab ID	Client ID	Sand. fraction %	Silt. fraction %	Clay. fraction %	OrgC (W/B) %	Emerson Class	ESP (calc) %
21S1027/042	De REF						3.2
21S1027/045	N ROM						1.7
21S1027/046	Bu REF						6.5
21S1027/048	GTS ROM						0.8
21S1027/049	HIA 1	81.5	5.0	13.5			
21S1027/050	HIA 2						1.8
21S1027/051	HIA 3				0.28		
21S1027/053	HDR 1	61.5	10.0	28.5			
21S1027/054	HDR 2						1.5
21S1027/055	HDR 3				0.31		
21S1027/001	HP1A					2	0.6
21S1027/002	HP1B					2	10.5
21S1027/003	HP2A				0.24	2	1.0
21S1027/004	HP2B					2	2.7
21S1027/005	HP3A	41.0	32.5	26.5	0.50		
21S1027/006	HP3B	70.0	11.0	19.0			
21S1027/007	HWRD1A	68.0	8.0	24.0	0.34		
21S1027/008	HWRD1B	60.0	11.5	28.5			
21S1027/009	HWRD2A					2	1.5
21S1027/010	HWRD2B					2	3.2
21S1027/011	HWRD3A				0.37		
21S1027/013	HWRD4A					1	2.9
21S1027/014	HWRD4B					2	11.9
21S1027/015	NP1A					3	1.9
21S1027/016	NP1B					3	8.5

Analyte Method Unit Lab ID	 Client ID	Sand. fraction %	Silt. fraction %	Clay. fraction %	OrgC (W/B) %	Emerson Class	ESP (calc) %
21S1027/017	NP2A	78.0	11.0	11.0	0.14	2	2.3
21S1027/018	NP2B	77.0	13.0	10.0		3	3.3
21S1027/019	NP3A	65.0	22.0	13.0	0.17		
21S1027/020	NP3B	75.0	13.0	12.0			
21S1027/021	NWRD1A	83.5	4.5	12.0	0.30		
21S1027/022	NWRD1B	83.0	10.0	7.0			
21S1027/023	NWRD2A				0.40	3	1.6
21S1027/024	NWRD2B					4	1.9
21S1027/025	NWRD3A	76.0	7.0	17.0		2	1.9
21S1027/026	NWRD3B	83.0	10.0	7.0		4	3.2
21S1027/027	GTSP1A					1	7.6
21S1027/028	GTSP1B					1	4.0
21S1027/029	GTSP2A				0.15	1	1.8
21S1027/030	GTSP2B					1	6.8
21S1027/031	GTSP3A	76.0	10.0	14.0	0.81		
21S1027/032	GTSP3B	75.0	12.0	13.0			
21S1027/033	GTSWRD1A	86.0	8.0	6.0			
21S1027/034	GTSWRD1B	82.0	11.5	7.5			
21S1027/035	GTSWRD2A				0.22	2	1.2
21S1027/036	GTSWRD2B					4	13.1
21S1027/039	GTSWRD4A	63.0	14.0	23.0	0.50	2	2.7
21S1027/040	GTSWRD4B	74.0	11.5	14.5		3	4.6

Analyte Method Unit Lab ID	 Client ID	N (total) %	Ca (exch) cmol(+)/kg	K (exch) cmol(+)/kg	Mg (exch) cmol(+)/kg	Na (exch) cmol(+)/kg	Al (exch) cmol(+)/kg
21S1027/001	HP1A		0.37	0.21	0.18	<0.02	1.0
21S1027/002	HP1B		1.5	0.16	2.1	0.56	0.97
21S1027/003	HP2A	0.027	0.88	0.26	0.33	0.02	0.51
21S1027/004	HP2B		5.2	0.72	1.7	0.22	0.24
21S1027/005	HP3A	0.045					
21S1027/007	HWRD1A	0.028					
21S1027/009	HWRD2A		3.8	0.63	1.7	0.09	0.09
21S1027/010	HWRD2B		5.4	0.66	2.8	0.29	
21S1027/011	HWRD3A	0.034					
21S1027/013	HWRD4A		1.0	0.28	0.66	0.07	0.31
21S1027/014	HWRD4B		6.2	0.83	4.8	1.6	
21S1027/015	NP1A		6.0	0.26	3.1	0.34	
21S1027/016	NP1B		9.8	0.13	8.3	1.7	
21S1027/017	NP2A	0.019	6.1	0.36	4.2	0.25	
21S1027/018	NP2B		13	0.12	7.6	0.71	
21S1027/019	NP3A	0.022					
21S1027/021	NWRD1A	0.028					
21S1027/023	NWRD2A	0.044	7.0	0.82	1.2	0.15	0.08
21S1027/024	NWRD2B		13	1.0	2.1	0.31	
21S1027/025	NWRD3A		4.1	0.79	0.90	0.11	
21S1027/026	NWRD3B		5.0	0.46	0.48	0.20	
21S1027/027	GTSP1A		2.4	0.59	0.93	0.32	

Analyte Method Unit Lab ID	Client ID	N (total) %	Ca (exch) cmol(+)/kg	K (exch) cmol(+)/kg	Mg (exch) cmol(+)/kg	Na (exch) cmol(+)/kg	Al (exch) cmol(+)/kg
21S1027/028	GTSP1B		2.0	0.16	1.2	0.14	
21S1027/029	GTSP2A	0.016	1.7	0.25	0.75	0.05	
21S1027/030	GTSP2B		5.1	0.26	4.5	0.72	
21S1027/031	GTSP3A	0.068					
21S1027/035	GTSWRD2A	0.028	1.5	0.45	1.1	0.03	0.14
21S1027/036	GTSWRD2B		13	1.8	4.6	2.9	
21S1027/039	GTSWRD4A	0.049	2.4	0.60	0.85	0.11	0.09
21S1027/040	GTSWRD4B		8.4	0.76	1.5	0.52	0.08
21S1027/042	De REF		0.98	0.38	0.43	0.07	0.25
21S1027/045	N ROM		2.6	0.56	1.1	0.08	0.13
21S1027/046	Bu REF		2.2	0.27	1.2	0.26	0.11
21S1027/048	GTS ROM		2.6	0.63	0.62	0.03	
21S1027/050	HIA 2		2.3	0.36	1.4	0.08	0.09
21S1027/051	HIA 3	0.033					
21S1027/054	HDR 2		1.7	0.27	0.71	0.04	0.20
21S1027/055	HDR 3	0.034					

Analyte Method Unit Lab ID	Client ID	Mn (exch) cmol(+)/kg	Al (M3) mg/kg	B (M3) mg/kg	Ca (M3) mg/kg	Cd (M3) mg/kg	Co (M3) mg/kg
21S1027/001	HP1A	0.03					
21S1027/002	HP1B	0.17					
21S1027/003	HP2A	0.04	460	<0.1	160	0.03	1.4
21S1027/004	HP2B	0.12					
21S1027/005	HP3A		550	<0.1	130	0.03	0.84
21S1027/007	HWRD1A		>550	<0.1	63	0.03	0.16
21S1027/009	HWRD2A	0.03					
21S1027/011	HWRD3A		390	<0.1	150	0.03	0.33
21S1027/013	HWRD4A	0.03					
21S1027/017	NP2A		380	0.1	1300	0.05	2.8
21S1027/019	NP3A		400	1.0	3100	0.05	1.2
21S1027/021	NWRD1A		320	0.2	340	0.03	1.4
21S1027/023	NWRD2A	0.07	420	0.5	1200	0.06	2.4
21S1027/029	GTSP2A		220	<0.1	350	0.03	0.92
21S1027/031	GTSP3A		360	0.7	870	0.06	1.9
21S1027/035	GTSWRD2A	0.04	490	<0.1	280	0.05	1.2
21S1027/039	GTSWRD4A	0.04	450	0.1	450	0.05	1.0
21S1027/040	GTSWRD4B	0.02					
21S1027/042	De REF	0.05					
21S1027/045	N ROM	0.02					
21S1027/046	Bu REF	0.03					
21S1027/050	HIA 2	<0.02					
21S1027/051	HIA 3		360	<0.1	140	0.03	0.31
21S1027/054	HDR 2	0.03					
21S1027/055	HDR 3		440	<0.1	390	0.04	0.96

Analyte Method Unit Lab ID	 Client ID	Cu (M3) mg/kg	Fe (M3) mg/kg	K (M3) mg/kg	Mg (M3) mg/kg	Mn (M3) mg/kg	Mo (M3) mg/kg
21S1027/003	HP2A	0.8	38	110	38	48	<0.01
21S1027/005	HP3A	1.0	29	140	37	33	<0.01
21S1027/007	HWRD1A	1.0	34	94	23	8.2	<0.01
21S1027/011	HWRD3A	0.7	44	180	55	23	<0.01
21S1027/017	NP2A	1.8	67	140	560	72	<0.01
21S1027/019	NP3A	2.5	71	220	550	20	<0.01
21S1027/021	NWRD1A	0.9	34	180	110	43	<0.01
21S1027/023	NWRD2A	1.7	39	330	140	67	<0.01
21S1027/029	GTSP2A	0.9	65	88	95	33	<0.01
21S1027/031	GTSP3A	1.5	50	380	140	130	0.01
21S1027/035	GTSWRD2A	1.4	41	200	140	53	<0.01
21S1027/039	GTSWRD4A	1.1	37	290	110	37	<0.01
21S1027/051	HIA 3	0.9	27	200	43	19	<0.01
21S1027/055	HDR 3	1.4	55	280	130	44	<0.01

Analyte Method Unit Lab ID	 Client ID	Na (M3) mg/kg	Ni (M3) mg/kg	P (M3) mg/kg	S (M3) mg/kg	Zn (M3) mg/kg	As (M3) mg/kg
21S1027/003	HP2A	<1	0.2	3	20	0.4	0.2
21S1027/005	HP3A	<1	0.1	3	13	0.2	0.2
21S1027/007	HWRD1A	<1	<0.1	3	35	3.2	0.1
21S1027/011	HWRD3A	6	0.4	5	9	0.5	0.1
21S1027/017	NP2A	36	1.0	3	5	1.3	0.1
21S1027/019	NP3A	110	0.3	4	170	1.6	<0.1
21S1027/021	NWRD1A	10	0.3	3	3	0.9	<0.1
21S1027/023	NWRD2A	27	0.8	6	8	1.1	0.1
21S1027/029	GTSP2A	4	0.6	2	2	0.6	<0.1
21S1027/031	GTSP3A	77		14	11	4.6	<0.1
21S1027/035	GTSWRD2A	4	0.5	5	5	0.9	0.1
21S1027/039	GTSWRD4A	21	1.2	9	6	1.4	0.1
21S1027/051	HIA 3	25	<0.1	2	32	0.3	<0.1
21S1027/055	HDR 3	1	0.3	2	4	0.9	<0.1

Analyte Method Unit Lab ID	 Client ID	Pb (M3) mg/kg	Se (M3) mg/kg
21S1027/003	HP2A	0.6	<0.1
21S1027/005	HP3A	0.6	<0.1
21S1027/007	HWRD1A	0.6	<0.1
21S1027/011	HWRD3A	0.5	<0.1
21S1027/017	NP2A	0.2	<0.1
21S1027/019	NP3A	0.2	<0.1
21S1027/021	NWRD1A	0.4	<0.1
21S1027/023	NWRD2A	0.5	<0.1
21S1027/029	GTSP2A	0.2	<0.1
21S1027/031	GTSP3A		<0.1
21S1027/035	GTSWRD2A	0.4	<0.1

Analyte		Pb	Se
Method		(M3)	(M3)
Unit		mg/kg	mg/kg
Lab ID	Client ID		
21S1027/039	GTSWRD4A	0.7	<0.1
21S1027/051	HIA 3	0.5	<0.1
21S1027/055	HDR 3	0.5	<0.1

Analyte	Method	Description
Stones	(>2mm)	Stones - sieved particles greater than 2 mm (sample preparation method manual 3.3.2)
EC	(1:5)	Electrical conductivity of 1:5 soil extract at 25 C by in-house method S02
ESP	(calc)	Exchangeable Sodium Percentage (calculated)
K	(exch)	Potassium, K exchangeable (ref. Rayment & Lyons 2011)
Mg	(exch)	Magnesium, Mg exchangeable (ref. Rayment & Lyons 2011)
Mn	(exch)	Manganese, Mn exchangeable (ref. Rayment & Lyons 2011)
Ca	(exch)	Calcium, Ca exchangeable (ref. Rayment & Lyons 2011)
Na	(exch)	Sodium, Na exchangeable (ref. Rayment & Lyons 2011)
Al	(exch)	Aluminium, Al exchangeable (ref. Rayment & Lyons 2011)
pH	(H2O)	pH of 1:5 soil extract in water by in-house method S01
S	(M3)	Sulphur, S extracted by Mehlich No 3 - method S42
P	(M3)	Phosphorus, P extracted by Mehlich No 3 - method S42
Pb	(M3)	Lead, Pb extracted by Mehlich No 3 - method S42
Zn	(M3)	Zinc, Zn extracted by Mehlich No 3 - method S42
Se	(M3)	Selenium, Se extracted by Mehlich No 3 - method S42
Na	(M3)	Sodium, Na extracted by Mehlich No 3 - method S42
Ni	(M3)	Nickel, Ni extracted by Mehlich No 3 - method S42
Mo	(M3)	Molybdenum, Mo extracted by Mehlich No 3 - method S42
Ca	(M3)	Calcium,Ca extracted by Mehlich No 3 - method S42
Cd	(M3)	Cadmium,Cd extracted by Mehlich No 3 - method S42
Mg	(M3)	Magnesium, Mg extracted by Mehlich No 3 - method S42
K	(M3)	Potassium, K extracted by Mehlich No 3 - method S42
Fe	(M3)	Iron, Fe extracted by Mehlich No 3 - method S42
Cu	(M3)	Copper,Cu extracted by Mehlich No 3 - method S42
B	(M3)	Boron,B extracted by Mehlich No 3 - method S42
Co	(M3)	Cobalt,Co extracted by Mehlich No 3 - method S42
As	(M3)	Arsenic, As extracted by Mehlich No 3 - method S42
Mn	(M3)	Manganese, Mn extracted by Mehlich No 3 - method S42
Al	(M3)	Aluminium,Al extracted by Mehlich No 3 - method S42
N	(total)	Nitrogen N, total by method S10
OrgC	(W/B)	Organic Carbon C, Walkley and Black method S09.
Emerson	Class	Emerson class number by AS 1289 C.8.1
Clay.	fraction	Clay, less than 0.002mm by method S06. ref. Australian Standard AS1289.C6.3
Sand.	fraction	Sand, 0.02 to 2.0mm by method S06. ref. Australian Standard AS1289.C6.3
Silt.	fraction	Silt, 0.02 to 0.002mm by method S06. ref. Australian Standard AS1289.C6.3
Ni	iMET2SAICP	Nickel, dry basis
Co	iMET2SAICP	Cobalt, dry basis
Cu	iMET2SAICP	Copper, dry basis
Mn	iMET2SAICP	Manganese, dry basis
Cr	iMET2SAICP	Chromium, dry basis
Co	iMET2SAMS	Cobalt, dry basis
Hg	iMET2SAMS	Mercury, dry basis
Cd	iMET2SAMS	Cadmium, dry basis
As	iMET2SAMS	Arsenic, dry basis
Ni	iMET2SAMS	Nickel, dry basis
Sb	iMET2SAMS	Antimony, dry basis
Pb	iMET2SAMS	Lead, dry basis
Se	iMET2SAMS	Selenium, dry basis
Zn	iMET2SAMS	Zn, dry basis Zinc has not been validated HB 28.12
Ag	iMET2SAMS	Silver, dry basis

Results are based on a air-dry (40C) , < 2 mm basis. Stones (>2mm) if present are reported on an air dry whole sample basis.

EMERSON CLASS CLASSIFICATION

The swelling and dispersive properties of the soils were tested by placing natural peds and samples re-moulded at or near field capacity moisture content in deionised water. Based on their slaking and dispersive behaviour, the samples were classified into one of 8 classes according to the Emerson Classification scheme as described in Australian Standard AS 1289.C8.1-1980.

Summary of classification scheme:

Class 1 Soil slakes, air-dried crumbs are strongly dispersive
Class 2 Soil slakes, air-dried crumbs show slight to moderate dispersion
Class 3 Soil slakes, air-dried crumbs do not disperse, re-moulded soil disperses
Class 4 Soil slakes, air-dried crumbs do not disperse, calcium carbonate or calcium sulphate are present.
Class 5 Soil slakes, air-dried and re-moulded soil do not disperse, 1:5 soil:water extract remains dispersed after 5 minutes.
Class 6 Soil slakes, air-dried and re-moulded soil do not disperse, 1:5 soil:water extract begins to flocculate within 5 minutes
Class 7 Soil does not slake, air-dried crumbs remain coherent and swell.
Class 8 Soil does not slake, air-dried crumbs remain coherent, but do not swell.

A sample with a result of 0, indicates the sample was not suitable for the test, i.e air-dried sample did not contain soil peds between 4.75 - 2.36mm diameter.

Exchangeable Sodium Percentage (ESP)

The ESP is a measure of sodicity (i.e exchangeable Na+) based on a soils exchange complex . High levels of sodium can adversley effect plant growth and soil structure.
The table below (categorised by Northcote and Skene, 1972) relates % ESP to soil sodicity. This table should only be used as a guide as it tolerance can vary on soil type and plant species.

ESP<6 non-sodic
ESP6-15 sodic
ESP>15 strongly sodic

Multi-Element Soil Extraction Universal Extractants (Mehlich No.3)

The Mehlich No.3 Test is an alternate soil test using universal extractants for multi-elemental analysis. Results obtained using the Mehlich 3 extractant are highly correlated with the standard "single element" soil tests currently used for a wide range of Western Australian soil types. The test provides information on the amount of plant-available nutrients including phosphorus, potassium, sulphur, calcium, magnesium, sodium, boron, copper, iron, manganese and zinc, in the soil . It can be used as a "screening*" tool (see note below) to measure concentrations of cobalt, aluminium, molybdenum and toxic metals such as cadmium, lead, arsenic, selenium and nickel in soil. It is ideally suited to acid and neutral soils, the amounts of nutrients extracted being similar to those of other soil tests used in WA .

*Results that are reported as ">" are outside the linear range of the calibration and outside the scope of the method. This results should only be used as a guide and consideration should be given to a more specific test method if the actual "value" need to be determined, hence these results should only be used as a guide.
Bolland, Allen & Walton. Aust J Soil Research 2002.
Soil Chemical Methods, Australasia (Rayment & Lyons) 2010

The silt and clay components were determined by sedimentation using Stokes' Law principles whereas the sand fractions were determined by dry sieving the >0.075 mm fraction.

B. Price

Barry Price
Snr Chemist & Research Officer
Scientific Services Division
22-Oct-2021

Hannah Burton
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Scientific Services Division

APPENDIX 3: DETAILED FLORA AND VEGETATION SURVEY OF THE REDCLIFFE GOLD PROJECT (BOTANICA 2021)

Detailed Flora and Vegetation Survey of the Redcliffe Gold Project

Prepared For
Dacian Gold Ltd.

October 2021
Version FINAL

Prepared by:
Botanica Consulting Pty Ltd
33 Brewer Street, Perth, WA 6000

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Document Job Number:	2021/111
Prepared by:	Kelby Jennings Senior Environmental Consultant Botanica Consulting
Reviewed by:	Andrea Williams Director Botanica Consulting
Approved by:	Jim Williams Director Botanica Consulting

Contents **Page No.**

Tables

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Glossary

Acronym	Description
ANCA	Australian Nature Conservation Agency.
BA	Birdlife Australia (Formerly RAOU, Birds Australia).
BAM Act	*Biosecurity and Agriculture Management Act* 2007, WA Government.
BC Act	*Biodiversity Conservation Act* 2016, WA Government.
Botanica	Botanica Consulting.
BoM	Bureau of Meteorology.
CAMBA	China Australia Migratory Bird Agreement 1998.
DAFWA	Department of Agriculture and Food (now DPIRD), WA Government.
DAWE	Department Agriculture, Water and Environment (formerly DotEE), Australian Government.
DBCA	Department of Biodiversity, Conservation and Attractions (formerly DPaW), WA Government.
DEC	Department of Environment and Conservation (now DBCA), WA Government.
DER	Department of Environment Regulation (now DWER), WA Government.
DMIRS	Department of Mines, Industry Regulation and Safety (formerly DMP), WA Government.
DMP	Department of Mines and Petroleum (now DMIRS), WA Government.
DotEE	Department of the Environment and Energy (now DAWE), Australian Government.
DoW	Department of Water (now DWER), WA Government.
DPaW	Department of Parks and Wildlife (now DBCA), WA Government.
DPIRD	Department of Primary Industries and Regional Development, WA Government.
DWER	Department of Water and Environmental Regulation (formerly OEPA, DER and DoW), WA Government.
EP Act	*Environmental Protection Act 1986,* WA Government.
EPA	Environmental Protection Authority, WA Government.
EPBC Act	*Environment Protection and Biodiversity Conservation Act* 1999, Australian Government.
ESA	Environmentally Sensitive Area.
Ha	Hectare (10,000 square metres).
IBRA	Interim Biogeographic Regionalisation for Australia.
IUCN	International Union for the Conservation of Nature and Natural Resources – commonly known as the World Conservation Union.
JAMBA	Japan Australia Migratory Bird Agreement 1981.
Km	Kilometre (1,000 metres).
MVG	Major Vegetation Groups.
NVIS	National Vegetation Information System.
PEC	Priority Ecological Community.
RAOU	Royal Australia Ornithologist Union.
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement 2007.
SRE	Short Range Endemic.
SSC	Species Survival Commission, International.
TEC	Threatened Ecological Community.
UCL	Unallocated Crown Land
WA	Western Australia.
WAHERB	Western Australian Herbarium.
WAM	Western Australian Museum, WA Government.
WC Act	*Wildlife Conservation Act* 1950 (now BC Act), WA Government.

EXECUTIVE SUMMARY

Botanica Consulting Pty Ltd (Botanica) was commissioned by Dacian Gold Ltd. (Dacian) to undertake a detailed flora and vegetation survey of the Redcliffe Gold Project (RGP). The RGP is located approximately 50 km north-east of Leonora, Western Australia. The survey area is 1,731 ha in extent and encompasses the proposed Nambi, Hub, Bindy and Gold Terrace South deposits, as well as the Nambi road alignment. These areas are located within mining tenements M37/134, M37/1286, M37/1276, M37/1295. The flora and vegetations assessment is required to inform and support the development of a Mining Proposal for the RGP.

The study area lies within the Eastern Murchison (MUR1) subregion of the Murchison Bioregion, as defined by the Interim Biogeographic Regionalisation of Australia (IBRA).

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).

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

- G&G Environmental Pty Ltd (2010). *Flora and Vegetation survey of the Golden Terrace South Tenement, M37/1276*. Unpublished report prepared on behalf of Pacrim Energy Limited.
- Botanica Consulting Pty Ltd (2019). *Reconnaissance Flora/ Vegetation & Fauna Survey Redcliffe Gold Project*. Unpublished report prepared on behalf of NTM Gold Limited.
- Botanica Consulting Pty Ltd. (2021). *Flora, Vegetation and Fauna Assessment of the Leonora-Laverton Road Material Pits (SLK 53, 75 & 76)*. Unpublished report prepared on behalf of Main Roads Western Australia.
- Botanica Consulting Pty Ltd. (2021). *Reconnaissance Flora and Basic Fauna Survey of the Malcom Challenger Project.* Unpublished report prepared on behalf of Kumarina Resources Ltd.

In addition to the literature review, searches of the following databases were undertaken to aid in the compilation of a list of significant flora within the survey area:

- DBCA Threatened/ Priority Flora spatial data (DBCA, 2019a);
- DBCA NatureMap database (DBCA, 2021b); and
- EPBC Protected Matters search tool (DAWE, 2021a).

The NatureMap species search and EPBC Protected Matters search were conducted with a 40 km buffer from the survey area.

The NatureMap search identified 90 vascular flora species as occurring within 40 km of the survey area, representing 50 genera from 25 families. The most diverse families were Scrophulariaceae (16 species), Fabaceae (13 species) and Asteraceae (10 species). Significant genera were *Eremophila* (16 species), *Acacia* (10 species) and *Sclerolaena*, *Atriplex*, *Maireana* and *Eucalyptus* (three species each).

The desktop review identified eight introduced flora (weed) species as potentially occurring in the vicinity of the survey area, representing six families. One species, *Cylindropuntia* spp. (Prickly Pear) is listed as a Declared Pest on the Western Australian Organism List (WAOL) under the *Biosecurity and Agriculture Management* (BAM) *Act 2007* and as a Weeds of National Significance (WONS). In addition, *Tamarix aphylla* (Athel Tamarisk) is also listed as a WONS.

The desktop assessment identified 16 significant flora species recorded within a 40 km radius of the survey area. These are comprised of three Priority 1, seven Priority 3 and one Priority 4 taxa.
These taxa were assessed for distribution and known habitat to determine their likelihood of occurrence within the survey area. The assessment identified two significant flora taxa as likely to occur in the survey area, consisting of one Priority 3 and one Priority 4 taxa. In addition, nine significant taxa were identified as possibly occurring in the survey area, consisting of three Priority 1 and six Priority 3 taxa.

The Protected Matters search (DAWE, 2021a) did not identify any Threatened Ecological Communities as potentially occurring within the survey area. Analysis of the Priority Ecological Communities within the Midwest region (DBCA, 2021a) did not identify any significant communities as likely or possibly occurring within the survey area.

There are no DBCA managed or interest lands located within or adjacent to the survey area.

There are no Environmentally Sensitive Areas located within or adjacent to the survey area.

There are no Nationally Important or RAMSAR wetlands located within or adjacent to the survey area.

The nearest significant environmental feature is an un-named nature reserve (R46847), located approximately 85 km south of the survey area. Development within the survey area is unlikely to impact the environmental values of this area.

Botanica conducted a detailed flora and vegetation survey on the 13th-15th July 2021, with the area traversed on foot and 4WD by Jim Williams (Director/Principal Botanist, Diploma of Horticulture) and Jennifer Jackson (Senior Botanist, BSc (Honours) Environmental Management).

A total of 44 quadrats were installed and surveyed, and opportunistic observations were taken throughout the survey effort.

The field survey identified 122 vascular flora taxa within the survey area. These taxa represented 62 genera across 31 families, with the most diverse families being Fabaceae (19 species), Scrophulariaceae (17 species) and Asteraceae (14 species). The most diverse genera were *Eremophila* (17 species), Acacia (14 species) and *Maireana* (six species). There were no recorded introduced (weed) species.

No Threatened flora species were recorded within the survey area.

No Priority or otherwise significant flora were recorded within the survey area.
A total of eight broad-scale vegetation communities were identified within the survey area. Vegetation community descriptions and extents were determined from field survey results, aerial imagery interpretation and extrapolation of the communities.

The survey found SLP-AFW1 was the most widespread vegetation type in the survey area, occupying 396.7 ha (22.9%), while B-MWS1 was the most restricted with 9.4 ha (0.5%). Species diversity averaged 34 species per quadrat. The most diverse vegetation type was QRP-AFW1 with 64 species (52.5%), while the least diverse was B-MWS1 with 11 species (9.0%).

Native vegetation within the survey area was rated as ‘good‘ to ‘very good’. ‘Very Good’ condition shows relatively slight signs of damage caused by human activities such as the presence of some relatively non-aggressive weeds or occasional vehicle tracks ‘Good’ condition depicts more significant damage caused by human activity since European settlement, including impacts to vegetation structure and composition from historical clearing, significant grazing, changed fire regimes and/or aggressive weeds. Cleared areas associated with mining operations access roads were rated as ‘completely degraded’.

1 INTRODUCTION

1.1 Project Description

Botanica Consulting Pty Ltd (Botanica) was commissioned by Dacian Gold Ltd. (Dacian) to undertake a detailed flora and vegetation survey of the Redcliffe Gold Project (RGP). The RGP is located approximately 50 km north-east of Leonora, Western Australia (Figure 1-1). The survey area is 1,731 ha in extent and encompasses the proposed Nambi, Hub, Bindy and Gold Terrace South deposits, as well as the Nambi road alignment. These areas are located within mining tenements M37/134, M37/1286, M37/1276, M37/1295. The flora and vegetation assessment is required to inform and support the development of a Mining Proposal for the RGP.

1.2 Objectives

1.2.1 Detailed Flora Survey

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:

- Gather background information on flora and vegetation in the desktop study area (literature review, database and map-based searches);
- Conduct a field survey to verify / ground truth the desktop study findings through reconnaissance survey;
- 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);
- Record the species composition (abundance and diversity) of each vegetation community within the survey area and compile a species list for the survey area by vegetation type;
- Provide quadrat-based data from plots representative of each vegetation type (minimum of three quadrats per vegetation type) according to Environmental Protection Authority (EPA) guidelines;
- Assess the species composition of each quadrat;
- Determine the local and regional conservation significance of flora and vegetation within the survey area;
- Identify and record the locations of any conservation significant flora/vegetation within the survey area;
- Identify and record the locations of any introduced flora species (including Declared Pests) within the survey area;
- Provide a map showing the distribution of conservation significant flora/vegetation within the survey area; and
- 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).

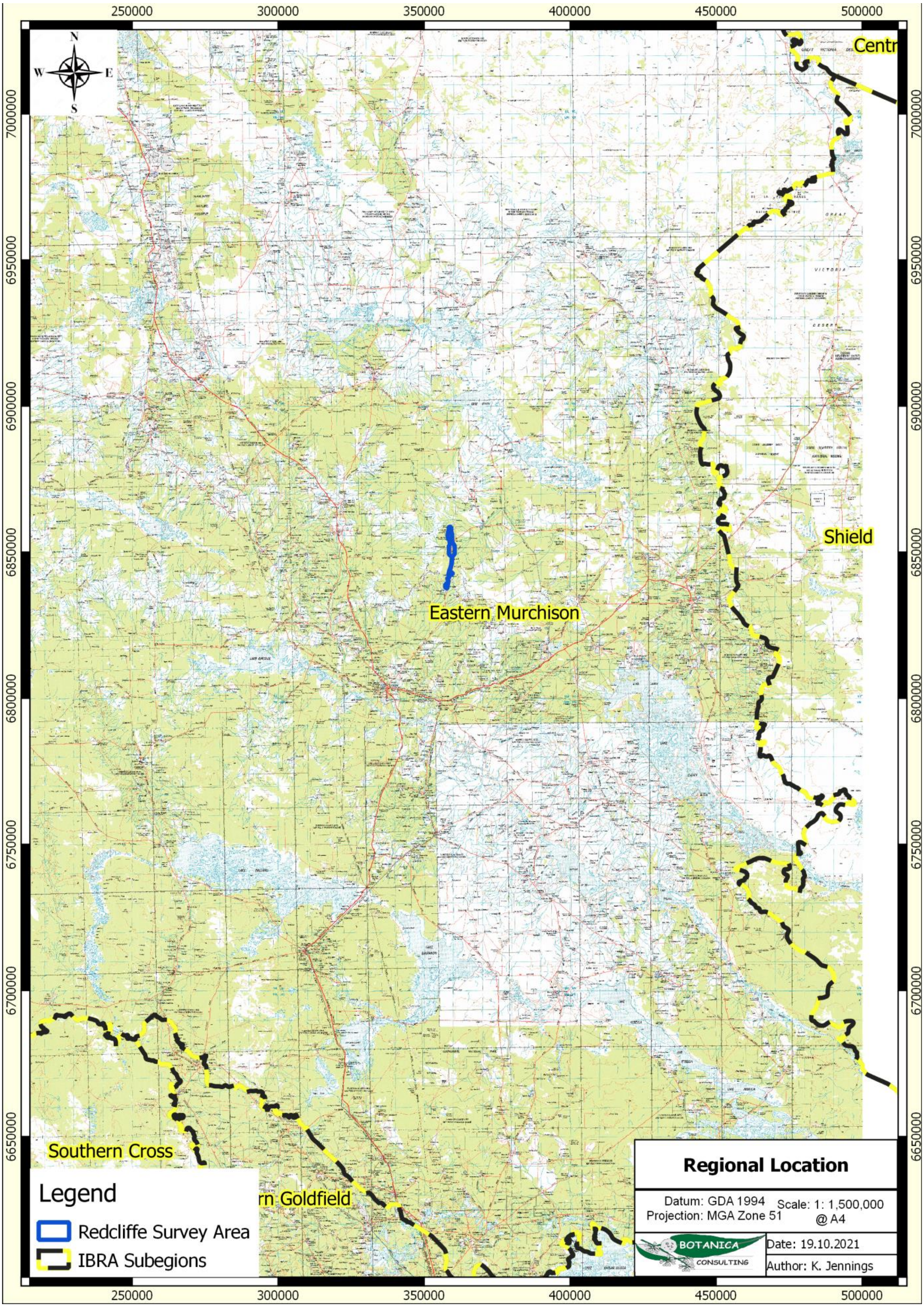


Figure 1-1: Regional location of the survey area

2 BIOPHYSICAL ENVIRONMENT

2.1 Regional Environment

The study area lies within the Eastern Murchison (MUR1) subregion of the Murchison Bioregion, as defined by the Interim Biogeographic Regionalisation of Australia (IBRA).

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).

In accordance with Beard (1990), the Murchison region is located in the Austin Botanical District within the Eremaean Province of WA. It is defined by the vegetational expression of geological boundaries of the Yilgarn Block, described as Archaean granite with infolded volcanics and meta-sediments (greenstones) of a like age. The topography is undulating, with occasional ranges of low hills and extensive sandplains in the eastern half. The principal soil type is shallow earthy loam overlying red-brown hardpan, with shallow stony loams on hills and red earthy sands on sandplains. The western half of the region more or less coincides with the basin of the Murchison River, the eastern half embraces the drainage of former rivers, now dry, draining towards the Eucla Basin. Vegetation is predominantly mulga low woodland *(Acacia aneura)* on plains, reduced to scrub on hills, with a tree steppe of *Eucalyptus* spp. and *Triodia basedowii* on sandplains. The climate is arid, with summer and winter rains and an average annual precipitation of 200 mm.

2.2 Land Use

The dominant land uses of the Eastern Murchison subregion include grazing native pastures (85.47%), unallocated crown reserves (11.34%), conservation (1.4%) and mining (1.79%) (Cowan, 2001). The survey area is located within the Nambi and Mertondale pastoral stations.

2.3 Soils and Landscape Systems

The study area lies within the Murchison Province, which 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 is further divided into soil landscape systems (Government of Western Australia, 2019), with the survey area located within eight soil landscape systems, as described in Table 2-1 and shown in Figure 2-1.

Table 2-1: Soil landscape systems within the desktop study area/ survey area

System Name	Description	Area (ha)	% of survey area
Bevon System	Irregular low ironstone hills with stony lower slopes supporting mulga shrublands.	144	8.3
Bullimore System	Gently undulating sandplain with occasional linear dunes and stripped surfaces supporting spinifex grasslands with mallees and acacia shrubs.	28	1.6
Desdemona System	Plains with deep sandy or loamy soils supporting mulga tall shrublands and wanderrie grasses.	30	1.7
Jundee System	Hardpan plains with variable gravelly mantles and minor sandy banks supporting weakly groved mulga shrublands.	769	44.4
Monk System	Hardpan plains with occasional sandy banks supporting mulga tall shrublands and wanderrie grasses.	245	14.2
Nubev System	Gently undulating stony plains, minor limonitic low rises and drainage floors supporting mulga and halophytic shrublands.	35	2
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.	447	25.8
Wyarri System	Granite domes, hills and tor fields with gritty-surfaced fringing plains supporting mulga and granite wattle shrublands.	33	1.9

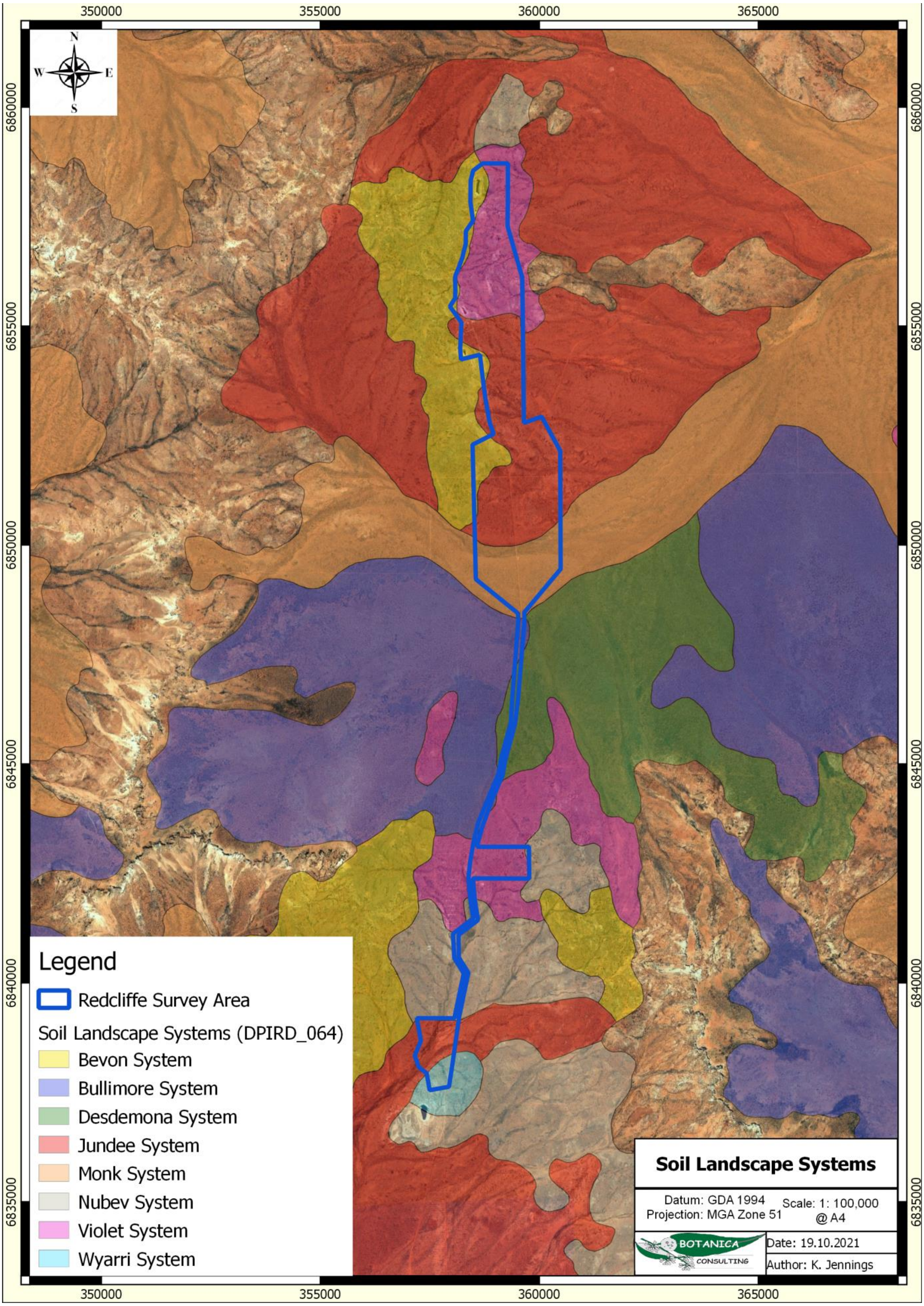


Figure 2-1: Soil landscape systems within the survey area

2.4 Regional Vegetation

The vegetation of the Murchison Bioregion is described by Tille (2006) as Mulga (*Acacia aneura*) shrublands and woodlands with gidgee (*A. pruinocarpa*), kurara (*A. tetragonophylla*), *A. linophylla,* bowgada (*A. ramulosa*)*,* jam (*A. acuminata*), minniritchie (*A. grasbyi*), *Senna* spp. and *Eremophila* spp. which dominate the hardpan wash plains. Denser, taller mulga woodlands are found on groves while the sandy banks support mulga, bowgada and kurara shrublands with an understorey of wanderrie grasses (*Eragrostis* and *Eriachne* spp. and *Monachather paradoxa*). Snakewood (*A. xiphophylla*), bluebush (*Maireana* spp.) and saltbush (*Atriplex* spp.) grow on the saline drainage tracts.

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. longissima*, *E. brachycorys* and *E. youngiana*), bowgada and spinifex wattle (*A. coolgardiensis*). In places denser woodlands of mulga, spinifex wattle or mallee are found over the spinifex. On western sandplains shrublands are dominated by bowgada with cypress pine (*Callitris columellaris*), mallees (*e.g. E. leptopoda* and *E. kingsmillii*), mulga and *Grevillea* spp. On the yellow sandplains in the south-west are closed mixed shrublands with *Melaleuca*, *Hakea*, *Calothamnus*, *Baeckea*, *Banksia prionotes*, *Allocasuarina*. and *Acacia* spp. The mesas have bowgada, mulga and *A. linophylla* shrublands above the breakaways, while the footslopes support shrublands with saltbush (*Atriplex* spp.), *Frankenia* spp., *Ptilotus* spp. and *Eremophila pterocarpa*. The hilly terrain has shrublands of mulga, minniritchie, *Eremophila* spp. and cotton bush (*Ptilotus obovatus*). Hills in the far west have woodlands of York gum (*Eucalyptus loxophleba*), salmon gum (*E. salmonophloia*) and jam (*Acacia acuminata).* The stony plains support shrublands of mulga, gidgee, granite wattle (*Acacia quadrimarginea*), minniritchie, prickly wattle, snakewood, jam and *Eremophila* spp. in the valley floors there are shrublands of samphire (*Tecticornia* spp.), saltbush, 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* (Tille 2006).

2.5 Conservation Values

The Murchison Bioregion contains 41 vegetation associations (hummock grasslands, succulent steppe or low woodlands) that have at least 85 per cent of their total extent in the Bioregion. The Bioregion is rich and diverse in flora and fauna but most species are wide ranging and usually occur in adjoining regions. A snake (*Pseudechis butleri*) is the only known regionally endemic vertebrate species.

There are six wetlands of national importance in the Bioregion, all of which are salt lakes: Lake Ballard, Lake Barlee, Lake Marmion, Lake Wooleen, Lake Breberle and Lake Anneen. There is one wetland of regional importance within the Murchison Bioregion; the Mungawolagudgi Claypan on Muggon Station.

No ecosystems are listed as threatened under WA State legislation occur within the Murchison Bioregion, but 52 communities and vegetation associations are thought to be at risk for a variety of reasons. Grazing from livestock, goats and rabbits and changed fire regimes are the main threatening processes in the region, with clearing, impacts of mining, erosion and sedimentation also causing significant impacts.

2.6 Climate

The climate of the Eastern Murchison subregion is characterised as an arid climate with mainly winter rainfall and annual rainfall of approximately 200 millimetres (mm) (Beard, 1990); Cowan, 2001b). Rainfall data for the Leonora aero weather station (#12241), located approximately 45 km south-west of the survey area is shown in Figure 2-2. Rainfall received prior to the field survey (July-August) was above average due to significant rains in July, although rain for June was below average. Climate conditions are not expected to be a limiting factor to the survey.

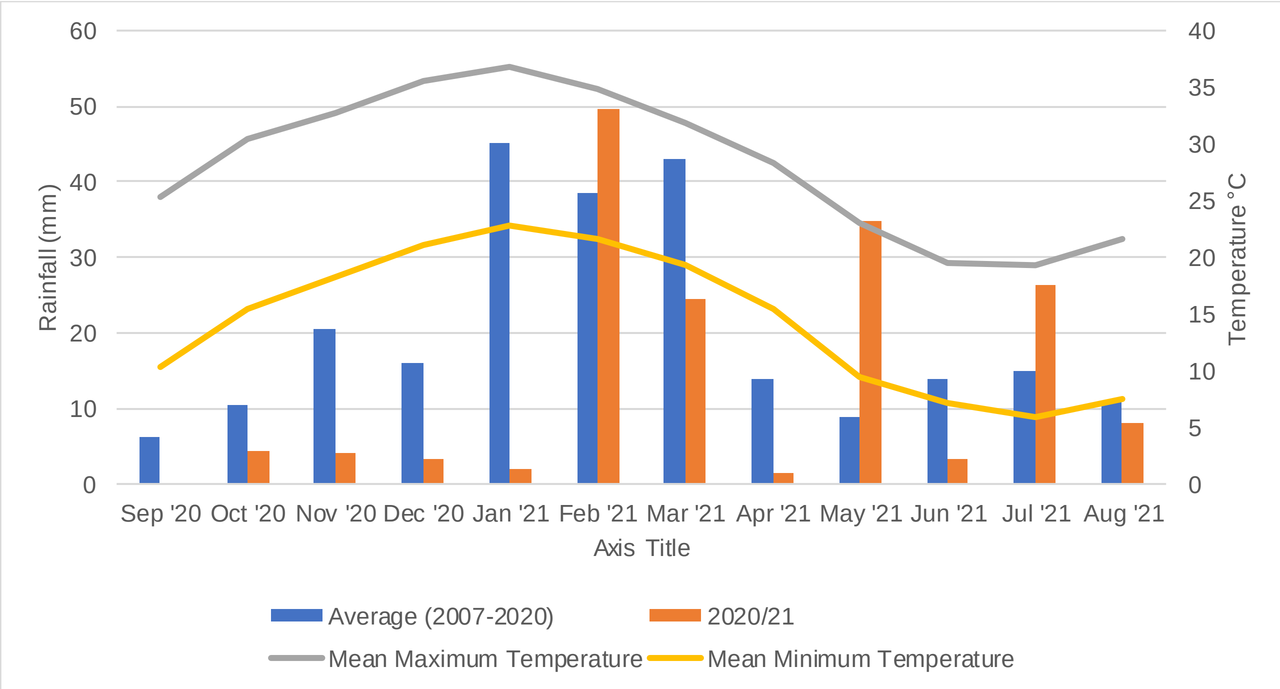


Figure 2-2: Rainfall and temperature data for Leonora aero weather station (#12241) (BOM, 2021a)

2.7 Hydrology

According to the Geoscience Australia database (2015) there are no surface water bodies within the survey area. However, there are several ephemeral drainage lines that intersect the survey area, including Dillon Creek (Figure 2-3).

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, 2021b) database, there are no known or potential aquatic GDE's within the survey area (Figure 2-3).
The survey area has low potential to contain a terrestrial GDE, described as 'hardpan plains with occasional sandy banks supporting mulga tall shrublands and wanderrie grasses' (BoM, 2021b).

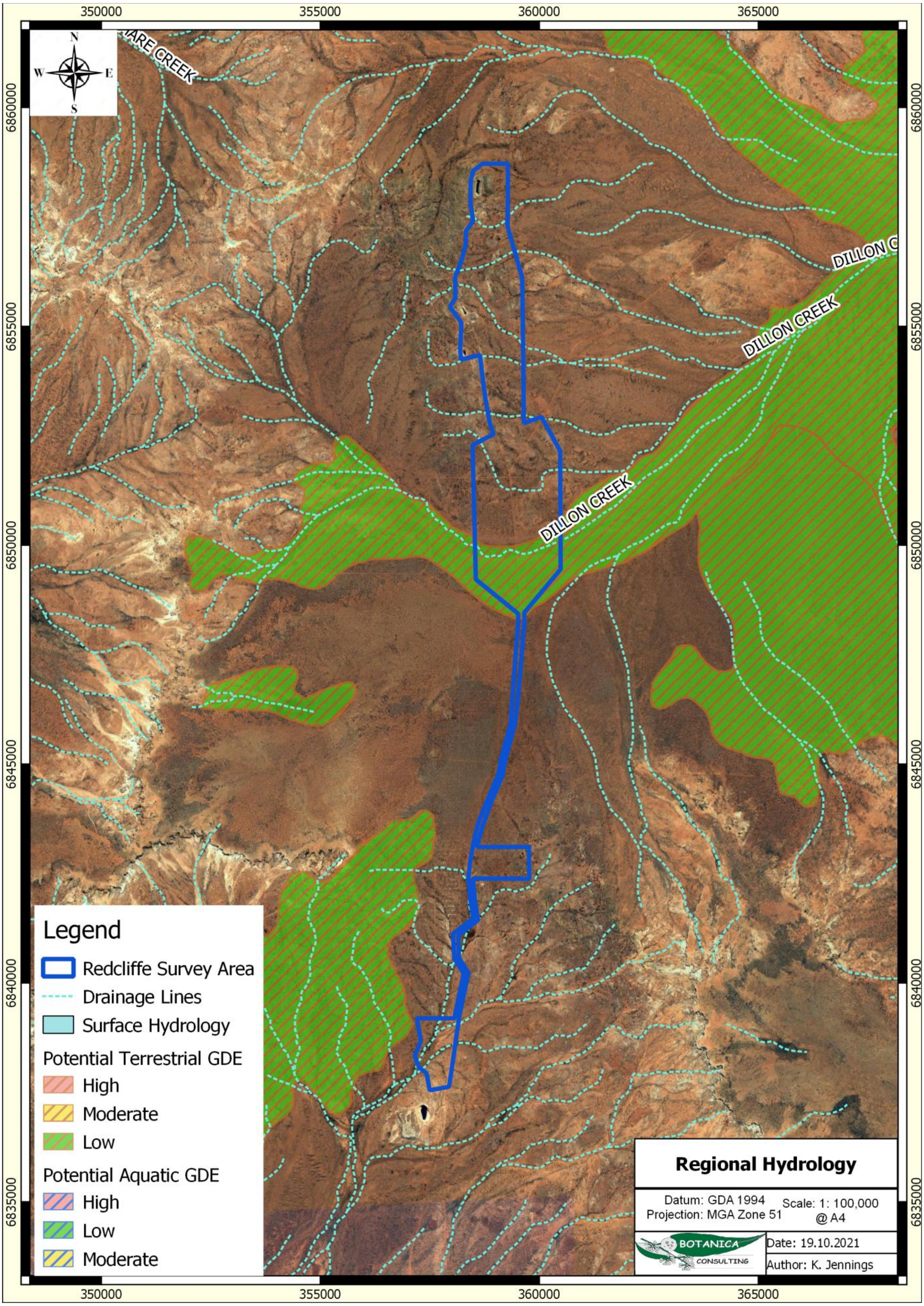


Figure 2-3: Regional hydrology of the survey area

3 SURVEY METHODOLOGY

3.1 Desktop Assessment

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

- G&G Environmental Pty Ltd (2010). *Flora and Vegetation survey of the Golden Terrace South Tenement, M37/1276*. Unpublished report prepared on behalf of Pacrim Energy Limited.
- Botanica Consulting Pty Ltd (2019). *Reconnaissance Flora/ Vegetation & Fauna Survey Redcliffe Gold Project*. Unpublished report prepared on behalf of NTM Gold Limited.
- Botanica Consulting Pty Ltd. (2021). *Flora, Vegetation and Fauna Assessment of the Leonora-Laverton Road Material Pits (SLK 53, 75 & 76)*. Unpublished report prepared on behalf of Main Roads Western Australia.
- Botanica Consulting Pty Ltd. (2021). *Reconnaissance Flora and Basic Fauna Survey of the Malcom Challenger Project.* Unpublished report prepared on behalf of Kumarina Resources Ltd.

In addition to the literature review, searches of the following databases were undertaken to aid in the compilation of a list of significant flora within the survey area:

- DBCA Threatened/ Priority Flora spatial data (DBCA, 2019a);
- DBCA NatureMap database (DBCA, 2021b); and
- EPBC Protected Matters search tool (DAWE, 2021a).

The NatureMap species search and EPBC Protected Matters search were conducted with a 40 km buffer from the survey area.

Significant flora identified by the desktop review were assessed with regards to their population extent and distribution and preferred habitat to determine their likelihood of occurrence within the survey area.

The assessment categorised flora species as follows:

- Unlikely- Suitable habitat is not expected to occur and/or the survey area is outside the known range of the species.
- Possible- Suitable habitat may be present, and the area is within the known range of the species. This option is also used when there is insufficient information to determine the preferred habitat of a species.
- Likely- Suitable habitat is expected to occur and there are records within 10 km of the survey area.
- Previously Recorded- A record for this species is located within the survey area. Field survey will ground-truth currently occurring individuals and populations.

It should be noted that these lists are based on observations from a broader area than the assessment area (40 km radius) and therefore 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 these sources should therefore be taken as indicative only and local knowledge and information also needs to be taken into consideration when determining what actual species may be present within the specific area being investigated.

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

- *Environment Protection and Biodiversity and Conservation* (EPBC) *Act 1999*. Administered by the Australian Government (DAWE);
- *Biodiversity Conservation* (BC) *Act 2016*. Administered by the WA Government (DBCA); and
- Priority Flora list. A non-legislative list maintained by DBCA for management purposes (released December 2018).

3.2 Flora Field Assessment

Botanica conducted a detailed flora/ vegetation survey on the 13^{th}-15^{th} July 2021, with the area traversed on foot and 4WD by Jim Williams (Director/Principal Botanist, Diploma of Horticulture) and Jennifer Jackson (Senior Botanist, BSc (Honours) Environmental Management).

A total of 44 quadrats were installed and surveyed, and opportunistic observations were taken throughout the survey effort. The location of quadrats within the survey area and the GPS track log from the field survey are shown in Figure 3-1 and Figure 3-2. The geographic locations (Easting/ Northing (GDA 94, Zone 51)) of the north-west corner of the quadrats are listed in Appendix 3.

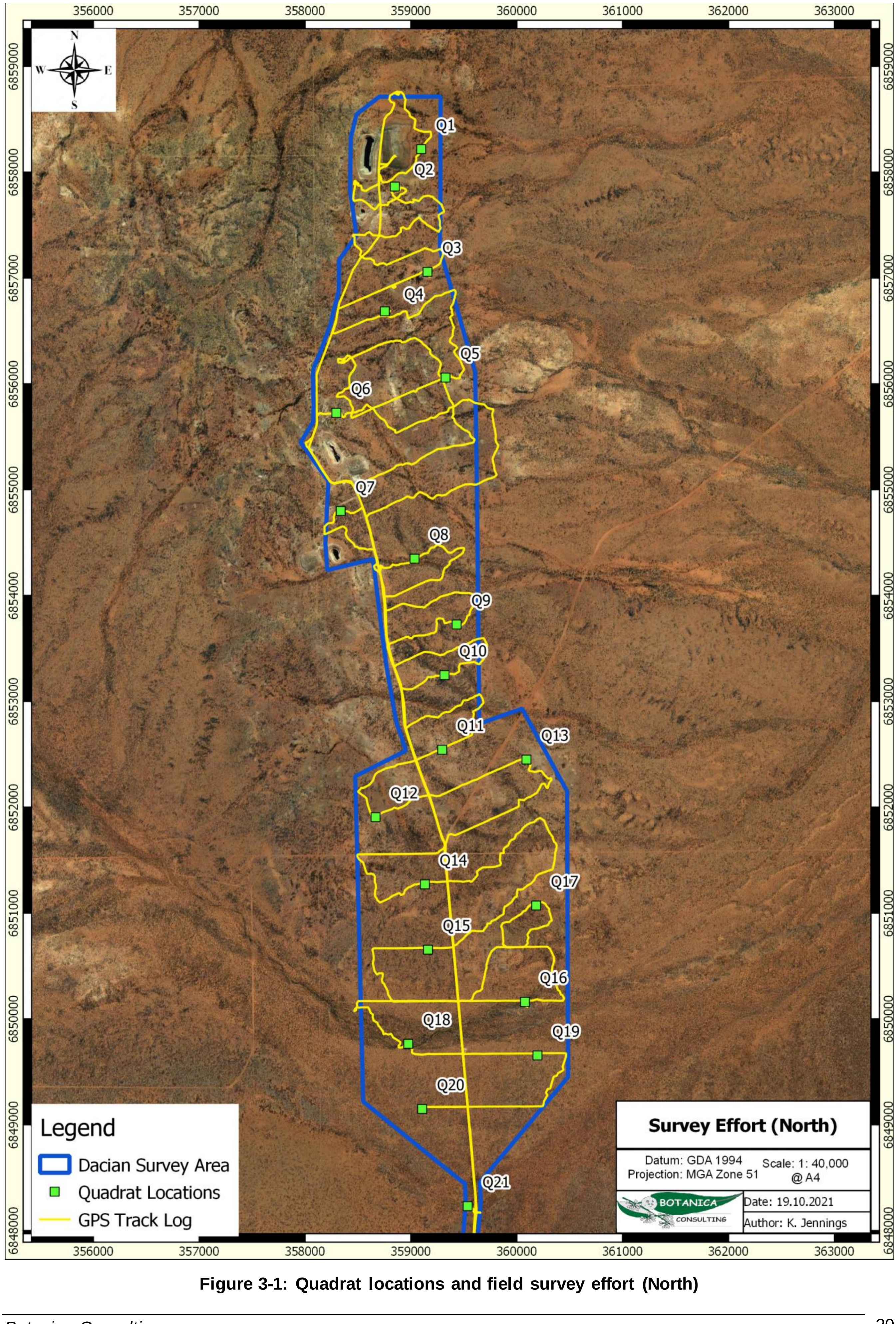


Figure 3-1: Quadrat locations and field survey effort (North)

Figure 3-2: Quadrat locations and field survey effort (South)

3.2.1 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 conservation significance if encountered.

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

3.2.2 Detailed Flora and Vegetation Survey

A total of 44 quadrats were established within the survey area (Figure 3-1 and Appendix 3). According to the recommended quadrat size specified in the Environmental Protection Authority (EPA) Guidelines, 20m X 20m quadrats are recommended for the Murchison Bioregion. However, due to the low level of species richness present within the survey area, 50m X 50m quadrats were established to allow for a better representation of species composition. 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. Quadrats were not established within regrowth/ modified vegetation.

Following their establishment and boundary verification, the NW corner of each quadrat was recorded by GPS and three photographs of the quadrat were taken from the NW corner. All vascular plants within the quadrat were recorded (Appendix 8). 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 8). 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.

3.2.3 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.

3.3 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 within the survey area was calculated. Spatial maps illustrating the location of vegetation types and any significant flora and/or vegetation were generated using QGIS.

3.3.1 PATN Analysis

The PATN software package was used to assess the similarities/ dissimilarities between quadrats based on presence/absence of species. A total of 51 species were excluded from the analysis; 26 annuals and 25 singleton species. A total of 59 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.).

3.3.2 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.

3.4 Scientific Licences

Table 3-1: Scientific Licences of Botanica Staff coordinating the survey

Licensed staff	Permit Number	Valid Until
Jim Williams	FB62000108 (Licence to flora for scientific purposes)	27/05/2022
Jennifer Jackson	FB62000309 (Licence to take flora for scientific purposes)	11/01/2024

3.5 Survey Limitations and Constraints

It is important to note that flora and vegetation surveys will entail limitations notwithstanding careful planning and design. Potential limitations are listed in Table 3-2.

Table 3-2: Limitations and constraints associated with the flora and vegetation survey

Variable	Potential Impact on Survey	Details
Access problems	Not a constraint	The survey was conducted via 4WD and on foot. Numerous access tracks were present within the survey area providing ease of access.
Competency/ Experience	Not a constraint	The Botanica personnel that conducted the survey were regarded as suitably qualified and experienced. **Coordinating Staff**: Jim Williams (Botanist) **Field Staff**: Jim Williams and Jennifer Jackson **Data Interpretation**: Jim Williams, Jennifer Jackson and Kelby Jennings.
Timing of survey, weather & season	Not a constraint	Fieldwork was conducted in July 2021, within the EPA recommended approximate timing (6-8 weeks post wet season). Flowering material was available and multiple annual species were present and able to be identified to species level.
Area disturbance	Not a constraint	The majority of the survey area was in very good condition and comprised of native vegetation. Disturbance in the area was a result of access roads and historical mining activity.
Survey Effort/ Extent	Not a constraint	Survey intensity was appropriate for the size/significance of the area with a detailed flora and vegetation survey completed to identify vegetation types and significant flora and vegetation.
Availability of contextual information at a regional and local scale	Not a constraint	Conservation 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 DAWE 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 Murchison Bioregion and was also 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 within EPAs recommended approximate timing (6-8 weeks post wet season), and multiple annual species were present and able to be identified to species level. The vegetation associations for this study were based on visual descriptions of locations in the field. The distribution of these vegetation associations outside the study area is not known, however vegetation associations identified were categorised via comparison to vegetation distributions throughout WA given on NVIS (DotEE, 2017).

4 RESULTS

4.1 Desktop Assessment

4.1.1 Flora

The NatureMap search identified 90 vascular flora species as occurring within 40 km of the survey area, representing 50 genera from 25 families. The most diverse families were Scrophulariaceae (16 species), Fabaceae (13 species) and Asteraceae (10 species). Significant genera were *Eremophila* (16 species), *Acacia* (10 species) and *Sclerolaena*, *Atriplex*, *Maireana* and *Eucalyptus* (three species each). This total includes no introduced (weed) species.

4.1.1.1 Introduced Flora

The desktop review identified eight introduced flora (weed) species as potentially occurring in the vicinity of the survey area, representing six families. One species, *Cylindropuntia* spp. (Prickly Pear) is listed as a Declared Pest on the Western Australian Organism List (WAOL) under the *Biosecurity and Agriculture Management* (BAM) *Act 2007* and as a Weeds of National Significance (WONS). In addition, *Tamarix aphylla* (Athel Tamarisk) is also listed as a WONS.

The full list of potential weed species is contained in Appendix 2.

4.1.1.2 Significant Flora

The assessment of the DBCA Priority/ Threatened flora data (DBCA, 2019a), NatureMap search (DBCA, 2021b), Protected Matters searches (DAWE, 2021a) and previous relevant literature identified 12 significant flora species recorded within a 40 km radius of the survey area. These are comprised of three Priority 1, eight Priority 3 and one Priority 4 taxa (Appendix 4).

These taxa were assessed for distribution and known habitat to determine their likelihood of occurrence within the survey area. The assessment identified two significant flora taxa as likely to occur in the survey area, consisting of one Priority 3 and one Priority 4 taxa. In addition, nine significant taxa were identified as possibly occurring in the survey area, consisting of three Priority 1 and six Priority 3 taxa (Table 4-1). The full flora likelihood assessment is listed in Appendix 4. The locations of the DBCA database records are illustrated spatially in Figure 4-1.

Table 4-1: Potentially occurring significant flora species

DBCA Rank	Taxon	Habitat	Comments	Likelihood
P1	*Acacia websteri*	Red sand, clay or loam. Low-lying areas, flats.	Recorded within 40 km, habitat may be present	Possible
	Philotheca tubiflora	Rocky rises & hills, outcrops	Recorded within 40 km, habitat may be present	Possible
	Stenanthemum patens	Rocky hillside.	Recorded within 40 km, habitat may be present	Possible
P3	*Acacia* sp. Marshall Pool (G. Cockerton 3024)	-	Little known, records within 30km.	Possible
	Calytrix praecipua	Skeletal sandy soils over granite or laterite. Breakaways, outcrops.	Recorded within 40 km, habitat may be present	Possible
	Cratystylis centralis	Red sandy loam with ironstone gravel. Flat plains, breakaway country.	Recorded within 40 km, habitat may be present	Possible
	Eremophila annosicaulis	On stony loams (ironstone laterite).	Recorded within 40 km, habitat may be present	Possible
	Eremophila shonae subsp. *diffusa*	Stony yellow or red sandy soils	Recorded within 10 km, habitat may be present	Possible
	Eremophila simulans subsp. *megacalyx*	-	Recorded within 20 km, habitat may be present	Possible
	Hybanthus floribundus subsp. *chloroxanthus*	Dark red-brown soil, never sandy, rich in iron oxide, laterite. Rocky areas, creek banks, along drainage lines.	Recorded within 40 km, habitat may be present	Possible
P4	*Hemigenia exilis*	Laterite. Breakaways, slopes.	Recorded within 40 km, habitat likely to be present	Likely

4.1.2 Vegetation and Ecological Communities

4.1.2.1 Vegetation Associations

The Pre-European vegetation association spatial mapping dataset (DPIRD, 2018) identified two vegetation association as occurring within the survey area (Table 4-2). The association descriptions and their remaining extents, as specified in the 2018 Statewide Vegetation Statistics (DBCA, 2019b) are provided in Table 4-2. 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). All vegetation associations retain >99% of their pre-European extent, and development within the survey area will not significantly reduce the current extent of these vegetation associations.

Table 4-2: Pre-European Vegetation Associations within the survey area

Vegetation Association	Current Extent (ha)	Pre-European extent remaining	% Protected for Conservation	Floristic Description	Extent within Survey Area
Laverton 18	2,339,335	99.95	-	Low woodland; mulga (*Acacia aneura*)	1,669 ha (96.4%)
Laverton 109	152,223	99.37	-	Hummock grasslands, shrub steppe; *Eucalyptus youngiana* over hard spinifex	62 ha (3.6%)

4.1.2.2 Significant Ecological Communities

The Protected Matters search (DAWE, 2021a) did not identify any Threatened Ecological Communities as potentially occurring within the survey area. Analysis of the Priority Ecological Communities within the Midwest region (DBCA, 2021a) did not identify any significant communities as likely or possibly occurring within the survey area.

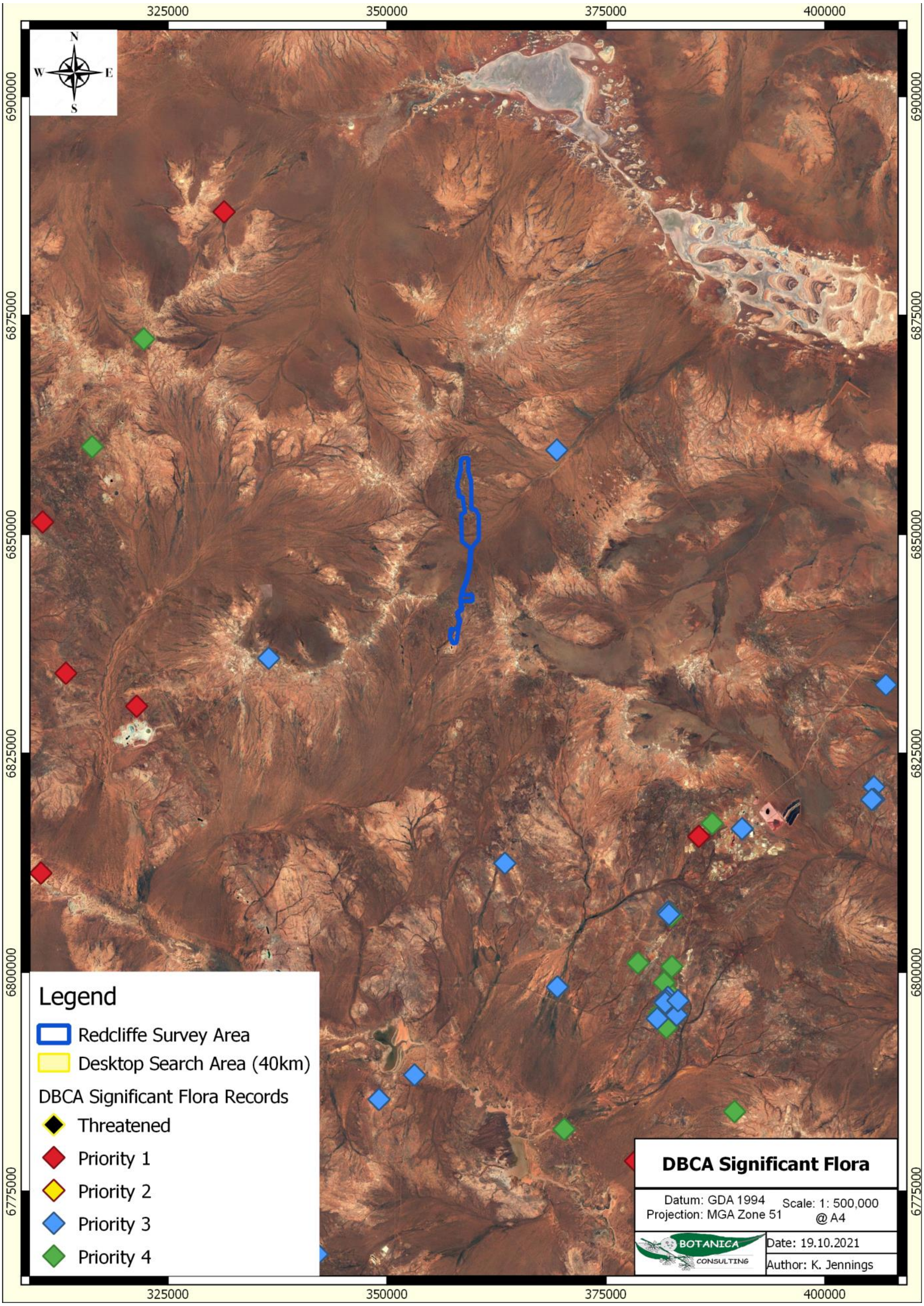


Figure 4-1: Significant flora within the desktop search area (40 km)

4.1.3 Conservation Areas

There are no DBCA managed or interest lands located within or adjacent to the survey area.

There are no Environmentally Sensitive Areas located within or adjacent to the survey area.

There are no Nationally Important or RAMSAR wetlands located within or adjacent to the survey area.

The nearest significant environmental feature is an un-named nature reserve (R46847), located approximately 85 km south of the survey area. Development within the survey area is unlikely to impact the environmental values of this reserve. The location of proposed and vested Conservation Reserves, ESA's and Nationally Important Wetlands in relation to the survey area is provided in Figure 4-2.

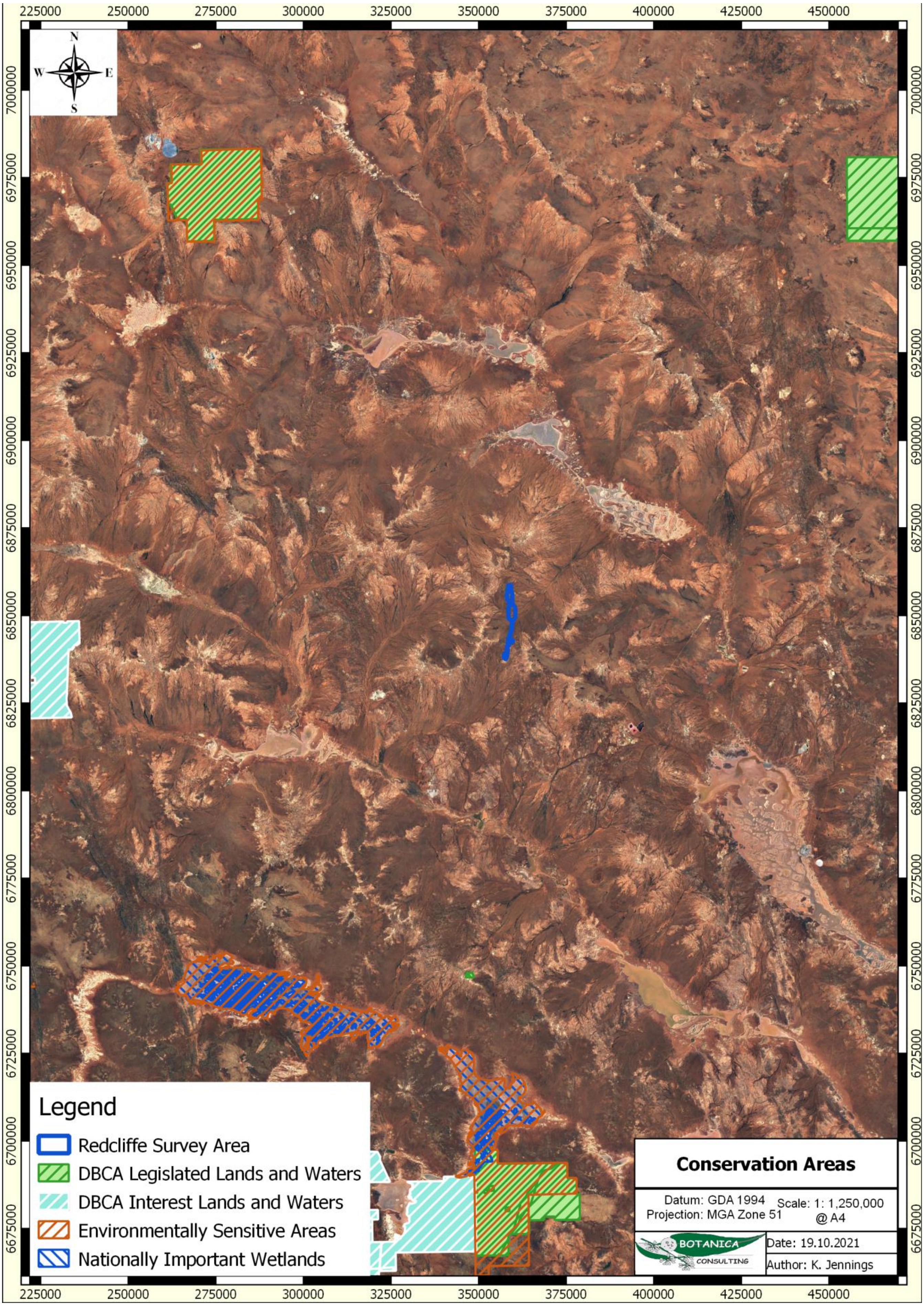


Figure 4-2: Conservation Areas

4.2 Field Assessment

4.2.1 Flora

The field survey identified 122 vascular flora taxa within the survey area. These taxa represented 62 genera across 31 families, with the most diverse families being Fabaceae (19 species), Scrophulariaceae (17 species) and Asteraceae (14 species). The most diverse genera were *Eremophila* (17 species), Acacia (14 species) and *Maireana* (six species). There were no recorded introduced (weed) species. The full field species inventory is listed in Appendix 5.

4.2.1.1 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 species were recorded within the survey area. No Priority or otherwise significant flora were recorded within the survey area.

4.2.2 Vegetation Communities

A total of eight broad-scale vegetation communities were identified within the survey area. Vegetation community descriptions and extents were determined from field survey results, aerial imagery interpretation and extrapolation of the communities. Vegetation community descriptions and extent are listed below in Table 4-3 and illustrated spatially in Figure 4-3 and Figure 4-4.

The survey found SLP-AFW1 was the most widespread vegetation type in the survey area, occupying 396.7 ha (22.9%), while B-MWS1 was the most restricted with 9.4 ha (0.5%). Species diversity averaged 34 species per quadrat. The most diverse vegetation type was QRP-AFW1 with 64 species (52.5%), while the least diverse was B-MWS1 with 11 species (9.0%).

Table 4-3: Summary of vegetation types within the survey area

Landform	Vegetation Community	Broad Floristic Formation (NVIS III)	Vegetation Description (NVIS V)	Image
Breakaway	B-AFW1 17.8 ha (1.0%)	Acacia Forests and Woodlands (MVG 6)	Low woodland of *Acacia quadrimarginea* over tall shrubland of *Acacia ramulosa* var. *linophylla/ Thryptomene decussata* and low open shrubland of *Calytrix uncinata/ Eremophila latrobei* on breakaway	
Breakaway	B-MWS1 9.4 ha (0.5%)	Mallee Woodlands and Shrublands (MVG 14)	Mid open mallee forest of *Eucalyptus carnei* over mid sparse shrubland of *Eremophila pantonii* and low shrubland of *Olearia muelleri/ Ptilotus obovatus* on breakaway	

Landform	Vegetation Community	Broad Floristic Formation (NVIS III)	Vegetation Description (NVIS V)	Image
Drainage Depression	DD-AFW1 54.5 ha (3.1%)	Acacia Forests and Woodlands (MVG 6)	Low woodland of *Acacia incurvaneura, A. tetragonophylla* and *A. burkittii* over sparse shrubland of *Eremophila citrina, Senna artemisioides* subsp. *artemisioides* and *Grevillea deflexa* over low sparse shrubland of *Ptilotus obovatus* var. *obovatus, Lepidium platypetalum* and *Roepera eremaea*	
Open Depression	OD-AFW1 330.1 ha (15.9%)	Acacia Forests and Woodlands (MVG 6)	Low open forest of *Acacia caesaneura/ A. incurvaneura* over tall shrubland of *Acacia ramulosa/ A. tetragonophylla* and low tussock grassland of *Eragrostis eriopoda* in drainage line	

Landform	Vegetation Community	Broad Floristic Formation (NVIS III)	Vegetation Description (NVIS V)	Image
Quartz Rocky Plain	QRP-AFW1 732.4 ha (42.3%)	Acacia Forests and Woodlands (MVG 6)	Low open forest of *Acacia caesaneura/ A. incurvaneura* over tall open shrubland of *Acacia ramulosa/ A. tetragonophylla* and low shrubland of *Ptilotus obovatus/* low tussock grassland of *Eragrostis eriopoda* on quartz-rocky plain	
Rocky Hillslope	RH-AFW1 22.8 ha (1.3%)	Acacia Forests and Woodlands (MVG 6)	Low open forest of *Acacia incurvaneura/ A. quadrimarginea* over tall shrubland of *Acacia ramulosa* and low shrubland of *Ptilotus obovatus/* low tussock grassland of *Eragrostis eriopoda* on rocky hillslope	

Landform	Vegetation Community	Broad Floristic Formation (NVIS III)	Vegetation Description (NVIS V)	Image
Sand-Loam Plain	SLP-AFW1 396.7 ha (22.9%)	Acacia Forests and Woodlands (MVG 6)	Low open forest of *Acacia caesaneura/ A. incurvaneura* over mid shrubland of *Eremophila forrestii* subsp. *forrestii/ Eremophila margarethae* and low tussock grassland of *Eragrostis eriopoda* on sand-loam plain	
Sand-Loam Plain	SLP-AFW2 113.5 ha (6.6%)	Acacia Forests and Woodlands (MVG 6)	Open mallee shrubland of *Eucalyptus youngiana/* Low open forest of *Acacia caesaneura/ A. incurvaneura* over mid hummock grassland of *Triodia scariosa* on sand-loam plain	

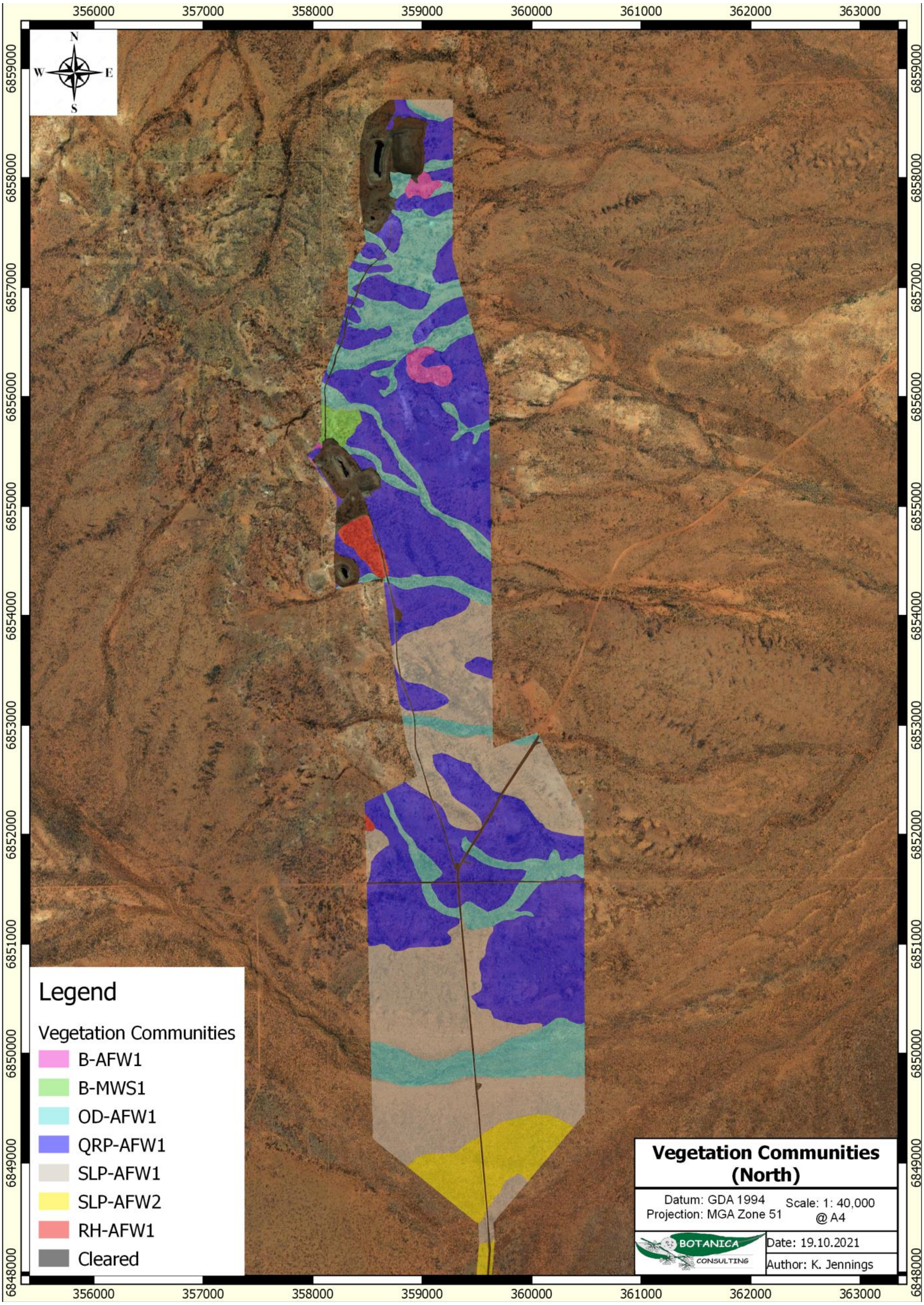


Figure 4-3: Vegetation types within the survey area (North)

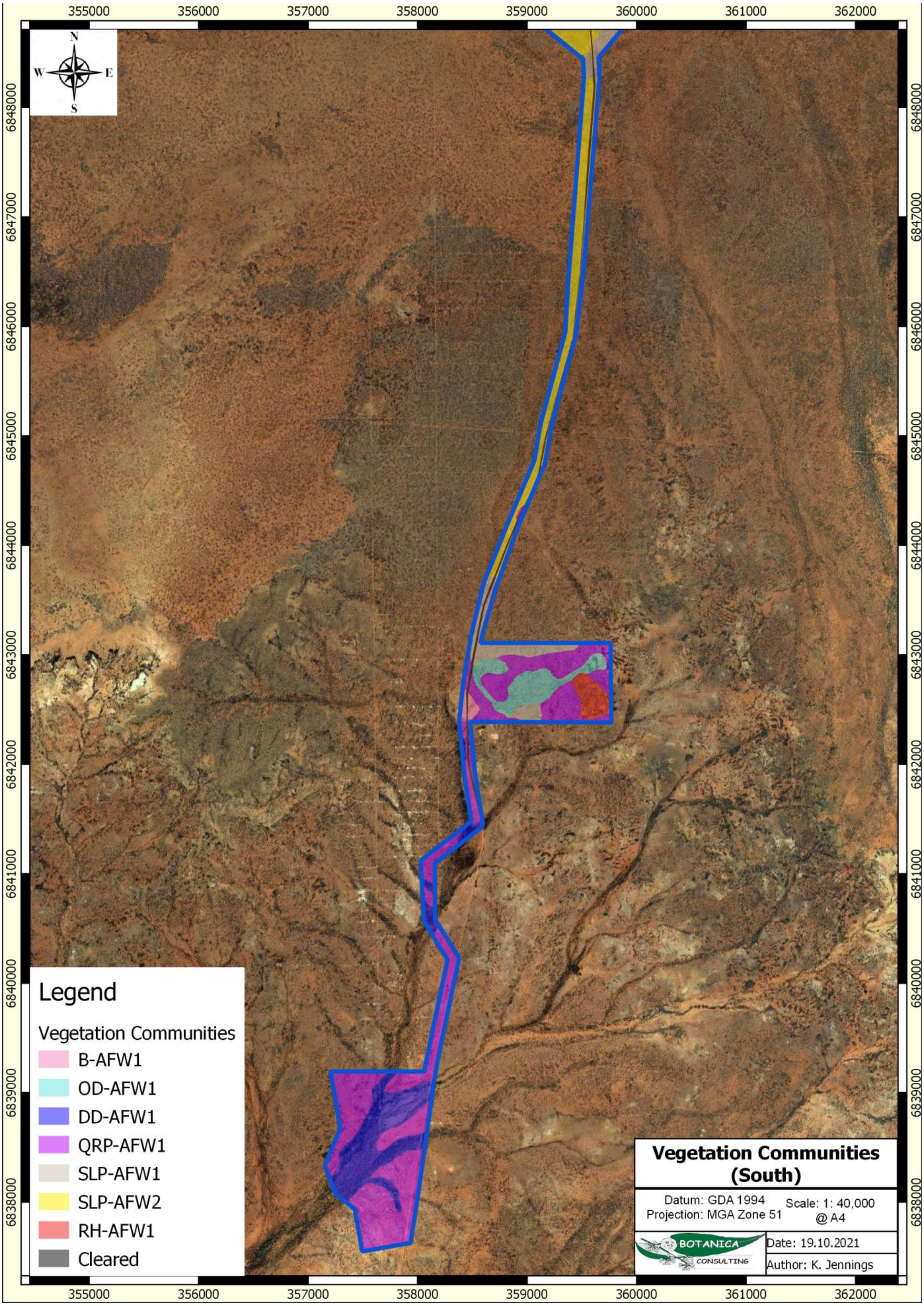


Figure 4-4: Vegetation types within the survey area (South)

4.2.3 Floristic Composition

Statistical analysis was conducted on quadrat data obtained from the survey to determine the similarities or differences in floristic composition between vegetation associations. The dendrogram, two-way table and ordination graph generated from the PATN statistical analysis is provided in Appendix 6. A list of the 44 quadrats and their respective vegetation associations are provided in Table 4-4. The PATN analysis produced a stress value of 0.1816.

Table 4-4: Vegetation communities with corresponding quadrats

Vegetation Community	Vegetation Code	Quadrats
Low open forest of *Acacia caesaneura/ A. incurvaneura* over tall open shrubland of *Acacia ramulosa/ A. tetragonophylla* and low shrubland of *Ptilotus obovatus/* low tussock grassland of *Eragrostis eriopoda* on quartz-rocky plain	QRP-AFW1	Q1, Q3, Q4, Q5, Q8, Q12, Q31, Q41
Open mallee shrubland of *Eucalyptus youngiana/* Low open forest of *Acacia caesaneura/ A. incurvaneura* over mid hummock grassland of *Triodia scariosa* on sand-loam plain	SLP-AFW2	Q19-Q27
Low open forest of *Acacia caesaneura/ A. incurvaneura* over mid shrubland of *Eremophila forrestii* subsp. *forrestii/ Eremophila margarethae* and low tussock grassland of *Eragrostis eriopoda* on sand-loam plain	SLP-AFW1	Q9-Q11, Q13, Q14, Q16-Q18, Q33, Q36, Q38, Q40, Q42
Acacia incurvaneura, A. tetragonophylla and *A. burkittii* low woodland over *Eremophila citrina, Senna artemisioides* subsp. *artemisioides* and *Grevillea deflexa* sparse shrubland over *Ptilotus obovatus* var. *obovatus, Lepidium platypetalum* and *Roepera eremaea* low sparse shrubland	DD-AFW1	Q 37, Q39, Q44
Low open forest of *Acacia caesaneura/ A. incurvaneura* over tall shrubland of *Acacia ramulosa/ A. tetragonophylla* and low tussock grassland of *Eragrostis eriopoda* in drainage line	OD-AFW1	Q7, Q29, Q30, Q32, Q34, Q35, Q43
Low woodland of *Acacia quadrimarginea* over tall shrubland of *Acacia ramulosa* var. *linophylla/ Thryptomene decussata* and low open shrubland of *Calytrix uncinata/ Eremophila latrobei* on breakaway	B-AFW1	Q2, Q28
Mid open mallee forest of *Eucalyptus carnei* over mid sparse shrubland of *Eremophila pantonii* and low shrubland of *Olearia muelleri/ Ptilotus obovatus* on breakaway	B-MWS1	Q6
Low open forest of *Acacia incurvaneura/ A. quadrimarginea* over tall shrubland of *Acacia ramulosa* and low shrubland of *Ptilotus obovatus/* low tussock grassland of *Eragrostis eriopoda* on rocky hillslope	RH-AFW1	Q7, Q31, Q32

Seven species groups were identified in the analysis (species group A to G) as shown in the two-way table (Appendix 6).

The first floristic group was characterised by species group E (see two-way table provided in Appendix 7), with an average species richness of 18 taxa per quadrat (ranged from 12 to 25 taxa per quadrat).

The second floristic group was mostly characterised by species groups B, D and E (Appendix 6). This floristic group had an average species richness of 15 taxa per quadrat.

The third floristic group was mostly characterised by species groups B and E. This floristic group had an average species richness of 14.3 taxa per quadrat (ranged from 12 to 19 taxa per quadrat).

The fourth floristic group was characterised by species groups B and C, with an average species richness of 13.8 taxa per quadrat (ranged from seven to 24 taxa per quadrat).

The fifth floristic group was characterised by species groups A and B, with an average species richness of 16.7 taxa per quadrat (ranged from 16 to 17 taxa per quadrat).

The sixth floristic group was characterised by species group B, with an average species richness of 7.5 taxa per quadrat (ranged from seven to eight taxa per quadrat).

The seventh floristic group was characterised by species groups B and F, with an average species richness of 8.2 taxa per quadrat (ranged from five to 11 taxa per quadrat).

Field based observations of vegetation type delineations were mostly supported by the results of the PATN analysis.

Species Richness and Accumulation Estimates

A total of 111 species were recorded within the 44 quadrats. The Chao 2 richness estimator provided an estimated species richness of 122 species in 60 sample sites (quadrats). 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 4-5. Species accumulation ranged from 10 to two species per quadrat from 1-24 sample sites, and one species per quadrat between 25-60 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.

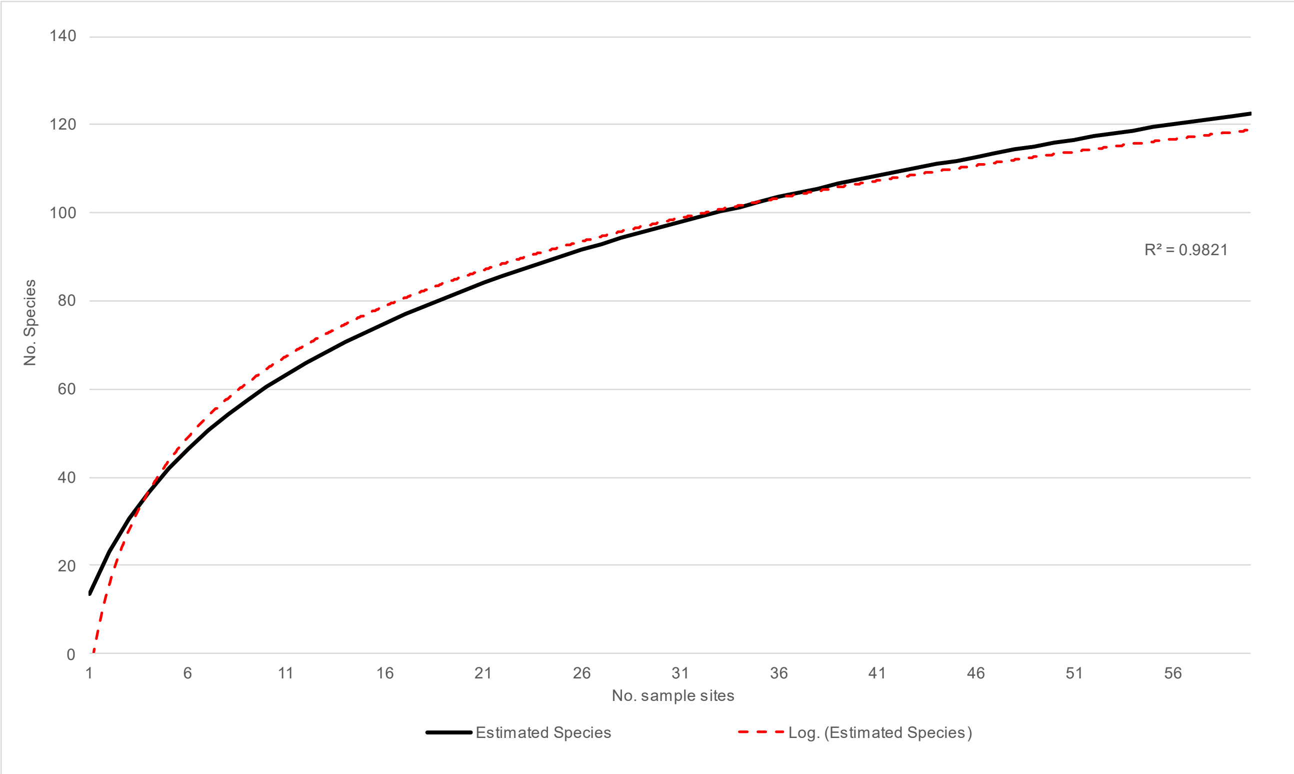


Figure 4-5: Species accumulation curve

4.2.4 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.

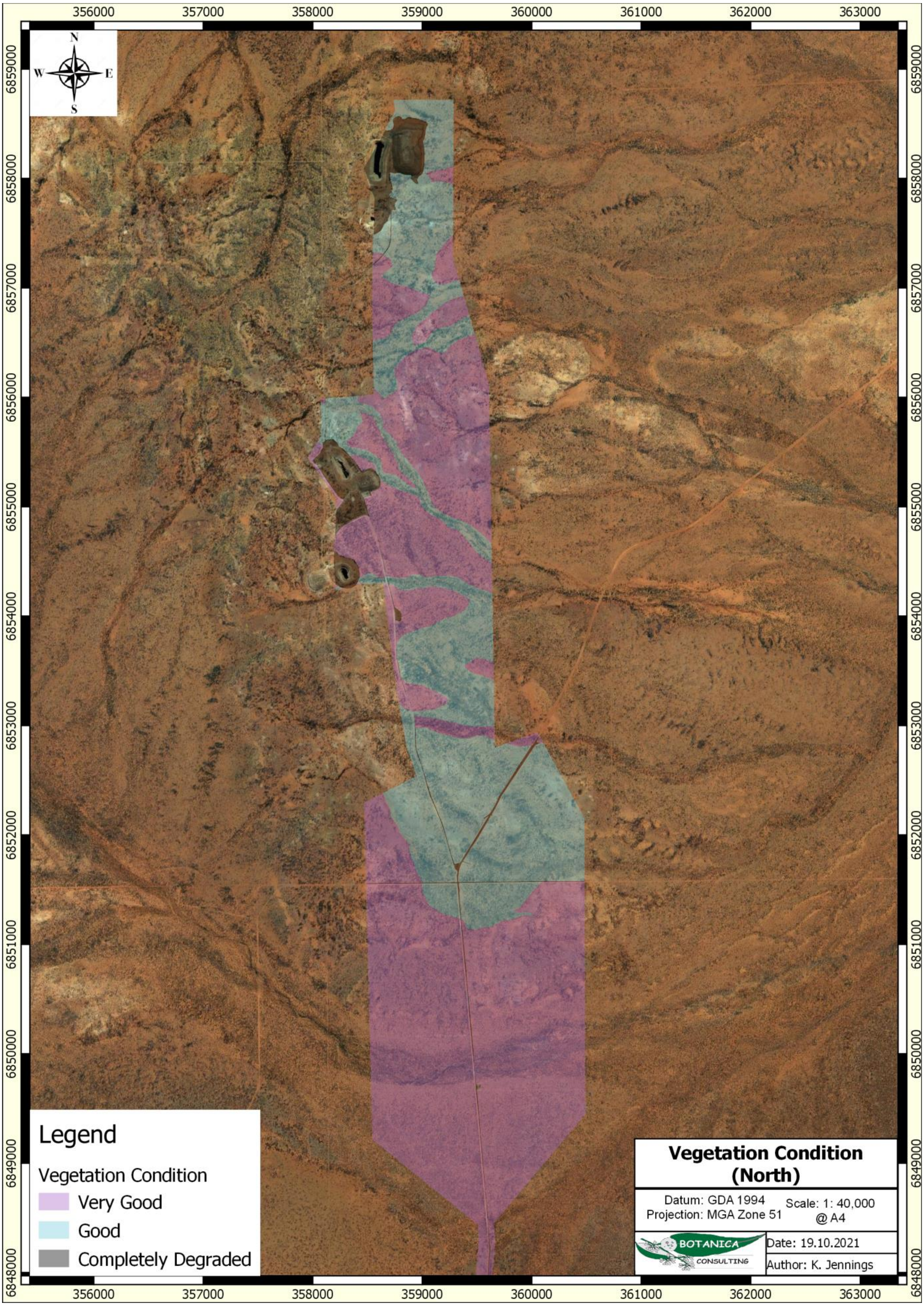
No significant vegetation as described above was identified within the survey area.

4.2.5 Vegetation Condition

Based on the vegetation condition rating scale obtained from the EPA (2016a), provided in Appendix 7, the majority of native vegetation was rated as 'good' to 'very good' (Table 4-5). 'Disturbance in the area was a result of existing mining operations and access roads. These areas were categorised as completely degraded. Vegetation condition within the survey area is shown spatially in Figure 4-6.

Table 4-5: vegetation condition within the survey area

Condition rating	Description (EPA, 2016a)	Area (ha)	Area (%)
Very Good	Relatively slight signs of damage caused by human activities such as the presence of some relatively non-aggressive weeds or occasional vehicle tracks	1,128	65 %
Good	More obvious signs of damage caused by human activity since European settlement, including historical clearing, grazing by introduced animals, changed fire regimes and the presence of aggressive weed species.	495	29%
Completely Degraded	Existing gravel extraction pits, access roads and water discharge areas	108	6%


356000
357000
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6858000
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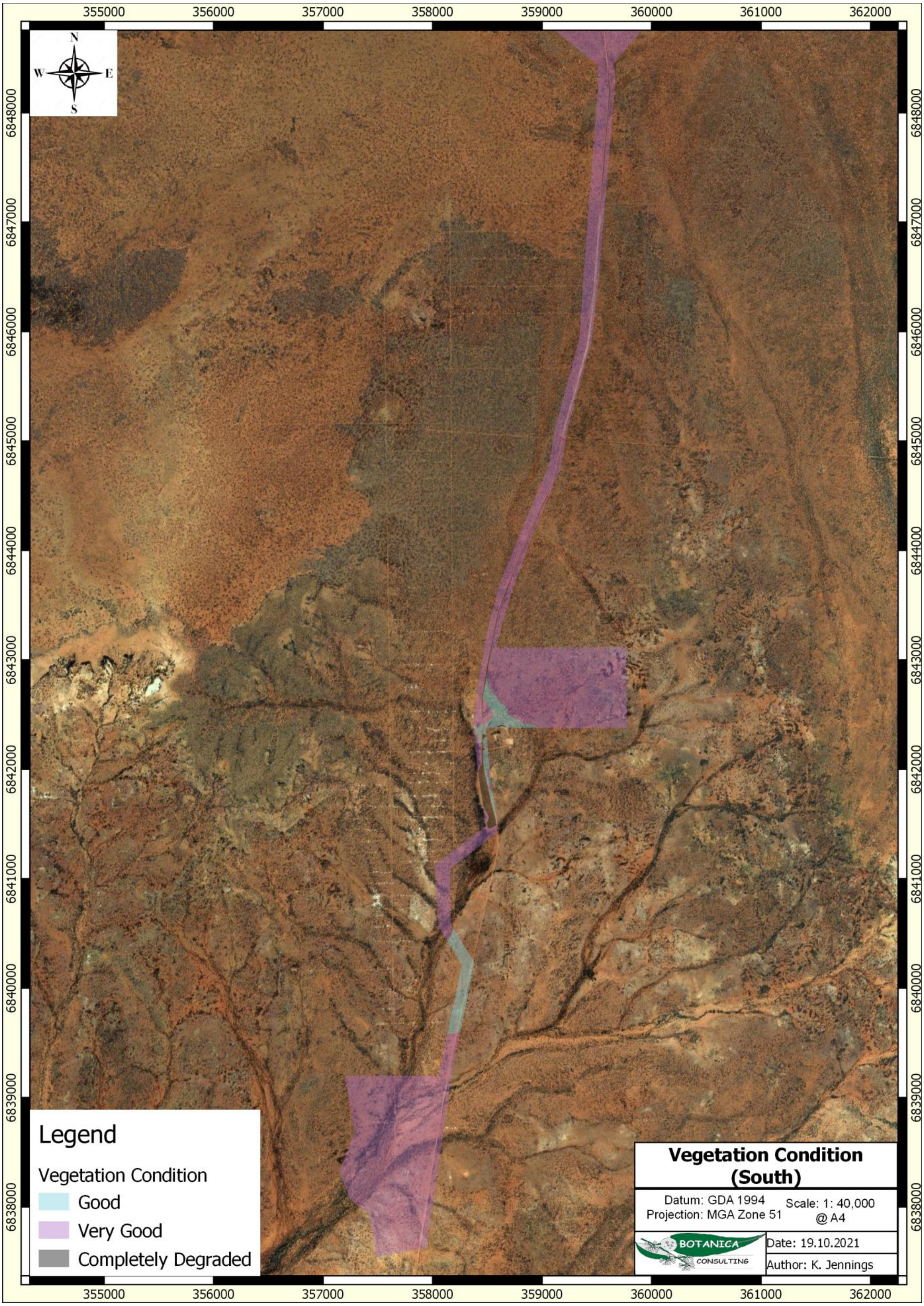
6856000
6855000
6854000
6853000
6852000
6851000
6850000
6849000
6848000
N
S
E
W
Legend
Vegetation Condition
Very Good
Good
Completely Degraded
Vegetation Condition (North)
Datum: GDA 1994
Projection: MGA Zone 51
Scale: 1: 40,000 @ A4
BOTANICA CONSULTING
Date: 19.10.2021
Author: K. Jennings

Figure 4-6: Vegetation condition rating of the survey area (North)


355000
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6845000
6844000
6843000
6842000
6841000
6840000
6839000
6838000
N
S
W
E
Legend
Vegetation Condition
Good
Very Good
Completely Degraded
Vegetation Condition (South)
Datum: GDA 1994
Projection: MGA Zone 51
Scale: 1: 40,000 @ A4
BOTANICA CONSULTING
Date: 19.10.2021
Author: K. Jennings

Figure 4-7: Vegetation condition rating of the survey area (South)

4.3 Matters of National Environmental Significance

4.3.1 *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 and fauna 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.

4.4 Matters of State Environmental Significance

4.4.1 *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 was found during the survey period. The survey area is not located within an ESA.

4.4.2 *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 license.

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.

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Appendix 1: Conservation 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.	

<table>
<tr><th>Code</th><th>Category</th></tr>
<tr><td>IA</td><td>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.
Published as migratory birds protected under an international agreement under schedule 5 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.</td></tr>
<tr><td>CD</td><td>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.</td></tr>
<tr><td>OS</td><td>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.</td></tr>
<tr><td colspan="2">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.</td></tr>
<tr><td>P1</td><td>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.</td></tr>
<tr><td>P2</td><td>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.</td></tr>
<tr><td>P3</td><td>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</td></tr>
</table>

Code	Category
	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.
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** 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).

Category Code	Category
Priority Ecological Communities (PEC)	
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 2: Potentially Occurring Introduced (Weed) Flora Species

Family	Taxon	Common Name	WAOL Status	Control Category	WONS
Brassicaceae	*Carrichtera annua*	Ward's Weed	Permitted - s11	No Control Category	No
Cactaceae	*Cylindropuntia* spp.	Prickly Pears	Declared Pest - s22(2)	C3 Management, Whole of State	Yes
Cucurbitaceae	*Cucumis myriocarpus* subsp. *myriocarpus*	-	Permitted - s11	No Control Category	No
Geraniaceae	*Erodium cicutarium*	Common Storksbill	Permitted - s11	No Control Category	No
Poaceae	*Cenchrus ciliaris*	Buffel Grass	Permitted - s11	No Control Category	No
Primulaceae	*Lysimachia arvensis*	Pimpernel	Permitted - s11	No Control Category	No
Tamaricaceae	*Tamarix aphylla*	Athel Tamarisk	Exempt	No Control Category	Yes

Appendix 3: Quadrat locations (NW Corner)(GDA94, Zone 51J))

Quadrat	Easting	Northing
Q1	359097	6858219
Q2	358848	6857865
Q3	359156	6857059
Q4	358754	6856686
Q5	359327	6856060
Q6	358295	6855727
Q7	358336	6854799
Q8	359034	6854349
Q9	359432	6853727
Q10	359317	6853249
Q11	359295	6852544
Q12	358666	6851906
Q13	360091	6852450
Q14	359131	6851272
Q15	359161	6850654
Q16	360077	6850161
Q17	360183	6851072
Q18	358975	6849765
Q19	360195	6849655
Q20	359106	6849149
Q21	359536	6848231
Q22	359447	6847149
Q23	359409	6846651
Q24	359354	6845993
Q25	359203	6845373
Q26	358996	6844609
Q27	358718	6843946
Q28	358519	6842658
Q29	359229	6843002
Q30	359309	6842776
Q31	359506	6842463
Q32	359611	6842709
Q33	359026	6842609
Q34	359002	6842890
Q35	358616	6842949
Q36	357855	6839039
Q37	357587	6838836
Q38	357441	6839178
Q39	357392	6838576
Q40	357840	6838583
Q41	357813	6838381
Q42	357549	6837978
Q43	357757	6837753
Q44	358357	6841293

Appendix 4: Significant Flora Likelihood Assessment

DBCA Rank	Taxon	Habitat	Comments	Likelihood
P1	*Acacia websteri*	Red sand, clay or loam. Low-lying areas, flats.	Recorded within 40 km, habitat may be present	Possible
	Philotheca tubiflora	Rocky rises & hills, outcrops	Recorded within 40 km, habitat may be present	Possible
	Stenanthemum patens	Rocky hillside.	Recorded within 40 km, habitat may be present	Possible
P3	*Acacia* sp. Marshall Pool (G. Cockerton 3024)	-	Little known, records within 30km.	Possible
	Calytrix praecipua	Skeletal sandy soils over granite or laterite. Breakaways, outcrops.	Recorded within 40 km, habitat may be present	Possible
	Cratystylis centralis	Red sandy loam with ironstone gravel. Flat plains, breakaway country.	Recorded within 40 km, habitat may be present	Possible
	Eremophila annosicaulis	On stony loams (ironstone laterite).	Recorded within 40 km, habitat may be present	Possible
	Eremophila shonae subsp. *diffusa*	Stony yellow or red sandy soils	Recorded within 10 km, habitat may be present	Possible
	Eremophila simulans subsp. *megacalyx*	-	Recorded within 20 km, habitat may be present	Possible
	Hybanthus floribundus subsp. *chloroxanthus*	Dark red-brown soil, never sandy, rich in iron oxide, laterite. Rocky areas, creek banks, along drainage lines.	Recorded within 40 km, habitat may be present	Possible
P4	*Hemigenia exilis*	Laterite. Breakaways, slopes.	Recorded within 40 km, habitat likely to be present	Likely

Appendix 5: List of species identified within each vegetation community

Family	Taxon	B-AFW1	B-MWS1	DD-AFW1	OD-AFW1	QRP-AFW1	RH-AFW1	SLP-AFW2	SLP-AF1
Amaranthaceae	*Ptilotus aervoides (A)*					X			
	Ptilotus exaltatus					X			
	Ptilotus helipteroides				X	X	X		
	Ptilotus obovatus var. *obovatus*	X		X	X	X	X		X
	Ptilotus schwartzii	X			X	X	X		X
Apocynaceae	*Leichardtia australis*	X		X	X	X	X		X
Asparagaceae	*Thysanotus manglesii*							X	
Asteraceae	*Angianthus milnei (A)*				X				
	Brachyscome ciliaris (A)				X				X
	Bulbine semibarbata (A)			X					
	Calotis multicaulis (A)					X			
	Cephalipterum drummondii (A)					X			X
	Cratystylis subspinescens					X			
	Helipterum craspedioides (A)							X	
	Lemooria burkittii (A)					X			X
	Olearia muelleri					X			
	Podolepis capillaris (A)					X			
	Podotheca wilsonii (A)				X				
	Rhodanthe charsleyae (A)			X					X
	Rhodanthe chlorocephala (A)								X
	Rhodanthe chlorocephala subsp. *rosea (A)*				X		X		
Brassicaceae	*Lepidium platypetalum*			X					
Casuarinaceae	*Casuarina pauper*	X				X	X		

Family	Taxon	B-AFW1	B-MWS1	DD-AFW1	OD-AFW1	QRP-AFW1	RH-AFW1	SLP-AFW2	SLP-AF1
Chenopodiaceae	*Atriplex bunburyana*					X			
	Enchylaena tomentosa			X					X
	Maireana convexa								X
	Maireana georgei			X	X	X	X		X
	Maireana pyramidata								X
	Maireana sedifolia					X			
	Maireana trichoptera					X			
	Maireana triptera			X	X		X		X
	Rhagodia eremaea		X	X	X	X	X	X	X
	Sclerolaena densiflora					X			
	Sclerolaena diacantha					X			
Convolvulaceae	*Convolvulus remotus*			X					
	Duperreya commixta								X
Euphorbiaceae	*Euphorbia boophthona (A)*					X			
Fabaceae	*Acacia aptaneura*					X			X
	Acacia ayersiana			X	X	X	X		X
	Acacia burkittii			X		X	X		X
	Acacia caesaneura		X	X	X	X	X	X	X
	Acacia craspedocarpa	X							X
	Acacia effusifolia							X	
	Acacia incurvaneura		X	X	X	X	X	X	X
	Acacia kempeana					X	X		
	Acacia mulganeura	X			X	X			X
	Acacia oswaldii					X			
	Acacia quadrimarginea	X			X	X	X		

Family	Taxon	B-AFW1	B-MWS1	DD-AFW1	OD-AFW1	QRP-AFW1	RH-AFW1	SLP-AFW2	SLP-AF1
	Acacia ramulosa				X		X	X	X
	Acacia tetragonophylla			X	X	X	X	X	X
	Acacia youngiana							X	
	Senna artemisioides subsp. *artemisioides*			X					X
	Senna artemisioides subsp. *filifolia*			X		X	X		X
	Senna cardiosperma					X			
	Senna charlesiana								X
	Senna manicula								X
Frankeniaceae	*Frankenia georgei*					X			
Geraniaceae	*Erodium crinitum (A)*			X		X			
Goodeniaceae	*Brunonia australis*							X	
	Goodenia macroplectra (A)				X	X	X		
	Goodenia peacockiana (A)			X					
	Goodenia rosea (A)			X		X		X	X
	Goodenia xanthosperma (A)					X		X	X
	Scaevola spinescens	X			X	X	X		X
Haloragaceae	*Haloragis odontocarpa*			X					
Hemerocallidaceae	*Dianella revoluta*		X					X	X
Lamiaceae	*Teucrium teucriiflorum*				X	X		X	X
Loranthaceae	*Amyema fitzgeraldii*					X			
Malvaceae	*Abutilon otocarpum*							X	
	Androcalva luteiflora							X	
	Brachychiton gregorii				X				
	Sida calyxhymenia	X			X	X	X	X	X

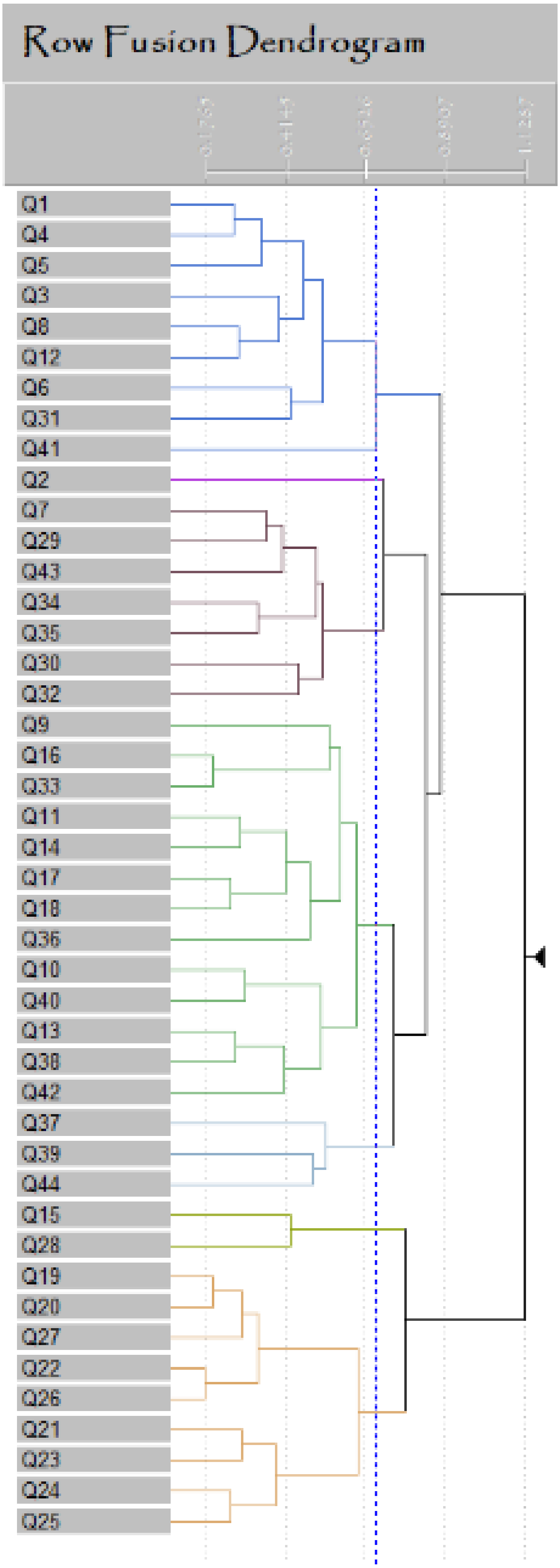
Family	Taxon	B-AFW1	B-MWS1	DD-AFW1	OD-AFW1	QRP-AFW1	RH-AFW1	SLP-AFW2	SLP-AF1
	Sida sp. Excedentifolia (J.L. Egan 1925)					X	X		X
	Sida sp. Golden calyces glabrous (H.N. Foote 32)	X				X			
Montiaceae	*Calandrinia balonensis*			X		X			
	Calandrinia eremaea								X
Myrtaceae	*Calytrix erosipetala*	X							
	Eucalyptus carnei					X			
	Eucalyptus kingsmillii		X					X	
	Eucalyptus lucasii				X				
	Eucalyptus youngiana							X	
	Thryptomene decussata		X						
Pittosporaceae	*Pittosporum angustifolium*					X			
Plantaginaceae	*Plantago drummondii (A)*								X
Poaceae	*Aristida contorta (A)*	X							
	Cymbopogon ambiguus	X							
	Enneapogon caerulescens					X			
	Eriachne maculata (A)				X				
	Eriachne scleroides (A)					X			
	Monacantha paradoxa				X				
	Triodia rigidissima							X	
Proteaceae	*Grevillea acuaria*					X			
	Grevillea berryana			X					
	Grevillea deflexa			X					
	Hakea kippistiana								X

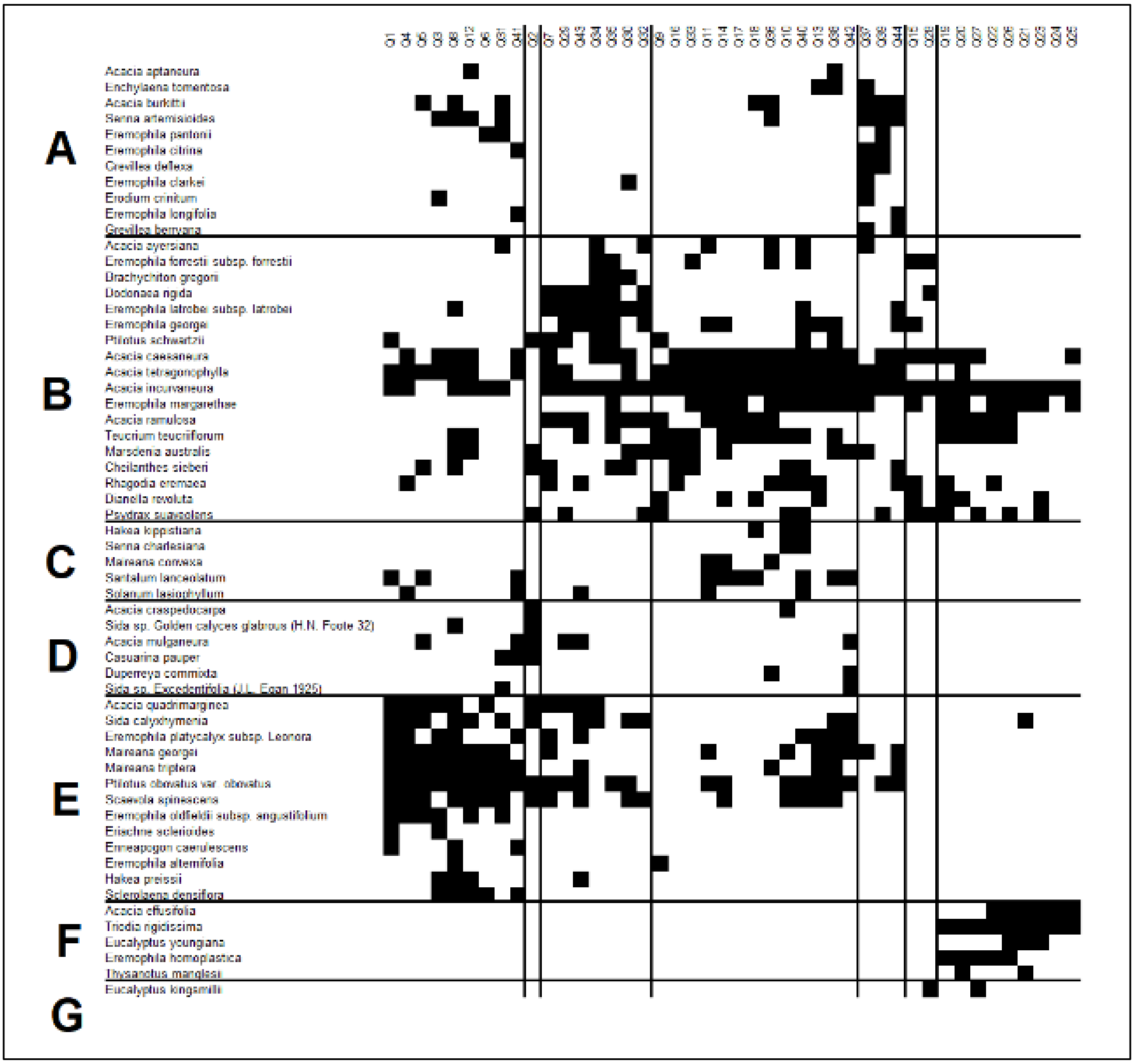
Family	Taxon	B-AFW1	B-MWS1	DD-AFW1	OD-AFW1	QRP-AFW1	RH-AFW1	SLP-AFW2	SLP-AF1
	Hakea preissii				X	X			
Pteridaceae	*Cheilanthes sieberi*	X		X	X		X		X
Rubiaceae	*Psydrax latifolia*				X		X		
	Psydrax suaveolens	X	X	X	X		X	X	X
Santalaceae	*Santalum lanceolatum*					X			X
	Santalum spicatum					X			
Sapindaceae	*Dodonaea rigida*		X		X		X		
Scrophulariaceae	*Eremophila alternifolia*					X			X
	Eremophila citrina			X		X			
	Eremophila clarkei			X	X				
	Eremophila eriocalyx				X		X		
	Eremophila forrestii subsp. *forrestii*		X		X				X
	Eremophila georgei		X	X	X		X		X
	Eremophila gilesii								X
	Eremophila granitica	X							
	Eremophila homoplastica							X	
	Eremophila latrobei subsp. *latrobei*			X	X	X	X		X
	Eremophila longifolia			X		X			
	Eremophila malacoides					X			
	Eremophila margarethae		X	X	X			X	X
	Eremophila oldfieldii subsp. *angustifolium*					X	X		
	Eremophila oppositifolia								
	Eremophila pantonii			X		X	X		

Family	Taxon	B-AFW1	B-MWS1	DD-AFW1	OD-AFW1	QRP-AFW1	RH-AFW1	SLP-AFW2	SLP-AF1
	Eremophila platycalyx subsp. Leonora				X	X	X		X
Solanaceae	*Solanum lasiophyllum*				X	X			X
Zygophyllaceae	*Roepera eremaea (A)*			X	X	X	X		X
	Zygophyllum eremaeum (A)					X	X		

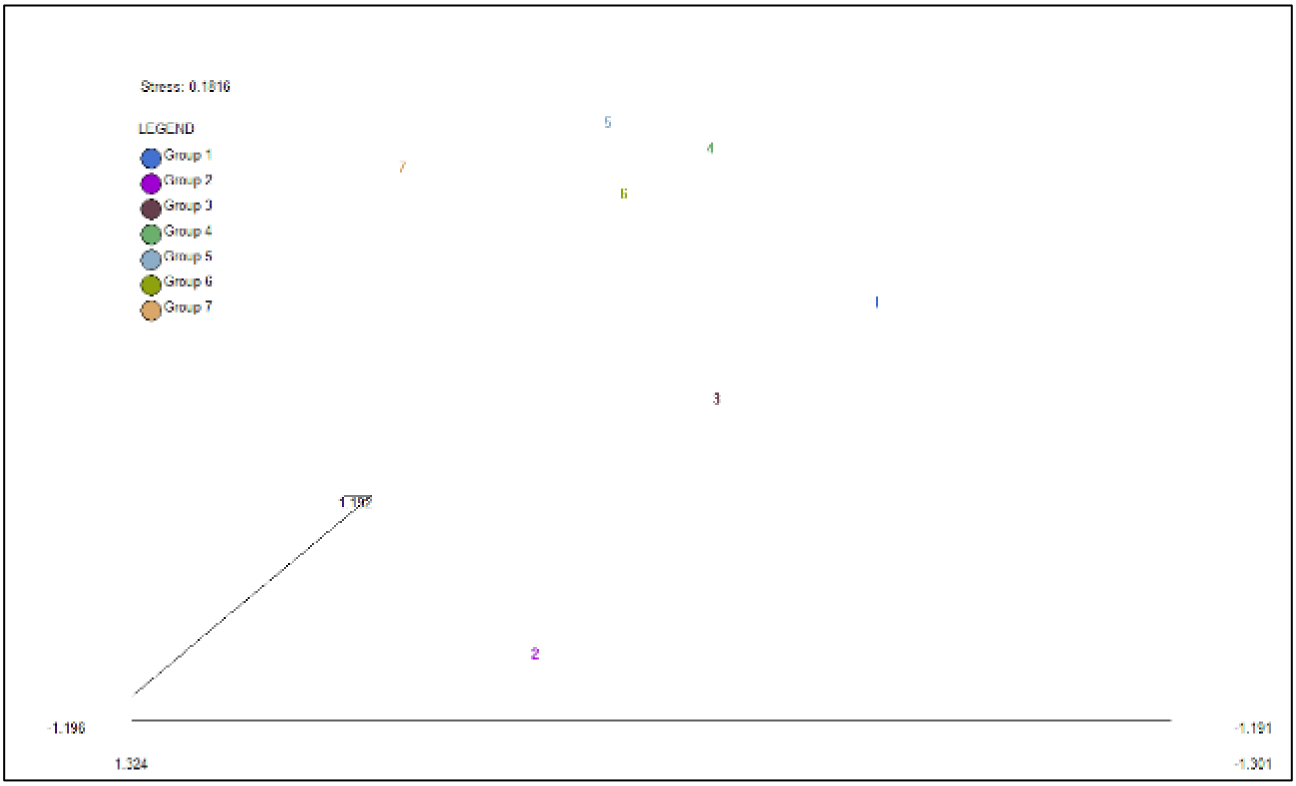
(A) Denotes annual species

Appendix 6: PATN Analysis





A
Acacia aptaneura
Enchylaena tomentosa
Acacia burkittii
Senna artemisioides
Eremophila pantonii
Eremophila citrina
Grevillea deflexa
Eremophila clarkei
Erodium crinitum
Eremophila longifolia
Grevillea berryana
B
Acacia ayersiana
Eremophila forrestii subsp. forrestii
Brachychiton gregorii
Dodonaea rigida
Eremophila latrobei subsp. latrobei
Eremophila georgei
Ptilotus schwartzii
Acacia caesaneura
Acacia tetragonophylla
Acacia incurvaneura
Eremophila margarethae
Acacia ramulosa
Teucrium teucriiflorum
Marsdenia australis
Cheilanthes sieberi
Rhagodia eremaea
Dianella revoluta
Psydrax suaveolens
C
Hakea kippistiana
Senna charlesiana
Maireana convexa
Santalum lanceolatum
Solanum lasiophyllum
D
Acacia craspedocarpa
Sida sp. Golden calyces glabrous (H.N. Foote 32)
Acacia mulganeura
Casuarina pauper
Duperreya commixta
Sida sp. Excedentifolia (J.L. Egan 1925)
E
Acacia quadrimarginea
Sida calyxhymenia
Eremophila platycalyx subsp. Leonora
Maireana georgei
Maireana triptera
Ptilotus obovatus var. obovatus
Scaevola spinescens
Eremophila oldfieldii subsp. angustifolium
Eriachne scleroides
Enneapogon caerulescens
Eremophila alternifolia
Hakea preissii
Sclerolaena densiflora
F
Acacia effusifolia
Triodia rigidissima
Eucalyptus youngiana
Eremophila homoplastica
Thysanotus manglesii
G
Eucalyptus kingsmillii



Stress: 0.1816
LEGEND
Group 1
Group 2
Group 3
Group 4
Group 5
Group 6
Group 7
5
4
7
6
1
3
2
1.196
-1.196
-1.191
1.324
-1.301

Appendix 7: 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.	N/A
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	N/A	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 8: Quadrat Data Sheets

Project Name: Dacian		
Date: 13/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 185-187
Quadrat: Q1	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 31
Coordinates (GDA94): 51 J 359097 6858219		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone/ 50-90%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Red-brown/ Clay Loam		
Cover leaf litter: 20%		
Cover bare ground: 70%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.5-1 m
Crown cover: 10-30%	**Crown cover:** <10%	**Crown cover:** <10%
Dominant taxa		
Acacia incurvaneura	*Eremophila oldfieldii* subsp. *angustifolia*	*Ptilotus obovatus* var. *obovatus*
Other Taxa		
Acacia quadrimarginea	*Eremophila platycalyx*	*Maireana triptera*
Santalum lanceolatum	*Sida calyxhymenia*	*Maireana georgei*
	Senna cardiosperma	*Ptilotus schwartzii*
	Scaevola spinescens	*Ptilotus helipteroides*
	Acacia tetragonophylla	*Roepera eremaea*
		Eriachne sclerioides
		Marsdenia australis
		Goodenia peacockiana
		Enneapogon caerulescens

Project Name: Dacian		
Date: 13/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 194-196
Quadrat: Q2	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 37
Coordinates (GDA94): 51 J 358848 6857865		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Midslope		
Coarse fragments on the surface: Laterite/ 50-90%/ 6-20 mm		
Rock outcrop (abundance/runoff): Nil/ rapid		
Soil (profile/field texture/soil surface): Red-brown/ Clay Loam		
Cover leaf litter: 10%		
Cover bare ground: 60%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5 m	**Height:** 0.5-1 m	**Height:** 0.5-1 m
Crown cover: 30-70%	**Crown cover:** 10-30%	**Crown cover:** <10%
Dominant taxa		
Acacia mulganeura	*Calytrix erosipetala*	*Ptilotus obovatus* var. *obovatus*
Other Taxa		
Acacia quadrimarginea	*Dodonaea rigida*	*Aristida contorta*
Casuarina pauper	*Sida calyxhymenia*	*Cymbopogon ambiguus*
	Acacia craspedocarpa	*Ptilotus schwartzii*
	Scaevola spinescens	*Sida sp.* Golden calyces glabrous
	Psydrax suaveolens	*Cheilanthes sieberi*
	Eremophila granitica	*Marsdenia australis*

Project Name: Dacian		
Date: 13/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 197-199
Quadrat: Q3	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 43
Coordinates (GDA94): 51 J 359156 6857059		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone/ 50-90%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 50%		
Cover bare ground: 50%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Chenopod Shrub
Height: 5-12 m	**Height:** 0.5-1 m	**Height:** 0.5-1 m
Crown cover: 30-70%	**Crown cover:** 10-30%	**Crown cover:** 10-30%
Dominant taxa		
Acacia caesaneura	*Ptilotus obovatus* var. *obovatus*	*Maireana triptera*
Other Taxa		
Acacia quadrimarginea	*Eremophila platycalyx*	*Goodenia peacockiana*
Acacia oswaldii	*Eremophila longifolia*	*Maireana georgei*
	Senna artemisioides subsp. *filifolia*	*Ptilotus aervoides*
	Hakea preissii	*Ptilotus helipteroides*
	Acacia tetragonophylla	*Roepera eremaea*
	Eremophila oldfieldii subsp. angustifolia	*Ptilotus exaltatus*
		Sclerolaena densiflora
		Sclerolaena diacantha
		Eriachne sclerioides
		Erodium crinitum

Project Name: Dacian		
Date: 13/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 200-202
Quadrat: Q4	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 49
Coordinates (GDA94): 51 J 358754 6856686		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Limestone/ 10-20%/ 6-20		
Rock outcrop (abundance/runoff): Nil/ Rapid		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 40%		
Cover bare ground: 60%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Chenopod Shrub
Height: 5-12 m	**Height:** 0.5-1 m	**Height:** <0.25 m
Crown cover: 30-70%	**Crown cover:** 30-70%	**Crown cover:** <10%
Dominant taxa		
Acacia incurvaneura	*Ptilotus obovatus var. obovatus*	*Maireana georgei*
Other Taxa		
Acacia quadrimarginea	*Eremophila platycalyx*	*Maireana triptera*
Acacia caesaneura	*Sida calyxhymenia*	*Ptilotus exaltatus*
Eremophila oldfieldii subsp. *angustifolia*	*Rhagodia eremaea*	*Ptilotus aervoides*
	Scaevola spinescens	*Ptilotus helipteroides*
	Acacia tetragonophylla	*Roepera eremaea*
		Solanum lasiophyllum
		Goodenia rosea
		Goodenia peacockiana
		Calotis multicaulis

Project Name: Dacian		
Date: 13/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 204-206
Quadrat: Q5	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 54
Coordinates (GDA94): 51 J 359327 6856060		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Midslope		
Coarse fragments on the surface: Laterite/>90%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ rapid		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 20%		
Cover bare ground: 80%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Chenopod Shrub
Height: 3-5 m	**Height:** 0.5-1 m	**Height:** <0.25 m
Crown cover: 30-70%	**Crown cover:** 10-30%	**Crown cover:** <10%
Dominant taxa		
Acacia mulganeura	*Scaevola spinescens*	*Maireana triptera*
Other Taxa		
Acacia quadrimarginea	*Eremophila pantonii*	*Maireana georgei*
Acacia burkittii	*Sida calyxhymenia*	*Ptilotus obovatus* var. *obovatus*
Eremophila oldfieldii subsp. *angustifolia*	*Acacia tetragonophylla*	*Cheilanthes sieberi*
Santalum lanceolatum		

Project Name: Dacian		
Date: 13/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 210-212
Quadrat: Q6	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 62
Coordinates (GDA94): 51 J 358295 6855727		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Midslope		
Coarse fragments on the surface: Laterite/ >90%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ rapid		
Soil (profile/field texture/soil surface): Red-brown/ Clay Loam		
Cover leaf litter: 20%		
Cover bare ground: 80%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Chenopod Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.5-1 m
Crown cover: 10-30%	**Crown cover:** <10%	**Crown cover:** <10%
Dominant taxa		
Eucalyptus carnei	*Eremophila pantonii*	*Maireana georgei*
Other Taxa		
Acacia quadrimarginea	*Ptilotus obovatus* var. *obovatus*	*Maireana triptera*
Acacia incurvaneura	*Scaevola spinescens*	*Frankenia georgei*
		Ptilotus exaltatus
		Olearia muelleri
		Sclerolaena densiflora
		Maireana trichoptera

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 213-215
Quadrat: Q7	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 69
Coordinates (GDA94): 51 J 358336 6854799		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone/ 50-90%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ very slow		
Soil (profile/field texture/soil surface): Red-brown/ Clay Loam		
Cover leaf litter: 20%		
Cover bare ground: 80%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5 m	**Height:** 1-3 m	**Height:** 0.5-1 m
Crown cover: 30-70%	**Crown cover:** <10%	**Crown cover:** <10%
Dominant taxa		
Acacia incurvaneura	*Eremophila platycalyx*	*Ptilotus schwartzii*
Other Taxa		
Acacia quadrimarginea	*Ptilotus obovatus* var. *obovatus*	*Cheilanthes sieberi*
Acacia caesaneura	*Dodonaea rigida*	*Maireana georgei*
	Eremophila latrobei subsp. latrobei	
	Scaevola spinescens	
	Acacia tetragonophylla	
	Acacia ramulosa	
	Psydrax latifolia	
	Rhagodia eremaea	

Project Name: Dacian		
Date: 13/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 216-218
Quadrat: Q8	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 73
Coordinates (GDA94): 51 J 359034 6854349		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Open Depression		
Coarse fragments on the surface: Quartz, ironstone/ 50-90%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 35%		
Cover bare ground: 65%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Chenopod Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0<.25 m
Crown cover: 30-70%	**Crown cover:** <10%	**Crown cover:** <10%
Dominant taxa		
Acacia incurvaneura	*Eremophila latrobei* subsp. *latrobei*	*Maireana triptera*
Other Taxa		
Acacia quadrimarginea	*Eremophila platycalyx*	*Dysphania kalpari*
Acacia caesaneura	*Sida calyxhymenia*	*Maireana georgei*
Acacia burkittii	*Senna artemisioides* subsp. *filifolia*	*Ptilotus exaltatus*
Acacia tetragonophylla	*Scaevola spinescens*	*Cheilanthes sieberi*
Santalum spicatum	*Eremophila alternifolia*	*Roepera eremaea*
	Hakea preissii	*Teucrium teucriiflorum*
	Sida sp. Golden calyces glabrous	*Marsdenia australis*
	Amyema fitzgeraldii	*Goodenia peacockiana*
	Sclerolaena densiflora	*Ptilotus obovatus* var. *obovatus*
		Enneapogon caerulescens

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 219-221
Quadrat: Q9	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 77
Coordinates (GDA94): 51 J 359432 6853727		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone/ 20-50%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ very slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 20%		
Cover bare ground: 80%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** <0.25 m
Crown cover: 30-70%	**Crown cover:** 10-30%	**Crown cover:** <10%
Dominant taxa		
Acacia incurvaneura	*Eremophila alternifolia*	*Ptilotus schwartzii*
Other Taxa		
Acacia ramulosa	*Acacia tetragonophylla*	*Marsdenia australis*
	Psydrax suaveolens	*Teucrium teucriiflorum*
		Dianella revoluta

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 222-122487
Quadrat: Q10	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 83
Coordinates (GDA94): 51 J 359317 6853249		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone/ 20-50%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ very slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 40%		
Cover bare ground: 60%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.25-0.5 m
Crown cover: >70%	**Crown cover:** <10%	**Crown cover:** <10%
Dominant taxa		
Acacia incurvaneura	*Eremophila margarethae*	*Ptilotus obovatus* var. *obovatus*
Other Taxa		
Acacia caesaneura	*Scaevola spinescens*	*Cheilanthes sieberi*
Acacia craspedocarpa	*Rhagodia eremaea*	*Maireana georgei*
Acacia tetragonophylla	*Senna charlesiana*	*Teucrium teucriiflorum*
	Psydrax suaveolens	
	Hakea kippistiana	

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 226-228
Quadrat: Q11	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 88
Coordinates (GDA94): 51 J 359295 6852544		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone/ 50-90%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Red-brown/ Clay Loam		
Cover leaf litter: 20%		
Cover bare ground: 80%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Chenopod Shrub
Height: 5-12 m	**Height:** 0.5-1 m	**Height:** 0.25-0.5 m
Crown cover: 30-70%	**Crown cover:** <10%	**Crown cover:** <10%
Dominant taxa		
Acacia incurvaneura	*Eremophila georgei*	*Maireana georgei*
Other Taxa		
Acacia caesaneura	*Maireana convexa*	*Ptilotus obovatus* var. *obovatus*
Acacia ayersiana	*Acacia tetragonophylla*	*Solanum lasiophyllum*
Santalum lanceolatum	*Acacia ramulosa*	
	Eremophila margarethae	

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 229-231
Quadrat: Q12	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 93
Coordinates (GDA94): 51 J 358666 6851906		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone/ 20-50%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ very slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 20%		
Cover bare ground: 80%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Chenopod Shrub
Height: 3-5 m	**Height:** 1-3 m	**Height:** 0.25-0.5 m
Crown cover: <10%	**Crown cover:** 10-30%	**Crown cover:** <10%
Dominant taxa		
Acacia incurvaneura	*Eremophila oldfieldii subsp. angustifolia*	*Maireana georgei*
Other Taxa		
Acacia aptaneura	*Acacia tetragonophylla*	*Maireana triptera*
Acacia caesaneura	*Sida calyxhymenia*	*Ptilotus obovatus* var. *obovatus*
Psydrax suaveolens	*Senna artemisioides subsp. filifolia*	*Marsdenia australis*
Santalum spicatum	*Scaevola spinescens*	*Roepera eremaea*
	Hakea preissii	*Sclerolaena densiflora*
		Teucrium teucriiflorum

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 232-234
Quadrat: Q13	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 97
Coordinates (GDA94): 51 J 360091 6852450		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone/ 50-90%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ very slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 20%		
Cover bare ground: 80%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Chenopod Shrub
Height: 3-5 m	**Height:** 1-3 m	**Height:** 0.25-0.5 m
Crown cover: 10-30%	**Crown cover:** 10-30%	**Crown cover:** <10%
Dominant taxa		
Acacia caesaneura	*Eremophila platycalyx*	*Maireana georgei*
Other Taxa		
Acacia incurvaneura	*Eremophila georgei*	*Dianella revoluta*
	Eremophila margarethae	*Maireana triptera*
	Rhagodia eremaea	*Enchylaena tomentosa*
	Scaevola spinescens	*Ptilotus obovatus* var. *obovatus*
	Acacia tetragonophylla	

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 235-237
Quadrat: Q14	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 101
Coordinates (GDA94): 51 J 359131 6851272		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone/ 20-50%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 15%		
Cover bare ground: 85%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Chenopod Shrub
Height: 3-5-12 m	**Height:** 0.5-1 m	**Height:** 0.5-1 m
Crown cover: 30-70%	**Crown cover:** <10%	**Crown cover:** <10%
Dominant taxa		
Acacia incurvaneura	*Eremophila margarethae*	*Maireana convexa*
Other Taxa		
Acacia caesaneura	*Eremophila georgei*	*Dianella revoluta*
Acacia tetragonophylla	*Acacia ramulosa*	*Marsdenia australis*
Santalum lanceolatum	*Scaevola spinescens*	*Ptilotus obovatus* var. *obovatus*
		Teucrium teucriiflorum

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 238-240
Quadrat: Q15	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 105
Coordinates (GDA94): 51 J 359161 6850654		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone/ 2-10%/ 2-6mm		
Rock outcrop (abundance/runoff): Nil/ very slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 20%		
Cover bare ground: 80%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.5-1 m
Crown cover: 30-70%	**Crown cover:** <10%	**Crown cover:** <10%
Dominant taxa		
Acacia incurvaneura	*Eremophila forrestii* subsp. *forrestii*	*Eremophila margarethae*
Other Taxa		
Acacia caesaneura	*Eremophila georgei*	*Dianella revoluta*
Psydrax suaveolens	*Rhagodia eremaea*	

Project Name: Dacian		
Date: 16/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 241-243
Quadrat: Q16	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 109
Coordinates (GDA94): 51 J 360077 6850161		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone/ 10-20%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ very slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 20%		
Cover bare ground: 80%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** <0.25 m
Crown cover: 30-70%	**Crown cover:** <10%	**Crown cover:** <1%
Dominant taxa		
Acacia incurvaneura	*Acacia tetragonophylla*	*Rhodanthe chlorocephala*
Other Taxa		
Acacia caesaneura	*Rhagodia eremaea*	*Cheilanthes sieberi*
Santalum spicatum		*Marsdenia australis*
		Rhodanthe charsleyae
		Teucrium teucriiflorum

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 244-246
Quadrat: Q17	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 113
Coordinates (GDA94): 51 J 360183 6851072		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Quartz/ 2-10%/ 6-20 mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 15%		
Cover bare ground: 85%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Chenopod Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.5-1 m
Crown cover: 30-70%	**Crown cover:** <10%	**Crown cover:** <10%
Dominant taxa		
Acacia incurvaneura	*Acacia tetragonophylla*	*Maireana georgei*
Other Taxa		
Acacia caesaneura	*Acacia ramulosa*	*Maireana convexa*
Santalum lanceolatum	*Eremophila margarethae*	*Ptilotus schwartzii*
	Scaevola spinescens	*Ptilotus obovatus* var. *obovatus*
		Teucrium teucriiflorum

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 247-249
Quadrat: Q18	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 117
Coordinates (GDA94): 51 J 358975 6849765		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Open Depression		
Coarse fragments on the surface: Quartz, ironstone/ 20-50%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 20%		
Cover bare ground: 80%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5 m	**Height:** 1-3 m	**Height:** 0.5-1 m
Crown cover: 30-70%	**Crown cover:** <10%	**Crown cover:** <10%
Dominant taxa		
Acacia incurvaneura	*Acacia tetragonophylla*	*Eremophila gilesii*
Other Taxa		
Acacia caesaneura	*Acacia ramulosa*	*Brachyscome ciliaris*
Santalum lanceolatum	*Acacia burkittii*	*Dianella revoluta*
	Eremophila margarethae	*Goodenia rosea*
	Hakea kippistiana	*Rhodanthe charsleyae*
		Teucrium teucriiflorum

Project Name: Dacian		
Date: 13/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 250-252
Quadrat: Q19	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 121
Coordinates (GDA94): 51 J 360195 6849655		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Ironstone/ 20-50%/ 2-6mm		
Rock outcrop (abundance/runoff): Nil/ very slow		
Soil (profile/field texture/soil surface): Sandy clay loam		
Cover leaf litter: 12%		
Cover bare ground: 85%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Hummock Grass
Height: 3-5-12 m	**Height:** 1-3 m	**Height:** 0.5-1 m
Crown cover: <10%	**Crown cover:** <10%	**Crown cover:** 10-30%
Dominant taxa		
Acacia caesaneura	*Acacia ramulosa*	*Triodia rigidissima*
Other Taxa		
Acacia incurvaneura	*Eremophila margarethae*	*Dianella revoluta*
Psydrax suaveolens	*Eremophila homoplastica*	*Teucrium teucriiflorum*
	Rhagodia eremaea	

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 253-255
Quadrat: Q20	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 125
Coordinates (GDA94): 51 J 359106 6849149		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone/ 10-20%/ 2-6mm		
Rock outcrop (abundance/runoff): Nil/ very slow		
Soil (profile/field texture/soil surface): Brown/ Sandy Clay Loam		
Cover leaf litter: 15%		
Cover bare ground: 85%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Hummock Grass
Height: 3-5 m	**Height:** 0.5-1 m	**Height:** 0.25-0.5 m
Crown cover: 30-70%	**Crown cover:** 10-30%	**Crown cover:** 30-70%
Dominant taxa		
Acacia caesaneura	*Eremophila margarethae*	*Triodia rigidissima*
Other Taxa		
Acacia incurvaneura	*Acacia ramulosa*	*Dianella revoluta*
	Acacia tetragonophylla	*Teucrium teucriiflorum*
	Eremophila homoplastica	*Thysanotus manglesii*

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 256-258
Quadrat: Q21	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 132
Coordinates (GDA94): 51 J 359536 6848231		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Good
Landform: Flat		
Coarse fragments on the surface: Ironstone/ 20-50-90%/ 2-6mm		
Rock outcrop (abundance/runoff): Nil/ very slow		
Soil (profile/field texture/soil surface): Brown/ Sandy Clay Loam		
Cover leaf litter: 20%		
Cover bare ground: 80%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree Mallee	**Growth form:** Shrub	**Growth form:** Hummock Grass
Height: 5-12 m	**Height:** 3-5 m	**Height:** 0.25-0.5 m
Crown cover: <10%	**Crown cover:** >70%	**Crown cover:** 30-70%
Dominant taxa		
Acacia youngiana	*Acacia effusifolia*	*Triodia rigidissima*
Other Taxa		
Acacia incurvaneura	*Eremophila margarethae*	*Goodenia xanthosperma*
	Sida calyxhymenia	*Malvaceae yellow*
		Androcalva luteiflora
		Thysanotus manglesii

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 259-261
Quadrat: Q22	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 137
Coordinates (GDA94): 51 J 359447 6847149		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Ironstone/ 10-20%/ 2-6mm		
Rock outcrop (abundance/runoff): Nil/ very slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 20%		
Cover bare ground: 80%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.25-0.5 m
Crown cover: <10%	**Crown cover:** 30-70%	**Crown cover:** 10-30%
Dominant taxa		
Acacia incurvaneura	*Acacia ramulosa*	*Eremophila homoplastica*
Other Taxa		
	Acacia effusifolia	*Teucrium teucriiflorum*
	Eremophila margarethae	*Triodia rigidissima*
	Rhagodia eremaea	

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 262-264
Quadrat: Q23	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 141
Coordinates (GDA94): 51 J 359409 6846651		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Good
Landform: Flat		
Coarse fragments on the surface: Ironstone/ 2-10%/ 2-6mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam Sandy		
Cover leaf litter: 20%		
Cover bare ground: 80%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree mallee	**Growth form:** Shrub	**Growth form:** Hummock Grass
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.25-0.5 m
Crown cover: <1%	**Crown cover:** <10%	**Crown cover:** >70%
Dominant taxa		
Eucalyptus youngiana	*Acacia effusifolia*	*Triodia rigidissima*
Other Taxa		
Acacia incurvaneura	*Psydrax suaveolens*	*Dianella revoluta*
	Eremophila margarethae	

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 265-267
Quadrat: Q24	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 145
Coordinates (GDA94): 51 J 359354 6845993		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Ironstone/ 10-20%/ 2-6mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 20%		
Cover bare ground: 60%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Hummock Grass
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.5-1 m
Crown cover: 10-30%	**Crown cover:** <10%	**Crown cover:** <10%
Dominant taxa		
Eucalyptus youngiana	*Acacia effusifolia*	*Triodia rigidissima*
Other Taxa		
Acacia incurvaneura		*Goodenia xanthosperma*
		Goodenia rosea
		Brunonia australis

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 268-270
Quadrat: Q25	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 149
Coordinates (GDA94): 51 J 359203 6845373		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Good
Landform: Flat		
Coarse fragments on the surface: Ironstone/ 10-20%/ 2-6mm		
Rock outcrop (abundance/runoff): Nil/ very slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam Sandy		
Cover leaf litter: 20%		
Cover bare ground: 30%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree Mallee	**Growth form:** Shrub	**Growth form:** Hummock grass
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.5-1 m
Crown cover: <1%	**Crown cover:** 30-70%	**Crown cover:** <10%
Dominant taxa		
Eucalyptus youngiana	*Acacia effusifolia*	*Triodia rigidissima*
Other Taxa		
Acacia caesaneura	*Acacia ramulosa*	
Acacia incurvaneura	*Eremophila margarethae*	

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 271-273
Quadrat: Q26	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 153
Coordinates (GDA94): 51 J 358996 6844609		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Good
Landform: Flat		
Coarse fragments on the surface: Ironstone/ 10-20%/ 2-6mm		
Rock outcrop (abundance/runoff): Nil/ very slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam Sandy		
Cover leaf litter: 15%		
Cover bare ground: 70%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Hummock grass
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.25-0.5 m
Crown cover: <10%	**Crown cover:** 10-30%	**Crown cover:** 30-70%
Dominant taxa		
Acacia incurvaneura	*Acacia ramulosa*	*Triodia rigidissima*
Other Taxa		
Acacia caesaneura	*Eremophila margarethae*	*Teucrium teucriiflorum*
Eucalyptus youngiana	*Eremophila homoplastica*	
	Psydrax suaveolens	

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 274-276
Quadrat: Q27	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 157
Coordinates (GDA94): 51 J 358718 6843946		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
arse fragments on the surface: Ironstone/ 2-10%/ 2-6mm		
Rock outcrop (abundance/runoff): Nil/ very slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 25%		
Cover bare ground: 65%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5 m	**Height:** 1-3 m	**Height:** 0.25-0.5 m
Crown cover: >70%	**Crown cover:** <10%	**Crown cover:** <10%
Dominant taxa		
Acacia caesaneura	*Acacia ramulosa*	*Eremophila homoplastica*
Other Taxa		
Acacia incurvaneura	*Psydrax suaveolens*	*Teucrium teucriiflorum*
Eucalyptus kingii		*Triodia rigidissima*

Project Name: Dacian		
Date: 14/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 277-279
Quadrat: Q28	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 161
Coordinates (GDA94): 51 J 358519 6842658		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Good
Landform: Flat		
Coarse fragments on the surface: Ironstone/ 20-50%/ -6-20 mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 25%		
Cover bare ground: 70%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** -
Height: 3-5 m	**Height:** 0.5-1 m	**Height:** -
Crown cover: 30-70%	**Crown cover:** <10%	**Crown cover:** -
Dominant taxa		
Acacia caesaneura	*Eremophila forrestii* subsp. *forrestii*	-
Other Taxa		
Acacia incurvaneura	*Dodonaea rigida*	
Eucalyptus kingsmillii	*Psydrax suaveolens*	
	Thryptomene decussata	

Project Name: Dacian		
Date: 15/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 280-282
Quadrat: Q29	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 165
Coordinates (GDA94): 51 J 359229 6843002		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Midslope		
Coarse fragments on the surface: Quartz, ironstone/ 50-90%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ moderate		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 10%		
Cover bare ground: 90%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5 m	**Height:** 1-3 m	**Height:** 0.25-0.5 m
Crown cover: 10-30%	**Crown cover:** <10%	**Crown cover:** <10%
Dominant taxa		
Acacia mulganeura	*Eremophila latrobei* subsp. *latrobei*	*Ptilotus schwartzii*
Other Taxa		
Acacia quadrimarginea	*Acacia ramulosa*	*Eriachne maculata*
Acacia incurvaneura	*Acacia tetragonophylla*	*Ptilotus obovatus* var. *obovatus*
	Dodonaea rigida	
	Eremophila georgei	
	Psydrax suaveolens	

Project Name: Dacian		
Date: 15/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 283-285
Quadrat: Q30	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 169
Coordinates (GDA94): 51 J 359309 6842776		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone, laterite/ 20-50%/ 6-20mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 25%		
Cover bare ground: 70%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** <0.25 m
Crown cover: 30-70%	**Crown cover:** 10-30%	**Crown cover:** <10%
Dominant taxa		
Acacia caesaneura	*Eremophila latrobei* subsp. *latrobei*	*Podotheca wilsonii*
Other Taxa		
Acacia incurvaneura	*Acacia ramulosa*	*Angianthus milnei*
Brachychiton gregorii	*Acacia tetragonophylla*	*Cheilanthes sieberi*
Santalum spicatum	*Eremophila clarkei*	*Marsdenia australis*
	Ptilotus obovatus var. *obovatus*	*Ptilotus helipteroides*
	Sida calyxhymenia	*Roepera eremaea*
	Scaevola spinescens	

Project Name: Dacian		
Date: 15/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 286-288
Quadrat: Q31	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 173
Coordinates (GDA94): 51 J 359506 6842463		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Limestone/ 50-90%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 25%		
Cover bare ground: 75%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.5-1 m
Crown cover: 30-70%	**Crown cover:** 10-30%	**Crown cover:** <10%
Dominant taxa		
Casuarina pauper	*Eremophila oldfieldii* subsp. *angustifolia*	*Ptilotus obovatus* var. *obovatus*
Other Taxa		
Acacia incurvaneura	*Eremophila pantonii*	*Maireana triptera*
Acacia kempeana	*Sida calyxhymenia*	*Maireana georgei*
Acacia ayersiana	*Sida* sp. Excedentifolia (J.L. Egan 1925)	*Ptilotus helipteroides*
Acacia burkittii	*Senna artemisioides* subsp. *filifolia*	*Roepera eremaea*
	Scaevola spinescens	

Project Name: Dacian		
Date: 15/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 289-291
Quadrat: Q32	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 177
Coordinates (GDA94): 51 J 359611 6842709		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Crest (BIF)		
Coarse fragments on the surface: Ironstone, laterite/ 50-90%/ 20-60mm		
Rock outcrop (abundance/runoff): 2-10%/ moderate		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 10%		
Cover bare ground: 90%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5 m	**Height:** 1-3 m	**Height:** 0.5-1 m
Crown cover: 10-30%	**Crown cover:** 10-30%	**Crown cover:** 10-30%
Dominant taxa		
Acacia incurvaneura	*Eremophila latrobei* subsp. *latrobei*	*Eremophila eriocalyx*
Other Taxa		
Acacia ayersiana	*Acacia ramulosa*	*Rhodanthe chlorocephala* subsp. *rosea*
	Dodonaea rigida	*Marsdenia australis*
	Eremophila georgei	*Goodenia macroplectra*
	Psydrax suaveolens	
	Scaevola spinescens	
	Sida calyxhymenia	

Project Name: Dacian		
Date: 15/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 292-294
Quadrat: Q33	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 182
Coordinates (GDA94): 51 J 359026 6842609		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone/ 50-90%/ 6-20mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 25%		
Cover bare ground: 75%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.25-0.5 m
Crown cover: 10-30%	**Crown cover:** <10%	**Crown cover:** <10%
Dominant taxa		
Acacia caesaneura	*Acacia tetragonophylla*	*Cheilanthes sieberi*
Other Taxa		
Acacia incurvaneura	*Eremophila forrestii* subsp. *forrestii*	*Marsdenia australis*
	Eremophila margarethae	*Teucrium teucriiflorum*

Project Name: Dacian		
Date: 15/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 295-297
Quadrat: Q34	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 186
Coordinates (GDA94): 51 J 359002 6842890		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone/ 50-90%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter:		
Cover bare ground:		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5 m	**Height:** 1-3 m	**Height:** 0.25-0.5 m
Crown cover: 10-30%	**Crown cover:** 10-30%	**Crown cover:** <1%
Dominant taxa		
Acacia incurvaneura	*Acacia quadrimarginea*	*Ptilotus schwartzii*
Other Taxa		
Acacia ayersiana	*Dodonaea rigida*	
Acacia caesaneura	*Eremophila forrestii* subsp. *forrestii*	
Brachychiton gregorii	*Eremophila georgei*	
Eucalyptus lucasii	*Eremophila latrobei* subsp. *latrobei*	
	Sida calyxhymenia	

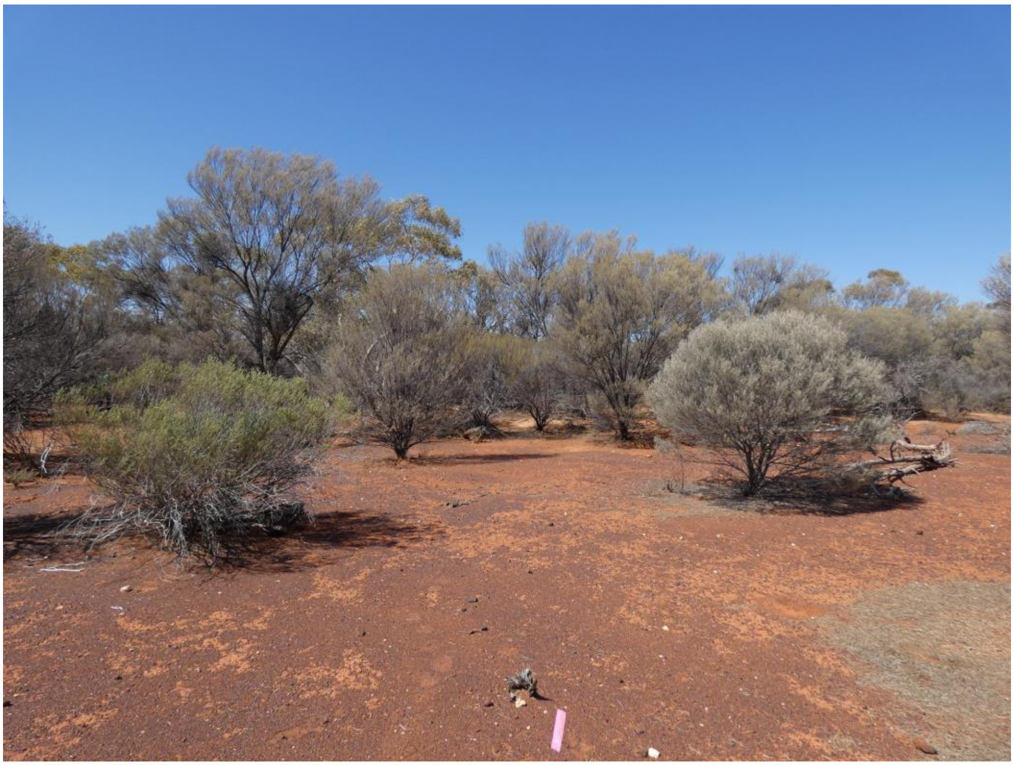
Project Name: Dacian		
Date: 15/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 298-300
Quadrat: Q35	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 190
Coordinates (GDA94): 51 J 358616 6842949		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Ironstone/ 50-90%/ 6-20mm		
Rock outcrop (abundance/runoff): Nil/ very slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 20%		
Cover bare ground: 80%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5 m	**Height:** 1-3 m	**Height:** 0.25-0.5 m
Crown cover: 10-30%	**Crown cover:** <10%	**Crown cover:** <1%
Dominant taxa		
Acacia caesaneura	*Acacia ramulosa*	*Ptilotus schwartzii*
Other Taxa		
Acacia incurvaneura	*Dodonaea rigida*	*Cheilanthes sieberi*
Brachychiton gregorii	*Eremophila forrestii* subsp. *forrestii*	*Ptilotus obovatus* var. *obovatus*
	Eremophila georgei	*Teucrium teucriiflorum*
	Eremophila margarethae	
	Eremophila latrobei subsp. latrobei	

Project Name: Dacian		
Date: 15/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 301-303
Quadrat: Q36	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 194
Coordinates (GDA94): 51 J 357855 6839039		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone, limestone		
Rock outcrop (abundance/runoff): 10-20%/ slow		
Soil (profile/field texture/soil surface): Brown/ Sandy Loam		
Cover leaf litter:		
Cover bare ground:		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.25 m
Crown cover: <10%	**Crown cover:** 10-30%	**Crown cover:** <10%
Dominant taxa		
Eucalyptus lucasii	*Acacia tetragonophylla*	*Roepera eremaea*
Other Taxa		
Acacia ayersiana	*Acacia burkittii*	*Maireana convexa*
Acacia caesaneura	*Acacia ramulosa*	*Maireana triptera*
Acacia incurvaneura	*Eremophila forrestii subsp. forrestii*	*Cephalipterum drummondii*
	Eremophila margarethae	*Calandrinia eremaea*
	Maireana pyramidata	*Plantago drummondii*
	Lemooria burkittii	*Duperreya commixta*
	Senna artemisioides subsp. artemisioides	*Teucrium teucriiflorum*
	Senna artemisioides subsp. filifolia	*Goodenia rosea*
		Helipterum craspedioides

Project Name: Dacian		
Date: 15/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 304-306
Quadrat: Q37	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 198
Coordinates (GDA94): 51 J 357587 6838836		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Open depression		
Coarse fragments on the surface: Mixed/ 50-90%/ 6-20mm		
Rock outcrop (abundance/runoff): Sandstone (creek)/ moderate		
Soil (profile/field texture/soil surface): Brown/ Clay Loam Sandy		
Cover leaf litter: 35%		
Cover bare ground: 60%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.25-0.5 m
Crown cover: <10%	**Crown cover:** 30-70%	**Crown cover:** <1%
Dominant taxa		
Eucalyptus lucasii	*Acacia tetragonophylla*	*Enchylaena tomentosa*
Other Taxa		
Acacia ayersiana	*Acacia burkittii*	*Erodium crinitum*
Acacia incurvaneura	*Eremophila citrina*	*Lepidium platypetalum*
	Eremophila clarkei	*Maireana georgei*
	Eremophila margarethae	*Marsdenia australis*
	Grevillea berryana	*Rhodanthe charsleyae*
	Grevillea deflexa	*Rhodanthe chlorocephala*
	Senna artemisioides subsp. *artemisioides*	*Roepera eremaea*
	Senna artemisioides subsp. filifolia	

Project Name: Dacian		
Date: 15/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 309-311
Quadrat: Q38	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 202
Coordinates (GDA94): 51 J 357441 6839178		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Very Good
Landform: Flat		
Coarse fragments on the surface: Ironstone/ 50-90%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ very slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 10%		
Cover bare ground: 90%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Chenopod Shrub
Height: 3-5 m	**Height:** 0.5-1 m	**Height:** 0.25-0.5 m
Crown cover: 10-30%	**Crown cover:** 10-30%	**Crown cover:** 10-30%
Dominant taxa		
Acacia incurvaneura	*Ptilotus obovatus var. obovatus*	*Maireana triptera*
Other Taxa		
Acacia aptaneura	*Acacia tetragonophylla*	*Enchylaena tomentosa*
Acacia caesaneura	*Eremophila georgei*	*Maireana georgei*
Santalum lanceolatum	*Eremophila margarethae*	*Leichardtia australis*
	Eremophila platycalyx subsp. Leonora	*Ptilotus helipteroides*
	Scaevola spinescens	*Ptilotus schwartzii*
	Sida calyxhymenia	*Teucrium teucriiflorum*

Project Name: Dacian		
Date: 15/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 312-314
Quadrat: Q39	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 206
Coordinates (GDA94): 51 J 357392 6838576		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Good
Landform: Open depression		
Coarse fragments on the surface: Ironstone/ 50-90%/ 20-60mm		
Rock outcrop (abundance/runoff): 2-10%/ moderate		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 35%		
Cover bare ground: 65%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.25-0.5 m
Crown cover: <10%	**Crown cover:** 10-30%	**Crown cover:** <10%
Dominant taxa		
Eucalyptus lucasii	*Acacia tetragonophylla*	*Ptilotus obovatus* var. *obovatus*
Other Taxa		
Acacia burkittii	*Eremophila citrina*	*Goodenia peacockiana*
Acacia caesaneura	*Eremophila pantonii*	*Rhodanthe charsleyae*
Acacia incurvaneura	*Grevillea deflexa*	*Haloragis odontocarpa*
	Psydrax suaveolens	*Roepera eremaea*
	Senna artemisioides subsp. *artemisioides*	*Convolvulus remotus*
		Bulbine semibarbata
		Goodenia rosea



Project Name: Dacian		
Date: 15/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 315-317
Quadrat: Q40	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 210
Coordinates (GDA94): 51 J 357840 6838583		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone/ 20-50%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 30%		
Cover bare ground: 70%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5 m	**Height:** 1-3 m	**Height:** 0.5-1 m
Crown cover: 30-70%	**Crown cover:** 10-30%	**Crown cover:** 10-30%
Dominant taxa		
Acacia caesaneura	*Acacia tetragonophylla*	*Ptilotus obovatus* var. *obovatus*
Other Taxa		
Acacia ayersiana	*Eremophila forrestii* subsp. *forrestii*	*Cheilanthes sieberi*
Acacia incurvaneura	*Eremophila margarethae*	*Goodenia rosea*
Hakea kippistiana	*Eremophila georgei*	*Goodenia xanthosperma*
Psydrax suaveolens	*Eremophila latrobei* subsp. *latrobei*	*Ptilotus schwartzii*
Santalum lanceolatum	*Eremophila platycalyx* subsp. Leonora	*Podotheca wilsonii*
	Rhagodia eremaea	*Lemooria burkittii*
	Scaevola spinescens	*Rhodanthe charsleyae*
	Senna charlesiana	*Teucrium teucriiflorum*
		Solanum lasiophyllum

Project Name: Dacian		
Date: 15/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 318-320
Quadrat: Q41	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 214
Coordinates (GDA94): 51 J 357813 6838381		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Good
Landform: Flat		
Coarse fragments on the surface: Quartz, ironstone/ 50-90%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 10%		
Cover bare ground: 90%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5 m	**Height:** 1-3 m	**Height:** 0.25-0.5 m
Crown cover: 10-30%	**Crown cover:** 10-30%	**Crown cover:** 10-30%
Dominant taxa		
Acacia caesaneura	*Maireana sedifolia*	*Maireana triptera*
Other Taxa		
Acacia mulganeura	*Acacia tetragonophylla*	*Maireana georgei*
Santalum lanceolatum	*Eremophila citrina*	*Lemooria burkittii*
	Eremophila longifolia	*Cephalipterum drummondii*
	Eremophila malacoides	*Goodenia xanthosperma*
	Eremophila platycalyx subsp. Leonora	*Ptilotus helipteroides*
	Calandrinia balonensis	*Ptilotus exaltatus*
	Calandrinia eremaea	*Ptilotus aervoides*
	Enneapogon caerulescens	*Ptilotus obovatus* var. *obovatus*
	Roepera eremaea	*Solanum lasiophyllum*
		Sclerolaena densiflora

Project Name: Dacian		
Date: 15/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 321-323
Quadrat: Q42	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 218
Coordinates (GDA94): 51 J 357549 6837978		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Good
Landform: Flat		
Coarse fragments on the surface: Quartz/ 50-90%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 10%		
Cover bare ground: 90%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.25-0.5 m
Crown cover: 10-30%	**Crown cover:** <10%	**Crown cover:** <10%
Dominant taxa		
Acacia caesaneura	*Acacia tetragonophylla*	*Maireana georgei*
Other Taxa		
Acacia incurvaneura	*Eremophila platycalyx* subsp. Leonora	*Leichardtia australis*
Acacia mulganeura	*Eremophila margarethae*	*Ptilotus obovatus* var. *obovatus*
Santalum lanceolatum	*Sida calyxhymenia*	*Roepera eremaea*
	Sida sp. Excedentifolia *(J.L. Egan 1925)*	*Cephalipterum drummondii*
		Ptilotus helipteroides
		Duperreya commixta
		Podotheca wilsonii
		Helipterum craspedioides

Project Name: Dacian		
Date: 15/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 324-326
Quadrat: Q43	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 222
Coordinates (GDA94): 51 J 357757 6837753		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Good
Landform: Mid-slope		
Coarse fragments on the surface: Quartz/ 50-90%/ 20-60mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 10%		
Cover bare ground: 90%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 3-5 m	**Height:** 1-3 m	**Height:** 0.5-1 m
Crown cover: <10%	**Crown cover:** <10%	**Crown cover:** 10-30%
Dominant taxa		
Acacia mulganeura	*Acacia ramulosa*	*Ptilotus obovatus* var. *obovatus*
Other Taxa		
Acacia incurvaneura	*Eremophila latrobei* subsp. *latrobei*	*Brachyscome ciliaris*
Acacia quadrimarginea	*Eremophila georgei*	*Maireana triptera*
	Eremophila platycalyx subsp. Leonora	*Ptilotus helipteroides*
	Dodonaea rigida	*Roepera eremaea*
	Scaevola spinescens	*Solanum lasiophyllum*
	Sida calyxhymenia	*Teucrium teucriiflorum*
	Rhagodia eremaea	
	Hakea preissii	

Project Name: Dacian		
Date: 15/07/2021	**Botanist:** JW/JJ	**Photo (NW corner):** 327-329
Quadrat: Q44	**Quadrat size:** 50m x 50m	**Waypoint (NW corner):** 226
Coordinates (GDA94): 51 J 358357 6841293		
Aspect: SW	**Fire (yrs):** >20	**Condition rating:** Good
Landform: Open depression		
Coarse fragments on the surface: Ironstone/ 20-50%/ 20-60 mm		
Rock outcrop (abundance/runoff): Nil/ slow		
Soil (profile/field texture/soil surface): Brown/ Clay Loam		
Cover leaf litter: 35%		
Cover bare ground: 65%		
Upper stratum	**Mid-stratum**	**Lower stratum**
Growth form: Tree	**Growth form:** Shrub	**Growth form:** Shrub
Height: 5-12 m	**Height:** 1-3 m	**Height:** 0.5-1 m
Crown cover: >70%	**Crown cover:** 10-30%	**Crown cover:** <10%
Dominant taxa		
Acacia incurvaneura	*Acacia tetragonophylla*	*Rhagodia eremaea*
Other Taxa		
Acacia burkittii	*Eremophila latrobei* subsp. *latrobei*	*Cheilanthes sieberi*
Acacia caesaneura	*Eremophila georgei*	*Calandrinia balonensis*
Eremophila longifolia	*Senna artemisioides subsp. artemisioides*	*Maireana georgei*
Grevillea berryana	*Senna artemisioides subsp. filifolia*	*Maireana triptera*
		Ptilotus obovatus var. *obovatus*

Appendix 9: NatureMap Species List (40km buffer)

Appendix 10: EPBC Protected Matters Search (40km buffer)

APPENDIX 4: FAUNA AND HABITAT SURVEY FOR THE REDCLIFFE GOLD PROJECT (PHOENIX 2021A)

PHOENIX
ENVIRONMENTAL SCIENCES

Fauna and habitat survey for the Redcliffe Gold Project

Prepared for Dacian Gold Limited

December 2021

Final

Fauna and habitat survey for the Redcliffe Gold Project

Prepared for Dacian Gold Limited

Version history

Author/s	Reviewer/s	Version	Version number	Date submitted	Submitted to
J. Scanlon, C. Nagle, J. Larkman	S. Pynt	Draft for client comments	0.1	08-Dec-21	P. Dunstan
J. Scanlon, C. Nagle, J. Larkman	C. Nagle	Final, client comments addressed	1.0	10-Dec-21	P. Dunstan

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PHOENIX ENVIRONMENTAL SCIENCES

EXECUTIVE SUMMARY

Dacian Gold Limited (Dacian) is seeking to develop the Redcliffe Gold Project (the Project), located 45-60 km northeast of Leonora, Western Australia, comprising 1730.6 ha on tenements M37/1286, M37/1348 and M37/1276. Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Dacian to undertake a desktop review, basic vertebrate fauna and short-range endemic (SRE) invertebrate survey (Winter-Spring, 30 August – 5 September 2021) and additional targeted searches for conservation significant vertebrates (late Spring, 22-26 November 2021).

A search of relevant databases combined with information from reports of other surveys in the Eastern Murchison bioregion were used to determine the significant fauna potentially occurring in the study area and thus to design the field survey. The identified regional fauna assemblage included 277 vertebrate species; 27 of these are listed as conservation significant, only one of which (Peregrine Falcon *Falco peregrinus*, listed as OS 'other specially protected' under Western Australia's Biodiversity Conservation Act) has previously been recorded within the study area.

The field survey included an assessment of vertebrate fauna, SRE invertebrate and Malleefowl habitat as well as active searches at sites throughout the study area, and targeted search transects for evidence of Malleefowl in suitable habitat. Recording devices were used to target Night Parrot and echolocating bats, and motion-activated cameras were used where suitable locations were identified. The survey recorded 70 vertebrate species, approximately 25% of those identified as potentially occurring.

Apart from a few low rocky hills and areas previously cleared/disturbed by earlier mining operations, fauna habitats in the study area mostly comprise mulga woodland and shrubland on undulating plains of clay loam soils. Based on attributes relevant to significant fauna species, the following habitat types were delineated and mapped:

1. Breakaway and upper slope with open shrubland
2. Open/sparse shrubland on slopes and stony plains
3. Open shrubland on lower slopes and plains
4. Groved mulga on lower slopes, minor drainages and plain
5. Mulga woodland/tall shrubland on drainage
6. Mulga tall shrubland on sandplain
7. Mallee over mulga shrubland with hummock grass on sandplain
8. Mine pit with deep pool
9. Other cleared/disturbed

Habitat types 6 and 7 were assessed as highly suitable foraging and potential breeding habitat for Malleefowl *Leipoa ocellata* (Vulnerable), and types 3, 4 and 5 as Medium suitability (dispersal and possible foraging). Evidence of this species (tracks and foraging signs) was recorded in habitat types 6 and 7. High intensity targeted searches along transects were conducted in 'High' and 'Medium' suitability habitats in November, and found no evidence of either active or inactive Malleefowl nest mounds.

Habitat type 1 was assessed as highly suitable foraging, dispersal and possible denning habitat for Chuditch *Dasyurus geoffroii* (Vulnerable), and types 7, 8 and 9 as Medium suitability. Searches along several kilometres of breakaway (habitat type 1) recorded skeletal remains of indeterminate age, and two recent (but not fresh) scats of this species. It is concluded that both Malleefowl and Chuditch use the study area intermittently for dispersal and foraging, but the evidence does not indicate resident or breeding populations.

Habitat types 1 and 8 contain suitable nesting cliffs for the previously recorded Peregrine Falcon (OS), and all types are suitable for foraging by this species. Scats of a small dasyurid marsupial were indeterminate to species but possibly represent Long-tailed Dunnart *Sminthopsis longicaudata*

(Priority 4), which is considered likely to occur in the study area (with similar habitat requirements to Chuditch). The survey also found evidence of current and former presence of Brushtail Possum *Trichosurus vulpecula*, not conservation listed but previously unrecorded in the area and thought to be extinct in most of the arid region; this is a regionally significant species record. A likelihood of occurrence assessment found that six Migratory or nomadic bird species may occur as occasional visitors.

The invertebrate fauna desktop review identified no records of confirmed SRE taxa and 27 potential SRE taxa from within the SRE desktop search area. A further 36 taxa of uncertain SRE status were identified. The majority of desktop records were mygalomorphs, followed by pseudoscorpions. The desktop records indicate three SRE taxa have previously been recorded within the study area:

- *Antichiropus* ‘sp. indet.’ (uncertain SRE status)
- *Aname* ‘sp. indet.’ (uncertain SRE status)
- *Idiosoma* ‘sp. indet.’ (uncertain SRE status)

Only one habitat type within the study area was deemed as having High potential to support SRE taxa. This was described as hills capped with weathered volcanic rock forming breakaway with overhangs, caves and/or boulder piles, with open mid shrubland of mulga, other *Acacia* and mixed shrubs. This habitat primarily occurs in the north of the study area and extends out of the study area to the west. The remaining eight habitats were deemed as having Low potential to support SRE taxa.

Three previously unknown species of mygalomorph spider and one previously unknown species of centipede were collected from the study area:

- *Aname* 'Phoenix0077'
- *Kwonkan* 'Phoenix0078'
- *Idiosoma* 'Phoenix0079'
- *Mecistocephalus* 'Phoenix0075'

Five of the taxa collected are potential SREs, including all four of the previously unknown taxa. Of the potential SREs, three were recorded in mulga shrubland habitat on plains, slopes or drainage deemed to have Low potential to support SREs (*Aname* ‘Phoenix007’, *Kwonkan* 'Phoenix0078' and *Idiosoma* 'WAM T110336'). The remaining two potential SRE taxa were recorded from rocky breakaways and upper slopes deemed to have High potential to support SREs (*Idiosoma* 'Phoenix0079' and *Mecistocephalus 'Phoenix0075')*.

Poor representation or absence of some groups may be due to dry environmental conditions in the years preceding the survey. The region has been receiving substantially lower than average rainfall since 2019. Millipede, snail and isopod activity mostly requires humid conditions, and no members of these groups were collected.

It is considered likely that the discovery of previously unknown species is a result of the lack of surveys having been carried out in the region, rather than these taxa being true SREs. All specimens from SRE groups were obtained from habitats either widespread within the study area or habitats that are limited within the study area but are connected to similar and extensive habitat outside the study area.

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1 INTRODUCTION

Dacian Gold Limited (Dacian) is seeking to develop the Redcliffe Gold Project (the Project), located 45-60 km northeast of Leonora, Western Australia (WA; Figure 1-1). The initial stages of the Project development comprise the following deposits:

- Nambi deposit - situated on M37/1286
- Hub deposit – situated on M37/1348
- Gold Terrace South (GTS) deposit – situated on M37/1276.

Dacian proposes to develop the Nambi, Hub and GTS mining areas as one Mining Proposal (MP).

In August 2021, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Dacian to undertake a basic fauna and habitat survey for the Project, followed by Detailed or targeted surveys as deemed necessary.

The purpose of the surveys was to support the submission of the MP by updating existing survey works, confirming existing results, filling in any gaps and increasing knowledge of the survey area.

The study area is located in the Shire of Leonora and Shire of Laverton, and the Eremaean Botanical Province as defined by EPA (2016b).

1.1 BACKGROUND

Previous terrestrial fauna work completed for the Project includes:

- Short-range Endemic (SRE) invertebrate surveys in the Golden Terrace North and 727 prospects (Phoenix 2010b, c)
    - a number of Mygalomorphae Trapdoor spiders identified, although none considered to be SREs
    - no evidence that SRE species were present or likely to be present in the study area
- level 2 vertebrate fauna survey over part of the survey area (Phoenix 2010a)
    - two species of conservation significance recorded in the study area: the Peregrine Falcon (*Falco peregrinus*) and the Migratory Rainbow Bee-eater (*Merops ornatus*)
- reconnaissance fauna survey over part of the survey area (Botanica 2019)
    - no species of conservation significance recorded

1.2 SCOPE OF WORK

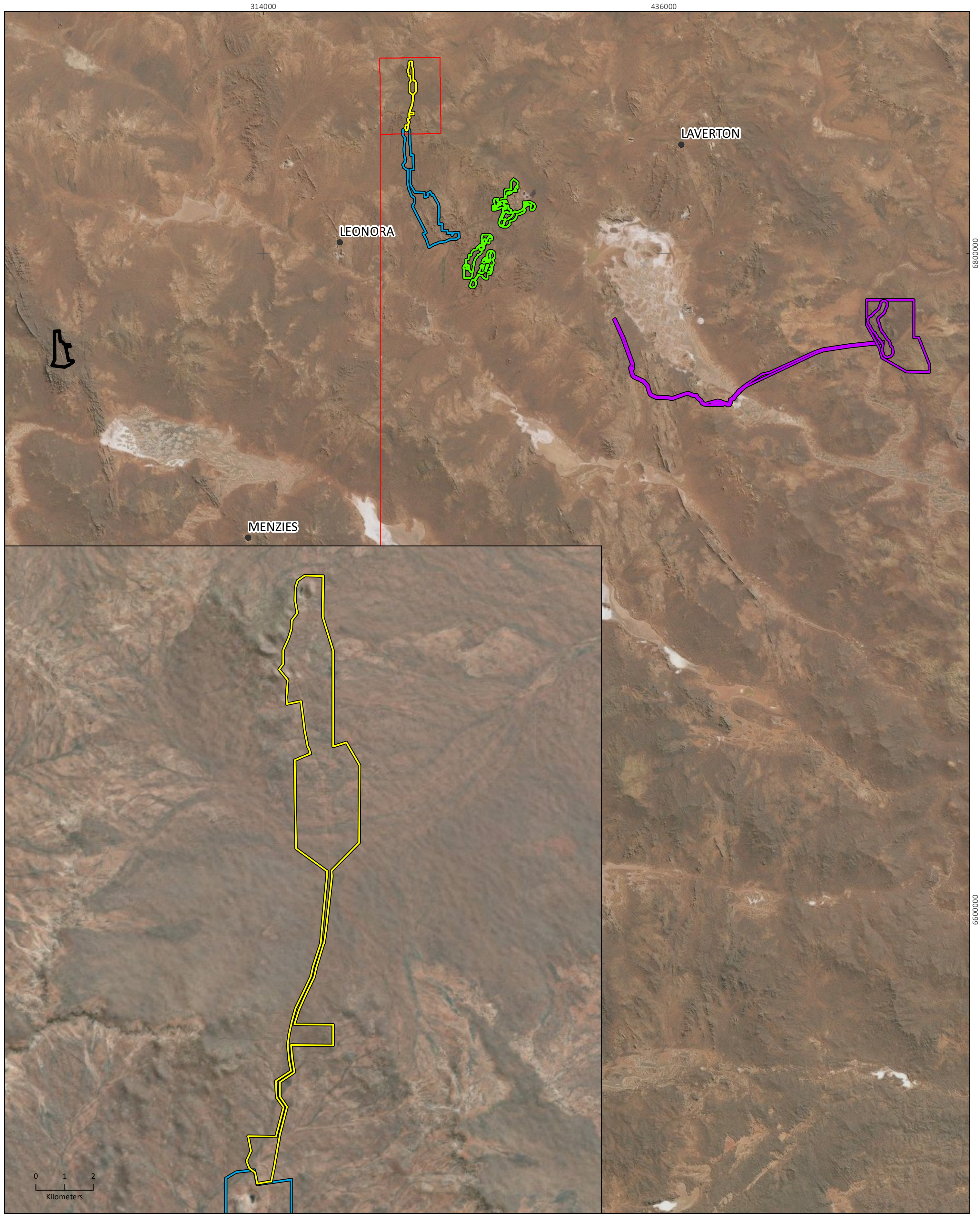
The scope of work for the basic fauna and habitat survey was as follows:

- Conduct a desktop review to identify likely and significant habitats, communities, and conservation significant species within and near M37/1348, M37/1286, M37/127
- undertake a basic fauna survey of the study area during the appropriate season(s) to delineate fauna species, habitats and determine requirements for follow-up Detailed or targeted surveys (if required)
- complete targeted surveys for conservation significant species as deemed necessary at completion of the Basic fauna survey
- conduct a desktop review of the area including potential habitats present to support SREs, database searches and literature review of locally relevant surveys and their results
- sampling of areas identified as having the potential to support SREs
- preparation of a report suitable for use to support Environmental Approval Applications to government

- Provision of IBSA standard GIS data.

1.3 STUDY AREA

The study area was approximately 1730.5 ha in area, extending 21.25 km north-south and less than 2.0 km in width, and encompasses historic mining areas (Figure 1-1).



Dacian Gold Limited
Redcliffe Gold Project

Project No	1440-RGP-DGL-VER
Date	8/12/2021
Drawn by	IN
Map author	JS

0 25 50
Kilometers

1:1,486,000 (at A4) GDA 1994 MGA Zone 51

Study area
Leonora Gold Project study area
Murrin Murrin Operations study area
Irwin Hills study area
Mt Ida Gold Project study area

Figure 1-1

Project location and study area

PHOENIX ENVIRONMENTAL SCIENCES

P:\GIS\Projects\RedcliffeGoldProject\1440-RGP-DGL-TER\Mapping\MapDocuments\Figures\Figure_1_1_Project_location.mxd

2 LEGISLATIVE CONTEXT

The protection of fauna in WA is principally governed by three acts:

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- State *Biodiversity Conservation Act 2016* (BC Act)
- State *Environmental Protection Act 1986* (EP Act).

The BC Act came into full effect on 1 January 2019 and replaced the functions of the *Wildlife Conservation Act 1950* (WC Act).

2.1 COMMONWEALTH

The EPBC Act is administered by the Federal Department of Agriculture, Water and the Environment (DAWE). The EPBC Act provides for the listing of Threatened fauna as matters of National Environmental Significance (NES). Under the EPBC Act, actions that have, or are likely to have, a significant impact on a matter of NES, require approval from the Australian Government Minister for the Environment through a formal referral process.

Conservation categories applicable to Threatened fauna species under the EPBC Act are as follows:

- Extinct (EX)[1] – there is no reasonable doubt that the last individual has died
- Extinct in the Wild (EW) – taxa known to survive only in captivity
- Critically Endangered (CR) – taxa facing an extremely high risk of extinction in the wild in the immediate future
- Endangered (EN) – taxa facing a very high risk of extinction in the wild in the near future
- Vulnerable (VU) – taxa facing a high risk of extinction in the wild in the medium term
- Conservation Dependent (CD)[1] – taxa whose survival depends upon ongoing conservation measures; without these measures, a conservation dependent taxon would be classified as Vulnerable, Endangered or Critically Endangered.

Ecological communities are defined as 'naturally occurring biological assemblages that occur in a particular type of habitat' (English & Blyth 1997). There are three categories under which ecological communities can be listed as TECs under the EPBC Act: Critically Endangered, Endangered and Vulnerable.

The EPBC Act is also the enabling legislation for protection of Migratory species as matters of NES under several international agreements:

- Japan-Australia Migratory Bird Agreement (JAMBA)
- China-Australia Migratory Bird Agreement (CAMBA)
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn)
- Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

[1] Species listed as Extinct and Conservation Dependent are not matters of NES and therefore do not trigger the EPBC Act.

2.2 State

2.2.1 Threatened and Priority species

In WA, the BC Act provides for the listing of Threatened fauna species (Government of Western Australia 2018a, b)[2] in the following categories:

- Critically Endangered (CR) – species facing an extremely high risk of extinction in the wild in the immediate future[3]
- Endangered (EN) – species facing a very high risk of extinction in the wild in the near future[3]
- Vulnerable (VU) – species facing a high risk of extinction in the wild in the medium term future[3].

Species may also be listed as specially protected under the BC Act in one or more of the following categories:

- species of special conservation interest (conservation dependent fauna, CD) – species with a naturally low population, restricted natural range, of special interest to science, or subject to or recovering from a significant population decline or reduction in natural range
- Migratory species (Mig.), including birds subject to international agreement
- species otherwise in need of special protection (OS).

The Department of Biodiversity, Conservation and Attractions (DBCA) administers the BC Act and also maintains a non-statutory list of Priority fauna. Priority species are still considered to be of conservation significance – that is they may be Threatened – but cannot be considered for listing under the BC Act until there is adequate understanding of threat levels imposed on them. Species on the Priority fauna list are assigned to one of four Priority (P) categories, P1 (highest) – P4 (lowest), based on level of knowledge/concern.

2.2.2 Critical habitat

Under the BC Act, habitat is eligible for listing as critical habitat if it is critical to the survival of a Threatened species or a TEC and its listing is otherwise in accordance with the ministerial guidelines.

2.2.3 Threatened and Priority Ecological Communities

The BC Act provides for the listing of TECs in the following categories:

- Critically Endangered – facing an extremely high risk of becoming eligible for listing as a collapsed ecological community in the immediate future[3]
- Endangered – facing a very high risk of becoming eligible for listing as a collapsed ecological community in the near future[3]
- Vulnerable – facing a high risk of becoming eligible for listing as a collapsed ecological community in the medium term future[3].

An ecological community may be listed as a collapsed ecological community under the BC Act if there is no reasonable doubt that the last occurrence of the ecological community has collapsed or the

[2] The *Wildlife Conservation (Specially Protected Fauna) Notice 2018* and the *Wildlife Conservation (Rare Flora) Notice 2018* have been transitioned under regulations 170, 171 and 172 of the *Biodiversity Conservation Regulations 2018* to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the BC Act.

[3] As determined in accordance with criteria set out in the ministerial guidelines.

ecological community has been so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure.

The DBCA also maintains a non-statutory list of Priority Ecological Communities (PECs), which may become TECs in the future; however, do not currently meet survey criteria or that are not adequately defined. PECs are assigned to one of five categories depending on their priority for survey or definition, with Priority 1 of highest concern and Priority 5 of lowest concern.

2.2.4 Other significant fauna

Under the EPA's environmental factor guidelines, fauna may be considered significant for a range of reasons other than listing as a Threatened or Priority species or ecological community.

In addition to listing as Threatened or Priority, EPA (2016a) identifies the following attributes that constitute significant fauna:

- species with restricted distribution (see also section 2.2.5)
- species subject to a degree of historical impact from threatening processes
- providing an important function required to maintain the ecological integrity of a significant ecosystem.

2.2.5 Short-range endemic invertebrates

SRE fauna are defined as animals that display restricted geographic distributions, nominally less than 10,000 km^2, that may also be disjunct and highly localised (Harvey 2002). EPA (2016a) identifies species with restricted distributions as being significant fauna in the context of environmental impact assessments (EIA). SRE fauna need to be considered in EIA as localised, small populations of species that are generally at greater risk of changes in conservation status due to environmental change than other, more widely distributed taxa.

Short-range endemism in terrestrial invertebrates is believed to have evolved through two primary processes (Harvey 2002):

Relictual – where the drying climate reduced the area of suitable habitat available to a species, forcing a range contraction. Such habitats typically maintain historic mesic conditions (e.g. south-facing rock faces or slopes of mountains or gullies)

Habitat speciality – where species settled in particular isolated habitat types (e.g. rocky outcrops) by means of dispersal and evolved in isolation into distinct species.

However, SRE invertebrates have also been reported in more widespread habitats such as spinifex plains or woodlands, mainly in groups with low dispersal capabilities, for example mygalomorph spiders and millipedes (see for example Car & Harvey 2014; Rix *et al.* 2018).

There can be uncertainty in categorising a specimen as an SRE due to several factors including poor regional survey density, lack of taxonomic research and problems of identification, i.e. specimens that may represent SREs cannot be identified to species level based on the life stage at hand. For example, in contrast to mature males, juvenile and female millipedes, mygalomorph spiders and scorpions cannot be identified to species level. Molecular techniques such as 'barcoding' (Hebert *et al.* 2003a; Hebert *et al.* 2003b) are routinely employed to overcome taxonomic or identification problems.

Currently, there is no accepted system to determine the likelihood that a species is an SRE. The WA Museum applies four categories which were adopted in this assessment: confirmed, potential, uncertain and not SRE. Confirmed SREs are taxa for which the distribution is known to be less than 10,000 km^2, the taxonomy is well known and the group is well represented in collections and/ or via comprehensive sampling (WAM 2013). Potential SREs include those taxa for which there is incomplete knowledge of the geographic distribution of the group and its taxonomy, and the group is not well represented in collections.

3 EXISTING ENVIRONMENT

3.1 INTERIM BIOGEOGRAPHIC REGIONALISATION OF AUSTRALIA

The Interim Biogeographic Regionalisation of Australia (IBRA) classifies Australia's landscapes into large 'bioregions' and 'subregions' based on climate, geology, landform, native vegetation and species information (DoEE 2016). The study area is located in the Eastern Murchison subregion (MUR1) of the Murchison bioregion (Figure 3-1) which is characterised by

- internal drainage, and extensive areas of elevated red desert sandplains with minimal dune development
- salt lake systems associated with the occluded Paleodrainage system
- broad plains of red-brown soils and breakaway complexes as well as red sandplains
- vegetation is dominated by Mulga Woodlands often rich in ephemerals; hummock grasslands, saltbush shrublands and *Halosarcia* [i.e. *Tecticornia*] shrublands.

3.2 LAND SYSTEMS AND SURFACE GEOLOGY

DPIRD undertakes land system mapping for WA using a nesting soil-landscape mapping hierarchy (Schoknecht & Payne 2011). While the primary purpose of the mapping is to inform pastoral and agricultural land capability, it is also useful for informing biological assessments. Under this hierarchy, land systems are defined as areas with recurring patterns of landforms, soils, vegetation and drainage (Payne & Leighton 2004).

The study area intersects eight land systems (Table 3-1; Figure 3-2). The Jundee System dominates the study area at 44.4%, Violet System occupies 25.8%, and the other six systems comprise the remaining 29.8% of the area.

Table 3-1 Land systems and extent in study area

Land system	Description	Area (ha)	% of study area
Bevon System	Irregular low ironstone hills with stony lower slopes supporting mulga shrublands.	144.4	8.3
Bullimore System	Gently undulating sandplain with occasional linear dunes and stripped surfaces supporting spinifex grasslands with mallees and *Acacia* shrubs.	27.7	1.6
Desdemona System	Plains with deep sandy or loamy soils supporting mulga tall shrublands and wanderrie grasses.	30.0	1.7
Jundee System	Hardpan plains with variable gravelly mantles and minor sandy banks supporting weakly groved mulga shrublands.	768.4	44.4
Monk System	Hardpan plains with occasional sandy banks supporting mulga tall shrublands and wanderrie grasses.	245.3	14.2
Nubev System	Gently undulating stony plains, minor limonitic low rises and drainage floors supporting mulga and halophytic shrublands.	35.4	2.0
Violet System	Gently undulating gravelly plains on greenstone, laterite and hardpan, with low stony rises and minor saline plains;	446.7	25.8

Land system	Description	Area (ha)	% of study area
	supporting groved mulga and bowgada shrublands and occasionally chenopod shrublands.		
Wyarri System	Granite domes, hills and tor fields with gritty-surfaced fringing plains supporting mulga and granite wattle shrublands.	32.7	1.9
Total		**1,730.5**	**100**

According to the Surface Geology of Australia 1:1,000,000 scale, Western Australia database (Stewart *et al.* 2008), the study area intersects five geological formations (Table 3-2; Figure 3-2). The study area is dominated by Quaternary colluvium (63.5% by area) flanking weathered outcrops of granite and mafic rocks in the northern part (30.1%) and sedimentary rocks in the south (6.4%).

Table 3-2 Surface geology of the study area, extent by deposit type

Surface geology	Abbreviation	Description	Area (ha)	% of study area
colluvium 38491	Qrc	Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite	1,099.2	63.5
hi-Ca granite 74296	Agh	Monzogranite, granodiorite, tonalite, quartz monzonite; in places recrystallised and foliated; some mixed granite and country rock assemblages; high-Ca granite	6.5	0.4
mafic extrusive rocks 74248	Abe	Basalt, high-Mg basalt, minor mafic intrusive rocks; some andesite; agglomerate; mafic schist; amphibolite; dolerite; komatiitic basalt; carbonated basalt; basaltic andesite; mafic rock interleaved with minor granitic rock	512.2	29.6
mafic intrusive rocks 74263	Ade	Mafic intrusive rocks, medium to coarse-grained; layered mafic to ultramafic intrusions - dolerite, gabbro, olivine gabbro, peridotite, pyroxenite, leucogabbro, quartz dolerite, quartz gabbro, gabbronorite	1.3	<0.1
sedimentary rocks 74322	Ase	Phyllitic schist, siltstone, sandstone, greywacke, pelite, conglomerate, quartzite, phyllite, shale, slate, claystone, chert, minor felsic volcanic and volcaniclastic rocks; arkose, para- and orthoamphibolites; rare banded iron formation	111.2	6.4
Total			**1,730.5**	**100**

Dacian Gold Limited
Redcliffe Gold Project

Project No	1440-RGP-DGL-VER
Date	8/12/2021
Drawn by	IN
Map author	JS

0 10 20
Kilometers

1:900,000 (at A4) GDA 1994 MGA Zone 51

Study area

IBRA region and subregion

Murchison, Eastern Murchison

Great Victoria Desert, Shield

Figure 3-1

Study area in relation to IBRA bioregions and subregions

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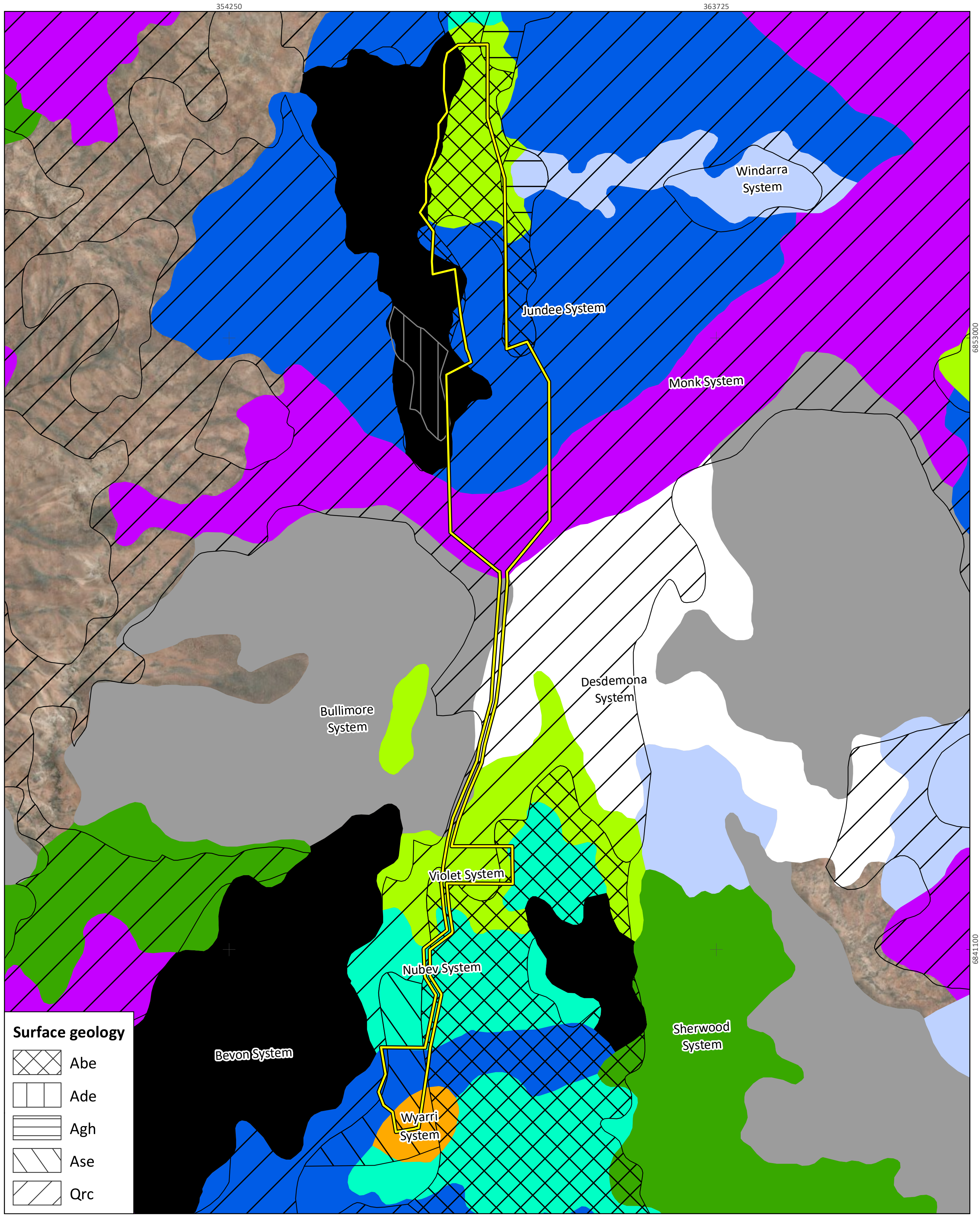


Dacian Gold Limited
Redcliffe Gold Project

Project No	1440-RGP-DGL-VER
Date	8/12/2021
Drawn by	IN
Map author	JS

0 1 2
Kilometers

1:94,900 (at A4) GDA 1994 MGA Zone 51

Study area

Land system

- Bevon System
- Bullimore System
- Desdemona System
- Jundee System
- Monk System
- Nubev System
- Sherwood System
- Violet System
- Windarra System
- Wyarri System

Figure 3-2

Land systems and surface geology in the study area

PHOENIX ENVIRONMENTAL SCIENCES

3.3 CLIMATE AND WEATHER

The climate of the Eastern Murchison subregion is described as arid with mainly winter rainfall (Cowan 2001). The nearest Bureau of Meteorology (BoM) weather station with comprehensive data collection and recent historic climate data is Leonora (no. 012241), Latitude: 28.89°S Longitude 121.33°E), located 52km SW of the study area.

Leonora records the highest mean maximum monthly temperature (37°C) in January (lowest in July, 18.5°C) and the lowest minimum mean monthly temperature (6.1°C) in July (highest in January, 21.8°C) (BoM 2021b) (Figure 3-3). Average annual rainfall is 236.4mm with February and March recording the highest monthly averages (30.9 and 29 mm respectively; Figure 3-3). Rainfall is highly variable between seasons and years, influenced by northwest cloudbands in the winter months, and occasionally by tropical cyclones (BoM 2021a).

Daily mean temperatures at Leonora preceding the survey were generally warmer than long-term averages, however January, February and June were cooler than expected. In the three months prior to the survey, the mean maximum and minimum temperatures were higher than average for July and August. Temperatures were likely slightly warmer than expected during the month of the survey (Figure 3-3).

Records from Leonora show rainfall levels were much lower than average for most months. February experienced the highest rainfall levels at 49.6mm (18.7mm above the long-term average). September, April and January received the lowest amounts of rain throughout the year (0, 1.4 and 2mm respectively). Even though June had low levels of rain, July received a substantial amount, 7.9mm above average. (Figure 3-3).

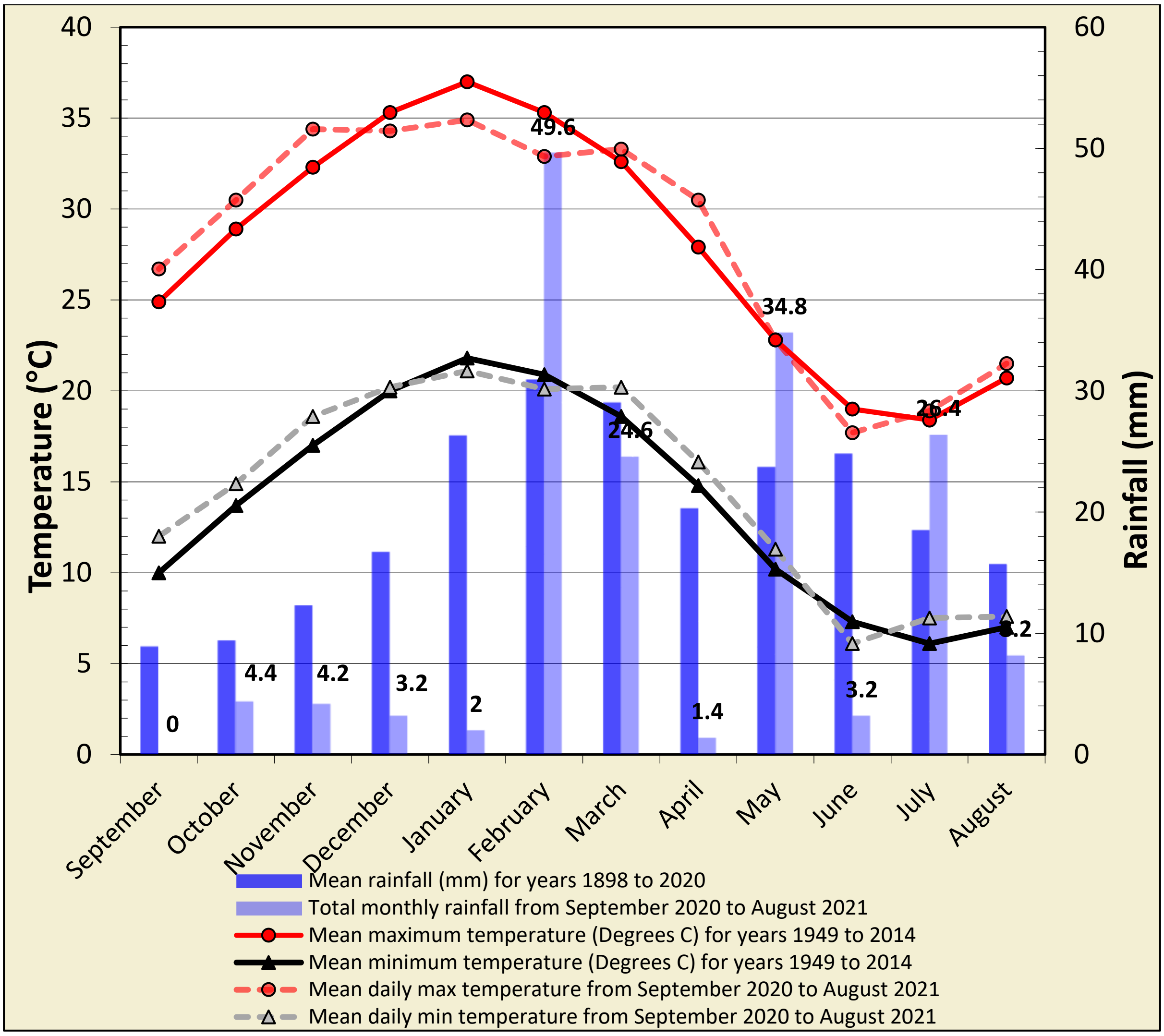


Figure 3-3 **Annual climate and weather data for Leonora (no. 012241) and mean monthly data for the 12 months preceding the survey (BoM 2021b)**

3.4 Land use

The dominant land uses of the East Murchison subregion are grazing, UCL and Crown Reserves, mining and conservation (Cowan 2001). The study area includes disused mine pits, and extends across two pastoral stations, Mertondale and Nambi (DAFWA 2019).

3.5 Conservation reserves and ESAs

The nearest Environmentally Sensitive Area is located approximately 107 km southwest of the study area. The study area does not intersect any current or proposed conservation reserves (Figure 1-1).

4 METHODS

The basic fauna and habitat survey was conducted in accordance with relevant survey guidelines and guidance, including:

- EPA Environmental Factor Guideline: Terrestrial fauna (EPA 2016a)
- EPA Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020)
- EPA Technical Guidance: Sampling of short-range endemic invertebrate fauna (EPA 2016d)

4.1 DESKTOP REVIEW

Searches of several biological databases were undertaken to identify and prepare lists of significant fauna that may occur within the study area (Table 4-1). A literature search was conducted for accessible reports for biological surveys conducted within 150 km of the study area to build on the lists developed from the database searches (Table 4-2).

Table 4-1 Database searches conducted for the desktop review

Database	Target group/s	Search coordinates and extent
Protected Matters Search Tool (DAWE 2021a)	EPBC Act Threatened flora, fauna and ecological communities	Approximate centre point of study area (28.46239°S, 121.55953°E) with 55 km buffer
DBCA Threatened and Priority Fauna Database (DBCA 2021b)	Threatened and Priority fauna	Study area plus a 100 km buffer
DBCA NatureMap Database (DBCA 2021a)	Flora and fauna records	Study area plus a 40 km buffer
Atlas of Living Australia (ALA 2021)	Fauna records	Study area plus a 55 km buffer
WA Museum Arachnid and Myriapod Database, Mollusca Database	Arachnid, myriapod and mollusc SREs	100 km^2 search area encompassing the study area between -27.639 °S, 120.577°E (northwest corner) and -29.449°S, 122.592°E (southeast corner)

Table 4-2 Survey reports included in the desktop review

Report author	Survey description	Project
McKenzie *et al.* (1994)	Vertebrate fauna surveys (Erlistoun only, Wanjarri excluded)	Biological Survey of the Eastern Goldfields of WA
Phoenix (2010a)	Level 2 fauna survey	Redcliffe Gold Project
Phoenix (2010b, 2010c)	SRE invertebrate surveys	Redcliffe Gold Project
MWH Australia (2017)	Flora, vegetation and fauna surveys	Leonora Gold Project
MWH Australia (2018)	Flora, vegetation and fauna surveys	Leonora Gold Project
Phoenix (2019b)	Level 1 fauna survey	Leonora Gold Project
Ecosmart Ecology (2012)	Level 2 fauna survey	Murrin Murrin Nickel-Cobalt Project
Phoenix (2019a, 2021a)	Basic and Detailed fauna surveys	Murrin Murrin Nickel-Cobalt Project

4.2 FIELD SURVEY

4.2.1 Survey timing

Field survey dates are provided in Table 4-3.

Table 4-3 Survey dates

Survey type	Season	Dates
Basic fauna and habitat survey	Winter/Spring	30 August – 5 September 2021
Targeted Malleefowl and Chuditch survey	Spring	22 – 26 November 2021

4.2.2 Terrestrial fauna

Field methods for the fauna survey included:

- habitat assessment (4.2.2.1)
- mammal/reptile foraging (4.2.2.2)
- avifauna surveys and Night Parrot habitat assessment (4.2.2.3)
- bat echolocation recordings (4.2.2.4)
- camera trapping (4.2.2.5)
- Malleefowl habitat assessment (4.2.2.6)
- targeted Malleefowl surveys (4.2.2.7)
- targeted Chuditch surveys (4.2.2.8)
- SRE invertebrate sampling (4.2.2.9)

A total of 32 survey sites were sampled in the basic fauna and habitat survey (Figure 4-1; Appendix 1).

4.2.2.1 Habitat assessment

Initial habitat characterisation was undertaken using various remote geographical tools, including aerial photography (Google Earth®), land system maps and topographic maps. Habitats with the potential to support significant terrestrial fauna species were identified based on known habitats of such species within the Murchison bioregion. Tentative sites were selected for the terrestrial fauna survey to represent all habitat types. Final survey site selection was conducted after ground-truthing of site characteristics.

At the broadest scale, site selection considered aspect, topography and land systems. At the finer scale, consideration was given to proximity to water bodies (drainage lines and creek), vegetation complexes and condition and soil type. Sites were primarily chosen to represent the best example of distinct habitats within the broader habitat associations of the study area with a focus on species of conservation significance identified in the desktop review. Habitat descriptions and characteristics were recorded at all basic fauna and targeted survey sites (Figure 4-1; Table 4-4; Appendix 2).

Habitat types are distinguished and mapped based on various aspects of topography, substrate, vegetation structure, and/or presence of distinct landscape features relevant to significant fauna species potentially present.

Table 4-4 Terrestrial fauna survey effort

Site	Site type	Audio recording (nights)	Birding (hrs)	Camera trap (nights)	Foraging (hrs)	Litter sieve (#)	Opp. Sighting (#)	SRE foraging (hrs)	Transect (hrs)	Ultrasonic recording (nights)
RCG001	Fauna site		2.3	5	2.3	3		2.3		4
RCG002	Fauna site		1.3		2		1	2		2
RCG003	Fauna site		1.3		2.5	3		2.5		
RCG004	Fauna site		0.7		1.2			1.2		
RCG005	Fauna site		0.7		0.9			0.9		
RCG006	Fauna site				2	3	1	2		
RCG007	Fauna site		0.7		2.4	3		2.4		
RCG008	Fauna site		0.7		3.6			3.6		
RCG009	Fauna site								6	
RCG010	Fauna site				2		7	2		4
RCG011	Fauna site		0.7		3.2	3		3.2		
RCG013	Fauna site		0. 7		2			2		
RCG014	Fauna site		0. 7		2		1	2		
RCG016	Fauna site						1			
RCG017	Fauna site		1		4	3		4		
RCG018	Fauna site		0. 7		1	3	1	1		
RCG019	Fauna site				1.2			1.2		
RCG020	Fauna site		1. 7		1.6			1.6		
RCG021	Fauna site		0. 7		2	3		2		
RCG022	Fauna site		0. 7							
RCG023	Fauna site		0.7		1			1		
RCG024	Fauna site		0.7		2			2		
RCG025	Fauna site				1.1			1.1	2	
RCG026	Fauna site		1.4		3.4			3.4		2
RCG027	Fauna site		0.7		2	3		2		
RCG028	Fauna site		0. 7		2	3		2		

Site	Site type	Audio recording (nights)	Birding (hrs)	Camera trap (nights)	Foraging (hrs)	Litter sieve (#)	Opp. Sighting (#)	SRE foraging (hrs)	Transect (hrs)	Ultrasonic recording (nights)
RCG029	Fauna site		0.7		4			4	2	
RCG030	Fauna site								2	
RCG031	Fauna site				2					
RCG-NP01	Fauna site	6	2.3			3			0.9	
Total		**6**	**15.9**	**5**	**53.4**	**33**	**12**	**53.4**	**12.9**	**12**

4.2.2.2 Mammal/reptile foraging

Foraging was undertaken at 25 sites throughout the study area (Figure 4-1). Foraging primarily targeted diurnal herpetofauna and mammals from direct sightings and secondary evidence. Searches focused primarily on significant species identified in the desktop review as potentially occurring within the study area, including Chuditch and Long-tailed Dunnart.

Searches were undertaken in any observable microhabitats considered likely to support mammals, reptiles and amphibians. Techniques included: raking leaf and bark litter, overturning logs, searching beneath the bark of trees, investigating dead trees and logs, investigating burrows, crevices and overhangs and identifying any secondary evidence including tracks, diggings, scats, fur or sloughs (shed skins), predation or feeding sites, and fauna constructed structures such as nests.

A minimum of one person hour was spent active searching at each site for a total of 53.4 hours over the duration of the field survey (Table 4-4).

4.2.2.3 Avifauna surveys

A minimum of twenty-minute avifauna surveys were undertaken at each fauna site (Figure 4-1; Table 4-4). Avifauna surveys were confined to the habitat type (up to 2 ha) represented by each site to collect assemblage data for each habitat. Avifauna surveys were undertaken throughout the day with a focus on periods of higher activity around sunrise and sunset. Surveys consisted of bird recordings from visual sightings and call recognition. A total of 15.9 person hours of avifauna census was undertaken during the field survey (Table 4-4).

Additional avifauna observations were also recorded at opportunistically while other field work was being completed, including observations made during travel and active searches.

A SongMeter SM4 recording device was deployed at one site to record bird calls and activity over a longer period outside of disturbance periods during the field survey (RCG-NP01, six nights; Figure 4-1). This location was targeted as potential habitat for significant species identified in the desktop review, in particular Night Parrot.

4.2.2.4 Bat echolocation recordings

Song Meter SM4 recording devices were used to record bat echolocation calls at four sites during the field survey (RCG001, RCG002, RCG010, RCG026; Figure 4-1). Recording devices were deployed at each site for two to four nights of recording between sunset and sunrise (Table 4-4). Devices were aimed at a 45° angle to the ground. The SongMeters were positioned in areas of habitat likely to have increased insect activity and to attract bats (i.e. likely foraging areas or movement corridors) and/or potential roosting sites.

4.2.2.5 Camera trapping

One motion-activated camera was deployed for five days and nights at a rocky breakaway site (RCG001) considered potential habitat for significant fauna (e.g. Chuditch), where evidence of fauna presence had been detected, and fauna movements would be constrained by a gap between rocks. No other highly suitable locations for camera trapping were identified.

4.2.2.6 Malleefowl habitat assessment

Malleefowl habitat was assessed in the field using a set of environmental variables based on features of critical Malleefowl habitat in Western and Central Australia, as described in the National Recovery

Plan (Benshemesh 2007). Individual sites were assessed with a numerical score as a basis for mapping areas of suitable habitat in the study area. The score used is an unweighted sum of binary values (0 absent, one present) for the following attributes:

- sandy substrate (sand/sandy loam/sandy clay)
- litter (leaf litter forming distinct patches under trees/shrubs or - rarely in this area - continuous blanket over soil)
- canopy (tall shrubs or trees forming more or less continuous canopy, contributing to suitable ground microclimates and screen from aerial predators)
- level (ground approximately level, tending to prevent disturbance of soil and litter by rainfall runoff)
- mallee (presence of any mallee-form *Eucalyptus* sp.)
- *Melaleuca* (presence of any *Melaleuca* sp.)
- mulga s.l. (presence of any *Acacia* sp. of subgenus *Juliflorae*)
- *Triodia* (presence of any *Triodia* sp.).

Scores of four or greater (meaning a site contained at least 50% of features that comprise critical Malleefowl habitat) were considered to represent potential Malleefowl habitat. Sites that attained a value of four or greater were applied to vegetation type polygons and the entire polygon (usually) assigned as potential Malleefowl habitat. Where two or more sites were assessed within a single polygon, the higher score was applied unless features of the lower-scored site(s) were more representative. Where no site occurred within a polygon, polygons were classified based on scores for similar vegetation nearby and inspection of relative vegetation density.

4.2.2.7 Targeted Malleefowl surveys

During the basic survey, low intensity searches were conducted for Malleefowl in areas identified as being suitable habitat based on the Malleefowl habitat assessment scores (see 4.2.2.6). In these areas, transects were walked to search for nest mounds, tracks, foraging traces or other signs of this species. Transects were spaced approximately 100m apart and covered approximately 1 km sq. of the highest quality Malleefowl habitat in the project area.

The transects conducted during the basic fauna survey indicated the need for additional targeted surveys for Malleefowl nest mounds to ensure none are destroyed or disturbed by the proposed works. These additional surveys were conducted using aerial imagery review and high intensity ground searches.

4.2.2.7.1 Aerial imagery review

High quality aerial imagery of the project area was provided to Phoenix by Dacian. The imagery was broken into grid sections and each section was thoroughly checked in a bid to detect any potential mounds. The aerial imagery was deemed insufficient to allow for detection of mounds in areas that were heavily vegetated, so further ground searches were deemed necessary.

4.2.2.7.2 Ground searches

High intensity ground searches were conducted within the proposed disturbance footprint (including a buffer provided by Dacian) in areas of habitat deemed as being of Medium or High suitability for Malleefowl. Systematic transects were traversed on foot by four personnel spaced 20 m apart. Areas that were too sparse to provide adequate canopy cover for a mound, and areas of major drainage were excluded from the ground searches. Areas that had been extensively drilled were also excluded as the drill lines were as little as 10m apart and these areas have been well explored.

4.2.2.8 Targeted Chuditch surveys

Active foraging for mammals during the basic fauna survey indicated the need for further targeted surveys for Chuditch. As such, further searches were conducted along the breakaway to the west of the study area, which was identified as potential Chuditch habitat. Searches were conducted by a team of two people who walked sections of the breakaway that were deemed most suitable and were in close proximity to the study area. Searchers investigated crevices, caves, the base and walls of the breakaway, and the vegetation near the breakaway looking for Chuditch scats. Any scats found that were deemed as potential Chuditch scats were collected for morphological identification and genetic sequencing.

Chuditch scats are identified based on characteristic shape, size, composition (almost always containing abundant insect remains in a matrix of fibrous plant material and seeds), lack of associated urates (usually found with reptile and bird scats), and smell (faint or undetectable in older samples until moistened; cf. stronger characteristic odours of goanna, snake, cat, dog or fox) (Triggs 1996). The only items visually confusable with Chuditch scat would be pellets regurgitated by Currawongs (e.g. *Strepera versicolor*, recorded in the survey), but this is a woodland species unlikely to occur in (e.g.) breakaway overhangs, and although omnivorous, pellets rarely contain obvious insect remains.

After morphological identifications were complete, remaining samples were sent to Genotyping Australia for genetic sequencing.

4.2.2.9 SRE invertebrate sampling

Sampling for SRE invertebrates was conducted at 25 sites (Figure 4-1), in areas identified as suitable habitat for SREs. Potential SRE habitat was rated as follows:

- Low - vegetation is widespread, does not contain landforms, soils or vegetation likely to give rise to short-range endemism in the terrestrial invertebrate assemblage, may or may not have recorded Potential or Confirmed SRE taxa
- High – vegetation is locally restricted or regionally significant, contains landforms, soils or vegetation that acts to hold water in the landscape or is associated with surface water, likely to have recorded numerous Confirmed SRE taxa.

Sampling comprised the following methods:

- active foraging
- litter/soil sieving.

Active foraging for SRE invertebrate groups comprised inspection of logs, larger plant debris, the underside of bark of larger trees and the underside of rocks. Methodical searches were conducted amongst the leaf litter of shade-bearing tall shrubs and trees, including raking of litter, and spinifex bases were inspected thoroughly. Rocks and rock crevices were inspected, particularly for pseudoscorpions.

Active foraging for SREs were undertaken concurrently with active searches for vertebrate fauna, with a total search effort of approximately 53.4 hours (Table 4-4). Trapdoor spider burrows identified during the searches were excavated if they were considered inhabited. Excavation involved removing soil from around the burrow to carefully expose the burrow chamber and remove the spider.

Combined litter/soil sifts were undertaken at 11 sites, with up to three sifts conducted at each site dependent on abundance of leaf litter. In total, 33 sifts were undertaken (Table 4-4). The collection of leaf litter samples was standardised volumetrically by the diameter and height (310 mm x 50 mm = 1.55 L) of the sieves which were completely filled with compressed litter and the upper layers of underlying soil. Samples were sieved through three stages of decreasing mesh size over a round tray and invertebrates were picked from the sieves and tray with forceps. These samples particularly targeted small spiders (Araneomorphae), pseudoscorpions, buthid scorpions, millipedes, centipedes (in particular Geophilomorpha and Cryptopidae), smaller species of molluscs (e.g. Pupillidae) and isopods.

4.2.2.10 Likelihood of occurrence assessment

Following the field survey, the likelihood of occurrence for each significant fauna species identified in the desktop review was assessed and assigned to one of four ratings:

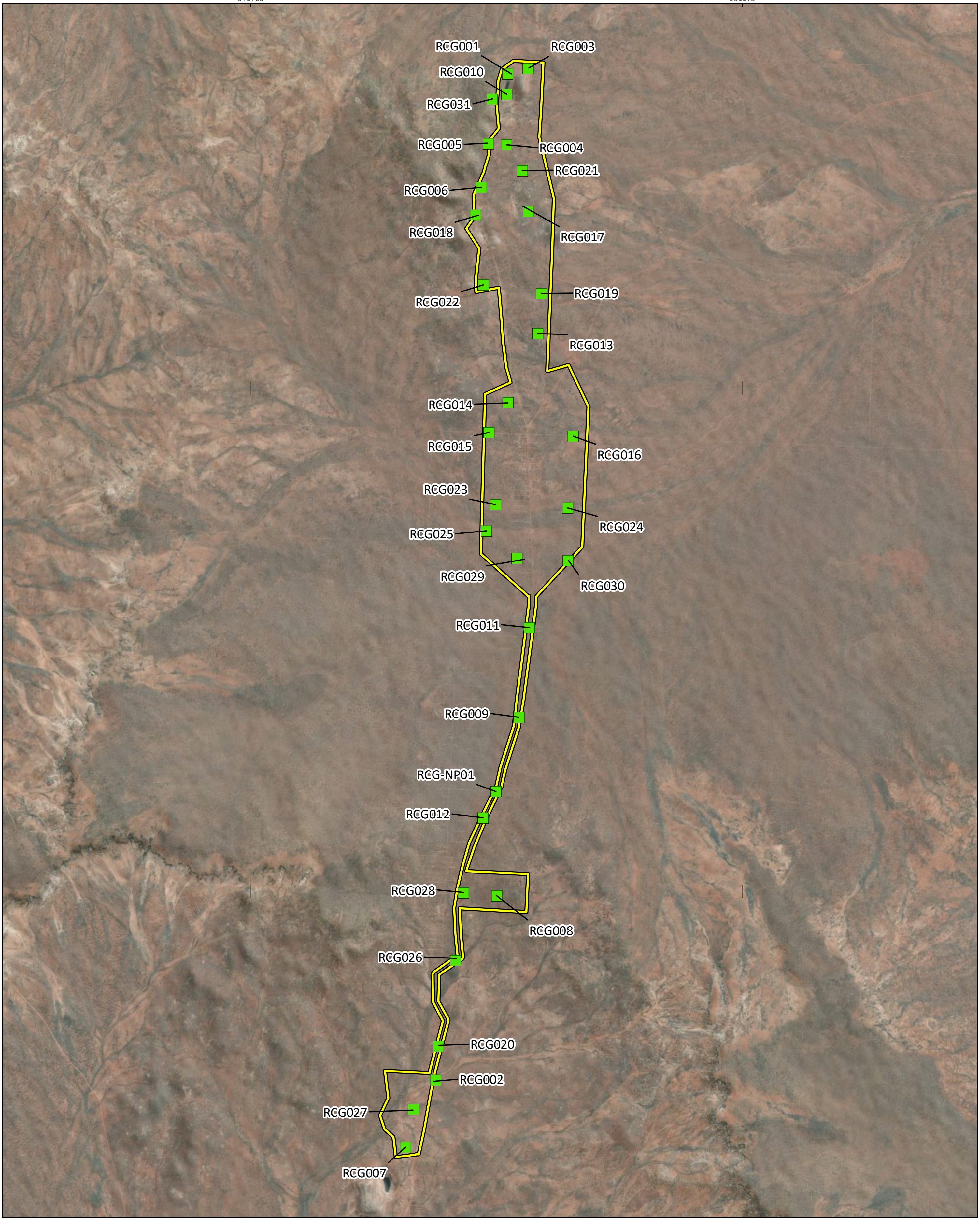
- recorded – species recorded within the study area by previous or current survey
- likely – study area within current known range of species, suitable habitat within the study area and home range of species intersects study area based on known records
- possible – study area within current known range of species, suitable habitat within the study area and home range of species does not intersect study area based on known records
- unlikely – study area outside current known range of species or no suitable habitat present in study area.

4.2.3 Survey personnel

The personnel involved in the surveys are listed in Table 4-5. All survey work was carried out under relevant licences issued by DBCA under the BC Act (Table 4-5).

Table 4-5 Survey personnel

Name	Permit	Qualifications	Role/s
Jarrad Clark	N/A	B.Sc. (Environmental Management)	Project oversight
Dr John Scanlon	Fauna taking (biological assessment) licence no. BA27000478	Ph.D. (Zoology)	Field survey, reporting
Caitlin Nagle		M. Sc. (Conservation Biology)	Project Manager, field survey, reporting
Paula Strickland	N/A	MSc (Cons. Biol)	Field survey
Jade Larkman	N/A	B.Sc. (Environmental Management)	Reporting



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Project No	1440-RGP-DGL-VER
Date	8/12/2021
Drawn by	IN
Map author	JS

0 1 2
Kilometers

1:94,900 (at A4)
GDA 1994 MGA Zone 50

Study area
Site

Figure 4-1

Terrestrial fauna survey sites

PHOENIX
ENVIRONMENTAL SCIENCES

5 RESULTS

5.1 DESKTOP REVIEW

5.1.1 Threatened and Priority Ecological Communities

The desktop review identified one PEC, the Nambi calcrete groundwater assemblage type on Carey paleodrainage on Nambi Station. This PEC is a subterranean fauna community located approximately 34km north of the study area. No TECs or terrestrial PECs were identified within 55km of the study area.

5.1.2 Vertebrate fauna

The desktop review identified records of 277 vertebrate taxa within the desktop search extent, and a further six species (from DAWE 2021a) where potential presence is predicted based on habitat models. The list comprised six frogs, 74 reptiles, 176 birds including two naturalised species, and 39 mammals including 11 introduced (Table 5-1; Appendix 3). A previous survey overlapping the southern end of the present study area recorded 86 vertebrate species comprising two frogs, 23 reptiles, 47 birds and 14 mammals (Phoenix 2010a).

Twenty-seven conservation significant vertebrate species were identified in the desktop review, comprising nine species listed as Threatened, Conservation Dependent or Specially Protected under the EPBC Act and/or BC Act (Table 5-2). Fifteen bird species are listed as Migratory under the EPBC Act and BC Act, and a further two species are listed as Priority by DBCA (Table 5-2). Several mammals are listed that are considered regionally or totally extinct (Boodie and both species of Stick-nest Rat); evidence of their former presence would contribute to understanding of the existing habitats and fauna assemblage.

One significant vertebrate species has previously been recorded within the study area (Figure 5-1):

- *Falco peregrinus* (OS), recorded by (Phoenix 2010a).

Table 5-1 Summary of terrestrial fauna desktop results

Class	Native	Introduced	Total
Amphibians	6	0	6
Reptiles	74	0	74
Birds	174	2	176
Mammals	28	11	39
Total	**270**	**13**	**283**

Table 5-2 Significant vertebrate fauna identified in the desktop review

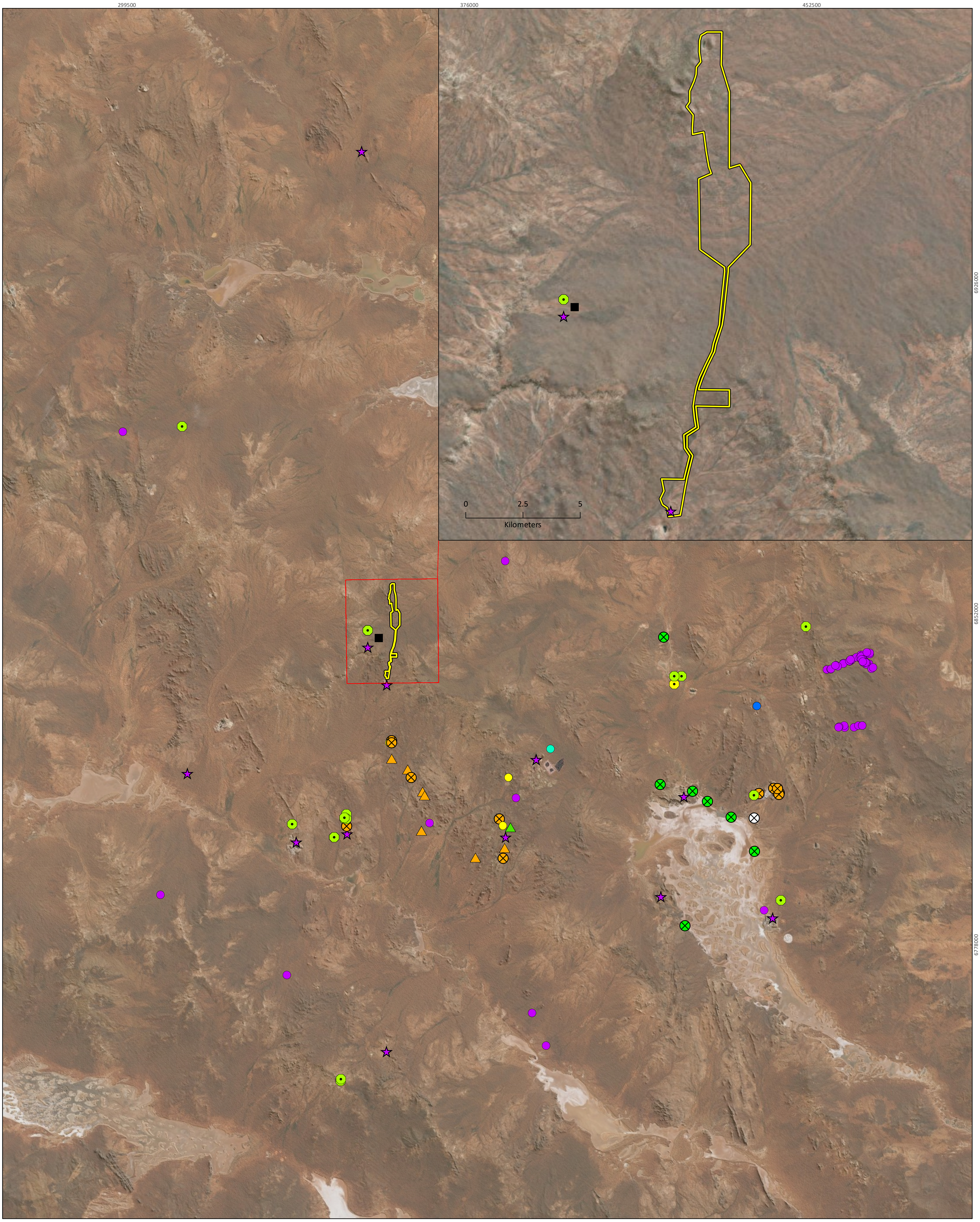
Species	Status	Proximity to study area	Habitat
Birds			
Leipoa ocellata Malleefowl	VU (EPBC & BC Acts)	26 km E	Malleefowl occur mainly in scrubs and thickets of mallee (*Eucalyptus* spp.), boree (*Melaleuca lanceolata*) and bowgada (*Acacia linophylla*), and other dense litter forming shrublands including mulga shrublands (Johnstone and Storr, 2004). Nest mounds require sandy soil as well as abundant litter (Benshemesh 2007).
Apus pacificus Fork-tailed Swift	Mig. (EPBC & BC Acts)	*	Widespread Migratory species that does not breed in Australia, typically present from October to April. It occurs in a wide range of dry or open habitats across most of WA (DoEE 2020).
Plegadis falcinellus Glossy Ibis	Mig. (EPBC & BC Acts)	64 km ESE	This bird has a nearly global distribution, and in Australia mostly occurs in eastern and northeastern areas, but also patchily in most of WA. It usually occurs in freshwater marshes, floodplains and artificial wetlands, but also uses coastal wetlands including saltmarsh and estuary habitats (DAWE 2021b).
Falco hypoleucos Grey Falcon	VU (BC Act)	*	The Grey Falcon is a widespread but rare species inhabiting much of the hot, semi-arid and arid interior of Australia. Occurs in a wide variety of arid habitats including open woodlands and open *Acacia* shrubland, hummock and tussock grasslands and low shrublands, particularly where crossed by tree-lined water courses (Schoenjahn *et al.* 2019; Threatened Species Scientific Committee 2020). Range has contracted northwards in WA, now rarely occurs south of 26°S (Johnstone & Storr 1998).
Falco peregrinus Peregrine Falcon	OS (BC Act)	Within study area	Preferred habitat includes cliffs and wooded watercourses. Nesting occurs mainly on cliff ledges, granite outcrops, quarries and in trees with old raven or Wedge-tailed Eagle nests (Johnstone & Storr 1998).
Charadrius veredus Oriental Plover	Mig. (EPBC & BC Acts)	*	Non-breeding migrant (Sep-Mar) in northern Australia, uses inland habitats including flat, open, semi-arid or arid grasslands, particularly locations with short, sparse grass interspersed with hard, bare ground, such as claypans, dry paddocks, lawns, cattle camps, or recently burnt grasslands (DAWE 2021c).
Pluvialis fulva Pacific Golden Plover	Mig. (EPBC & BC Acts)	39 km SSW	Most Australian sightings are on coastal beaches and rocky shorelines, but also inland on major river systems and lakes;

Species	Status	Proximity to study area	Habitat
			occasionally forages on low saltmarsh vegetation (DAWE 2021d).
Thinornis rubricollis Hooded Plover	P4 (DBCA list)	34 km SSW	The Hooded Plover population extends from coastal New South Wales to the west coast of WA. Most of the West Australian population is found on the coast from Jurien to the east of Esperance, and a part of the population nests inland (Prószyński 2017). Nesting pairs of Hooded Plovers can be found on the shore of inland salt lakes, freshwater marshes, inlets and coastal sandy beaches.
Actitis hypoleucos Common Sandpiper	Mig. (EPBC & BC Acts)	39 km SSW	Breeds in Eurasia, a small population winters in Australia. Found across all Australian states, they never occur in large flocks, mostly singly. In WA the species is mostly coastal with some inland records (Geering *et al.* 2007). They are found across a wide range of wetlands: small ponds, large inlets and mudflats where they forage on the shore usually close to the vegetation.
Calidris acuminata Sharp-tailed Sandpiper	Mig. (EPBC & BC Acts)	39 km SSW	One of the most common Australian shorebirds. They breed in Arctic north-east Siberia and a large population winters in Australia. The distribution of the species in Australia depends on water quantity conditions; some large wetlands may be available inland after important rainfall, but only occasionally. The distribution on the coast is more regular, the conditions being more consistent. The species is semi-gregarious and occurs in scattered flocks, mainly on non-tidal flats, often inland.
Calidris canutus Red Knot	EN/Mig. (EPBC Act; BC Act)	6 km W	Non-breeding visitor along coast, adults mostly Aug-Apr (Johnstone *et al.* 2013); only occasionally recorded inland.
Calidris melanotos Pectoral Sandpiper	Mig. (EPBC & BC Acts)	*	Uncommon solitary shorebird that breeds in the Arctic tundra of North America and eastern Siberia. Only a fractional part of the population winters in Australia. Found in wetlands, inland as well as on the coast. The species typically uses shallow fresh to saline wetlands such as coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands.
Calidris ruficollis Red-necked Stint	Mig. (EPBC & BC Acts)	87 km SE	Non-breeding migrant present on Australian coasts from August to April, first-year birds also present in winter; recorded inland where they may forage in samphire or around pools on salt flats (DAWE 2021b).
Limosa lapponica Bar-tailed Godwit	Mig. (EPBC & BC Acts)	*	Non-breeding migrant, in Australia found mainly in coastal habitats including intertidal

Species	Status	Proximity to study area	Habitat
			sand and mudflats, estuaries, saltmarshes etc. (DAWE 2021b).
Tringa glareola Wood Sandpiper	Mig. (EPBC & BC Acts)	6 km W	Non-breeding migrant, only a small proportion of the global population reaching Australia; typically uses well-vegetated, shallow freshwater wetlands, rarely in brackish wetlands or saltmarsh (DAWE 2021b).
Tringa nebularia Common Greenshank	Mig. (EPBC & BC Acts)	6 km W	The species is present in summer across all Australian states, mostly on the coast but sometimes inland. The species is not gregarious. Small groups can sometimes be seen when roosting at high tide (Geering *et al.* 2007). They prefer coastal open mudflats.
Tringa stagnatilis Marsh Sandpiper	Mig. (EPBC & BC Acts)	*	Non-breeding migrant, found on coastal and inland wetlands throughout Australia; usually forages in shallow water at the edge of wetlands, and recorded roosting around low saltmarsh vegetation and swamps (DAWE 2021b).
Gelochelidon nilotica Gull-billed Tern	Mig. (BC Act)	63 km E	This taxon comprises non-breeding migrants of an Asian subspecies (*G. nilotica affinis*) on the northwestern coasts, and a larger-bodied Australian resident population now considered a distinct species *G. macrotarsa* (Johnstone *et al.* 2021; Rogers *et al.* 2005). Nomadic inland distribution, foraging and breeding around temporary water on mudflats, claypans, salt marsh etc.
Pezoporus occidentalis Night Parrot	CR (BC Act), EN (EPBC Act)	*	Night Parrot appears to favour areas of dense vegetation comprising old-growth (often > 50 years unburnt) spinifex (*Triodia* spp.) especially hummocks that are ring-forming for roosting and nesting. Such areas may also be associated with dense chenopod shrubs. It is thought that spinifex hummocks that are <40-50 cm in height are not likely to provide adequate shelter for roosting and nesting (DPaW 2017a). Foraging appears to take place in habitats containing various native grasses and herbs in addition to spinifex, and these areas may or may not contain shrubs or low trees. Favoured sites may vary with the season and local conditions, and may not necessarily occur within or adjacent to roosting areas, as they have been observed to fly up to 40 km in a night (DPaW 2017b). *Triodia* species are thought to provide a food resource while flowering and seeding. The succulent genus *Sclerolaena* has also been shown to be a source of food and moisture and other

Species	Status	Proximity to study area	Habitat
			succulent chenopods species are also considered likely to be important. Foraging habitat is likely to be more important if it is adjacent to or within about 10 km of patches of *Triodia* deemed suitable as roosting habitat. Home ranges are up to 3,000 ha (Murphy *et al.* 2017).
Polytelis alexandrae Princess Parrot	(VU EPBC Act; P4 DBCA list)	82 km ESE	The Princess Parrot is one of the most elusive, unknown Australian parrots. They are only found in the arid inland desert of central Australia with most of their range extending between the Great Victoria Desert and the Great Sandy Desert, in WA. Princess Parrots inhabit sandy deserts where they feed on seeds and flowers (Garnett & Crowley 2000). The species is highly irruptive and after important rainfall, can occur in numbers in areas previously unoccupied.
Motacilla cinerea Grey Wagtail	Mig. (EPBC & BC Acts)	*	A vagrant visitor to Australia that inhabits fast flowing streams and rivers (IUCN 2019).
Motacilla flava Yellow Wagtail	Mig. (EPBC & BC Acts)	*	Migratory species that breeds in northeastern Asia and Alaska; non-breeding range in South-East Asia extends regularly to northwestern Australia and occasionally to other parts of the continent. Australian records are mostly now referred to *M. tschutschensis simillima*. Occurs in open country near swamps, saltmarshes, and occasionally dry inland plains.
Mammals			
Dasyurus geoffroii Chuditch	VU (EPBC & BC Acts)	*	The Chuditch is now confined to south-WA, occurring in only 5% of its former range. Prior to European settlement the species occupied approximately 70% of continental Australia (Smith *et al.* 2004; Van Dyck & Strahan 2008). They are now mostly found in woodland, heath and mallee habitats.
Sminthopsis longicaudata Long-tailed Dunnart	P4 (DBCA list)	40 km SE	The Long-tailed Dunnart is found in WA and the Northern Territory. In WA, the species seems to occur across a large portion of the State, mostly in arid and semi-arid rocky inland deserts, typically rugged rocky landscapes and occasionally in more open countries with a stony substrate. The species is generally rare or uncommon and often present in low densities (Van Dyck & Strahan 2008).
Bettongia lesueur graii Burrowing Bettong, Boodie	EX (EPBC & BC Acts)	17.9 km SSE	Formerly occurred at high abundance in much of the semi-arid and southern arid zone of Australia, but extinct on the mainland by about 1960. Other populations extant at Shark Bay, some offshore islands

Species	Status	Proximity to study area	Habitat
			and mainland reintroduction sites are considered distinct subspecies (DAWE 2021b). Burrow complexes (warrens) and spoil mounds commonly persist in calcrete, clay or laterite soils, often still in use by rabbits and large varanid lizards (Burbidge *et al.* 2007).
Leporillus apicalis Lesser Stick-nest Rat	EX (EPBC & BC Acts)	*	Formerly inhabited much of the semi-arid and southern arid zone of Australia; last known to be extant in 1933, now completely extinct (Copley 1999).
Leporillus conditor Greater Stick-nest Rat	VU (EPBC Act), CD (BC Act)	*	Formerly inhabited much of the semi-arid and southern arid zone of Australia, but disappeared from the mainland by the 1930s (Copley 1999); the only natural extant population is on Franklin Island in the Nuyts Archipelago, South Australia, but has been reintroduced to other islands and fenced reserves on the mainland (DSEWPaC 2008). Both *Leporillus* species constructed nests of tightly interwoven sticks either around the base of a tree or shrub, or in caves and overhangs of breakaways and rock outcrops; open-air nests have now completely disappeared, but nests in sheltered sites can persist for thousands of years and preserve valuable information on the local vegetation and fauna (Pearson *et al.* 1999). Stick nests previously recorded in the vicinity (Phoenix 2019a, b) could represent either or both species.



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Project No	1440-RGP-DGL-VER
Date	8/12/2021
Drawn by	IN
Map author	JS

0 10 20
Kilometers

1:770,400 (at A3) GDA 1994 MGA Zone 51

Study area

Status

- EN/Mig./EN (EPBC Act, BC Act)
- VU (EPBC Act); P4 (DBCA list)
- VU (BC Act)
- VU (EPBC Act, BC Act)
- VU/CD (EPBC Act, BC Act)
- EX (BC Act)
- EX (EPBC Act, BC Act)
- Mig. (BC Act)
- Mig. (EPBC Act, BC Act)
- OS (BC Act)
- P1 (DBCA list)
- P3 (DBCA list)
- P4 (DBCA list)

Figure 5-1

Desktop records of significant vertebrate fauna

PHOENIX ENVIRONMENTAL SCIENCES

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5.1.3 SRE invertebrate fauna

The desktop review identified no records of confirmed SRE taxa and 27 potential SRE taxa from within the SRE desktop search area (Table 5-4; Figure 5-2). A further 36 taxa of uncertain SRE status were identified. The majority of desktop records were mygalomorphs, followed by pseudoscorpions.

The desktop records indicate three SRE taxa have previously been recorded within the study area (Figure 5-2):

- *Antichiropus* 'sp. indet.' (uncertain SRE status), recorded by J. Clark as an opportunistic sighting in 2009. Not reported in the literature.
- Aname 'sp. indet.' (uncertain SRE status), recorded by J. Clark in 2015. Reported as unlikely to be an SRE based on its morphology (long legged, agile) (Phoenix 2010b, c).
- Idiosoma 'sp. indet.' (uncertain SRE status), recorded by J. Clark in 2015. Reported as unlikely to be an SRE based on distribution within the study area and no apparent habitat specialisation (Phoenix 2010b, c). Known range is less than 100 km sq.

Of the potential SRE taxa, one is a named species (*Kwonkan goongarriensis*). The remaining 26 comprise taxa named only to morphospecies codes as applied by the WA Museum or are not identified to confirmed species level (i.e. "sp." or "cf."). The majority of taxa records of uncertain SRE status are unidentifiable ("sp. indet.", i.e. female or juvenile specimens) or could not be identified to species or morphospecies and may represent new species or other species listed in the same genus where records exist (Table 5-4).

Table 5-3 Summary of SRE taxa identified in the desktop review

Higher taxon	Families	Genera	Taxa	% of taxa
Mygalomorphs (trapdoor spiders)	7	16	36	**59**
Pseudoscorpions	4	10	11	**18**
Scorpions	3	4	10	**16**
Isopods (slaters)	0	0	0	**0**
Centipedes	3	3	3	**5**
Millipedes	1	1	1	**2**
Total	**18**	**34**	**61**	**100**

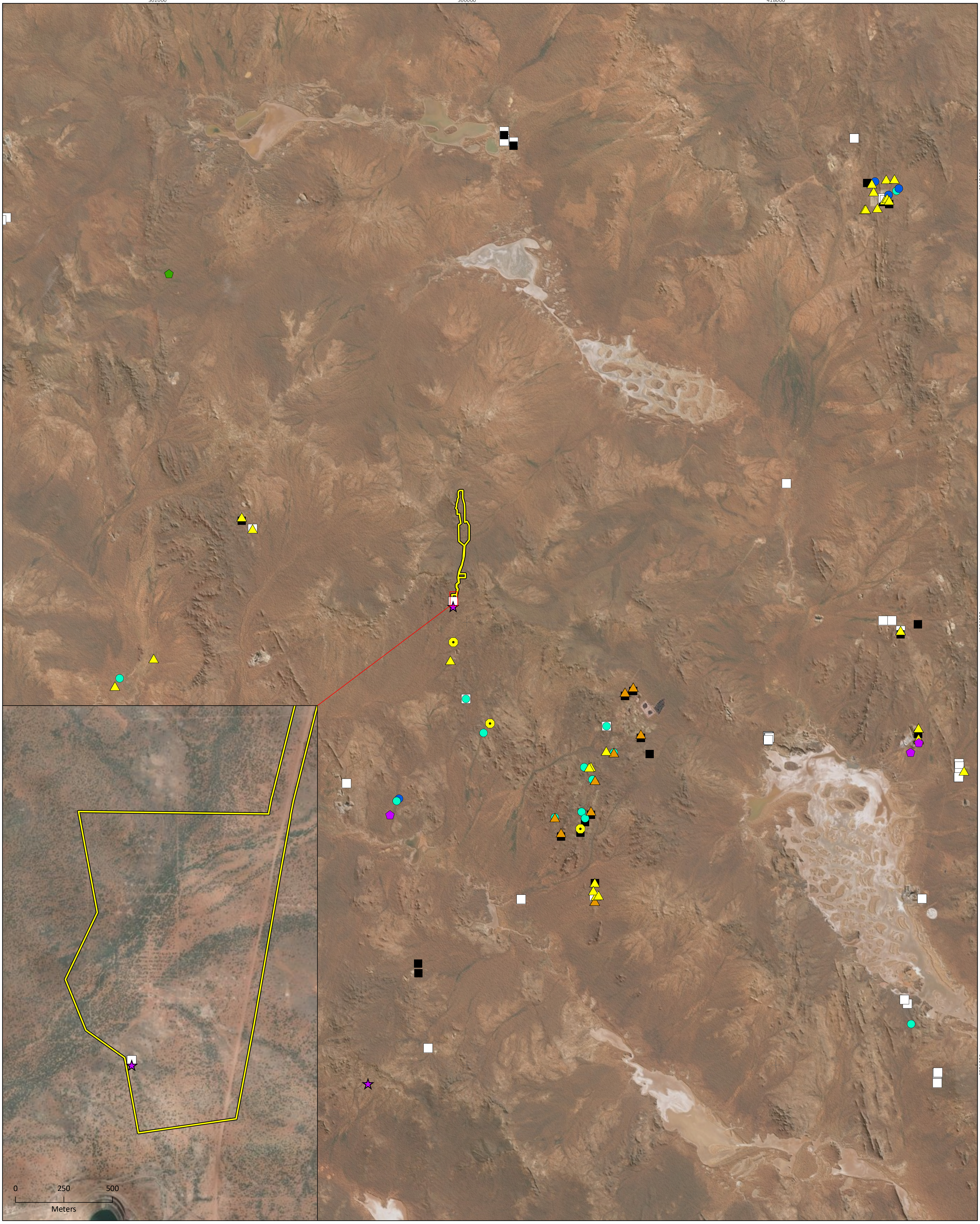
Table 5-4 SRE taxa identified in the desktop review. Taxa highlighted in grey were recorded within the study area.

Higher taxon, family	Species	SRE category	Proximity to study area	Habitat records	Notes
Class Arachnida, infraorder Mygalomorphae (trapdoor spiders)					
Actinopodidae (mouse spiders)	*Missulena* `sp. indet.`	Uncertain	Outside (39 - 99km)	Nil	May represent more than one species
Anamidae	*Aname* `glenorn sp. 2`	Potential	Outside (58km)	Nil	
	Aname `Goldfields sp. 1`	Potential	Outside (66-68km)	Mulga/*Triodia*	
	Aname `Goldfields sp. 2`	Potential	Outside (66km)	Mallee, mulga/*Triodia*	
	Aname `mellosa group?`	Potential	Outside (45-85km)	Nil	
	Aname `MYG216`	Potential	Outside (40-97km)	Nil	
	Aname `sp. indet. (?MYG216)`	Uncertain	Outside (96km)	Nil	
	Aname `Phoenix0055`	Potential	Outside (46km)	*Acacia* shrubland on calcrete undulating plain	
	Aname `Phoenix0056`	Potential	Outside (47km)	*Acacia* shrubland	
	Aname `Phoenix0058`	Potential	Outside (48km)	Calcrete hill slope with mulga	
	Aname `river wishbone group`	Potential	Outside (68km)	Dune *Triodia*	
	Aname `sp. indet.`	Uncertain	Inside, outside (63 - 113km)	Samphire, dune *Triodia*, mulga woodland, lignum	Likely represents more than one species
	Aname `sp. with chevrons`	Uncertain	Outside (99km)	Nil	
	Anamidae `sp. indet.`	Uncertain	Outside (36-126km)	Mulga, lignum	May represent more than one species
	Kwonkan `MYG719`	Potential	Outside (43km)	Open mulga woodland	
	Kwonkan `sp. indet.`	Uncertain	Outside (66-126km)	Mulga/shrubs	May represent more than one species
	Kwonkan goongarriensis	Potential	Outside (67km)	Nil	
	Proshermacha `MYG504`	Potential	Outside (64km)	Nil	
	Proshermacha `sp. indet.`	Uncertain	Outside (64-98km)	Nil	

Higher taxon, family	Species	SRE category	Proximity to study area	Habitat records	Notes
	Teyl `MYG444`	Potential	Outside (64km)	Nil	
	`Teyl?` `sp. indet.`	Uncertain	Outside (63-66km)	Mallee, mulga/*Triodia*	
Barychelidae	*Barychelidae* `sp. indet.`	Uncertain	Outside (61km)	Nil	
	Idiommata `sp. indet.`	Uncertain	Outside (18-64km)	Nil	
	Trittame `sp. indet.`	Uncertain	Outside (38km)	Nil	
Euagridae	*Cethegus* `sp. indet.`	Uncertain	Outside (66-100km)	Samphire	May represent more than one species
Halonoproctidae	*Conothele* `Phoenix0057`	Potential	Outside (36km)	Mulga woodland in low drainage area	
	Conothele `sp. indet.`	Uncertain	Outside (79km)	Nil	
Idiopidae	*Eucyrtops* `sp. indet.`	Uncertain	Outside (96-128km)	Mallee, mulga/*Triodia*	
	Euoplos `sp. indet.`	Uncertain	Outside (64km)	Nil	
	Euoplos `WAM T110336`	Potential	Outside (36-43km)	Mulga woodland	
	Idiosoma `MYG014`	Potential	Outside (47km)	Mulga woodland at base of hill slope	
	Idiosoma `MYG017`	Potential	Outside (90km)	Nil	
	Idiosoma `occidentalis sp. group`	Uncertain	Outside (57km)	Nil	
	Idiosoma `sp. indet.`	Uncertain	Inside, outside (60 - 126km)	Mulga woodland	Likely represents more than one species
Theraphosidae	*Selenocosmia* `sp. indet.`	Uncertain	Outside (82-126)	Nil	
	Selenocosmia `wacarina`	Potential	Outside (68-82km)	Nil	
Class Arachnida, order Pseudoscorpions					
Atemnidae	Atemnidae `sp. indet.`	Uncertain	Outside (44km)	Dense mulga woodland in drainage	
Chernetidae	`PSEAAF` `sp. indet.`	Uncertain	Outside (99km)	Under bark	
	Chernetidae `sp. indet.`	Uncertain	Outside (25-42km)	Mulga woodland at top of mesa	

Higher taxon, family	Species	SRE category	Proximity to study area	Habitat records	Notes
	Nesidiochernes `sp. indet.`	Uncertain	Outside (46km)	Mixed *Acacia* woodland	
Garypidae	*Synsphyronus* `PSE115`	Potential	Outside (97-99km)	Under bark	
Olpiidae	*Austrohorus* `sp. indet.`	Uncertain	Outside (39-64km)	Nil	
	Beierolpium `sp. 8/2`	Potential	Outside (96-97km)	Under bark	
	Beierolpium `sp. 8/3`	Potential	Outside (39km)	Nil	
	Euryolpium `sp. indet.`	Uncertain	Outside (46-47km)	Mixed *Acacia* woodland, mulga woodland at base of hill slope	
	Indolpium `sp. indet.`	Uncertain	Outside (37-41km)	Mulga woodland	
	Olpiidae `sp. indet.`	Uncertain	Outside (18-116km)	Nil	
Class Arachnida, order Scorpiones (scorpions)					
Bothriuridae	*Cercophonius* `sp. indet.`	Uncertain	Outside (65km)	Nil	
Buthidae	*Isometroides* `MM1`	Potential	Outside (37-44km)	Mulga woodland	
	Isometroides `sp. indet.`	Uncertain	Outside (11-96km)	Nil	
	Lychas `cf. jonesae`	Potential	Outside (35-47km)	Mulga woodland, side of breakaway with scattered mulga, *Acacia* shrubland on calcrete undulating plain	
	Lychas `pilbara 1`	Potential	Outside (90km)	Nil	
	Lychas `sp. indet.`	Uncertain	Outside (38-100km)	Nil	Likely represents more than one species
Urodacidae	*Urodacus* `GD`	Potential	Outside (90km)	Nil	
	Urodacus `gibson 1?`	Potential	Outside (62km)	Nil	
	Urodacus `sp. indet.`	Uncertain	Outside (40-100km)	Mulga woodland	May represent more than one species
	Urodacus `yeelirrie?`	Uncertain	Outside (60-61km)	Nil	
Class Chilopoda, order Geophilida (centipedes)					

Higher taxon, family	Species	SRE category	Proximity to study area	Habitat records	Notes
Chilenophilidae	Chilenophilidae `sp. indet.`	Uncertain	Outside (7km)	Nil	
Mecistocephalidae	Mecistocephalidae `sp. indet.`	Uncertain	Outside (48km)	Calcrete hill slope with mulga	
Class Chilopoda, order Scutigerida (centipedes)					
Scutigeridae	*Pilbarascutigera* `sp. indet.`	Uncertain	Outside (24km)	Nil	
Class Diplopoda, order Polydesmida (millipedes)					
Paradoxosomatidae	*Antichiropus* `sp. indet.`	Uncertain	Inside, outside (90km)	Nil	May represent more than one species
Class Gastropoda, order Littorinimorpha (snails)					
Bithyniidae	*Gabbia* cf. kendricki	Potential	Outside (68km)	Nil	
Class Gastropoda, order Stylommatophora (snails)					
Succineidae	Succinea sp.	Uncertain	Outside (41-90km)	Nil	



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0 10 20
Kilometers

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Study area

Species

Potential

- Mygalomorphae
- Pseudoscorpion
- Scorpion
- Snail

Uncertain

- Centipede
- Millipede
- Mygalomorphae
- Pseudoscorpion
- Scorpion
- Snail

Figure 5-2

Desktop records of SRE invertebrates

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5.2 Field survey

5.2.1 Vertebrate fauna

5.2.1.1 Habitats

Habitats in the study area can be described generally as 'mulga shrublands on undulating plain', but variation within this broad type is relevant to significant fauna species known or potentially occurring. Fauna habitat types are therefore distinguished and mapped based on topographic position, rock outcrop, soil, vegetation structure, and hydrological features (Table 5-5; Figure 5-3). Five habitat types refer to natural vegetation on clay loam and stony soils along a catenary from hill-tops to colluvial/alluvial plains and ephemeral drainage channels (types 1-5 in Table 5-5), two others (6-7) occur on sandplain. Areas previously cleared, excavated or buried by mining activities (8-9) include several significant water sources used by vertebrate fauna.

The most restricted and potentially significant fauna habitats are breakaways with caves and overhangs (type 1); large persistent pools located within old mine pits (8); and mallee-mulga-*Triodia* vegetation on sandplain (7; Table 5-5).

Narrow areas of disturbance such as unsealed access tracks and drill pads are not distinguished from adjacent natural vegetation, due to the coarse scale of mapping and the fact that they are used by fauna for dispersal and foraging.

Table 5-5 Extent and description of each fauna habitat in the study area

Habitat type	Site/s*	Description	Extent in study area and % of study area	Representative photograph
1. Breakaway and upper slope with open shrubland	RCG001 RCG005 RCG017 RCG018 RCG031	Hills capped with weathered volcanic rock forming breakaway with overhangs, caves and/or boulder piles, with open mid shrubland of mulga, other *Acacia* and mixed shrubs MF: Low suitability	9.8 ha 0.57%	
2. Open/sparse shrubland on slopes and stony plains	RCG001 RCG007 RCG014 RCG015 RCG017 RCG020 RCG021	Slopes, low hills and plains with clay loam soils and some low outcrop, mantle of rock fragments usually present (volcanic rocks, quartz, ironstone and/or calcrete), with open to very sparse shrubland including mulga and often *Casuarina* MF: Low suitability	324.6 ha 18.8%	

Habitat type	Site/s*	Description	Extent in study area and % of study area	Representative photograph
3. Open shrubland on lower slopes and plains	RCG013 RCG014 RCG015 RCG016 RCG023	Nearly level ground with open mid to tall mulga shrubland (mostly without grove structure) on clay loam soils with quartz and ironstone pebble mantle MF: Medium suitability	330.6 ha 19.1%	
4. Groved mulga on lower slopes, minor drainages and plain	RCG003 RCG004 RCG006 RCG008 RCG013 RCG015 RCG016 RCG018 RCG028	Mulga woodland and tall shrubland forming dense stands interspersed with open areas, on clay loam soils usually with quartz and ironstone mantle; minor drainage lines without distinct channel MF: Medium suitability	637.2 ha 36.8%	
5. Mulga woodland/tall shrubland on drainage	RCG002 RCG019 RCG024 RCG026 RCG027	Mulga woodland and tall shrubland (mallees variably present) over patchy dense low to mid shrubs, along drainage lines with distinct channels MF: Medium suitability	147.7 ha 8.5%	
6. Mulga tall shrubland on sandplain	RCG025, RCG029, RCG030	Mulga woodland and tall shrubland (scattered mallees variably present) over patchy dense low to mid shrubs, on deep sandy soils with ironstone pebbles MF: High suitability	177.5 ha 10.2%	

Habitat type	Site/s*	Description	Extent in study area and % of study area	Representative photograph
7. Mallee over mulga shrubland with hummock grass on sandplain	RCG009, RCG011, RCG-NP01	Scattered mallees over mulga mid-tall shrubland over *Triodia* (stage 3-5, i.e. ring-forming hummocks) on level sandy loam with few or no pebbles MF: High suitability	44.9 ha 2.6%	
8. Mine pit with deep pool	RCG010 RCG022	Disused mine pits with permanent pools, sparse low-mid shrub vegetation on walls MF: Low suitability	13.4 ha 0.8%	
9. Other cleared/disturbed	n/a	Mine pits, spoil heaps, and former infrastructure sites totally cleared of original vegetation; sparse low shrubland or herbland MF: Low suitability	44.8 ha 2.6%	

* Sites may be listed more than once where adjacent habitats sampled

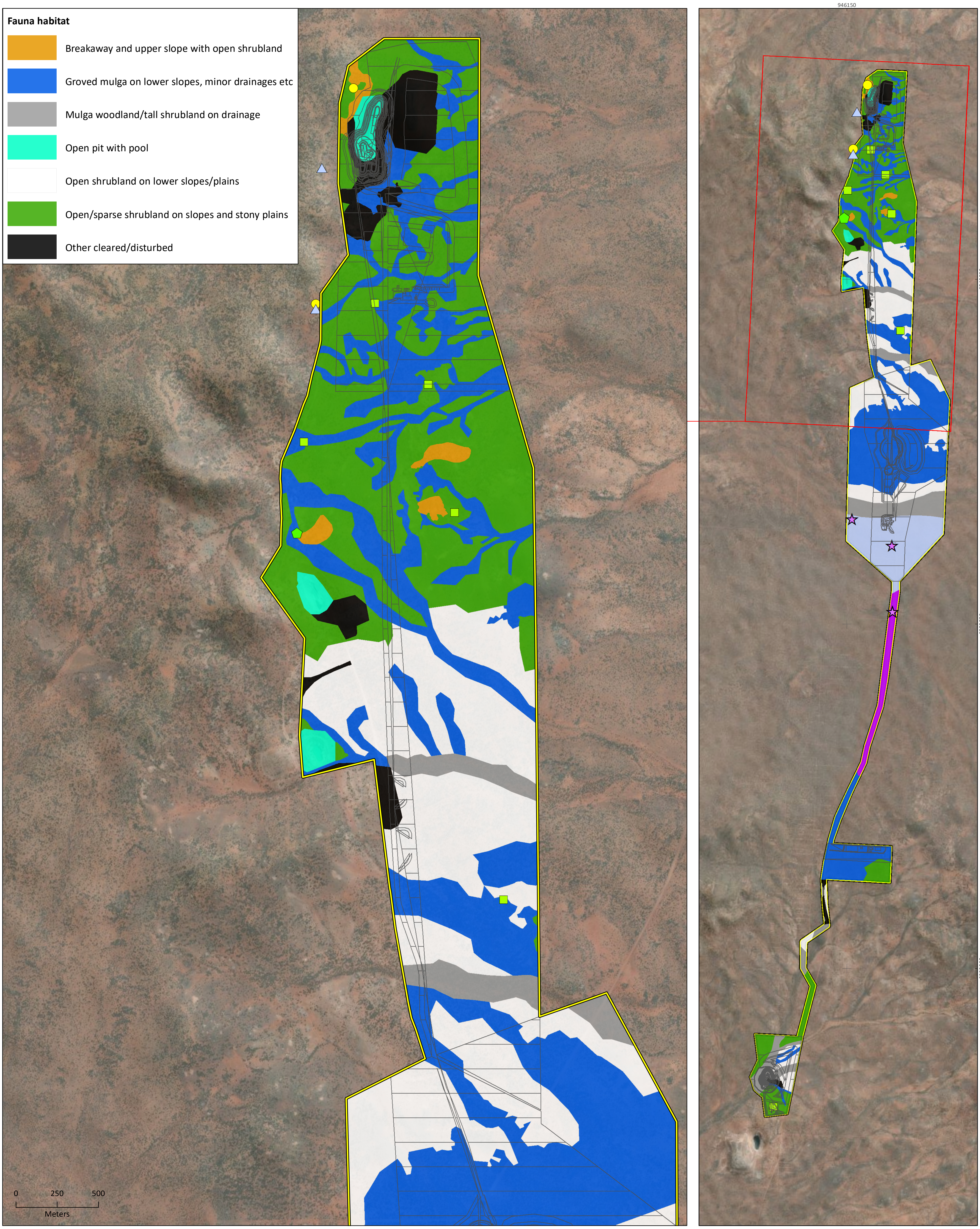
MF = Malleefowl

5.2.1.2 Malleefowl habitat assessments

The suitability for habitat to support Malleefowl was assessed at 32 locations (Table 5-6). The habitat was found to be suitable to support the species in 22 (68.8%) of the sites assessed, with approximately 1/3 of suitable sites being classified as High suitability (score of six or more). The remaining suitable sites were classified as Medium. The High suitability sites were located in mulga shrubland, often featuring scattered mallee and *Triodia*, in areas where the vegetation provided a consistent canopy cover. Malleefowl habitat suitability scores from assessed sites were used to extrapolate suitability for the entirety of the study area (Figure 5-4).

Table 5-6 Malleefowl habitat assessment scores

Malleefowl habitat	Score	Sites	Total	Total % (Malleefowl habitat %)
No	0	RCG010	1	3.1%
	1	RCG022	1	3.1%
	2	RCG005, RCG007, RCG021	3	9.4%
	3	RCG001, RCG004, RCG014, RCG018, RCG020	5	15.6%
Yes	4	RCG003, RCG015, RCG016, RCG019, RCG024, RCG027, RCG031	7	21.8% (31.8%)
	5	RCG002, RCG006, RCG008, RCG012, RCG013, RCG017, RCG023, RCG026	8	25.0% (36.4%)
	6	RCG028, RCG029, RCG030, RCG-NP01	4	12.5% (18.2%)
	7	RCG009, RCG011, RCG025	3	9.4% (13.6%)
	8	Nil	0	0.0
		Total	**32**	**100**



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Kilometers

1:70,000 (at A3) GDA 1994 MGA Zone 51

Study area

Disturbance footprint

Species

Bettongia lesueur graii, EX (EPBC Act, BC Act)

Dasyurus geoffroii, VU (EPBC Act, BC Act)

Leporillus apicalis, EX (EPBC Act, BC Act)

Sminthopsis longicaudata, P4 (DBCA list)

Figure 5-3a

Fauna habitats and significant fauna records from the field survey

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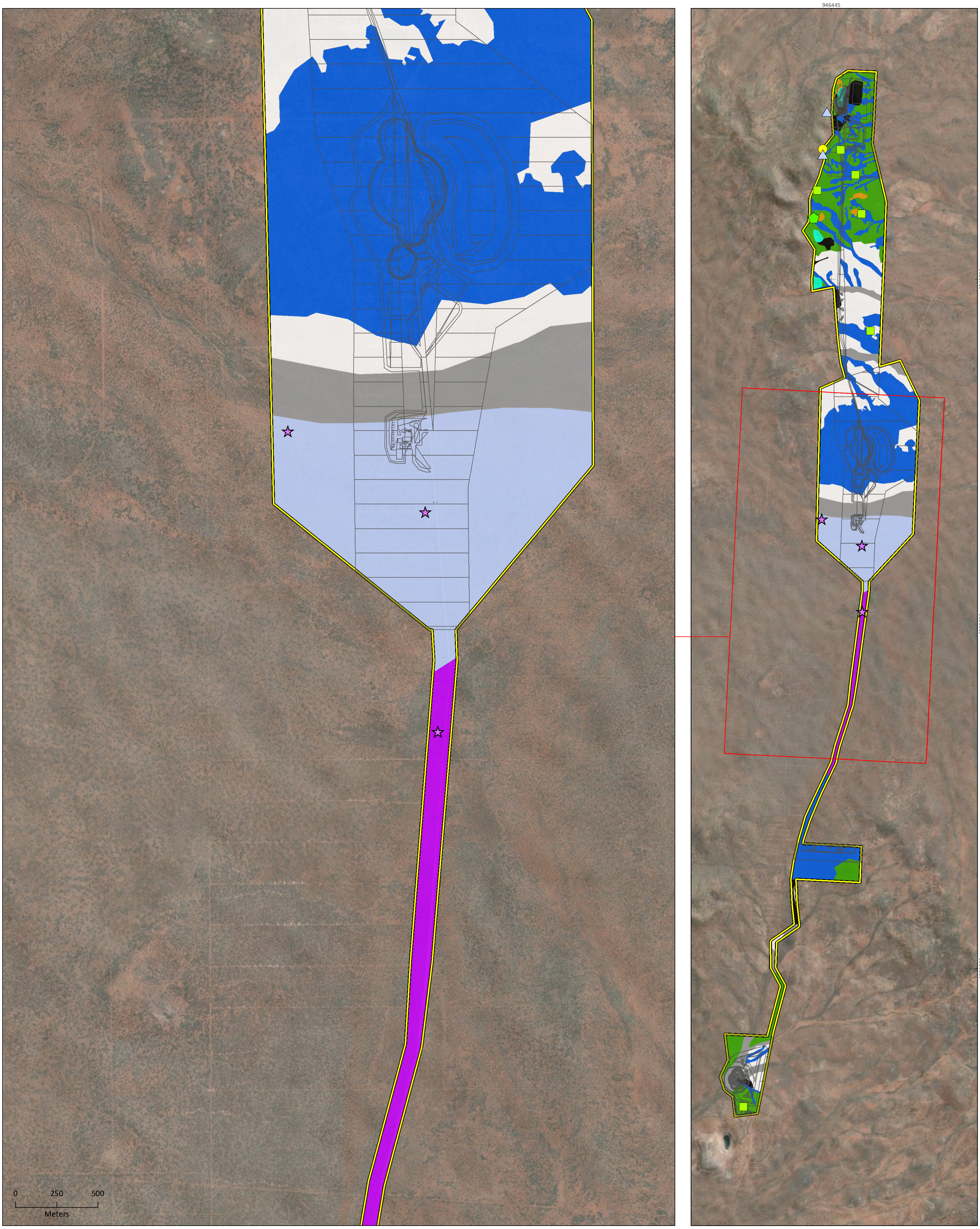

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Kilometers

1:70,000 (at A3) GDA 1994 MGA Zone 51

Study area
Disturbance footprint

Fauna habitat
- Groved mulga on lower slopes, minor drainages etc
- Mallee - mulga - triodia on sandplain
- Mulga tall shrubland on sandplain
- Mulga woodland/tall shrubland on drainage
- Open shrubland on lower slopes/plains

Species
- *Leipoa ocellata*, VU (EPBC Act, BC Act)

Figure 5-3b

Fauna habitats and significant fauna records from the field survey

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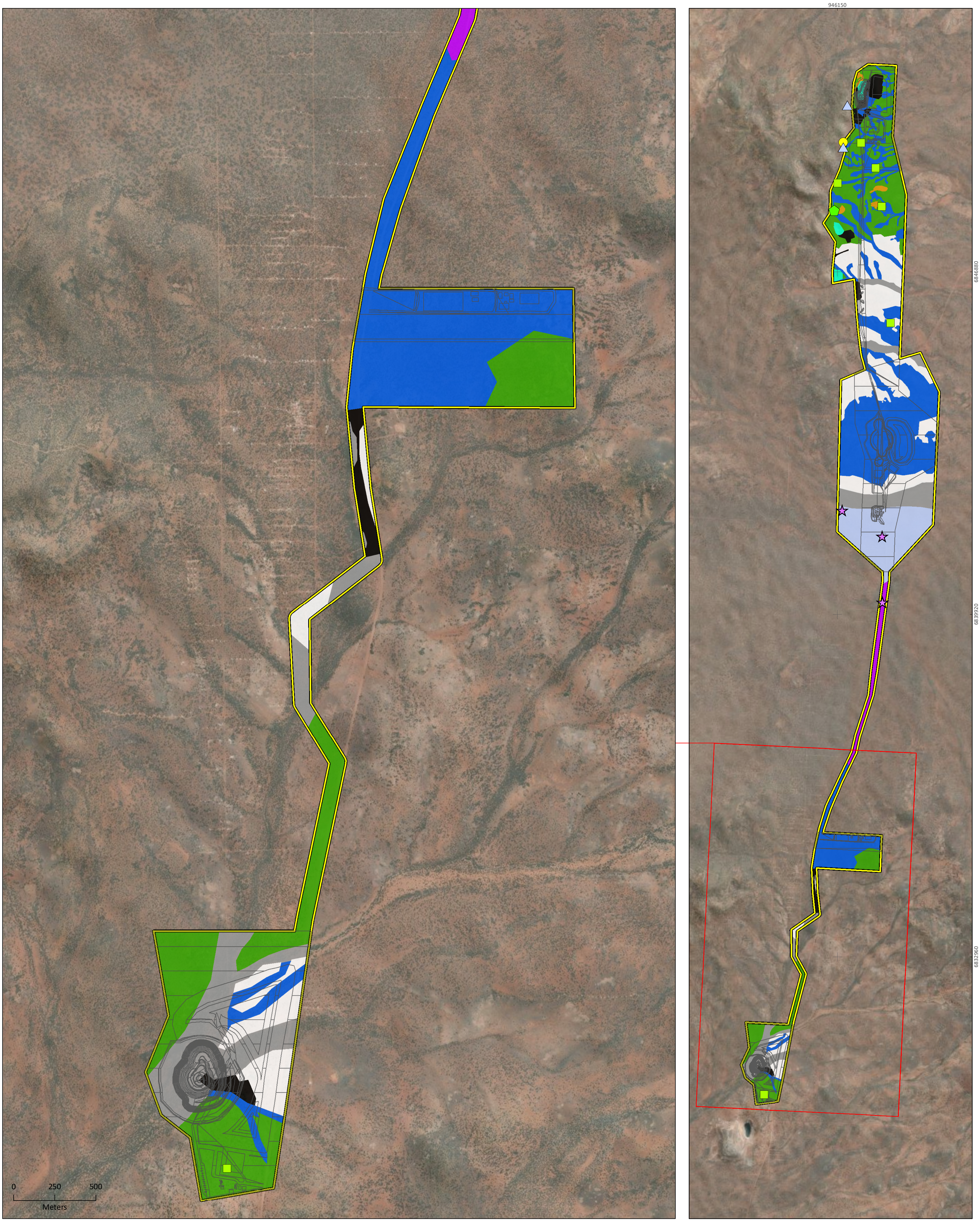

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Map author	JS

0 1 2
Kilometers

1:70,000 (at A3) GDA 1994 MGA Zone 51

Study area
Disturbance footprint

Fauna habitat

- Groved mulga on lower slopes, minor drainages etc
- Mallee - mulga - triodia on sandplain
- Mulga woodland/tall shrubland on drainage
- Open shrubland on lower slopes/plains
- Open/sparse shrubland on slopes and stony plains
- Other cleared/disturbed

Species

- *Bettongia lesueur graii*, EX (EPBC Act, BC Act)

Figure 5-3c

Fauna habitats and significant fauna records from the field survey

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Map author	JS

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Kilometers

1:66,600 (at A3) GDA 1994 MGA Zone 51

Study area

Habitat rating

High

Medium

Low

Figure 5-4

Malleefowl habitat suitability within the study area

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5.2.1.3 Assemblage

A total of 70 terrestrial vertebrate species representing 46 families and 65 genera were recorded in the study area during the field surveys (Table 5-7; Appendix 3). This assemblage represents 25% of the species identified in the desktop review. Birds were the most diverse class of vertebrates recorded, consistent with the results of the desktop review. Of the 21 mammal species recorded during the field survey, seven were introduced species.

Table 5-7 Number of vertebrate species recorded in survey in comparison to desktop results, by group

Group	No. species identified in desktop review	No. species recorded in survey
Amphibians	6	0
Reptiles	74	11
Birds	176	38
Mammals	39 (inc. 11 introduced)	21 (inc. 7 introduced)
Total	**283**	**70**

A number of reptiles and mammal taxa, and a few birds, were recorded only from tracks, scats, bones and other ‘secondary’ evidence. In some instances these could not be identified definitively due to likely presence of two or more similar species, e.g. species of *Sminthopsis* (Dasyuridae), *Osphranter* (Macropodidae), *Pseudechis* (Elapidae) and *Varanus* (*V. gouldii/panoptes*, Varanidae).

Seven microchiropteran bat species (families Emballonuridae, Molossidae and Vespertilionidae) were identified based on ultrasonic recordings of echolocation calls. All are widespread and expected to occur in the region, and none are conservation significant.

Two of the species recorded were not identified as potentially occurring in the desktop review. The gecko *Gehyra crypta*, found at multiple sites in the survey, was only recently distinguished from the common and widespread *G. variegata* (Kealley *et al.* 2018), hence not listed in previous reports and database records. The record of Common Brushtail Possum *Trichosurus vulpecula* represents a significant range extension and is discussed in the next section.

5.2.1.4 Significant vertebrate fauna

Two Threatened vertebrate species were recorded in the basic fauna survey by evidence indicating current or recent presence: Malleefowl *Leipoa ocellata* and Chuditch *Dasyurus geoffroii* (both VU; EPBC Act, BC Act) (Table 5-8; Figure 5-3).

5.2.1.4.1 Malleefowl

During the basic fauna survey, fresh Malleefowl tracks and scrapings of various ages were found during low intensity searches (Figure 5-3).

No nest mounds were detected in the aerial imagery searches. However, the imagery was deemed insufficient to confidently rule out the presence of mounds, particularly in areas of thicker vegetation which is where Malleefowl are most likely to build their nest mound.

During the follow-up high intensity ground searches the search team walked a total of approximately 205km through Medium- and High suitability Malleefowl habitat within the proposed disturbance footprint and did not detect any nest mounds in the area covered (Figure 5-5).

5.2.1.4.2 Chuditch

A maxilla fragment and scat identified as Chuditch were found during the basic fauna survey approximately 120m west of the study area. The maxilla fragment may be many decades old, but the scat from the same site was found in a more exposed position and appeared relatively fresh; it was submitted for DNA testing but diagnostic sequences were not obtained (Genotyping Australia 2021), so that very recent presence of the species could not be confirmed.

During the follow-up targeted searches, the field team searched approximately 5.5 km of breakaway and surrounding habitat (Figure 5-6). One potential Chuditch scat was found in breakaway at the far northern end of the study area. The scat was collected and morphologically identified as Chuditch before being sent to Genotyping Australia for DNA testing. Genetic sequences could not be obtained, likely due to the age of the scat. As such, this second recent record of the species could also not be confirmed genetically.

5.2.1.4.3 Other significant taxa

Other bones found at breakaway cave sites include diagnostic remains of Brushtail Possum *Trichosurus vulpecula*. This widespread species is not listed as conservation significant but has declined or disappeared from most arid parts of its former range (Abbott 2012), and no recent records were identified from the desktop search area. However, distinctive tracks of this species were also observed during Malleefowl transects. As an extension of the accepted current range by several hundred kilometres, this record is regionally significant.

Two extinct taxa were recorded at multiple sites based on historic evidence: Lesser Stick-nest Rat *Leporillus apicalis* and Boodie *Bettongia lesueur graii*. These are listed here as significant fauna records, but are considered to have been regionally extinct for many decades (Stick-nest Rat middens in sheltered sites may be thousands of years old; Pearson *et al.* 1999) and do not represent any limitation to proposed works.

Threatened and Priority fauna records will be reported to DBCA via the licencing return system.

Table 5-8 Details of significant vertebrate fauna recorded during the field survey

Species	Survey records	Photograph
Dasyurus geoffroii (Chuditch, VU)	RCG005, cave in breakaway (-28.40388, 121.55259): Maxilla fragment with alveoli of M2-M4, photographed on image of *D. geoffroii* skull (WAM M1864, Western Australian Museum 2021); Scat found in basic fauna survey (below left; similar example from near Koolyanobbing on right). Close to but not directly associated with Stick-nest Rat nests.	

Species	Survey records	Photograph
		
	RCG001, edge of burrow in breakaway (28.3929968, -121.5558332) Scat found in targeted Chuditch survey	

Species	Survey records	Photograph
Leipoa ocellata (Malleefowl, VU)	RCG011, RCG025, RCG029, RCG030: Foraging signs in leaf litter (various ages)	
	RCG011 (-28.47304, 121.57075; -28.48926, 121.56444): Single fresh trackway traversing study area east-west	

Species	Survey records	Photograph
Trichosurus vulpecula (Brush-tailed Possum) (no conservation listing, but extension of recent range; Abbott 2012)	RCG005, cave in breakaway (-28.40388, 121.55259): Left maxilla and humerus (subfossil, apparently weathered out of stick-nest)	
	RCG011 transect (-28.48942 121.56509): Fresh tracks	

Species	Survey records	Photograph
Leporillus apicalis (Lesser Stick-nest Rat, EX)	RCG005, cave in breakaway (-28.40388, 121.55259): Remnants of nests (sticks cemented by resinous urine or 'cave bitumen') in caves and overhangs along breakaway. Maxilla with well-preserved tooth-row approx. 7.5 mm long (not shown), consistent with *L. apicalis* but smaller than *L. conditor* (tooth-row ~10.5 mm; Copley 1999; Troughton 1923)	
	RCG031, breakaway (-28.39709, 121.55387): Abundant and well-preserved remnants of stick nests in overhangs along breakaway; partial skull and mandible consistent with *L. apicalis* embedded in nest material.	

Species	Survey records	Photograph
Bettongia lesueur graii (Boodie, EX)	RCG004, RCG006, RCG007, RCG013, RCG017, RCG021: Old burrows through calcrete hardpan, mostly reoccupied by rabbits and/or varanids	

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0 1 2
Kilometers

1:62,000 (at A3) GDA 1994 MGA Zone 51

Study area
Disturbance footprint
Malleefowl transect lines

Habitat rating
High
Medium
Low

Figure 5-5

Targeted Malleefowl transects

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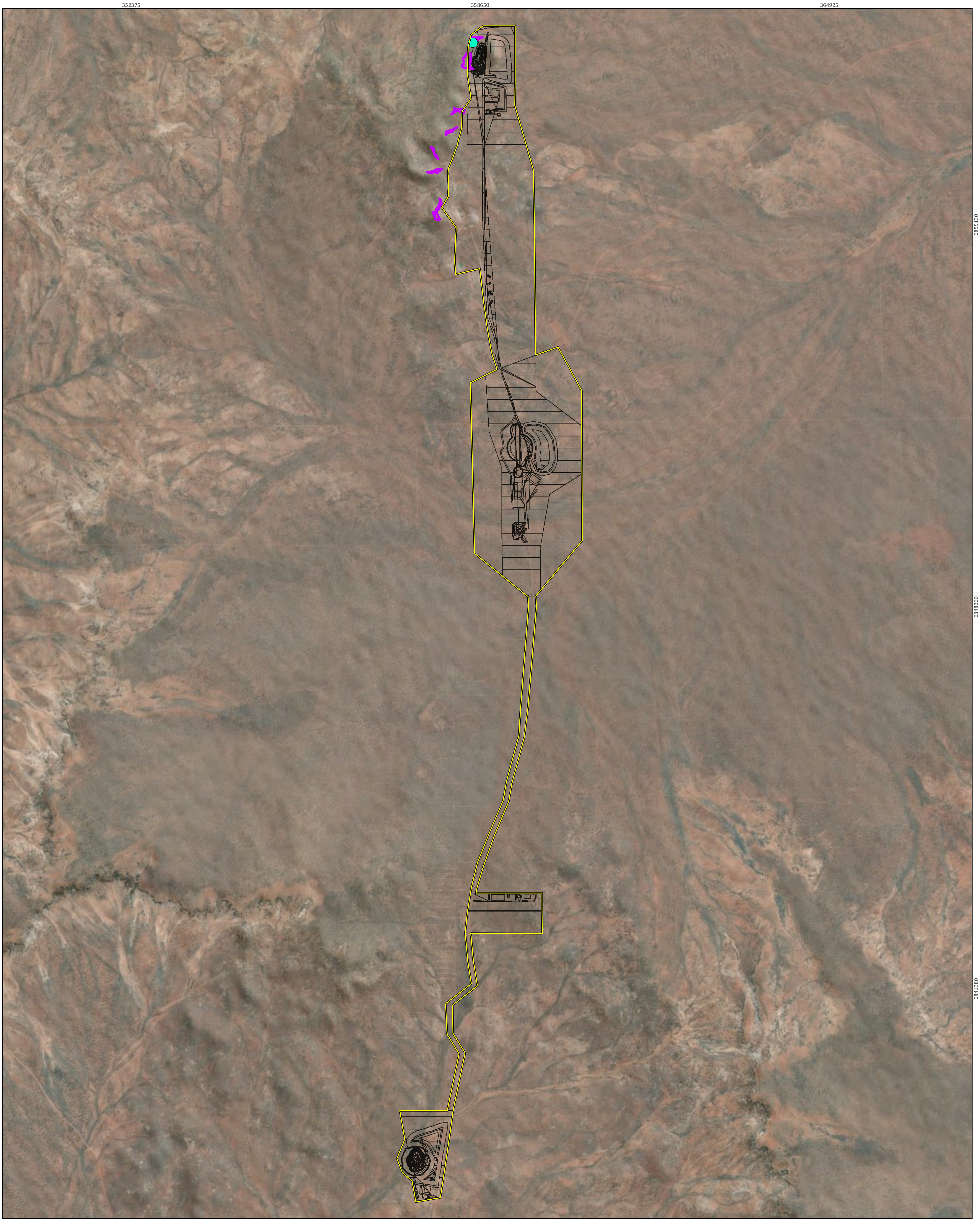

Dacian Gold Limited
Redcliffe Gold Project

Project No	1440-RGP-DGL-VER
Date	8/12/2021
Drawn by	IN
Map author	JS

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Kilometers

1:62,000 (at A3) GDA 1994 MGA Zone 51

Study area
Disturbance footprint
Targeted Chuditch search areas
Dasyurus geoffroii, VU (EPBC Act, BC Act)

Figure 5-6

Targeted Chuditch search areas and records

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The likelihood of occurrence assessment (section 4.2.2.10) for the remaining significant species identified in the desktop review (5.1.2) determined two species were **likely** to occur in the study area, four **possibly** occur and the rest are **unlikely** to occur (Table 5-9).

Table 5-9 Likelihood of occurrence for significant vertebrate fauna identified in the desktop review

Species	Status	Likelihood of occurrence	Habitats (as per Table 5-5)								
			Habitat 1	Habitat 2	Habitat 3	Habitat 4	Habitat 5	Habitat 6	Habitat 7	Habitat 8	Habitat 9
Leipoa ocellata Malleefowl	VU (EPBC & BC Acts)	Recorded; foraging and dispersal habitat present, possible breeding (L low suitability, M medium, H high)	L	L	• M	• M	• M	• H	• H	L	L
Apus pacificus Fork-tailed Swift	Mig. (EPBC & BC Acts)	Likely; occasional visitor (foraging, non-breeding)	•	•	•	•	•	•	•	•	•
Plegadis falcinellus Glossy Ibis	Mig. (EPBC & BC Acts)	Possible; occasional visitor in region, may forage at sites with water					•			•	
Falco hypoleucos Grey Falcon	VU (BC Act)	Possible; current distribution mainly north of 26°S but may occasionally occur further south. All habitat types suitable for foraging	•	•	•	•	•	•	•	•	•
Falco peregrinus Peregrine Falcon	OS (BC Act)	Recorded in previous survey; all habitats may be used for foraging as part of wide home range; possible breeding sites may include artificial cliffs of mine pits	• H	•	•	•	•	•	•	• H	•
Charadrius veredus Oriental Plover	Mig. (EPBC & BC Acts)	Possible; occasional visitor, may use sparsely vegetated plains and disturbed areas			•						•
Pluvialis fulva Pacific Golden Plover	Mig. (EPBC & BC Acts)	Unlikely; no suitable habitat in study area									
Thinornis rubricollis Hooded Plover	P4 (DBCA list)	Unlikely; widespread in region but no suitable habitat in study area									
Actitis hypoleucos Common Sandpiper	Mig. (EPBC & BC Acts)	Unlikely; no suitable habitat in study area									
Calidris acuminata Sharp-tailed Sandpiper	Mig. (EPBC & BC Acts)	Unlikely; no suitable habitat in study area									

Species	Status	Likelihood of occurrence	Habitats (as per Table 5-5)								
			Habitat 1	Habitat 2	Habitat 3	Habitat 4	Habitat 5	Habitat 6	Habitat 7	Habitat 8	Habitat 9
Calidris canutus Red Knot	EN/Mig. (EPBC Act; BC Act)	Unlikely; no suitable habitat in study area									
Calidris melanotos Pectoral Sandpiper	Mig. (EPBC & BC Acts)	Unlikely; no suitable habitat in study area									
Calidris ruficollis Red-necked Stint	Mig. (EPBC & BC Acts)	Unlikely; no suitable habitat in study area									
Limosa lapponica Bar-tailed Godwit	Mig. (EPBC & BC Acts)	Unlikely; no suitable habitat in study area									
Tringa glareola Wood Sandpiper	Mig. (EPBC & BC Acts)	Unlikely; no suitable habitat in study area									
Tringa nebularia Common Greenshank	Mig. (EPBC & BC Acts)	Unlikely; no suitable habitat in study area									
Tringa stagnatilis Marsh Sandpiper	Mig. (EPBC & BC Acts)	Unlikely; no suitable habitat in study area									
Gelochelidon nilotica Gull-billed Tern	Mig. (BC Act)	Unlikely; no suitable habitat in study area									
Pezoporus occidentalis Night Parrot	EN/CR (EPBC Act; BC Act)	Unlikely; hummock grass habitat mostly unsuitable, no records in desktop area							• L		
Polytelis alexandrae Princess Parrot	VU (EPBC Act), P4 (DBCA list)	Possible; occasional visitor after irruptions in core habitat to northeast							•		
Motacilla cinerea Grey Wagtail	Mig. (EPBC & BC Acts)	Unlikely; no records in area, no suitable habitat									
Motacilla flava Yellow Wagtail	Mig. (EPBC & BC Acts)	Unlikely; no records in area, no suitable habitat									

Species	Status	Likelihood of occurrence	Habitats (as per Table 5-5)								
			Habitat 1	Habitat 2	Habitat 3	Habitat 4	Habitat 5	Habitat 6	Habitat 7	Habitat 8	Habitat 9
Dasyurus geoffroii Chuditch	VU (EPBC & BC Acts)	Recorded; foraging/dispersal habitat and possible denning along breakaways, may also use other habitats including mallee, and rocky slopes of mine pits	• H	L	L	L	L	L	• M	• M	• M
Sminthopsis longicaudata Long-tailed Dunnart	P4 (DBCA list)	Likely (scats recorded possibly this species); potential resident of breakaway, outcrop, rockpiles including mine pits and rocky spoil; adjacent habitats may be used in foraging/dispersal	• H	L	L	L	L	L	L	• M	• M
Trichosurus vulpecula Common Brushtail Possum	Range extension (no conservation listing)	Recorded from fresh tracks on sandplain, and historic remains in breakaway cave; may use any habitat type	•	•	•	•	•	•	•	•	•
Bettongia lesueur graii Burrowing Bettong, Boodie	EX (EPBC & BC Acts)	Unlikely (extinct); multiple historic warrens recorded on tops and lower slopes of low hills with calcrete soil horizon	(•)	(•)	(•)	(•)					
Leporillus apicalis Lesser Stick-nest Rat	EX (EPBC & BC Acts)	Unlikely (extinct), but remains recorded from historic nests in breakaway caves and overhangs	(•)								
Leporillus conditor Greater Stick-nest Rat	VU (EPBC Act), CD (BC Act)	Unlikely (extinct on mainland), but possibly produced some of the remnant nests present in caves and overhangs	(•)								

5.2.2 SRE invertebrate fauna

5.2.2.1 Habitats

One habitat was identified within the study area as having High potential for SRE invertebrates (Table 5-10). This habitat primarily occurs in the north of the study area and extends out of the study area to the west. The remaining eight habitats were assessed as having Low potential under the criteria laid out in section 4.2.2.9 (Table 5-10; Figure 5-7).

Table 5-10 Extent and description of each SRE habitat in the study area

Habitat type	Site/s	Description	SRE potential
1. Breakaway and upper slope with open shrubland	RCG001 RCG005 RCG017 RCG018 RCG031	Hills capped with weathered volcanic rock forming breakaway with overhangs, caves and/or boulder piles, with open mid shrubland of mulga, other *Acacia* and mixed shrubs	**High**
2. Open/sparse shrubland on slopes and stony plains	RCG001 RCG007 RCG014 RCG015 RCG017 RCG020 RCG021	Slopes, low hills and plains with clay loam soils and some low outcrop, mantle of rock fragments usually present (volcanic rocks, quartz, ironstone and/or calcrete), with open to very sparse shrubland including mulga and often Casuarina	Low
3. Open shrubland on lower slopes and plains	RCG013 RCG014 RCG015 RCG016 RCG023	Nearly level ground with open mid to tall mulga shrubland (mostly without grove structure) on clay loam soils with quartz and ironstone pebble mantle	Low
4. Groved mulga on lower slopes, minor drainages and plain	RCG003 RCG004 RCG006 RCG008 RCG013 RCG015 RCG016 RCG018 RCG028	Mulga woodland and tall shrubland forming dense stands interspersed with open areas, on clay loam soils usually with quartz and ironstone mantle; minor drainage lines without distinct channel	Low
5. Mulga woodland/tall shrubland on drainage	RCG002 RCG019 RCG024 RCG026 RCG027	Mulga woodland and tall shrubland (mallees variably present) over patchy dense low to mid shrubs, along drainage lines with distinct channels	Low
6. Mulga tall shrubland on sandplain	RCG025 RCG029 RCG030	Mulga woodland and tall shrubland (scattered mallees variably present) over patchy dense low to mid shrubs, on deep sandy soils with ironstone pebbles	Low
7. Mallee over mulga shrubland with hummock grass on sandplain	RCG009 RCG011	Scattered mallees over mulga mid-tall shrubland over *Triodia* (stage 3-5, i.e. ring-forming hummocks) on level sandy loam with few or no pebbles	Low

Habitat type	Site/s	Description	SRE potential
8. Mine pit with deep pool	RCG010 RCG022	Disused mine pits with permanent pools, sparse low-mid shrub vegetation on walls	Low
9. Other cleared/disturbed	n/a	Mine pits, spoil heaps, and former infrastructure sites totally cleared of original vegetation; sparse low shrubland or herbland	Low

5.2.2.2 SRE records

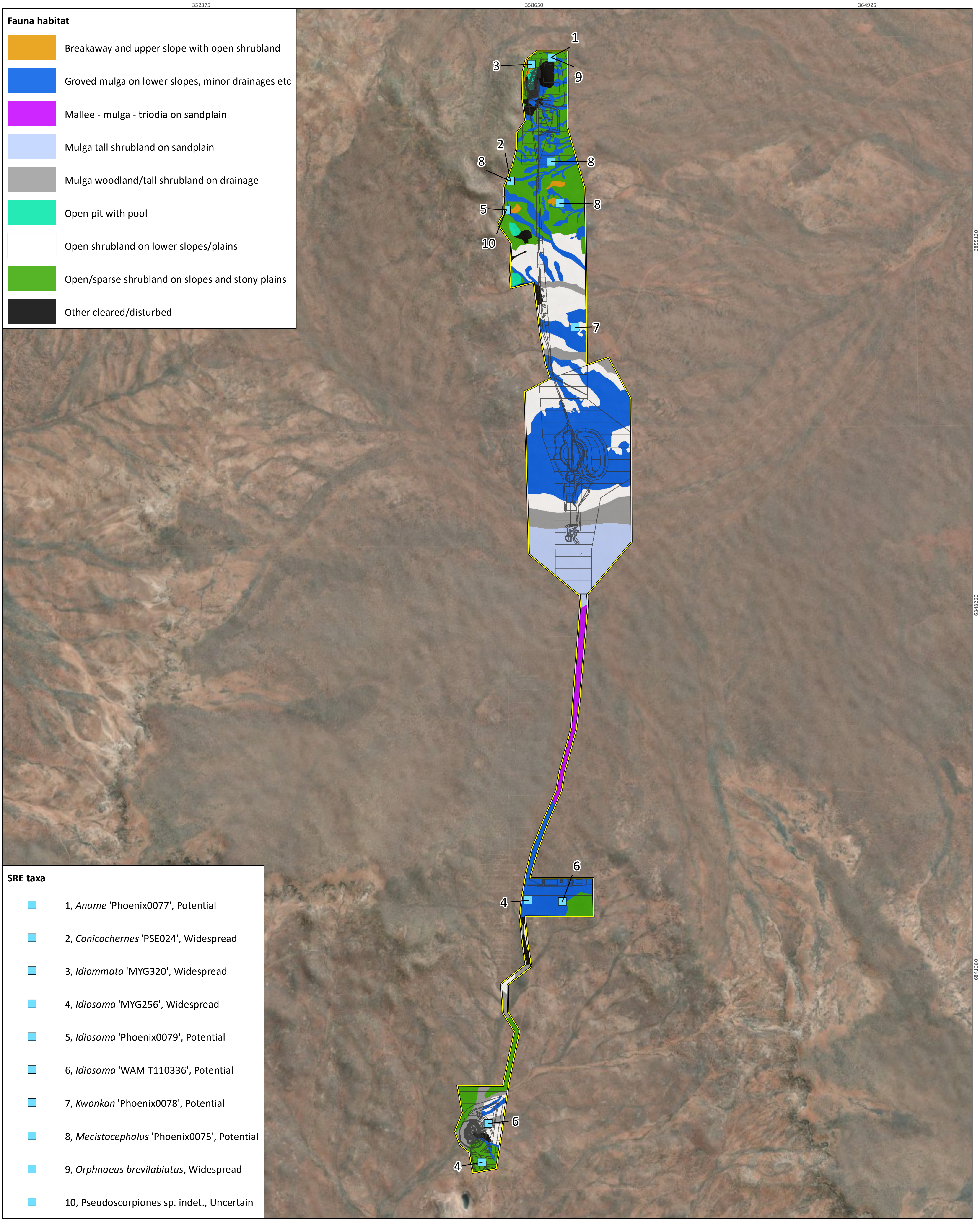
A total of 24 specimens representing ten taxa from SRE groups were collected within the study area (Figure 5-7; Table 5-12; Table 5-12). Of these ten taxa, four are considered new species. The remaining six are either known species or of unknown species status. Three of six known species collected were identified in the desktop review.

Five of the taxa collected are considered to be potential SREs. The remaining five taxa are either of uncertain SRE status or a widespread. The potential SREs collected are:

- *Aname* 'Phoenix0077' – new species collected from mulga shrubland on drainage. Habitat in which it was found appears to be continuous so this species is unlikely to be restricted to the study area.
- *Kwonkan* 'Phoenix0078' – new species collected from mulga shrubland on drainage. Habitat in which it was found appears to be continuous so this species is unlikely to be restricted to the study area.
- *Idiosoma* 'Phoenix0079' – new species collected from open mallee woodland on rocky outcrop. Habitat deemed to have High potential to support SREs but continues outside the study area so this species is unlikely to be restricted to the study area.
- *Mecistocephalus* 'Phoenix0075' – new species collected from several rocky sites. Habitat deemed to have High potential to support SREs but continues outside the study area so this species is unlikely to be restricted to the study area.
- *Idiosoma* 'WAM T110336' – known species with a current known distribution of less than 100 km^2. Known from approximately 50km south of the study area. Habitat in which it was found appears to be continuous so this species is unlikely to be restricted to the study area.

Table 5-11 Summary of SRE taxa collected during the field survey

Higher taxon	Families	Genera	Taxa	% of taxa
Mygalomorphs (trapdoor spiders)	3	4	6	**60**
Pseudoscorpions	2	2	2	**20**
Scorpions	0	0	0	**0**
Isopods (slaters)	0	0	0	**0**
Centipedes	2	2	2	**20**
Millipedes	0	0	0	**0**
Total	**7**	**8**	**10**	**100**



Western Australia

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Dacian Gold Limited
Redcliffe Gold Project

Project No	1440-RGP-DGL-VER
Date	8/12/2021
Drawn by	IN
Map author	JS

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Kilometers

1:65,000 (at A3)   GDA 1994 MGA Zone 51

Study area
Disturbance footprint

Figure 5-7

SRE habitat and recorded SRE taxa

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Table 5-12 Specimens from SRE groups recorded in the field survey

Higher order/family	Taxa	Site/s	SRE status	No. specimens	Habitats*					Comments
					L	L	L	L	H	
					Mallee over mulga shrubland	Mulga shrubland on drainage	Mulga shrubland on plains, lower slopes, minor drainage	Shrubland on stony plains/slopes	Breakaway and upper slopes	
Class Arachnida, infraorder Mygalomorphae (trapdoor spiders)										
Anamidae	*Aname* 'Phoenix0077'	RCG003	Potential	1			✓			This specimen is 10.4% divergent from its nearest relative in Genbank and is therefore considered here as a new species.
	Kwonkan 'Phoenix0078'	RCG013	Potential	1			✓			This specimen is 12.9% divergent from its nearest relative in Genbank and is therefore considered here as a new species.
Barychelidae	*Idiommata* 'MYG320'	RCG001	Widespread	1					✓	This specimen is 6% divergent from KJ745205 (*Idiommata* sp. MYG320 voucher T54155) and is therefore considered as a conservative conspecific.
Idiopidae	*Idiosoma* 'MYG256'	RCG007, RCG028	Widespread	2			✓	✓		This specimen is 7.4% divergent from KJ745099 (*Idiosoma* sp. MYG256 voucher T123106) and is therefore considered as a conservative conspecific.

Higher order/family	Taxa	Site/s	SRE status	No. specimens	Habitats*					Comments
					L	L	L	L	H	
					Mallee over mulga shrubland	Mulga shrubland on drainage	Mulga shrubland on plains, lower slopes, minor drainage	Shrubland on stony plains/slopes	Breakaway and upper slopes	
	Idiosoma 'Phoenix0079'	RCG018	Potential	1					✓	This specimen is 16.8% divergent from its nearest relative in Genbank and is therefore considered here as a new species.
	Idiosoma 'WAM T110336'	RCG008, RCG027	Potential	2		✓	✓			This specimen is 1.2% divergent from KY295274 (*Idiosoma* sp. WAM T110336) and is therefore considered conspecific.
Class Arachnida, order Pseudoscorpions										
Chernetidae	*Conicochernes* 'PSE024'	RCG006, RCG018	Widespread	9			✓		✓	Represents a known species.
Pseudoscorpiones	Pseudoscorpions sp. indet.	RCG018	Uncertain	3						Unknown if this specimen represents a known or undescribed species.
Class Chilopoda, order Geophilida (centipedes)										
Mecistocephalidae	*Mecistocephalus 'Phoenix0075'*	RCG006, RCG017, RCG021	Potential	6			✓	✓	✓	This specimen is 16.5% divergent from MW621080 Mecistocephalus sp. DNA10 voucher WAMT128077) and is therefore considered a new species.

Higher order/family	Taxa	Site/s	SRE status	No. specimens	Habitats*					Comments
					L	L	L	L	H	
					Mallee over mulga shrubland	Mulga shrubland on drainage	Mulga shrubland on plains, lower slopes, minor drainage	Shrubland on stony plains/slopes	Breakaway and upper slopes	
Oryidae	*Orphnaeus brevilabiatus*	RCG003	Widespread	1			✓			Represents a known species.

*L = low potential to support SREs, H = high potential to support SREs

5.3 SURVEY LIMITATIONS

The limitations of the flora and vegetation survey and terrestrial fauna survey have been considered in accordance with EPA (2016b, e) (Table 5-13).

Table 5-13 Consideration of potential survey limitations

Limitations	Comments
Availability of contextual information at a regional and local scale	Vertebrate fauna of the Goldfields region is well known in general, but there is often limited information available at the local scale. SREs are generally poorly known at the regional and local level, although knowledge is improving and barriers to dispersal are fewer than elsewhere, typically.
Competency/experience of the team carrying out the survey	The field team and report authors have sufficient experience in terrestrial biological surveys within the Goldfields region to satisfy EPA criteria and were competent in sampling the target fauna.
Scope and completeness	All items in the scope were achieved.
Proportion of flora and fauna recorded and/or collected, any identification issues	Fauna survey recorded 25% of vertebrate species identified as potentially occurring in the desktop review and is considered adequate for a basic survey. SRE invertebrate survey recorded several new and/or undescribed species (submitted to taxonomic specialists on relevant groups for identification), and including numerous taxa identified in the desktop review.
Access within the study area	Access was adequate to conduct surveys in the study area.
Timing, rainfall, season	Conditions during the survey were warm and dry. The survey was conducted outside the optimal survey periods for reptiles, birds and mammals but within the optimal survey period for SREs.
Disturbance that may have affected the results of the survey	No substantial disturbances were present within the study area which could have significantly affected the results of the survey.

6 DISCUSSION

6.1 VERTEBRATE FAUNA

Fauna habitat types occurring in the study area are mostly widespread in the region, the most restricted being breakaway low cliffs with caves and overhangs (type 1) and permanent pools within old mine pits (type 8, Table 5-5). The sections of breakaway habitat on the western edge of the study area are outliers of the extensive 'Terraces' cliff-line that extends for tens of kilometres northeast of Leonora.

The 70 vertebrate species recorded during the survey were almost all expected to occur based on previous surveys in the area and other sources reviewed in the desktop study. Two Threatened vertebrate species were recorded during the survey, and recent and historic evidence of several other species are regarded as significant.

Malleefowl (*Leipoa ocellata*, VU) was recorded from a fresh track, and signs of foraging activity in leaf litter, but no direct sightings or nest mounds. Habitat suitability for this species was assessed at 32 locations using a scoring system (5.2.1.2, Table 5-6), and extrapolated to mapping of the study area (Table 5-5, Figure 5-4); habitat of High suitability (with potential for nesting as well as foraging) comprises about 12.9% (222.5 ha) of the study area, Medium (foraging/dispersal habitat) 38.7% (669.7 ha), and the remaining 48.5% (838.4 ha) is assessed as Low suitability (may be used for dispersal). Targeted searches along walked transects in High- and Medium suitability habitat (Figure 5-5) found no evidence of current or former nesting activity by this species.

Chuditch (*Dasyurus geoffroii*, VU) was recorded from diagnostic skeletal remains (which may be very old) and also two scats which appear recent but did not retain identifiable DNA sequences. All three records were associated with the breakaway habitat type at the periphery of the study area, which may represent a significant (if intermittent) dispersal corridor for this species and also contains foraging and potential denning habitat (caves, overhangs, fig trees). The evidence does not indicate a current resident population, but is consistent with sporadic presence of dispersing individuals. Apart from the breakaway habitat, other rocky areas and mallee woodlands in the study area may be suitable for foraging and dispersal.

Brush-tailed Possum (*Trichosurus vulpecula*) was recorded from diagnostic skeletal remains (of indeterminate age) in breakaway habitat, and a fresh track of an adult in mallee-mulga-*Triodia* habitat on sandplain. This is considered a locally significant record because the most recent review (Abbott 2012) inferred the species is extinct across most of its former range in WA, and the desktop review identified no recent records within several hundred kilometres. In the past few years, Phoenix has recorded evidence that this species occurs at widely separated woodland sites across inland WA, e.g. Kambalda south of Kalgoorlie, around Koolyanobbing near the edge of the Wheatbelt, and Golden Grove in the Yalgoo (Phoenix 2020a, b, 2021b). It is not known positively that these represent remnant populations rather than reoccupation from the southwest, but the species is not considered well adapted for long-distance dispersal.

Former presence of two extinct mammal species, Lesser Stick-nest Rat (*Leporillus apicalis*) and Boodie (*Bettongia lesueur graii*), was indicated by nest structures recorded in the survey. Stick nests in caves and rock overhangs, and Boodie burrows through calcrete hardpan, can persist for many decades after disappearance of their makers, and continue to provide refugia used by other vertebrate species. The Greater Stick-nest Rat (*Leporillus conditor*, VU/CD; extinct in the wild on the mainland) may also have occurred, but only *L. apicalis* was identified from skeletal remains.

6.2 SRE INVERTEBRATE FAUNA

Three previously unknown species of mygalomorph spider and one previously unknown species of centipede were collected from the study area. This is not unusual for the region which is under-surveyed. Of the five potential SRE taxa collected, which includes all four previously unknown taxa, three were recorded in mulga shrubland habitat on plains, slopes or drainage deemed to have Low potential to support SREs (*Aname* 'Phoenix007', *Kwonkan* 'Phoenix0078' and *Idiosoma* 'WAM T110336'). Mulga shrubland in its various forms dominates that vast majority of the study area and is also widespread outside the study area.

The remaining two potential SRE taxa were recorded from rocky breakaways and upper slopes deemed to have High potential to support SREs (*Idiosoma* 'Phoenix0079' and *Mecistocephalus 'Phoenix0075')*.

A mygalomorph spider collected in the survey was genetically matched to *Idiommata* 'MYG320' that had previously been assigned potential SRE status as it had only been recorded from several locations in close proximity to one another. In mid-2021, it was found to have a significantly more extensive range than previous thought and is no longer considered an SRE. Similarly, *Idiosoma* 'MYG256' was previously thought to be a potential SRE but has since been recorded at Mt Ida, Murrin Murrin, Wiluna and Kalgoorlie. These links of species recently considered to be SREs between survey sites hundreds of kilometres apart suggests that many of the potential SREs in the region will be reassessed as widespread as survey coverage increases.

Poor representation or absence of some groups may be due to dry environmental conditions in the years preceding the survey. The region has been receiving substantially lower than average rainfall since 2019. Millipede, snail and isopod activity mostly requires humid conditions, and no members of these groups were collected.

Despite several new and potential SRE species being discovered during this survey, it is unlikely that these species are restricted to the study area. All specimens from SRE groups were obtained from habitats either widespread within the study area or habitats that are limited within the study area but are connected to similar and extensive habitat outside the study area.

6.3 CONCLUSION

The two Threatened vertebrate species recorded in the survey, Malleefowl *Leipoa ocellata* and Chuditch *Dasyurus geoffroii* (both VU), are inferred to use parts of the study area intermittently for dispersal and foraging, but not to be breeding residents. Peregrine Falcon *Falco peregrinus* (OS) has previously been recorded and may breed as well as foraging in habitats of the study area; the walls of disused mine pits have significant potential as nesting and foraging sites for this cliff-dwelling species. Habitat is also suitable for Grey Falcon *F. hypoleucos* (VU), but it is less likely to occur due to its rarity and more northerly distribution (and is not associated with cliffs). Some other Migratory or nomadic bird species may occasionally occur in the study area as part of much wider ranges, and it does not represent important or restricted habitat values for such species. Long-tailed Dunnart *Sminthopsis longicaudata* (P4) was not positively identified but considered a likely resident.

While several new and/or potential SRE taxa were recorded during the survey, it is considered unlikely that these species are restricted to the study area.

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Appendix 1 Survey site locations

Site	Site type	Latitude	Longitude
RCG001	Fauna site	-28.392606	121.55671
RCG002	Fauna site	-28.567519	121.55007
RCG003	Fauna site	-28.391512	121.56069
RCG004	Fauna site	-28.404875	121.55699
RCG005	Fauna site	-28.404824	121.55343
RCG006	Fauna site	-28.412407	121.55235
RCG007	Fauna site	-28.579368	121.54462
RCG008	Fauna site	-28.535152	121.56072
RCG009	Targeted fauna species site	-28.504104	121.5637
RCG010	Targeted fauna species site	-28.396151	121.55671
RCG011	Fauna site	-28.488496	121.56511
RCG012	Fauna site	-28.521723	121.55743
RCG013	Fauna site	-28.437429	121.56452
RCG014	Fauna site	-28.449581	121.5592
RCG015	Fauna site	-28.454881	121.55568
RCG016	Fauna site	-28.454959	121.57222
RCG017	Fauna site	-28.416269	121.56178
RCG018	Fauna site	-28.417325	121.5515
RCG019	Fauna site	-28.43046	121.56499
RCG020	Fauna site	-28.561663	121.55035
RCG021	Fauna site	-28.409241	121.56026
RCG022	Fauna site	-28.429308	121.55354
RCG023	Fauna site	-28.467343	121.55752
RCG024	Fauna site	-28.467441	121.57172
RCG025	Fauna site	-28.471962	121.55597
RCG026	Fauna site	-28.546686	121.55306
RCG027	Fauna site	-28.572788	121.54591
RCG028	Fauna site	-28.534885	121.55411
RCG029	Fauna site	-28.476539	121.56214
RCG030	Fauna site	-28.476584	121.57223
RCG031	Fauna site	-28.397088	121.55387
RCG-NP01	Fauna site	-28.517571	121.55995

Site details			
Site	**RCG001**	**Position (WGS84)**	-28.392606, 121.556705
Topography	breakaway	**Soil texture**	sandy loam, clay
Slope	moderate	**Rock type**	ferrous - ironstone, quartz
Soil colour	red-orange	**Rock cover (%)**	80

Sample and effort summary				
Visit	**Sample method**	**Sample quant. (hrs)**	**Date start**	**Date stop**
1	Birding	2.30	31 Aug 2021	31 Aug 2021
1	Camera trap	121.38	31 Aug 2021	05 Sep 2021
1	Foraging	2.30	30 Aug 2021	30 Aug 2021
1	Litter sieve	0.00	01 Sep 2021	01 Sep 2021
1	Site description	0.00	30 Aug 2021	30 Aug 2021
1	SRE foraging	1.17	01 Sep 2021	01 Sep 2021
1	Ultrasonic recording	90.55	30 Aug 2021	03 Sep 2021

Site description - visit 1 (30 Aug 2021)			
Breakaway with caves in mulga shrubland with *Melaleuca* shrubs over mixed low shrubs and herbs.			
Habitat	shrubland		
Disturbance	exploration (drill pads and access tracks)		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	40	**Litter distribution**	under vegetation
Tree cover (%)	30	**Litter depth(cm)**	1
Shrub cover (%)	10	**Litter cover (%)**	10
Grass cover (%)	0		
Herb cover (%)	10		

Site details			
Site	**RCG002**	**Position (WGS84)**	-28.567519, 121.550071
Topography	drainage line	**Soil texture**	gravel / alluvial, clay loam, sandy loam
Slope	negligible	**Rock type**	granite - rocks, quartz
Soil colour	light-brown, orange	**Rock cover (%)**	2

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Birding	1.34	31 Aug 2021	31 Aug 2021
1	Foraging	2.00	31 Aug 2021	31 Aug 2021
1	Site description	0.00	30 Aug 2021	30 Aug 2021
1	Ultrasonic recording	39.47	30 Aug 2021	01 Sep 2021

Site description - visit 1 (30 Aug 2021)

Open mallees and mulga trees and shrubs over mixed mid shrubs, tussock grasses and herbs along incised sandy gravel drainage channel.

Habitat	open woodland		
Disturbance	exploration (drill pads and access tracks), livestock tracks, vehicle tracks		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	50	**Litter distribution**	under vegetation
Tree cover (%)	30	**Litter depth(cm)**	1
Shrub cover (%)	20	**Litter cover (%)**	15
Grass cover (%)	3		
Herb cover (%)	0.1		

Site details			
Site	**RCG003**	**Position (WGS84)**	-28.391512, 121.56069
Topography	drainage line	**Soil texture**	clay loam
Slope	gentle	**Rock type**	none
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary				
Visit	**Sample method**	**Sample quant. (hrs)**	**Date start**	**Date stop**
1	Birding	1.30	01 Sep 2021	01 Sep 2021
1	Foraging	2.53	31 Aug 2021	31 Aug 2021
1	Litter sieve	0.00	01 Sep 2021	01 Sep 2021
1	Site description	0.00	31 Aug 2021	31 Aug 2021
1	SRE foraging	0.83	01 Sep 2021	01 Sep 2021

Site description - visit 1 (31 Aug 2021)			
Drainage line with mulga woodland surrounded by mulga shrubland on undulating plains. Mulga trees over lower mixed *Acacia* and *Eremophila* over grasses and herbs.			
Habitat	woodland		
Disturbance	grazing-low, vehicle tracks		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	70	**Litter distribution**	under vegetation
Tree cover (%)	60	**Litter depth(cm)**	1
Shrub cover (%)	20	**Litter cover (%)**	30
Grass cover (%)	30		
Herb cover (%)	20		

Site details			
Site	**RCG004**	**Position (WGS84)**	-28.404875, 121.556989
Topography	undulating plain	**Soil texture**	clay loam
Slope	negligible	**Rock type**	ferrous - ironstone, quartz
Soil colour	red-brown	**Rock cover (%)**	30

Sample and effort summary				
Visit	**Sample method**	**Sample quant. (hrs)**	**Date start**	**Date stop**
1	Birding	0.67	31 Aug 2021	31 Aug 2021
1	Foraging	1.17	31 Aug 2021	31 Aug 2021
1	Site description	0.00	31 Aug 2021	31 Aug 2021

Site description - visit 1 (31 Aug 2021)			
Open mulga woodland over mixed *Acacia, Eremophila* and other low shrubs over herbs on plains with ironstone and quartz gravel.			
Habitat	woodland		
Disturbance	grazing-low, vehicle tracks		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	50	**Litter distribution**	under vegetation
Tree cover (%)	30	**Litter depth(cm)**	1
Shrub cover (%)	20	**Litter cover (%)**	20
Grass cover (%)	0		
Herb cover (%)	10		

Site details			
Site	**RCG005**	**Position (WGS84)**	-28.404824, 121.553425
Topography	gully	**Soil texture**	clay loam, loam, rocks
Slope	moderate	**Rock type**	ferrous - ironstone, quartz
Soil colour	red-brown	**Rock cover (%)**	10

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Birding	0.67	31 Aug 2021	31 Aug 2021
1	Foraging	0.87	31 Aug 2021	31 Aug 2021
1	Site description	0.00	31 Aug 2021	31 Aug 2021

Site description - visit 1 (31 Aug 2021)

Gully between two breakaways. Mulga over mixed *Acacia* over mixed low shrubs on ironstone and quartz gravel.

Habitat	shrubland		
Disturbance	grazing-low, vehicle tracks		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	50	**Litter distribution**	under vegetation
Tree cover (%)	40	**Litter depth(cm)**	2
Shrub cover (%)	20	**Litter cover (%)**	20
Grass cover (%)	0		
Herb cover (%)	5		

Site details			
Site	**RCG006**	**Position (WGS84)**	-28.412407, 121.552354
Topography	drainage line	**Soil texture**	clay loam, loam, rocks
Slope	gentle	**Rock type**	ferrous - ironstone, quartz
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Foraging	1.97	31 Aug 2021	31 Aug 2021
1	Litter sieve	0.00	31 Aug 2021	31 Aug 2021
1	Site description	0.00	31 Aug 2021	31 Aug 2021
1	SRE foraging	2.00	31 Aug 2021	31 Aug 2021

Site description - visit 1 (31 Aug 2021)

Drainage line with mallee and mulga over mixed low shrubs. Surrounded by open mulga shrubland on undulating plains with ironstone and quartz gravel.

Habitat	woodland		
Disturbance	grazing-low, vehicle tracks		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	80	**Litter distribution**	even/continuous
Tree cover (%)	60	**Litter depth(cm)**	5
Shrub cover (%)	50	**Litter cover (%)**	80
Grass cover (%)	0		
Herb cover (%)	5		

Site details			
Site	**RCG007**	**Position (WGS84)**	-28.579368, 121.544616
Topography	hill top	**Soil texture**	clay loam, rocks
Slope	gentle	**Rock type**	quartz
Soil colour	red-brown	**Rock cover (%)**	10

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Birding	0.67	01 Sep 2021	01 Sep 2021
1	Foraging	2.40	01 Sep 2021	01 Sep 2021
1	Litter sieve	0.00	01 Sep 2021	01 Sep 2021
1	Site description	0.00	01 Sep 2021	01 Sep 2021
1	SRE foraging	2.00	01 Sep 2021	01 Sep 2021

Site description - visit 1 (01 Sep 2021)

Open mulga shrubland over mixed low *Acacia* over mixed low shrubs on quartz gravel on small hill top.

Habitat	shrubland		
Disturbance	grazing-low, vehicle tracks		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	50	**Litter distribution**	under vegetation
Tree cover (%)	20	**Litter depth(cm)**	2
Shrub cover (%)	30	**Litter cover (%)**	10
Grass cover (%)	5		
Herb cover (%)	5		

Site details			
Site	**RCG008**	**Position (WGS84)**	-28.535152, 121.560716
Topography	undulating plain	**Soil texture**	clay loam, rocks
Slope	negligible	**Rock type**	ferrous - ironstone, quartz
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Birding	0.70	01 Sep 2021	01 Sep 2021
1	Foraging	3.63	01 Sep 2021	01 Sep 2021
1	Site description	0.00	01 Sep 2021	01 Sep 2021

Site description - visit 1 (01 Sep 2021)

Tall open Mulga shrubland over low *Acacia, Eremophila* and other mixed low shrubs on ironstone and quartz gravel.

Habitat	shrubland		
Disturbance	exploration (drill pads and access tracks), grazing-low		
Vegetation condition	Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	50	**Litter distribution**	under vegetation
Tree cover (%)	40	**Litter depth(cm)**	1
Shrub cover (%)	20	**Litter cover (%)**	10
Grass cover (%)	5		
Herb cover (%)	5		

Site details			
Site	**RCG009**	**Position (WGS84)**	-28.504104, 121.5637
Topography	undulating plain	**Soil texture**	sandy loam
Slope	negligible	**Rock type**	calcrete, ferrous - ironstone
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Site description	0.02	01 Sep 2021	01 Sep 2021
1	Transect	6.00	01 Sep 2021	01 Sep 2021

Site description - visit 1 (01 Sep 2021)

Habitat			
Disturbance			
Vegetation condition		**Fire age**	
Total veg. cover (%)		**Litter distribution**	
Tree cover (%)		**Litter depth(cm)**	
Shrub cover (%)		**Litter cover (%)**	
Grass cover (%)			
Herb cover (%)			

Site description - visit 1 (01 Sep 2021)			
Low closed mulga shrubland with scattered mallee over triodia and other mixed low shrubs on sandy plain.			
Habitat	shrubland		
Disturbance	vehicle tracks		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	80	**Litter distribution**	even/continuous
Tree cover (%)	30	**Litter depth(cm)**	3
Shrub cover (%)	70	**Litter cover (%)**	80
Grass cover (%)	10		
Herb cover (%)	5		

Site details			
Site	**RCG010**	**Position (WGS84)**	-28.396151, 121.556708
Topography		**Soil texture**	
Slope		**Rock type**	
Soil colour		**Rock cover (%)**	0

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Foraging	2.00	01 Sep 2021	01 Sep 2021
1	Site description	0.00	01 Sep 2021	01 Sep 2021
1	Ultrasonic recording	89.82	01 Sep 2021	05 Sep 2021

Site description - visit 1 (01 Sep 2021)

Mine pit containing fresh water. Surrounding area is shrubland on rocky hills. No vegetation in pit beside scattered small shrubs. Water contains fish and yabbies.

Habitat	shrubland		
Disturbance	excavation, large-scale clearing		
Vegetation condition	Completely Degrade	**Fire age**	moderate (>5 years)
Total veg. cover (%)	0.1	**Litter distribution**	
Tree cover (%)		**Litter depth(cm)**	0
Shrub cover (%)	0.1	**Litter cover (%)**	0
Grass cover (%)			
Herb cover (%)			

Site details			
Site	**RCG011**	**Position (WGS84)**	-28.488496, 121.565114
Topography	undulating plain	**Soil texture**	sandy loam
Slope	negligible	**Rock type**	none
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Birding	0.67	04 Sep 2021	04 Sep 2021
1	Foraging	3.20	01 Sep 2021	01 Sep 2021
1	Litter sieve	0.00	05 Sep 2021	05 Sep 2021
1	Site description	0.00	01 Sep 2021	01 Sep 2021

Site description - visit 1 (01 Sep 2021)

Low closed mulga shrubland with scattered mallee over *Triodia* on sandy plain.

Habitat	shrubland		
Disturbance	vehicle tracks		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	80	**Litter distribution**	under vegetation
Tree cover (%)	40	**Litter depth(cm)**	2
Shrub cover (%)	40	**Litter cover (%)**	30
Grass cover (%)	50		
Herb cover (%)	0		

Site details			
Site	**RCG012**	**Position (WGS84)**	-28.521723, 121.557431
Topography	plain	**Soil texture**	clay loam, rocks
Slope	negligible	**Rock type**	ferrous - ironstone, quartz
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary				
Visit	**Sample method**	**Sample quant. (hrs)**	**Date start**	**Date stop**
1	Site description	0.00	01 Sep 2021	01 Sep 2021

Site description - visit 1 (01 Sep 2021)			
Tall open mulga shrubland over low *Acacia* over mixed low shrubs on ironstone and quartz gravel.			
Habitat	shrubland		
Disturbance	grazing-low, vehicle tracks		
Vegetation condition	Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	50	**Litter distribution**	under vegetation
Tree cover (%)	40	**Litter depth(cm)**	2
Shrub cover (%)	30	**Litter cover (%)**	30
Grass cover (%)	0		
Herb cover (%)	0		

Site details			
Site	**RCG013**	**Position (WGS84)**	-28.437429, 121.564523
Topography	plain	**Soil texture**	clay loam
Slope	negligible	**Rock type**	ferrous - ironstone, quartz
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary				
Visit	**Sample method**	**Sample quant. (hrs)**	**Date start**	**Date stop**
1	Birding	0.67	02 Sep 2021	02 Sep 2021
1	Foraging	2.00	02 Sep 2021	02 Sep 2021
1	Site description	0.00	02 Sep 2021	02 Sep 2021

Site description - visit 1 (02 Sep 2021)

Tall semi closed mulga shrubland over low *Acacia* over mixed low shrubs over scattered tussock grasses on ironstone and quartz gravel.

Habitat	shrubland		
Disturbance	grazing-low, vehicle tracks		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	60	**Litter distribution**	under vegetation
Tree cover (%)	50	**Litter depth(cm)**	2
Shrub cover (%)	30	**Litter cover (%)**	20
Grass cover (%)	5		
Herb cover (%)	2		

Site details			
Site	**RCG014**	**Position (WGS84)**	-28.449581, 121.559197
Topography	hill top	**Soil texture**	clay loam, rocks
Slope	gentle	**Rock type**	ferrous - ironstone
Soil colour	red-brown	**Rock cover (%)**	30

Sample and effort summary				
Visit	**Sample method**	**Sample quant. (hrs)**	**Date start**	**Date stop**
1	Birding	0.67	02 Sep 2021	02 Sep 2021
1	Foraging	2.00	02 Sep 2021	02 Sep 2021
1	Site description	0.00	02 Sep 2021	02 Sep 2021

Site description - visit 1 (02 Sep 2021)			
Ironstone outcrop at top of very low hill. Open *Allocasuarina* shrubland with mulga over mixed low shrubs on ironstone gravel.			
Habitat	shrubland		
Disturbance	exploration (drill pads and access tracks), grazing-low		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	30	**Litter distribution**	under vegetation
Tree cover (%)	20	**Litter depth(cm)**	2
Shrub cover (%)	10	**Litter cover (%)**	15
Grass cover (%)	0		
Herb cover (%)	5		

Site details			
Site	**RCG015**	**Position (WGS84)**	-28.454881, 121.555678
Topography	plain	**Soil texture**	clay loam, rocks
Slope	negligible	**Rock type**	ferrous - ironstone, quartz
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Site description	0.00	02 Sep 2021	02 Sep 2021

Site description - visit 1 (02 Sep 2021)

Tall semi open mulga shrubland over mixed low shrubs on quartz and ironstone gravel on flat plain.

Habitat	shrubland		
Disturbance	exploration (drill pads and access tracks), grazing-low		
Vegetation condition	Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	60	**Litter distribution**	under vegetation
Tree cover (%)	40	**Litter depth(cm)**	1
Shrub cover (%)	30	**Litter cover (%)**	20
Grass cover (%)	0		
Herb cover (%)	5		

Site details			
Site	**RCG016**	**Position (WGS84)**	-28.454959, 121.572215
Topography	plain	**Soil texture**	clay loam, rocks
Slope	negligible	**Rock type**	ferrous - ironstone, quartz
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Site description	0.00	02 Sep 2021	02 Sep 2021

Site description - visit 1 (02 Sep 2021)

Tall semi open mulga shrubland (thicker toward north) over mixed low shrubs on quartz and ironstone gravel on flat plain.

Habitat	shrubland		
Disturbance	exploration (drill pads and access tracks), grazing-low		
Vegetation condition	Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	50	**Litter distribution**	under vegetation
Tree cover (%)	40	**Litter depth(cm)**	2
Shrub cover (%)	20	**Litter cover (%)**	15
Grass cover (%)	0		
Herb cover (%)	5		

Site details			
Site	**RCG017**	**Position (WGS84)**	-28.416269, 121.561782
Topography	undulating plain	**Soil texture**	sandy clay, clay loam, rocks
Slope	gentle	**Rock type**	calcrete, ferrous - ironstone, quartz
Soil colour	brown, orange	**Rock cover (%)**	0

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Birding	1.00	02 Sep 2021	02 Sep 2021
1	Foraging	4.00	02 Sep 2021	02 Sep 2021
1	Litter sieve	0.00	04 Sep 2021	04 Sep 2021
1	Site description	0.00	02 Sep 2021	02 Sep 2021
1	SRE foraging	1.97	04 Sep 2021	04 Sep 2021

Site description - visit 1 (02 Sep 2021)

Calcrete gilgai with herbs surrounded by tall mostly closed mulga shrubland over ptilotus shrubs on rocky low hills and plains with ironstone and quartz gravel.

Habitat	shrubland		
Disturbance	exploration (drill pads and access tracks), grazing-high		
Vegetation condition	Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	70	**Litter distribution**	under vegetation
Tree cover (%)	40	**Litter depth(cm)**	1
Shrub cover (%)	40	**Litter cover (%)**	30
Grass cover (%)	0		
Herb cover (%)	40		

Site details			
Site	**RCG018**	**Position (WGS84)**	-28.417325, 121.551495
Topography	breakaway	**Soil texture**	gravel / alluvial, clay loam, sandy loam
Slope	moderate	**Rock type**	ferrous - Banded Iron Formation, quartz
Soil colour	brown, white	**Rock cover (%)**	50

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Birding	0.67	02 Sep 2021	02 Sep 2021
1	Foraging	1.00	02 Sep 2021	02 Sep 2021
1	Litter sieve	0.00	02 Sep 2021	02 Sep 2021
1	Site description	0.00	02 Sep 2021	02 Sep 2021
1	SRE foraging	2.00	02 Sep 2021	02 Sep 2021

Site description - visit 1 (02 Sep 2021)

Breakaway of banded sedimentary rock formation. Open mallee and tall mulga woodland over mixed low shrubs.

Habitat	open woodland		
Disturbance	exploration (drill pads and access tracks), vehicle tracks		
Vegetation condition	Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	60	**Litter distribution**	under vegetation
Tree cover (%)	40	**Litter depth(cm)**	4
Shrub cover (%)	40	**Litter cover (%)**	50
Grass cover (%)	0		
Herb cover (%)	10		

Site details			
Site	**RCG019**	**Position (WGS84)**	-28.43046, 121.564985
Topography	drainage line	**Soil texture**	clay loam, rocks
Slope	negligible	**Rock type**	ferrous - ironstone, quartz
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary				
Visit	**Sample method**	**Sample quant. (hrs)**	**Date start**	**Date stop**
1	Foraging	1.17	02 Sep 2021	02 Sep 2021
1	Site description	0.00	02 Sep 2021	02 Sep 2021

Site description - visit 1 (02 Sep 2021)			
Tall closed mulga shrubland over low *Acacia* and mixed shrubs in drainage line in ironstone and quartz gravel.			
Habitat	shrubland		
Disturbance	exploration (drill pads and access tracks)		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	80	**Litter distribution**	under vegetation
Tree cover (%)	60	**Litter depth(cm)**	2
Shrub cover (%)	30	**Litter cover (%)**	30
Grass cover (%)	5		
Herb cover (%)	5		

Site details			
Site	**RCG020**	**Position (WGS84)**	-28.561663, 121.550354
Topography	hill top	**Soil texture**	clay loam, rocks
Slope	gentle	**Rock type**	ferrous - ironstone, quartz
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary				
Visit	**Sample method**	**Sample quant. (hrs)**	**Date start**	**Date stop**
1	Birding	1.67	03 Sep 2021	03 Sep 2021
1	Foraging	1.60	03 Sep 2021	03 Sep 2021
1	Site description	0.00	03 Sep 2021	03 Sep 2021

Site description - visit 1 (03 Sep 2021)

Low stony rise with tall open mulga shrubland over chenopod shrubland with mixed medium and low shrubs including chenopods, low *Acacia, Eremophila* and *Ptilotus* over herbs on ironstone and quartz gravel.

Habitat	shrubland		
Disturbance	grazing-low, vehicle tracks		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	70	**Litter distribution**	under vegetation
Tree cover (%)	30	**Litter depth(cm)**	1
Shrub cover (%)	60	**Litter cover (%)**	10
Grass cover (%)	0		
Herb cover (%)	10		

Site details			
Site	**RCG021**	**Position (WGS84)**	-28.409241, 121.560262
Topography	breakaway	**Soil texture**	sand, clay loam, rocks
Slope	gentle	**Rock type**	quartz
Soil colour	red-brown	**Rock cover (%)**	50

Sample and effort summary				
Visit	**Sample method**	**Sample quant. (hrs)**	**Date start**	**Date stop**
1	Birding	0.67	03 Sep 2021	03 Sep 2021
1	Foraging	2.00	03 Sep 2021	03 Sep 2021
1	Litter sieve	0.00	03 Sep 2021	03 Sep 2021
1	Site description	0.00	03 Sep 2021	03 Sep 2021
1	SRE foraging	2.00	03 Sep 2021	03 Sep 2021

Site description - visit 1 (03 Sep 2021)			
Quartz outcrop surrounded by tall closed mulga shrubland over mixed low shrubs. Outcrop has scattered tall mulga shrubs over mixed low shrubs over herbs on quartz boulders and gravel.			
Habitat	shrubland		
Disturbance	grazing-low		
Vegetation condition	Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	50	**Litter distribution**	under vegetation
Tree cover (%)	20	**Litter depth(cm)**	1
Shrub cover (%)	30	**Litter cover (%)**	10
Grass cover (%)	0		
Herb cover (%)	40		

Site details			
Site	**RCG022**	**Position (WGS84)**	-28.429308, 121.553538
Topography		**Soil texture**	
Slope		**Rock type**	
Soil colour		**Rock cover (%)**	0

Sample and effort summary				
Visit	**Sample method**	**Sample quant. (hrs)**	**Date start**	**Date stop**
1	Birding	0.67	03 Sep 2021	03 Sep 2021
1	Site description	0.33	03 Sep 2021	03 Sep 2021

Site description - visit 1 (03 Sep 2021)			
Mine pit containing water. Walls of pit have some large shrubs.			
Habitat	shrubland		
Disturbance	excavation		
Vegetation condition	Completely Degrade	**Fire age**	moderate (>5 years)
Total veg. cover (%)	20	**Litter distribution**	under vegetation
Tree cover (%)	20	**Litter depth(cm)**	2
Shrub cover (%)	10	**Litter cover (%)**	10
Grass cover (%)	0		
Herb cover (%)	5		

Site details			
Site	**RCG023**	**Position (WGS84)**	-28.467343, 121.557522
Topography	plain	**Soil texture**	clay loam, rocks
Slope	negligible	**Rock type**	ferrous - ironstone, quartz
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Birding	0.67	03 Sep 2021	03 Sep 2021
1	Foraging	1.00	03 Sep 2021	03 Sep 2021
1	Site description	0.00	03 Sep 2021	03 Sep 2021

Site description - visit 1 (03 Sep 2021)

Open tall mulga shrubland over low mixed shrubs including *Acacia* and *Eremophila* over scattered tussock grass on quartz and ironstone gravel.

Habitat	shrubland		
Disturbance	exploration (drill pads and access tracks), grazing-low		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	60	**Litter distribution**	under vegetation
Tree cover (%)	40	**Litter depth(cm)**	2
Shrub cover (%)	30	**Litter cover (%)**	20
Grass cover (%)	5		
Herb cover (%)	2		

Site details			
Site	**RCG024**	**Position (WGS84)**	-28.467441, 121.57172
Topography	drainage line	**Soil texture**	clay loam
Slope	negligible	**Rock type**	none
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Birding	0.67	03 Sep 2021	03 Sep 2021
1	Foraging	2.00	03 Sep 2021	03 Sep 2021
1	Site description	0.00	03 Sep 2021	03 Sep 2021

Site description - visit 1 (03 Sep 2021)

Tall open mulga shrubland over scattered low shrubs on bare clay in drainage line.

Habitat	shrubland		
Disturbance	exploration (drill pads and access tracks)		
Vegetation condition	Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	70	**Litter distribution**	under vegetation
Tree cover (%)	60	**Litter depth(cm)**	2
Shrub cover (%)	20	**Litter cover (%)**	40
Grass cover (%)	5		
Herb cover (%)	5		

Site details			
Site	**RCG025**	**Position (WGS84)**	-28.471962, 121.555969
Topography	plain	**Soil texture**	sandy loam
Slope	negligible	**Rock type**	ferrous - ironstone, quartz
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Foraging	1.10	03 Sep 2021	03 Sep 2021
1	Site description	0.00	03 Sep 2021	03 Sep 2021
1	Transect	2.03	03 Sep 2021	03 Sep 2021

Site description - visit 1 (03 Sep 2021)

Semi closed mid to tall mulga shrubland with scattered mallee over low to mid *Acacia* and low mixed shrubs over tussock grass and *Triodia* on sandy plain.

Habitat	shrubland		
Disturbance	exploration (drill pads and access tracks), grazing-low		
Vegetation condition	Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	70	**Litter distribution**	under vegetation
Tree cover (%)	30	**Litter depth(cm)**	2
Shrub cover (%)	50	**Litter cover (%)**	30
Grass cover (%)	10		
Herb cover (%)	0		

Site details			
Site	**RCG026**	**Position (WGS84)**	-28.546686, 121.55306
Topography	drainage line	**Soil texture**	sandy loam, clay
Slope	negligible	**Rock type**	ferrous - ironstone, quartz
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Birding	1.43	05 Sep 2021	05 Sep 2021
1	Foraging	3.40	03 Sep 2021	03 Sep 2021
1	Site description	0.00	03 Sep 2021	03 Sep 2021
1	Ultrasonic recording	40.40	03 Sep 2021	05 Sep 2021

Site description - visit 1 (03 Sep 2021)

Drainage line with tree form *Acacia* over thick mid story of *Eremophila* and *Acacia* over mixed low shrubs over tussock grasses.

Habitat	woodland		
Disturbance	grazing-low		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	100	**Litter distribution**	even/continuous
Tree cover (%)	70	**Litter depth(cm)**	3
Shrub cover (%)	40	**Litter cover (%)**	80
Grass cover (%)	5		
Herb cover (%)	5		

Site details			
Site	**RCG027**	**Position (WGS84)**	-28.572788, 121.545908
Topography	drainage line	**Soil texture**	clay loam
Slope	negligible	**Rock type**	none
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Birding	0.73	04 Sep 2021	04 Sep 2021
1	Foraging	2.00	04 Sep 2021	04 Sep 2021
1	Litter sieve	0.00	04 Sep 2021	04 Sep 2021
1	Site description	0.00	04 Sep 2021	04 Sep 2021
1	SRE foraging	2.00	04 Sep 2021	04 Sep 2021

Site description - visit 1 (04 Sep 2021)

Tall closed mulga shrubland over mixed mid to low shrubs including *Acacia, Senna* and *Eremophila* over herbs and grasses in drainage line.

Habitat	shrubland		
Disturbance	exploration (drill pads and access tracks), grazing-medium		
Vegetation condition	Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	90	**Litter distribution**	under vegetation
Tree cover (%)	70	**Litter depth(cm)**	2
Shrub cover (%)	40	**Litter cover (%)**	50
Grass cover (%)	10		
Herb cover (%)	40		

Site details			
Site	**RCG028**	**Position (WGS84)**	-28.534885, 121.554105
Topography	plain	**Soil texture**	sand, clay loam
Slope	negligible	**Rock type**	ferrous - ironstone
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Birding	0.67	04 Sep 2021	04 Sep 2021
1	Foraging	2.00	04 Sep 2021	04 Sep 2021
1	Litter sieve	0.00	04 Sep 2021	04 Sep 2021
1	Site description	0.00	04 Sep 2021	04 Sep 2021
1	SRE foraging	1.10	04 Sep 2021	04 Sep 2021

Site description - visit 1 (04 Sep 2021)

Tall semi open mulga shrubland over medium *Acacia* over low mixed shrubs including *Acacia* and *Eremophila* over tussock grasses on ironstone gravel.

Habitat	shrubland		
Disturbance	exploration (drill pads and access tracks), grazing-low		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	60	**Litter distribution**	under vegetation
Tree cover (%)	40	**Litter depth(cm)**	2
Shrub cover (%)	30	**Litter cover (%)**	20
Grass cover (%)	10		
Herb cover (%)	0		

Site details			
Site	**RCG029**	**Position (WGS84)**	-28.476539, 121.562137
Topography	plain	**Soil texture**	sandy loam, clay
Slope	negligible	**Rock type**	ferrous - ironstone
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Birding	0.67	04 Sep 2021	04 Sep 2021
1	Foraging	4.00	04 Sep 2021	04 Sep 2021
1	Site description	0.00	04 Sep 2021	04 Sep 2021
1	Transect	2.00	04 Sep 2021	04 Sep 2021

Site description - visit 1 (04 Sep 2021)

Tall closed mulga shrubland over mid level *Acacia* over low shrubs over tussock grasses and *Triodia* on sandy plain with ironstone gravel.

Habitat	shrubland		
Disturbance	exploration (drill pads and access tracks), grazing-low		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	80	**Litter distribution**	under vegetation
Tree cover (%)	60	**Litter depth(cm)**	3
Shrub cover (%)	30	**Litter cover (%)**	40
Grass cover (%)	30		
Herb cover (%)	5		

Site details			
Site	**RCG030**	**Position (WGS84)**	-28.476584, 121.572229
Topography	plain	**Soil texture**	sandy loam, clay
Slope	negligible	**Rock type**	ferrous - ironstone
Soil colour	red-brown	**Rock cover (%)**	0

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Site description	0.00	04 Sep 2021	04 Sep 2021
1	Transect	2.00	04 Sep 2021	04 Sep 2021

Site description - visit 1 (04 Sep 2021)

Tall closed mulga shrubland over mid level *Acacia* over *Triodia* and low shrubs on sandy plain with ironstone gravel.

Habitat	shrubland		
Disturbance	exploration (drill pads and access tracks), grazing-low		
Vegetation condition	Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	70	**Litter distribution**	under vegetation
Tree cover (%)	60	**Litter depth(cm)**	2
Shrub cover (%)	20	**Litter cover (%)**	20
Grass cover (%)	40		
Herb cover (%)	0		

Site details			
Site	**RCG031**	**Position (WGS84)**	-28.397088, 121.553866
Topography	breakaway	**Soil texture**	sandy clay, rocks
Slope	moderate	**Rock type**	not recorded
Soil colour	light-brown, orange	**Rock cover (%)**	80

Sample and effort summary

Visit	Sample method	Sample quant. (hrs)	Date start	Date stop
1	Foraging	2.00	05 Sep 2021	05 Sep 2021
1	Site description	0.00	05 Sep 2021	05 Sep 2021

Site description - visit 1 (05 Sep 2021)

Mid open shrubland of mulga and mixed *Acacia* over *Senna, Melaleuca, Ficus* and misc. shrubs over scattered *Ptilotus*, tussocks etc.

Habitat	shrubland		
Disturbance			
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	40	**Litter distribution**	
Tree cover (%)	30	**Litter depth(cm)**	1
Shrub cover (%)	20	**Litter cover (%)**	10
Grass cover (%)	2		
Herb cover (%)	1		

Site details			
Site	**RCG-NP01**	**Position (WGS84)**	-28.517137, 121.559731
Topography	plain	**Soil texture**	sandy loam
Slope	negligible	**Rock type**	ferrous - ironstone, quartz
Soil colour	orange	**Rock cover (%)**	1

Sample and effort summary				
Visit	**Sample method**	**Sample quant. (hrs)**	**Date start**	**Date stop**
1	Audio recording	140.28	30 Aug 2021	05 Sep 2021
1	Site description	0.00	30 Aug 2021	30 Aug 2021
1	Transect	0.90	05 Sep 2021	05 Sep 2021

Site description - visit 1 (30 Aug 2021)			
Scattered mallees over open mulga shrubland over scattered low-mid shrubs e.g *Senna* sp. over low dead stage 4-5 hard spinifex.			
Habitat	shrubland		
Disturbance	exploration (drill pads and access tracks), grazing-low, livestock tracks, vehicle tracks		
Vegetation condition	Very Good	**Fire age**	moderate (>5 years)
Total veg. cover (%)	60	**Litter distribution**	under vegetation
Tree cover (%)	30	**Litter depth(cm)**	1
Shrub cover (%)	5	**Litter cover (%)**	15
Grass cover (%)	25		
Herb cover (%)			

Appendix 3 Vertebrate fauna desktop and field survey results

Family	Species	Common name	Conservation status	Protected Matters (DAWE 2021a)	Threatened fauna (DBCA 2021b)	NatureMap (DBCA 2021a)	ALA (2021)	McKenzie *et al.* (1994)	Murrin Murrin (Phoenix 2019a, 2021a)	Leonora Gold (Phoenix 2019b)	Redcliffe (Phoenix 2010a)	This survey
Amphibians (6)												
Hylidae	*Cyclorana maini*	Sheep Frog					3	•				
	Cyclorana occidentalis (ex *platycephala*)	Western Water-holding Frog				•	32	•	•	•		
	Litoria rubella	Little Red Tree Frog				•	17		•	•	•	
Limnodynastidae	*Neobatrachus kunapalari*	Kunapalari Frog					3	•				
	Notaden nichollsi	Desert Spadefoot									•	
Myobatrachidae	*Pseudophryne occidentalis*	Western Toadlet				•	6					
Reptiles (74)												
Cheluidae	*Chelodina steindachneri*	Dinner-plate Turtle					1					
Agamidae	*Ctenophorus infans* (*caudicinctus* s.l.)	Laverton Ring-tailed Dragon					2		•			
	Ctenophorus fordi	Mallee Military Dragon						•				
	Ctenophorus isolepis	Military Dragon					7	•	•			
	Ctenophorus nuchalis	Central Netted Dragon				•	5	•		•		
	Ctenophorus reticulatus	Western Netted Dragon				•	9	•				
	Ctenophorus salinarum	Claypan Dragon					5	•				
	Ctenophorus scutulatus	Lozenge-marked Dragon					2	•	•			•
	Diporiphora amphiboluroides	Mulga Dragon				•			•		•	
	Moloch horridus	Thorny Devil					1	•	•			
	Pogona minor	Western Bearded Dragon				•	2	•	•		•	
	Tympanocryptis pseudopsephos	Goldfields Pebble Dragon					6		•			

Family	Species	Common name	Conservation status	Protected Matters (DAWE 2021a)	Threatened fauna (DBCA 2021b)	NatureMap (DBCA 2021a)	ALA (2021)	McKenzie *et al.* (1994)	Murrin Murrin (Phoenix 2019a, 2021a)	Leonora Gold (Phoenix 2019b)	Redcliffe (Phoenix 2010a)	This survey
Gekkonidae	*Gehyra crypta*	Western Cryptic Gehyra										•
	Gehyra montium	Centralian Dtella							•			
	Gehyra purpurascens	Purplish Dtella					2	•				
	Gehyra variegata (s.l.)	Common Dtella				•	25	•	•	•	•	
	Heteronotia binoei	Bynoe's Prickly Gecko				•	34	•	•	•	•	•
Carphodactylidae	*Nephrurus vertebralis*	Midline Knob-tailed Gecko				•	1					
	Nephrurus w. wheeleri	Banded Knob-tailed Gecko					4					
	Underwoodisaurus milii	Barking Gecko				•	2	•	•		•	•
Diplodactylidae	*Diplodactylus conspicillatus* (s.l.)	Fat-tailed Gecko				•	2	•			•	
	Diplodactylus granariensis rex	Western Stone Gecko				•	6		•		•	
	Diplodactylus laevis	Desert Fat-tailed Gecko					2					
	Diplodactylus pulcher	Fine-faced Gecko				•	6		•		•	
	Lucasium squarrosum	Spotted Ground Gecko				•	6	•	•			
	Rhynchoedura ornata	Western Beaked Gecko				•	4	•	•		•	
	Strophurus assimilis	Goldfields Spiny-tail Gecko				•					•	
	Strophurus elderi	Jewelled Gecko					1	•				
	Strophurus strophurus	Western Spiny-tailed Gecko					2	•				
	Strophurus wellingtonae	Western Shield Spiny-tail Gecko				•	4	•	•		•	•
Pygopodidae	*Aprasia picturata*	Black-headed Worm lizard					2					
	Delma butleri	Unbanded Delma						•				
	Delma nasuta	Sharp-snouted Delma					1	•				
	Lialis burtonis	Burton's Legless Lizard						•				

Family	Species	Common name	Conservation status	Protected Matters (DAWE 2021a)	Threatened fauna (DBCA 2021b)	NatureMap (DBCA 2021a)	ALA (2021)	McKenzie *et al.* (1994)	Murrin Murrin (Phoenix 2019a, 2021a)	Leonora Gold (Phoenix 2019b)	Redcliffe (Phoenix 2010a)	This survey
	Pygopus nigriceps	Western Hooded Scaly-foot				•	5				•	
Scincidae	*Cryptoblepharus australis*	Inland Snake-eyed Skink					2	•				
	Cryptoblepharus buchananii	Buchanan's Snake-eyed Skink				•		•	•		•	
	Ctenotus greeri							•				
	Ctenotus helenae	Clay-soil Ctenotus					1	•				
	Ctenotus inornatus	Plain Ctenotus					7					
	Ctenotus leonhardii	Leonhard's Ctenotus					4					
	Ctenotus pantherinus ocellifer	Leopard Ctenotus					4	•				
	Ctenotus schomburgkii							•				
	Ctenotus severus	Stern Ctenotus							•			
	Ctenotus uber uber	Spotted Ctenotus				•	2		•	•	•	
	Egernia depressa	Southern Pygmy Spiny-tailed Skink				•			•	•	•	•
	Egernia formosa	Goldfields Crevice-skink							•			
	Eremiascincus richardsonii	Broad-banded Sandswimmer								•	•	
	Lerista desertorum	Central Deserts Robust Slider				•	20	•	•	•	•	
	Lerista kingi	King's Three-toed Slider					1					
	Lerista timida	Timid Slider				•	19	•	•		•	
	Liopholis inornata	Desert Skink					1					
	Menetia greyii	Common Dwarf Skink				•	5	•	•			•
	Morethia butleri	Woodland Morethia Skink				•	11	•	•		•	•
	Tiliqua multifasciata	Centralian Bluetongue						•				

Family	Species	Common name	Conservation status	Protected Matters (DAWE 2021a)	Threatened fauna (DBCA 2021b)	NatureMap (DBCA 2021a)	ALA (2021)	McKenzie *et al.* (1994)	Murrin Murrin (Phoenix 2019a, 2021a)	Leonora Gold (Phoenix 2019b)	Redcliffe (Phoenix 2010a)	This survey
	Tiliqua occipitalis	Western Bluetongue Skink					2	•				
	Tiliqua rugosa	Bobtail							•			
Varanidae	*Varanus brevicauda*	Short-tailed Monitor						•				
	Varanus caudolineatus	Stripe-tailed Monitor				•	3	•	•		•	•
	Varanus giganteus	Perentie							•			
	Varanus gouldii	Gould's Sand Monitor				•		•	•		•	?
	Varanus panoptes	Yellow-spotted Monitor				•	4		•	•	•	?
	Varanus tristis	Black-headed Monitor					1					
Typhlopidae	*Anilios hamatus*	Pale-headed Blindsnake					10	•	•			
	Anilios waitii	Beaked Blindsnake					2					
Pythonidae	*Antaresia childreni* (ex *stimsoni*)	Children's Python					1			•		
Elapidae	*Furina ornata*	Moon Snake						•				
	Pseudechis australis	Mulga Snake, King Brown					1	•				
	Pseudechis butleri	Spotted Mulga Snake					2			•		•
	Pseudonaja mengdeni	Western Brown Snake					3			•		
	Pseudonaja modesta	Ringed Brown Snake					3		•			
	Simoselaps bertholdi	Jan's Banded Snake					1	•				
	Suta fasciata	Rosen's Snake				•	5		•			
	Suta monachus	Monk Snake				•	2		•		•	
Birds (176)												
Casuariidae	*Dromaius novaehollandiae*	Emu				•	61	•	•	•	•	•
Megapodiidae	*Leipoa ocellata*	Malleefowl	VU (EPBC & BC Acts)	known	68		1					•

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Phasianidae	*Coturnix pectoralis*	Stubble Quail					1					
Anatidae	*Anas gracilis*	Grey Teal				•	79		•			
	Anas rhynchotis	Australian Shoveler					2					
	Anas superciliosus	Pacific Black Duck				•	45					
	Aythya australis	Hardhead					18					
	Biziura lobata	Musk Duck				•	9					
	Chenonetta jubata	Australian Wood Duck				•	42					
	Cygnus atratus	Black Swan					53					
	Malacorhynchus membranaceus	Pink-eared Duck					28					
	Tadorna tadornoides	Australian Shelduck					58		•			
Podicipedidae	*Podiceps cristatus*	Great Crested Grebe					1					
	Poliocephalus poliocephalus	Hoary-headed Grebe					41					
	Tachybaptus novaehollandiae	Australasian Grebe					16					
Columbidae	**Columba livia*	Rock Dove, Feral Pigeon		likely			4					
	Geopelia cuneata	Diamond Dove					16	•				
	Ocyphaps lophotes	Crested Pigeon				•	164	•	•	•	•	•
	Phaps chalcoptera	Common Bronzewing				•	48	•	•	•	•	
	**Streptopelia senegalensis*	Laughing Dove		likely			2					
Caprimulgidae	*Eurostopodus argus*	Spotted Nightjar					17		•			
Podargidae	*Podargus strigoides*	Tawny Frogmouth					5			•		•
Aegothelidae	*Aegotheles cristatus*	Australian Owlet Nightjar				•	5				•	
Apodidae	*Apus pacificus*	Fork-tailed Swift	Mig (EPBC & BC Acts)	likely								

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Anhingidae	*Anhinga novaehollandiae*	Australasian Darter					8					
Phalacrocoracidae	*Microcarbo melanoleucos*	Little Pied Cormorant					22					
	Phalacrocorax carbo	Great Cormorant					11					
	Phalacrocorax sulcirostris	Little Black Cormorant				•	44					
Pelecanidae	*Pelecanus conspicillatus*	Australian Pelican				•	25					
Ardeidae	*Ardea modesta*	Eastern Great Egret					7					
	Ardea pacifica	White-necked Heron				•	52		•			
	Egretta novaehollandiae	White-faced Heron					52			•		
	Nycticorax caledonicus	Nankeen Night-heron					2					
Threskiornithidae	*Plegadis falcinellus*	Glossy Ibis	Mig (EPBC & BC Acts)		1							
	Platalea flavipes	Yellow-billed Spoonbill					19					
	Platalea regia	Royal Spoonbill					1					
	Threskiornis moluccus	Australian White Ibis					2					
	Threskiornis spinicollis	Straw-necked Ibis					8		•			
Accipitridae	*Accipiter cirrocephalus*	Collared Sparrowhawk					9					
	Accipiter fasciatus	Brown Goshawk					7					
	Aquila audax	Wedge-tailed Eagle				•	81	•	•	•	•	•
	Circus assimilis	Spotted Harrier					9					
	Circus approximans	Swamp Harrier					3					
	Elanus caeruleus axillaris	Black-shouldered Kite					6					
	Hamirostra melanosternon	Black-breasted Buzzard					1					
	Haliastur sphenurus	Whistling Kite				•	56			•		

Family	Species	Common name	Conservation status	Protected Matters (DAWE 2021a)	Threatened fauna (DBCA 2021b)	NatureMap (DBCA 2021a)	ALA (2021)	McKenzie *et al.* (1994)	Murrin Murrin (Phoenix 2019a, 2021a)	Leonora Gold (Phoenix 2019b)	Redcliffe (Phoenix 2010a)	This survey
	Hieraeetus morphnoides	Little Eagle					6					
	Lophoictinia isura	Square-tailed Kite					2					
	Milvus migrans	Black Kite				•	9					
Falconidae	*Falco berigora*	Brown Falcon				•	49	•	•			
	Falco cenchroides	Nankeen Kestrel				•	92	•	•	•	•	•
	Falco hypoleucos	Grey Falcon	VU (BC Act)	likely	1							
	Falco longipennis	Australian Hobby					38		•			
	Falco peregrinus	Peregrine Falcon	OS (BC Act)		13	•	4		•		•	
	Falco subniger	Black Falcon					2					
Rallidae	*Fulica atra*	Eurasian Coot					46					
	Gallinula tenebrosa	Dusky Moorhen					3					
	Tribonyx ventralis	Black-tailed Native-hen					35		•			
Otididae	*Ardeotis australis*	Australian Bustard				•	8		•	•		•
Burhinidae	*Burhinus grallarius*	Bush Stone-curlew					2		•			•
Recurvirostridae	*Cladorhynchus leucocephalus*	Banded Stilt					5					
	Himantopus himantopus	Black-winged Stilt					29					
	Recurvirostra novaehollandiae	Red-necked Avocet					20					
Charadriidae	*Charadrius ruficapillus*	Red-capped Plover					45					
	Charadrius veredus	Oriental Plover	Mig (EPBC & BC Acts)	may			2					
	Elseyornis melanops	Black-fronted Dotterel					62					
	Erythrogonys cinctus	Red-kneed Dotterel					18					
	Peltohyas australis	Inland Dotterel					7					

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	Pluvialis fulva	Pacific Golden Plover	Mig (EPBC & BC Acts)		1		1					
	Thinornis rubricollis	Hooded Plover	P4 (DBCA list)	known	1							
	Vanellus tricolor	Banded Lapwing					32		•			
Scolopacidae	*Actitis hypoleucos*	Common Sandpiper	Mig (EPBC & BC Acts)	known	11		16					
	Calidris acuminata	Sharp-tailed Sandpiper	Mig (EPBC & BC Acts)	may	1		11					
	Calidris canutus	Red Knot	EN/Mig (EPBC & BC Acts)		1		1					
	Calidris melanotos	Pectoral Sandpiper	Mig (EPBC & BC Acts)	may								
	Calidris ruficollis	Red-necked Stint	Mig (EPBC & BC Acts)		4							
	Limosa lapponica	Bar-tailed Godwit	VU/Mig (EPBC & BC Acts)				2					
	Tringa glareola	Wood Sandpiper	Mig (EPBC & BC Acts)		4		14					
	Tringa nebularia	Common Greenshank	Mig (EPBC & BC Acts)	likely	14		13					
	Tringa stagnatilis	Marsh Sandpiper	Mig (EPBC & BC Acts)				1					
Turnicidae	*Turnix velox*	Little Button-quail					6					
Laridae	*Chlidonias hybrida*	Whiskered Tern					14					
	Chroicocephalus novaehollandiae	Silver Gull					8					
	Gelochelidon nilotica	Gull-billed Tern	Mig (EPBC & BC Acts)		1							
Cacatuidae	*Eolophus roseicapillus*	Galah				•	97	•	•	•	•	•
	Lophochroa leadbeateri	Major Mitchell's Cockatoo					2					
	Nymphicus hollandicus	Cockatiel				•	34	•			•	
Pstittaculidae	*Barnardius zonarius*	Australian Ringneck				•	77	•	•	•	•	•
	Melopsittacus undulatus	Budgerigar				•	44	•	•		•	

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	Neophema splendida	Scarlet-chested Parrot					3					
	Neopsephotus bourkii	Bourke's Parrot				•	28	•			•	
	Pezoporus occidentalis	Night Parrot	EN (EPBC Act), CR (BC Act)	may								
	Polytelis alexandrae	Princess Parrot	VU (EPBC Act), P4 (DBCA)	known	2		1					
	Psephotus varius	Mulga Parrot				•	44	•	•		•	•
Cuculidae	*Chrysococcyx basalis*	Horsfield's Bronze-Cuckoo				•	9	•			•	•
	Chrysococcyx osculans	Black-eared Cuckoo		known			5		•			
	Cacomantis flabelliformis	Fan-tailed Cuckoo							•			
	Cacomantis pallidus	Pallid Cuckoo				•	30					
Strigidae	*Ninox boobook*	Boobook Owl					6					
Tytonidae	*Tyto javanica*	Eastern Barn Owl					9					
Halcyonidae	*Todiramphus pyrrhopygius*	Red-backed Kingfisher				•	34					
	Todiramphus sanctus	Sacred Kingfisher					2					
Meropidae	*Merops ornatus*	Rainbow Bee-eater		may		•	11		•	•	•	
Climacteridae	*Climacteris affinis*	White-browed Treecreeper				•	8					
	Climacteris rufa	Rufous Treecreeper					3					
Ptilonorhynchidae	*Ptilonorhynchus maculatus guttatus*	Western Bowerbird				•	34		•	•	•	•
Maluridae	*Amytornis textilis*	Western Grasswren					1					
	Malurus assimilis (ex *lamberti*)	Purple-backed Fairy-wren					8	•	•	•		
	Malurus leucopterus leuconotus	White-winged Fairy-wren					27	•	•	•		

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	Malurus splendens	Splendid Fairy-wren				•	24		•		•	•
Acanthizidae	*Acanthiza apicalis*	Broad-tailed (Inland) Thornbill				•	31	•	•		•	
	Acanthiza chrysorrhoa	Yellow-rumped Thornbill				•	62	•		•	•	•
	Acanthiza iredalei	Slender-billed Thornbill							•	•		
	Acanthiza robustirostris	Slaty-backed Thornbill				•	14		•		•	
	Acanthiza uropygialis	Chestnut-rumped Thornbill				•	41	•	•	•	•	•
	Aphelocephala leucopsis	Southern Whiteface				•	43	•	•		•	
	Calamanthus campestris	Rufous Fieldwren					1					?
	Gerygone fusca	Western Gerygone					10			•		•
	Pyrrholaemus brunneus	Redthroat					6		•			•
	Smicrornis brevirostris	Weebill				•	19	•		•	•	•
Pardalotidae	*Pardalotus striatus*	Striated Pardalote				•	33	•	•			•
Meliphagidae	*Acanthagenys rufogularis*	Spiny-cheeked Honeyeater				•	116	•	•	•	•	•
	Anthochaera carunculata	Red Wattlebird							•			
	Certhionyx variegatus	Pied Honeyeater					14	•	•			
	Epthianura tricolor	Crimson Chat				•	52	•				
	Epthianura aurifrons	Orange Chat					20					
	Epthianura albifrons	White-fronted Chat					16					
	Gavicalis virescens	Singing Honeyeater				•	193	•	•	•	•	•
	Lacustroica whitei	Grey Honeyeater					1					
	Lichmera indistincta	Brown Honeyeater				•	22	•	•			•
	Manorina flavigula	Yellow-throated Miner				•	142	•	•	•	•	•

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	Ptilotula keartlandi	Grey-headed Honeyeater					1					
	Ptilotula penicillata	White-plumed Honeyeater				•	5					
	Ptilotula plumula	Grey-fronted Honeyeater					4	•				
	Purnella albifrons	White-fronted Honeyeater				•	32	•			•	
Pomatostomidae	*Pomatostomus superciliosus*	White-browed Babbler				•	30	•	•	•	•	•
Cinclosomatidae	*Cinclosoma clarum*	Copperback Quail-thrush					4					
	Cinclosoma marginatum	Western Quail-thrush				•	25				•	
Psophodidae	*Psophodes occidentalis*	Chiming Wedgebill					26					
Neosittidae	*Daphoenositta chrysoptera*	Varied Sitella					1					
Campephagidae	*Coracina maxima*	Ground Cuckoo-shrike				•	22	•				
	Coracina novaehollandiae	Black-faced Cuckoo-shrike				•	74	•	•	•	•	•
	Lalage tricolor	White-winged Triller				•	38	•	•	•	•	
Pachycephalidae	*Colluricincla harmonica*	Grey Shrike-thrush				•	40	•	•		•	•
	Oreoica gutturalis	Crested Bellbird				•	115	•	•	•	•	•
	Pachycephala occidentalis	Western Golden Whistler					1					
	Pachycephala rufiventris	Rufous Whistler				•	54	•	•	•	•	•
Artamidae	*Artamus cinereus*	Black-faced Woodswallow				•	111	•	•	•	•	
	Artamus minor	Little Woodswallow					2					•
	Artamus personatus	Masked Woodswallow				•	32	•	•		•	
Cracticidae	*Cracticus nigrogularis*	Pied Butcherbird				•	119	•	•	•	•	•
	Cracticus tibicen	Australian Magpie				•	94		•	•		•
	Cracticus torquatus	Grey Butcherbird				•	58	•	•	•	•	•

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	Strepera versicolor	Grey Currawong					20					•
Rhipiduridae	*Rhipidura albiscapa*	Grey Fantail					5					
	Rhipidura leucophrys	Willie Wagtail				•	134	•	•	•	•	•
Corvidae	*Corvus bennetti*	Little Crow				•	111	•	•	•		•
	Corvus coronoides	Australian Raven				•	7		•		•	
	Corvus orru	Torresian Crow				•	33					
Monarchidae	*Grallina cyanoleuca*	Magpie-Lark				•	151		•	•	•	
Petroicidae	*Melanodryas cucullata*	Hooded Robin					37	•				•
	Microeca fascinans	Jacky Winter				•	4	•			•	
	Petroica goodenovii	Red-capped Robin				•	90	•	•	•	•	•
Megaluridae	*Cincloramphus cruralis*	Brown Songlark				•	29					
	Cincloramphus mathewsi	Rufous Songlark					22					
Hirundinidae	*Cheramoeca leucosterna*	White-backed Swallow				•	41					
	Hirundo neoxena	Welcome Swallow				•	111		•			
	Petrochelidon ariel	Fairy Martin					26					
	Petrochelidon nigricans	Tree Martin				•	51				•	
Nectariniidae	*Dicaeum hirundinaceum*	Mistletoebird				•	9	•				
Estrildidae	*Emblema pictum*	Painted Finch					3					
	Taeniopygia guttata	Zebra Finch				•	133	•	•	•	•	
Motacillidae	*Anthus australis*	Australasian Pipit				•	118	•	•	•	•	
	Motacilla cinerea	Grey Wagtail	Mig. (EPBC & BC Acts)	may								

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	Motacilla flava	Yellow Wagtail	Mig. (EPBC & BC Acts)	may								
Mammals (39)												
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked Echidna						•	•	•		•
Dasyuridae	*Dasyurus geoffroii*	Chuditch	VU (EPBC & BC Acts)	may								•
	Ningaui ridei	Wongai Ningaui				•	1	•			•	
	Sminthopsis crassicaudata	Fat-tailed Dunnart					10	•				
	Sminthopsis dolichura	Little Long-tailed Dunnart				•			•		•	
	Sminthopsis hirtipes	Hairy-footed Dunnart						•				
	Sminthopsis longicaudata	Long-tailed Dunnart	P4 (DBCA list)		12					•		
	Sminthopsis macroura	Stripe-faced Dunnart				•	1	•			•	
	Sminthopsis ooldea	Ooldea Dunnart					1	•				
Potoroidae	*Bettongia lesueur graii*	Burrowing Bettong, Boodie	EX (EPBC & BC Acts)						•	•		•
Macropodidae	*Osphranter robustus*	Euro, Biggada				•	1	•	•	•	•	•
	Osphranter rufus	Red Kangaroo, Marlu				•	1	•	•	•	•	•
Phalangeridae	*Trichosurus vulpecula*	Common Brushtail Possum	(range extension)									•
Emballonuridae	*Taphozous hilli*	Hill's Sheathtail-bat				•			•		•	•
Molossidae	*Ozimops petersi*	Inland Free-tailed Bat				•		•			•	•
	Austronomus australis	White-striped Freetail-bat				•	1	•	•		•	•
Vespertilionidae	*Chalinolobus gouldii*	Gould's Wattled Bat				•	2	•	•	•	•	•
	Chalinolobus morio	Chocolate Wattled Bat							•			
	Nyctophilus geoffroyi	Lesser Long-eared Bat				•	3	•	•		•	•

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	Scotorepens balstoni	Inland Broad-nosed Bat				•	5	•	•		•	•
	Vespadelus baverstocki	Inland Forest Bat				•			•		•	
	Vespadelus finlaysoni	Finlayson's Cave Bat				•			•		•	•
	Vespadelus regulus	Southern Forest Bat							•			
Muridae	*Leporillus apicalis*	Lesser Stick-nest Rat	EX (EPBC & BC Acts)						?	?		•
	Leporillus conditor	Greater Stick-nest Rat	VU (EPBC Act), CD (BC Acts)						?	?		
	**Mus musculus*	House Mouse		likely			16	•	•	•		
	Notomys alexis	Spinifex Hopping-mouse						•				
	Pseudomys hermannsburgensis	Sandy Inland Mouse				•	15	•	•		•	
Leporidae	**Oryctolagus cuniculus*	Rabbit		likely		•		•	•	•	•	•
Camelidae	**Camelus dromedarius*	Camel, Dromedary		likely			1	•				•
Bovidae	**Bos taurus*	Domestic Cattle							•	•		•
	**Capra hircus*	Goat		likely					•	•		•
Suidae	**Sus scrofa*	Pig					1					
Equidae	**Equus asinus*	Donkey		likely						•		•
	**Equus caballus*	Horse							•			
Canidae	**Canis familiaris*	Dog/Dingo		likely			8		•	•		•
	**Vulpes vulpes*	Red Fox		likely				•				
Felidae	**Felis catus*	Domestic Cat		likely				•	•	•		•

Appendix 1 Short-range endemic invertebrate desktop results

Higher taxon, family	Species	Latitude	Longitude	SRE category	Proximity to study area	Habitat records
Class Arachnida, infraorder Mygalomorphae (trapdoor spiders)						
Actinopodidae (mouse spiders)	Missulena `sp. indet.`	-27.917	120.700	Uncertain	99.17	
	Missulena `sp. indet.`	-28.883	121.333	Uncertain	39.25	
	Missulena `sp. indet.`	-28.813	122.145	Uncertain	63.80	
	Missulena `sp. indet.`	-29.333	121.483	Uncertain	83.57	
	Missulena `sp. indet.`	-28.617	122.383	Uncertain	80.37	under bin
Anamidae	`Teyl?` `sp. indet.`	-28.811	122.146	Uncertain	63.81	
	`Teyl?` `sp. indet.`	-27.801	121.668	Uncertain	66.07	mallee, mulga/Triodia
	`Teyl?` `sp. indet.`	-28.811	122.146	Uncertain	63.81	
	`Teyl?` `sp. indet.`	-27.801	121.668	Uncertain	66.08	mallee, mulga/Triodia
	Aname `glenorn sp. 2`	-29.051	121.809	Potential	58.03	
	Aname `glenorn sp. 2`	-29.051	121.809	Potential	58.04	
	Aname `Goldfields sp. 1`	-27.783	121.650	Potential	67.81	
	Aname `Goldfields sp. 1`	-27.783	121.650	Potential	67.81	
	Aname `Goldfields sp. 1`	-27.783	121.650	Potential	67.81	
	Aname `Goldfields sp. 1`	-27.783	121.650	Potential	67.81	dune Triodia
	Aname `Goldfields sp. 1`	-27.801	121.668	Potential	66.08	mulga/Triodia

Higher taxon, family	Species	Latitude	Longitude	SRE category	Proximity to study area	Habitat records
	Aname `Goldfields sp. 2`	-27.801	121.668	Potential	66.08	mallee, mulga/Triodia
	Aname `mellosa group?`	-28.617	122.433	Potential	85.23	
	Aname `mellosa group?`	-29.200	121.467	Potential	68.99	
	Aname `mellosa group?`	-28.617	122.433	Potential	85.23	
	Aname `mellosa group?`	-28.617	122.433	Potential	85.23	
	Aname `mellosa group?`	-28.833	121.917	Potential	45.69	
	Aname `mellosa group?`	-28.833	121.917	Potential	45.69	
	Aname `mellosa group?`	-28.833	121.917	Potential	45.69	
	Aname `mellosa group?`	-28.617	122.433	Potential	85.23	
	Aname `MYG216`	-27.905	122.383	Potential	96.76	
	Aname `MYG216`	-27.902	122.379	Potential	96.65	
	Aname `MYG216`	-27.905	122.383	Potential	96.76	
	Aname `MYG216`	-27.905	122.383	Potential	96.76	
	Aname `MYG216`	-28.430	121.140	Potential	40.16	
	Aname `MYG216`	-27.901	122.371	Potential	96.02	
	Aname `MYG216`	-27.869	122.341	Potential	95.74	

Higher taxon, family	Species	Latitude	Longitude	SRE category	Proximity to study area	Habitat records
	Aname \`Phoenix0055\`	-28.935	121.803	Potential	46.54	acacia shrubland on calcrete undulating plain
	Aname \`Phoenix0055\`	-28.935	121.803	Potential	46.54	acacia shrubland on calcrete undulating plain
	Aname \`Phoenix0055\`	-28.935	121.803	Potential	46.54	acacia shrubland on calcrete undulating plain
	Aname \`Phoenix0055\`	-28.935	121.803	Potential	46.54	acacia shrubland on calcrete undulating plain
	Aname \`Phoenix0056\`	-28.971	121.745	Potential	47.42	acacia shrubland
	Aname \`Phoenix0058\`	-28.965	121.782	Potential	48.41	calcrete hill slope with mulga
	Aname \`Phoenix0058\`	-28.965	121.782	Potential	48.41	calcrete hill slope with mulga
	Aname \`river wishbone group\`	-27.783	121.650	Potential	67.81	dune Triodia
	Aname \`river wishbone group\`	-27.783	121.650	Potential	67.81	dune Triodia

Higher taxon, family	Species	Latitude	Longitude	SRE category	Proximity to study area	Habitat records
	Aname `sp. indet. (?MYG216)`	-27.901	122.371	Uncertain	96.02	
	Aname `sp. indet.`	-29.258	122.404	Uncertain	112.36	mulga/lignum
	Aname `sp. indet.`	-28.578	121.543	Uncertain	0.00	
	Aname `sp. indet.`	-29.265	122.410	Uncertain	113.28	
	Aname `sp. indet.`	-27.783	121.650	Uncertain	67.81	dune Triodia
	Aname `sp. indet.`	-27.797	121.651	Uncertain	66.30	samphire
	Aname `sp. indet.`	-28.578	121.543	Uncertain	0.00	
	Aname `sp. indet.`	-28.859	122.511	Uncertain	98.94	mulga woodland
	Aname `sp. indet.`	-28.811	122.146	Uncertain	63.81	
	Aname `sp. indet.`	-28.813	122.145	Uncertain	63.80	
	Aname `sp. indet.`	-28.814	122.147	Uncertain	64.03	
	Aname `sp. indet.`	-28.811	122.146	Uncertain	63.81	
	Aname `sp. indet.`	-28.813	122.145	Uncertain	63.80	
	Aname `sp. indet.`	-28.813	122.145	Uncertain	63.80	
	Aname `sp. with chevrons`	-27.800	122.317	Uncertain	98.78	
	Anamidae `sp. indet.`	-29.382	122.468	Uncertain	126.26	mulga/shrubs
	Anamidae `sp. indet.`	-29.382	122.468	Uncertain	126.26	mulga/shrubs
	Anamidae `sp. indet.`	-29.258	122.404	Uncertain	112.36	mulga/lignum
	Anamidae `sp. indet.`	-28.792	121.834	Uncertain	36.52	mulga woodland

Higher taxon, family	Species	Latitude	Longitude	SRE category	Proximity to study area	Habitat records
	Anamidae `sp. indet.`	-28.792	121.834	Uncertain	36.52	mulga woodland
	Kwonkan `MYG719`	-28.806	121.900	Potential	42.54	open mulga woodland
	Kwonkan `MYG719`	-28.806	121.900	Potential	42.54	open mulga woodland
	Kwonkan `sp. indet.`	-29.382	122.468	Uncertain	126.26	mulga/shrubs
	Kwonkan `sp. indet.`	-27.797	121.651	Uncertain	66.30	
	Kwonkan goongarriensis	-29.183	121.467	Potential	67.15	
	Proshermacha `MYG504`	-28.813	122.145	Potential	63.81	
	Proshermacha `sp. indet.`	-27.800	122.317	Uncertain	98.78	
	Proshermacha `sp. indet.`	-28.811	122.146	Uncertain	63.81	
	Teyl `MYG444`	-28.811	122.146	Potential	63.81	
	Teyl `MYG444`	-28.811	122.146	Potential	63.81	
Barychelidae	Barychelidae `sp. indet.`	-29.079	121.808	Uncertain	60.80	
	Idiommata `sp. indet.`	-28.811	122.146	Uncertain	63.81	
	Idiommata `sp. indet.`	-28.743	121.565	Uncertain	18.04	
	Trittame `sp. indet.`	-28.450	121.160	Uncertain	38.33	
Euagridae	Cethegus `sp. indet.`	-27.921	120.691	Uncertain	99.69	on ground in silk with dirt
	Cethegus `sp. indet.`	-27.800	121.650	Uncertain	65.97	samphire

Higher taxon, family	Species	Latitude	Longitude	SRE category	Proximity to study area	Habitat records
Halonoproctidae	Conothele `Phoenix0057`	-28.735	121.870	Potential	35.91	mulga woodland in low drainage area
	Conothele `sp. indet.`	-28.617	122.367	Uncertain	78.76	
Idiopidae	Eucyrtops `sp. indet.`	-29.400	122.467	Uncertain	127.58	mallee, mulga/Triodia
	Eucyrtops `sp. indet.`	-27.905	122.374	Uncertain	96.10	
	Euoplos `sp. indet.`	-28.811	122.146	Uncertain	63.81	
	Euoplos `sp. indet.`	-28.812	122.144	Uncertain	63.72	
	Euoplos `sp. indet.`	-28.811	122.146	Uncertain	63.81	
	Euoplos `sp. indet.`	-28.811	122.146	Uncertain	63.81	
	Euoplos `sp. indet.`	-28.812	122.144	Uncertain	63.72	
	Euoplos `sp. indet.`	-28.814	122.145	Uncertain	63.90	
	Euoplos `sp. indet.`	-28.812	122.145	Uncertain	63.82	
	Euoplos `sp. indet.`	-28.817	122.144	Uncertain	63.96	
	Euoplos `WAM T110336`	-28.806	121.900	Potential	42.54	open mulga woodland
	Euoplos `WAM T110336`	-28.806	121.900	Potential	42.54	open mulga woodland
	Euoplos `WAM T110336`	-28.735	121.870	Potential	35.91	mulga woodland in low drainage area

Higher taxon, family	Species	Latitude	Longitude	SRE category	Proximity to study area	Habitat records
	Euoplos `WAM T110336`	-28.726	121.887	Potential	36.89	mulga woodland
	Euoplos `WAM T110336`	-28.735	121.870	Potential	35.91	mulga woodland in low drainage area
	Idiosoma `MYG014`	-28.947	121.791	Potential	47.10	mulga woodland at base of hill slope
	Idiosoma `MYG017`	-28.802	122.433	Potential	89.62	
	Idiosoma `occidentalis sp. group`	-29.083	121.667	Uncertain	56.93	
	Idiosoma `occidentalis sp. group`	-29.083	121.667	Uncertain	56.93	
	Idiosoma `occidentalis sp. group`	-29.083	121.667	Uncertain	56.93	
	Idiosoma `sp. indet.`	-29.383	122.467	Uncertain	126.27	mulga/shrubs
	Idiosoma `sp. indet.`	-29.088	122.439	Uncertain	103.61	
	Idiosoma `sp. indet.`	-28.383	122.183	Uncertain	60.05	
	Idiosoma `sp. indet.`	-29.383	122.467	Uncertain	126.27	mulga/shrubs
	Idiosoma `sp. indet.`	-28.812	122.144	Uncertain	63.72	
	Idiosoma `sp. indet.`	-28.883	122.510	Uncertain	99.79	mulga woodland
	Idiosoma `sp. indet.`	-28.813	122.146	Uncertain	63.89	
	Idiosoma `sp. indet.`	-28.813	122.146	Uncertain	63.89	

Higher taxon, family	Species	Latitude	Longitude	SRE category	Proximity to study area	Habitat records
	Idiosoma `sp. indet.`	-28.864	122.512	Uncertain	99.16	mulga woodland
	Idiosoma `sp. indet.`	-28.578	121.543	Uncertain	0.00	
	Idiosoma `sp. indet.`	-28.578	121.543	Uncertain	0.00	
	Idiosoma `sp. indet.`	-29.088	122.439	Uncertain	103.61	
	Idiosoma `sp. indet.`	-28.882	122.511	Uncertain	99.82	mulga woodland
	Idiosoma `sp. indet.`	-28.814	122.147	Uncertain	64.06	
	Idiosoma `sp. indet.`	-28.813	122.147	Uncertain	63.98	
	Idiosoma `sp. indet.`	-28.875	122.512	Uncertain	99.64	mulga woodland
	Idiosoma `sp. indet.`	-28.818	122.145	Uncertain	64.04	
Theraphosidae	Selenocosmia `sp. indet.`	-29.382	122.468	Uncertain	126.26	mulga/shrubs
	Selenocosmia `sp. indet.`	-28.633	122.400	Uncertain	82.21	
	Selenocosmia `wacarina`	-28.633	122.400	Potential	82.21	
	Selenocosmia `wacarina`	-27.783	121.650	Potential	67.81	
Class Arachnida, order Pseudoscorpions						
Atemnidae	Atemnidae `sp. indet.`	-28.946	121.733	Uncertain	44.34	dense mulga woodland in drainage
Chernetidae	`PSEAAF` `sp. indet.`	-27.889	122.397	Uncertain	98.88	under bark
	Chernetidae `sp. indet.`	-28.882	121.806	Uncertain	41.87	mulga woodland at top of mesa
	Chernetidae `sp. indet.`	-28.801	121.598	Uncertain	24.91	

Higher taxon, family	Species	Latitude	Longitude	SRE category	Proximity to study area	Habitat records
	Nesidiochernes `sp. indet.`	-28.936	121.784	Uncertain	45.74	mixed acacia woodland
Garypidae	Synsphyronus `PSE115`	-27.900	122.377	Potential	96.60	under bark
	Synsphyronus `PSE115`	-27.889	122.397	Potential	98.88	under bark
	Synsphyronus `PSE115`	-27.889	122.397	Potential	98.88	under bark
	Synsphyronus `PSE115`	-27.889	122.397	Potential	98.88	under bark
Olpiidae	Austrohorus `sp. indet.`	-28.914	121.429	Uncertain	38.56	
	Austrohorus `sp. indet.`	-28.699	120.901	Uncertain	63.99	
	Beierolpium `sp. 8/2`	-27.900	122.377	Potential	96.60	under bark
	Beierolpium `sp. 8/2`	-27.877	122.351	Potential	96.03	under bark
	Beierolpium `sp. 8/3`	-28.914	121.429	Potential	38.56	
	Euryolpium `sp. indet.`	-28.947	121.791	Uncertain	47.10	mulga woodland at base of hill slope
	Euryolpium `sp. indet.`	-28.936	121.784	Uncertain	45.74	mixed acacia woodland
	Indolpium `sp. indet.`	-28.836	121.848	Uncertain	40.85	mulga woodland
	Indolpium `sp. indet.`	-28.792	121.834	Uncertain	36.52	mulga woodland
	Indolpium `sp. indet.`	-28.861	121.791	Uncertain	39.11	
	Olpiidae `sp. indet.`	-28.914	121.429	Uncertain	38.56	
	Olpiidae `sp. indet.`	-28.914	121.429	Uncertain	38.56	

Higher taxon, family	Species	Latitude	Longitude	SRE category	Proximity to study area	Habitat records
	Olpiidae \`sp. indet.\`	-29.300	122.417	Uncertain	116.38	
	Olpiidae \`sp. indet.\`	-28.743	121.565	Uncertain	18.04	
Class Arachnida, order Scorpiones						
Bothriuridae	Cercophonius \`sp. indet.\`	-28.712	120.891	Uncertain	65.19	
Buthidae	Isometroides \`MM1\`	-28.946	121.733	Potential	44.34	dense mulga woodland in drainage
	Isometroides \`MM1\`	-28.726	121.887	Potential	36.89	mulga woodland
	Isometroides \`sp. indet.\`	-28.817	122.433	Uncertain	90.17	
	Isometroides \`sp. indet.\`	-28.430	121.140	Uncertain	40.16	
	Isometroides \`sp. indet.\`	-27.877	122.349	Uncertain	95.91	
	Isometroides \`sp. indet.\`	-27.918	122.360	Uncertain	94.11	
	Isometroides \`sp. indet.\`	-28.860	121.804	Uncertain	39.84	
	Isometroides \`sp. indet.\`	-28.677	121.536	Uncertain	10.67	
	Lychas \`cf. jonesae\`	-28.806	121.900	Potential	42.54	open mulga woodland
	Lychas \`cf. jonesae\`	-28.806	121.900	Potential	42.54	open mulga woodland
	Lychas \`cf. jonesae\`	-28.935	121.803	Potential	46.54	acacia shrubland on calcrete undulating plain

Higher taxon, family	Species	Latitude	Longitude	SRE category	Proximity to study area	Habitat records
	Lychas `cf. jonesae`	-28.946	121.733	Potential	44.34	dense mulga woodland in drainage
	Lychas `cf. jonesae`	-28.883	121.811	Potential	42.28	side of breakaway with scattered mulga
	Lychas `cf. jonesae`	-28.836	121.848	Potential	40.85	mulga woodland
	Lychas `cf. jonesae`	-28.883	121.811	Potential	42.28	side of breakaway with scattered mulga
	Lychas `cf. jonesae`	-28.883	121.811	Potential	42.28	side of breakaway with scattered mulga
	Lychas `cf. jonesae`	-28.971	121.745	Potential	47.42	acacia shrubland
	Lychas `cf. jonesae`	-28.726	121.887	Potential	36.89	mulga woodland
	Lychas `cf. jonesae`	-28.726	121.887	Potential	36.89	mulga woodland
	Lychas `cf. jonesae`	-28.836	121.848	Potential	40.85	mulga woodland
	Lychas `cf. jonesae`	-28.836	121.848	Potential	40.85	mulga woodland
	Lychas `cf. jonesae`	-28.735	121.870	Potential	35.91	mulga woodland in low drainage area

Higher taxon, family	Species	Latitude	Longitude	SRE category	Proximity to study area	Habitat records
	Lychas `cf. jonesae`	-28.735	121.870	Potential	35.91	mulga woodland in low drainage area
	Lychas `cf. jonesae`	-28.726	121.887	Potential	36.89	mulga woodland
	Lychas `cf. jonesae`	-28.735	121.870	Potential	35.91	mulga woodland in low drainage area
	Lychas `pilbara 1`	-28.819	122.434	Potential	90.30	
	Lychas `sp. indet.`	-27.869	122.377	Uncertain	98.59	
	Lychas `sp. indet.`	-27.905	122.383	Uncertain	96.76	
	Lychas `sp. indet.`	-29.056	121.809	Uncertain	58.60	
	Lychas `sp. indet.`	-27.869	122.393	Uncertain	99.85	
	Lychas `sp. indet.`	-27.905	122.374	Uncertain	96.10	
	Lychas `sp. indet.`	-27.877	122.349	Uncertain	95.91	
	Lychas `sp. indet.`	-27.902	122.379	Uncertain	96.65	
	Lychas `sp. indet.`	-27.905	122.374	Uncertain	96.10	
	Lychas `sp. indet.`	-29.088	121.808	Uncertain	61.72	
	Lychas `sp. indet.`	-27.920	122.336	Uncertain	91.99	
	Lychas `sp. indet.`	-28.817	122.433	Uncertain	90.17	
	Lychas `sp. indet.`	-27.890	122.353	Uncertain	95.29	
	Lychas `sp. indet.`	-27.920	122.338	Uncertain	92.16	
	Lychas `sp. indet.`	-28.430	121.140	Uncertain	40.16	

Higher taxon, family	Species	Latitude	Longitude	SRE category	Proximity to study area	Habitat records
	Lychas `sp. indet.`	-28.450	121.160	Uncertain	38.33	
Urodacidae	Urodacus `GD`	-28.799	122.434	Potential	89.54	
	Urodacus `GD`	-28.799	122.434	Potential	89.54	
	Urodacus `gibson 1?`	-29.088	121.808	Potential	61.72	
	Urodacus `sp. indet.`	-28.833	121.833	Uncertain	39.57	mulga
	Urodacus `sp. indet.`	-28.872	122.521	Uncertain	100.30	mulga woodland
	Urodacus `sp. indet.`	-28.633	122.400	Uncertain	82.21	
	Urodacus `sp. indet.`	-28.633	122.400	Uncertain	82.21	
	Urodacus `sp. indet.`	-28.861	121.800	Uncertain	39.69	
	Urodacus `sp. indet.`	-28.799	122.434	Uncertain	89.54	
	Urodacus `sp. indet.`	-29.079	121.811	Uncertain	60.90	
	Urodacus `sp. indet.`	-28.667	120.967	Uncertain	56.94	under table on patio nr garden bed
	Urodacus `yeelirrie?`	-29.078	121.816	Uncertain	61.02	
	Urodacus `yeelirrie?`	-29.069	121.806	Uncertain	59.77	
Class Chilopoda, order Geophilda						
Chilenophilidae	Chilenophilidae `sp. indet.`	-28.647	121.542	Uncertain	7.26	
Mecistocephalidae	Mecistocephalidae `sp. indet.`	-28.965	121.782	Uncertain	48.41	calcrete hill slope with mulga
Class Chilopoda, order Scutigerida						
Scutigeridae	Pilbarascutigera `sp. indet.`	-28.785	121.610	Uncertain	23.52	
Class Diplopoda, order Polydemida						

Higher taxon, family	Species	Latitude	Longitude	SRE category	Proximity to study area	Habitat records
Paradoxosomatidae	Antichiropus \`sp. indet.\`	-29.383	121.367	Uncertain	90.55	
	Antichiropus \`sp. indet.\`	-28.578	121.543	Uncertain	0.00	
Class Gastropoda, order Littorinimorpha						
Bithyniidae	Gabbia cf. kendricki	-28.016	121.008	Potential	67.98	
Class Gastropoda, order Stylommatophora						
Succineidae	Succinea sp.	-28.840	122.418	Uncertain	89.68	
	Succinea sp.	-28.938	121.416	Uncertain	41.41	
	Succinea sp.	-28.824	122.434	Uncertain	90.49	

APPENDIX 5: SUBTERRANEAN FAUNA ASSESSMENT FOR THE REDCLIFFE GOLD PROJECT (PHOENIX 2021B)

PHOENIX
ENVIRONMENTAL SCIENCES

Subterranean fauna assessment for the Redcliffe Gold Project

Prepared for Dacian Gold Limited

December 2021

Final

Subterranean fauna assessment for the Redcliffe Gold Project
Prepared for Dacian Gold Limited

Version history

Author/s	Reviewer/s	Version	Version number	Date submitted	Submitted to
C. Nagle	A. Jacks	Draft for client comments	0.1	14-Dec-21	P. Dunstan
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EXECUTIVE SUMMARY

Dacian Gold Limited (Dacian) is seeking to develop the Redcliffe Gold Project (the Project), located 45-60 km northeast of Leonora, Western Australia, comprising 1,730.6 ha on tenements M37/1286 (Nambi), M37/1348 (Hub) and M37/1276 (GTS). Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Dacian to undertake a Pilot subterranean fauna survey for the Project (27 – 30 September 2021). The purpose of the survey was to support the submission of a Mining Proposal by determining if stygofauna and/or troglofauna are likely to be present in the study area. Given that the Project aims to develop three separate deposits, and there is a possibility that these deposits may be located within unconnected aquifers, it was proposed that each deposit is treated as an individual impact area.

A Level 2 stygofauna survey was previously conducted for the Project in the Golden Terrace North and 727 prospects, with a total of 287 samples taken from 25 uncased bores over two seasons (Phoenix 2010). These surveys overlapped with the southern portion of current study area. Two copepod species of the *Metacyclops* genera were recorded and were considered to be widespread over the study area and region in general. It was determined that they study area for these surveys was unlikely to contain calcrete aquifers that can restrict distributions and increase conservation significance.

Searches of relevant databases and reports identified records of 34 stygofauna taxa and 17 troglofauna taxa. Of the stygofauna taxa, none are confirmed SRE and 25 are potential SREs. A further five stygofauna taxa of uncertain SRE status and four widespread taxa were identified. The stygofauna records included the *Metacyclops* sp. recorded in the Level 2 survey previously conducted in the study area. Of the troglofauna taxa, 11 were potential SREs and the remaining six taxa were all of uncertain SRE status.

A total of 26 locations were sampled for stygofauna. Of these, ten samples were taken from Nambi, ten from Hub and six from GTS. There was not a sufficient number of suitable bores at GTS to allow for sampling of ten bores. However, together with the previous surveys conducted at GTS, sampling effort for the entire study meets EPA guidelines for a Pilot study.

The stygofauna survey was conducted using stygofauna net hauls with six hauls per bore completed however, obstructions such as tree roots or partial bore collapse prevented the recommended six hauls being conducted at a small number of bores. One sample was taken using the Karaman-Chappuis method. Water quality samples were taken and analysed at each sample site.

A total of 28 specimens from seven distinct stygofauna taxa were collected during the field survey. Of these, five are widespread species, also known from surface water habitats (stygophiles) and two are previously unknown species that are considered potential SREs:

- Parabathynellidae 'Phoenix0076'
    - A new species that has only been recorded from Hub. Based on the habitat from which it was collected, this species is thought to be a stygophile. However, it is considered a potential SRE as its ecotype and distribution remain unconfirmed.
- *Australoeucyclops* `BCY089`
    - A new species that has only been recorded from Nambi. Identified as a stygophile (not dependent of subterranean environments) as it was collected from the interstitial environment using the Karaman-Chappuis method. Not considered to be an SRE.

One unidentifiable copepod specimen (juvenile) was also collected that may represent one of the other identified taxa recorded or a different taxa.

A total of five distinct species, and one unidentifiable species were collected Nambi, one species was collected from Hub and one species from GTS. There was no overlap in the taxa recorded between the three deposit areas.

One species of troglofauna, *Paraplatyarthrus crebonisscus* (an isopod), was incidentally caught from Nambi during the stygofauna survey. *Paraplatyarthrus crebonisscus* is known from several records ranging from approximately 80 km north to 60 km east of Nambi, with a total linear range of over 100 km. It is a troglophile, inhabiting both surface and subterranean habitats.

The water quality results indicate that the physico-chemical properties of the water within the study area are suitable for subterranean fauna. As such, the absence of stygobitic and troglobitic fauna (fauna dependant on subterranean environments) in any particular area is likely the result of the paucity of suitable geology and/or hydrology.

The geology of the study area is primarily low permeability clays that are considered unsuitable subterranean fauna habitat. No detailed hydrological mapping was available for the Project at the time of writing, however, broadscale hydrogeological mapping indicates that the study area intersects two aquifer types:

- fractured and deeply weather rocks – local aquifers, minor groundwater resources, locally large supplies from fracture zones and permeable horizons in weathering profile
- surficial deposits – local aquifers, minor to major groundwater resources.

The results from the survey clearly indicate the study area supports a community of fauna that is not dependant of subterranean environments (ie. stygophiles and troglophiles, which have the ability to inhabit the subterranean environment (where suitable) and surface water habitats). It is therefore considered unlikely that the Redcliffe Gold Project hosts significant subterranean fauna values. No further surveys are recommended.

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1 INTRODUCTION

Dacian Gold Limited (Dacian) is seeking to develop the Redcliffe Gold Project (the Project), located 45 – 60 km northeast of Leonora, Western Australia (WA; Figure 1-1). The initial stages of the Project development comprise the following deposits:

- Nambi deposit – situated on M37/1286
- Hub deposit – situated on M37/1348
- Gold Terrace South (GTS) deposit – situated on M37/1276.

Dacian proposes to the develop Nambi, Hub and GTS mining areas as one Mining Proposal (MP).

In August 2021, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Dacian to undertake a subterranean fauna assessment for the Project. The purpose of the survey was to support the submission of the MP by determining if stygofauna and/or troglofauna are likely to be present in the study area. The study area is located in the Shire of Leonora and the Eremean Botanical Province as defined by EPA (2016b).

1.1 BACKGROUND

A Level 2 stygofauna survey was previously conducted for the Project in the Golden Terrace North and 727 prospects, with a total of 287 samples taken from 25 uncased bores over two seasons (Figure 1-1) (Phoenix 2010). The study area for these previous surveys overlaps with GTS, which forms the southern part of the current study area.

These surveys recorded two copepod species of the *Metacyclops* genera, which were considered to be widespread over the study area and region in general. It was determined that the study area for these surveys was unlikely to contain calcrete aquifers that can restrict distributions and increase conservation significance.

Given that an extensive stygofauna survey was previously conducted in the area which did not detect any restricted species or habitat likely to support restricted species (Phoenix 2010), Phoenix proposed to undertake a Pilot stygofauna survey for the Project. According to current EPA guidance (EPA 2016d), it is expected that six to ten stygofauna samples are collected from the impact areas as part of a Pilot survey. This approach is consistent with the Draft Technical Guidance - Subterranean Fauna Survey for EIA (EPA 2021).

Satellite imagery indicated that there are multiple drainage systems crossing the Project area. It was considered that if stygofauna were present, each drainage system has the potential to support separate assemblages. Given that the Project aims to develop three separate deposits, and there is a possibility that these deposits are associated with discrete aquifers, it was proposed that each deposit is treated as an individual impact area. As such, Phoenix proposed to sample up to ten bores/drill holes per deposit (up to 30 bores in total) to ensure adequate coverage.

1.2 SCOPE OF WORK

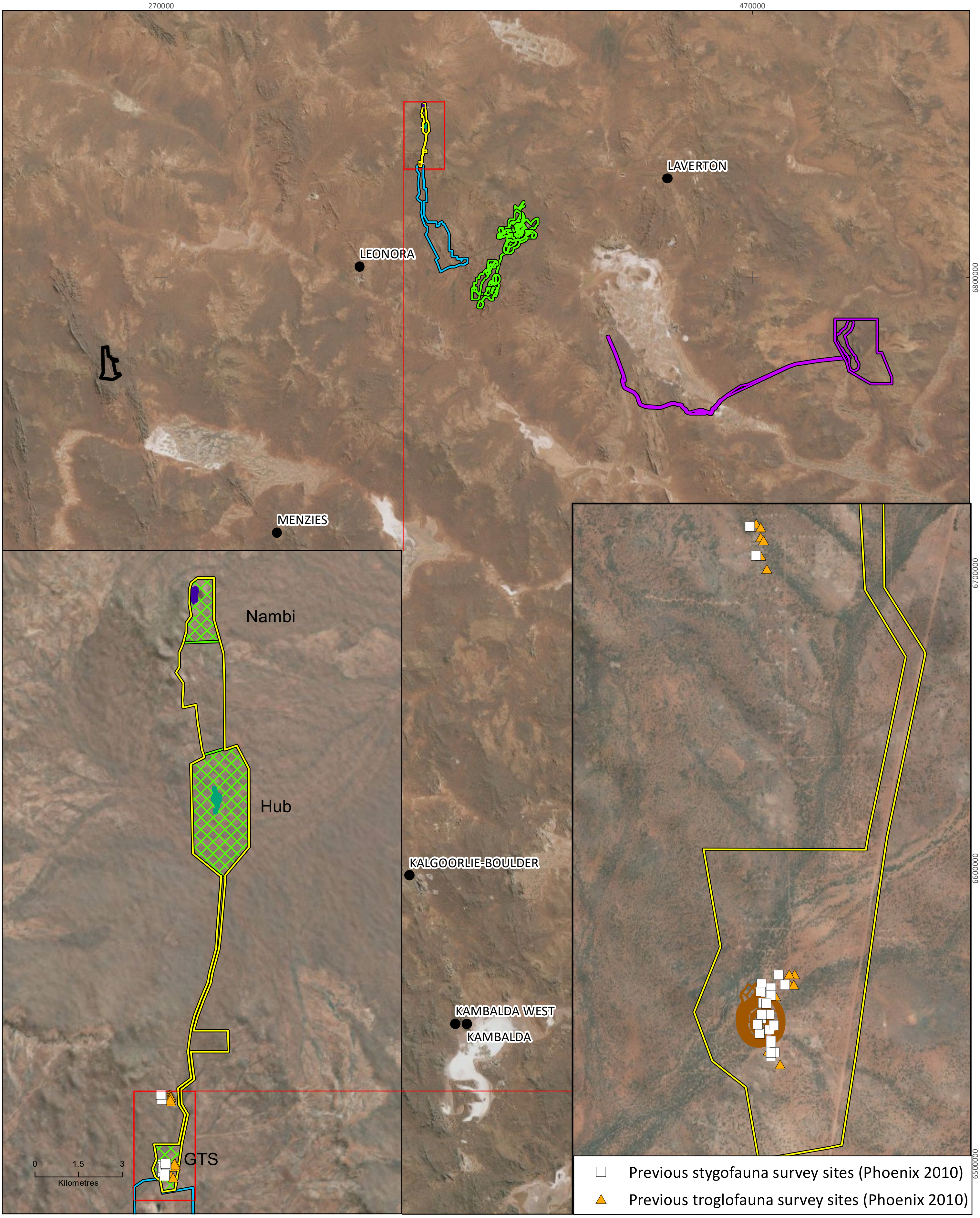
The scope of work for the subterranean fauna assessment was as follows:

- completion of desktop review, including a review of known Threatened and Priority Ecological Communities (TEC/PECS), groundwater aquifers (particularly calcrete), database searches, literature review of survey reports in the vicinity and relevant results
- undertake a Pilot stygofauna survey of the study area to expected EPA standards (EPA 2016d)

- troglofauna habitat assessment to determine likelihood of occurrence within the study area
- production of a report and associated maps suitable for use to support environmental approval applications
- creation of GIS to support the survey results and report
- provision of IBSA standard GIS data.

1.3 STUDY AREA

The study area is approximately 1,730.5 ha in area, and extends 21.25 km north-south, is less than 2 km in width, and envelopes historic mining areas (Figure 1-1). This report specifically focuses on the three deposit areas, Nambi (183.6 ha), Hub (736.6 ha) and GTS (121.9 ha), which form a portion of the total study area.



Dacian Gold Ltd
Redcliffe Gold Project

Project No	1441-RGP-DGL-SUB
Date	14-Dec-21
Drawn by	IN
Map author	CN

0 25 50
Kilometers

1:1,651,933(at A4) GDA 1994 MGA Zone 51

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Study area
Deposit areas
Murrin Murrin study area
Irwin Hills study area
Mt Ida study area
Leonora Gold Project study area

Proposed pits
GTS pit
Hub pit
Nambi pit

Figure 1-1

Project location and study area

PHOENIX
ENVIRONMENTAL SCIENCES

2 LEGISLATIVE CONTEXT

The protection of flora and fauna in WA is principally governed by three acts:

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- State *Biodiversity Conservation Act 2016* (BC Act)
- State *Environmental Protection Act 1986* (EP Act).

The BC Act came into full effect on 1 January 2019 and replaced the functions of the *Wildlife Conservation Act 1950* (WC Act).

2.1 COMMONWEALTH

The EPBC Act is administered by the Federal Department of Agriculture, Water and the Environment (DAWE). The EPBC Act provides for the listing of Threatened fauna and TECs as matters of National Environmental Significance (NES). Under the EPBC Act, actions that have, or are likely to have, a significant impact on a matter of NES, require approval from the Australian Government Minister for the Environment through a formal referral process.

Conservation categories applicable to Threatened fauna species under the EPBC Act are as follows:

- Extinct (EX)[1] – there is no reasonable doubt that the last individual has died
- Extinct in the Wild (EW) – taxa known to survive only in captivity
- Critically Endangered (CR) – taxa facing an extremely high risk of extinction in the wild in the immediate future
- Endangered (EN) – taxa facing a very high risk of extinction in the wild in the near future
- Vulnerable (VU) – taxa facing a high risk of extinction in the wild in the medium term
- Conservation Dependent (CD)[1] – taxa whose survival depends upon ongoing conservation measures; without these measures, a conservation dependent taxon would be classified as Vulnerable, Endangered or Critically Endangered.

Ecological communities are defined as 'naturally occurring biological assemblages that occur in a particular type of habitat' (English & Blyth 1997). There are three categories under which ecological communities can be listed as TECs under the EPBC Act: Critically Endangered, Endangered and Vulnerable.

2.2 STATE

2.2.1 Threatened and Priority species

In WA, the BC Act provides for the listing of Threatened fauna species (Government of Western Australia 2018a, b)[2] in the following categories:

- Critically Endangered (CR) – species facing an extremely high risk of extinction in the wild in the immediate future[3]

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[1] Species listed as Extinct and Conservation Dependent are not matters of NES and therefore do not trigger the EPBC Act.

[2] The *Wildlife Conservation (Specially Protected Fauna) Notice 2018* and the *Wildlife Conservation (Rare Flora) Notice 2018* have been transitioned under regulations 170, 171 and 172 of the *Biodiversity Conservation Regulations 2018* to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the BC Act.

[3] As determined in accordance with criteria set out in the ministerial guidelines.

- Endangered (EN) – species facing a very high risk of extinction in the wild in the near future[3]
- Vulnerable (VU) – species facing a high risk of extinction in the wild in the medium term future[3].

Species may also be listed as specially protected (SP) under the BC Act in one or more of the following categories:

- species of special conservation interest (conservation dependent fauna, CD) – species with a naturally low population, restricted natural range, of special interest to science, or subject to or recovering from a significant population decline or reduction in natural range
- migratory species (Mig.), including birds subject to international agreement
- species otherwise in need of special protection (OS).

The Department of Biodiversity, Conservation and Attractions (DBCA) administers the BC Act and also maintains a non-statutory list of Priority fauna. Priority species are still considered to be of conservation significance – that is they may be Threatened – but cannot be considered for listing under the BC Act until there is adequate understanding of threat levels imposed on them. Species on the Priority fauna lists are assigned to one of four Priority (P) categories, P1 (highest) – P4 (lowest), based on level of knowledge/concern.

2.2.2 Critical habitat

Under the BC Act, habitat is eligible for listing as critical habitat if it is critical to the survival of a Threatened species or a TEC and its listing is otherwise in accordance with the ministerial guidelines.

2.2.3 Threatened and Priority Ecological Communities

The BC Act provides for the listing of TECs in the following categories:

- Critically Endangered – facing an extremely high risk of becoming eligible for listing as a collapsed ecological community in the immediate future[3]
- Endangered – facing a very high risk of becoming eligible for listing as a collapsed ecological community in the near future[3]
- Vulnerable – facing a high risk of becoming eligible for listing as a collapsed ecological community in the medium term future[3].

An ecological community may be listed as a collapsed ecological community under the BC Act if there is no reasonable doubt that the last occurrence of the ecological community has collapsed or the ecological community has been so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure.

The DBCA also maintains a non-statutory list of Priority Ecological Communities (PECs), which may become TECs in the future; however, do not currently meet survey criteria or that are not adequately defined. PECs are assigned to one of five categories depending on their priority for survey or definition, with Priority 1 of highest concern and Priority 5 of lowest concern.

3 OVERVIEW OF SUBTERRANEAN FAUNA

3.1 CONSERVATION SIGNIFICANCE

The EPA (2016a) defines subterranean fauna as: *fauna which live their entire lives (obligate) below the surface of the earth*. They include stygofauna (aquatic and living in groundwater) and troglofauna (air-breathing and living in caves and voids). The EPA's objective with respect to subterranean fauna is *its protection so that biological diversity and ecological integrity are maintained*.

The obligate underground existence of subterranean fauna greatly increases the likelihood of short-range endemism and the possibility that a species' conservation status may be impacted as a result of the implementation of a proposal. Subterranean fauna species may therefore be considered to be significant due to being identified as Threatened or Priority species, locally endemic, potentially new species, occupying restricted habitats and/or forming part of a TEC or PEC (EPA 2016a).

Very few subterranean fauna species or communities are listed as Threatened Fauna or TECs, and therefore matters of national environmental significance (MNES), under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Cape Range Remipede (*Kumonga exleyi*) and a blind cave eel (*Ophisternon candidum*) from the Cape Range peninsula in WA are two species exceptions as is the Aquatic Root Mat Community three in Caves of the Leeuwin Naturaliste Ridge.

At the State level however, many subterranean communities are listed as TECs or PECs. TECs at the State level are ecological communities which are at risk of becoming destroyed as 'Threatened' and are listed by the Minister for Environment. PECs are non-statutory communities listed by the Departments of Biodiversity Conservation and Attractions (DBCA) that are also considered to be of conservation significance. Many subterranean species in WA are listed as Threatened (Protected) species under the *Biodiversity Conservation Act*, or as Priority fauna by DBCA.

A total of 27 troglofauna and 20 stygofauna species are currently listed as either Threatened or Priority in WA, with the majority from the Pilbara and Carnarvon Interim Biogeographic Regionalisation of Australia (IBRA) regions (DBCA 2020).

Subterranean TECs and PECs are listed for WA (DBCA 2020; Department of the Environment 2015). The majority occur within the calcretes of the Yilgarn Craton in the Midwest and northern Goldfields regions (i.e. Cooper *et al.* 2008; Guzik *et al.* 2008; Humphreys *et al.* 2009), however numerous subterranean PECs also occur within the Pilbara, e.g. "Subterranean invertebrate communities of mesas in the Robe Valley region" (P1/EN).

3.2 TROGLOFAUNA

Troglofauna are typically divided into three categories of specialisation to subterranean life:

- troglobites, that are restricted to subterranean habitats and usually perish on exposure to the surface environment (Barr 1968; Howarth 1983; Humphreys 2000)
- troglophiles, which facultatively use subterranean habitats but are not reliant on them for survival (Barr 1968; Howarth 1983; Humphreys 2000)
- trogloxenes, which use subterranean systems for specific purposes, such as roosts for reproduction (bats and swiftlets).

Both troglobites and troglophiles may be Short-Range Endemics (SREs) and are therefore conservation significant.

Troglobites are organisms that have adapted to exploit the special characteristics of air-filled subterranean networks. They are often characterised by specialised adaptations to subterranean life, such as:

- lack or reduction of eyes
- lack or reduction of wings (for species that are normally winged)
- lack or reduction of body pigmentation
- heightened chemosensory and mechano-sensory systems
- loss of circadian rhythms
- very low metabolic rate.

These adaptations allow troglobites to exploit the dark, humid, nutrient-poor subterranean void networks (Howarth 1983, 1993; Humphreys 2000; Poulson & Lavoie 2000). Several soil and litter dwelling groups are blind and pale, making determination of troglobitic status extremely difficult. In these instances, DNA sequencing is used to obtain regional context for such finds (Subterranean Ecology 2010); that is to determine if any records are conspecific with other recorded specimens.

Troglophiles are species that can live and reproduce in subterranean networks but are not restricted to them. These species are usually very tiny and exist within the soil. Some troglophiles appear to be widespread species, while others, like diplurans and cryptopids, are often SREs (Phoenix, unpublished data).

In WA, troglofauna invertebrates have been recorded from a number of taxonomic groups, in particular:

- arachnids:
    - spiders (Araneae) (Baehr *et al.* 2012; Burger *et al.* 2010; Harvey 2001b; Platnick 2008)
    - short-tailed whipscorpions (Schizomida) (Abrams & Harvey 2015; Harvey 2001a; Harvey *et al.* 2008)
    - pseudoscorpions (Pseudoscorpiones) (Edward & Harvey 2008; Harms & Harvey 2013)
    - scorpions (Scorpiones, (Volschenk & Prendini 2008)
- palpigrades (Barranco & Harvey 2008)
- myriapods:
    - millipedes (Diplopoda): (Humphreys & Shear 1993; Shear & Humphreys 1996)
    - centipedes (i.e. Scolopendromorpha) (Edgecombe 2005)
- crustaceans:
    - isopods (S. Judd, unpublished data)
- insects:
    - cockroaches (Roth 1991)
    - beetles
    - bugs (Hoch 1993).

3.3 STYGOFAUNA

Stygofauna represent the fauna living within subterranean water bodies or aquifers (Humphreys 2008). They typically show similar traits to troglobites in their specialisation to subterranean life, including loss of body pigment, eyes, and heightened mechano-sensory systems. Stygofauna are similarly termed to troglofauna:

- stygobites, that are restricted to subterranean habitats and usually perish on exposure to the surface environment
- stygophiles, which facultatively use subterranean habitats but are not reliant on them for survival (Humphreys 2008)
- stygoxenes, species inhabiting surface water which may also be able to freely move from surface to subterranean systems and back (Humphreys 2000).

SRE stygofauna are only represented by stygobitic species. In WA, stygofauna invertebrates have mainly been recorded within the crustaceans and insects, in particular (but not limited to):

- crustaceans:
    - ostracods (Karanovic 2007; Reeves *et al.* 2007)
    - copepods (Karanovic 2006; Karanovic *et al.* 2013)
    - amphipods (Bradbury & Williams 1997; Finston & Johnson 2004)
    - syncarids (Abrams *et al.* 2013)
    - isopods (Finston *et al.* 2009; Keable & Wilson 2006)
- insects:
    - beetles, in particular water beetles (Dytiscidae) (Eberhard *et al.* 2016; Watts & McRae 2013)
- oligochaetes (Pinder 2001)
- nematodes (Halse & Pearson 2014).

3.4 IDENTIFYING TROGLOFAUNA AND STYGOFAUNA

The characterisation of subterranean fauna into troglobites or stygobites is largely based on an understanding of species habitat requirements. The recognition and identification of these species are usually limited to the presence of troglomorphies, such as reduction or loss of eyes or wings etc. Troglomorphies are used to infer a species that have become specialised to subterranean existence over many generations of confinement to subterranean habitats.

The use of troglomorphies may be justified when a species being identified belongs to a genus (or other higher taxonomic rank) in which epigean species do not exhibit troglomorphic characteristics. Some groups, such as diplurans, cryptopid centipedes and atelurine silverfish, are more difficult to assess since all members of these groups, whether subterranean or not, lack eyes and are generally pale.

An additional complication to identification of subterranean SREs arises from some clearly troglobitic species (such as some species of Nocticola) which have been found to have wide distributions, well beyond the 10,000 km^2 threshold which limits the recognition of SREs. Widespread subterranean fauna appear to be rare and their means of dispersal is not well understood.

Taxonomic resolution is also difficult to achieve in taxa for which there is no expertise to provide regional context. The apparently strong evolutionary pressure of subterranean habitats has resulted in highly convergent, morphologically-similar species (Finston & Johnson 2004; Finston *et al.* 2007). Molecular techniques such as ‘barcoding’ (Hebert *et al.* 2003a; Hebert *et al.* 2003b) are routinely employed to overcome these identification problems. Barcoding methods can also resolve specimen identification where specimens represent taxonomically uninformative life stages or sexes.

3.5 THREATENING PROCESSES

Impacts to subterranean fauna can be classed as either:

- primary impacts – impacts that physically destroy the subterranean void networks
- secondary impacts – impacts that change the subterranean habitat without physically destroying the void networks.

Primary impacts are obvious, whereas secondary impacts tend to be cumulative and may affect a far greater area than that being developed (Hamilton-Smith & Eberhard 2000). There are commonly two key threatening processes from mining activities that impact subterranean fauna through the direct loss of habitat:

- Development of mine pits – the most obvious primary impact to subterranean habitats occurs as a result of their physical removal during mining. Troglofauna require air-filled void networks and most of this habitat exists in the overburden, which is typically destroyed during pit construction/excavation. Similarly, direct loss of stygofauna habitat may be caused by the removal of geological formations if any aquifers are associated with these formations.
- Depletion of an aquifer leading to loss of stygofauna habitat – depletion of an aquifer that is identified as suitable for stygofauna represents a direct loss of stygofauna habitat. The significance of the impact is dependent on the depth of drawdown, the size and extent of the aquifer and the connectivity of the aquifer with adjacent habitat for stygofauna.

Secondary impacts are those that affect the physico-chemical properties of subterranean habitats. The nature of these changes can be difficult to measure and there is limited empirical evidence to support or refute these putative impacts. They include:

- Depletion of an aquifer leading to altered relative humidity – troglofauna are dependent on high relative humidity (Barr 1968; Humphreys 1991; Humphreys 2000). Dewatering may impact troglofauna habitat in unsaturated strata above the water table by lowering relative humidity
- Nutrient starvation – surface vegetation is the primary source of nutrients entering subterranean systems. Large-scale clearing of vegetation may result in the localised nutrient starvation of underlying subterranean habitat. Smothering of these nutrient sources on which subterranean systems depend, in the form of waste and overburden stockpiles and tailings ponds, may reduce inflow of nutrients to subterranean systems and lead to nutrient deficient habitats (Howarth 1993; Humphreys 2000; Poulson & Lavoie 2000)
- Vibration – shock waves through subterranean strata from blasting or heavy vehicle traffic may result in the collapse of less-consolidated void spaces and also impact physically on subterranean fauna. There is little data to challenge or corroborate these observations and impacts may generally be localised rather than critically threatening
- Contamination – contamination of subterranean habitats from spills, such as diesel fuel, may degrade the quality of subterranean habitats. Such impacts would generally be highly localised and minor in scale; however, major contamination of subterranean habitats may have significant impacts.

4 EXISTING ENVIRONMENT

4.1 INTERIM BIOGEOGRAPHIC REGIONALISATION OF AUSTRALIA

The IBRA classifies Australia's landscapes into large 'bioregions' and 'subregions' based on climate, geology, landform, native vegetation and species information (DoEE 2016). The study area is located in the Eastern Murchison subregion (MUR1) of the Murchison bioregion (
Figure 4-1) which is characterised by

- internal drainage, and extensive areas of elevated red desert sandplains with minimal dune development
- salt lake systems associated with the occluded Paleodrainage system
- broad plains of red-brown soils and breakaway complexes as well as red sandplains
- vegetation is dominated by Mulga Woodlands often rich in ephemerals; hummock grasslands, saltbush shrublands and *Halosarcia* shrublands (Cowan 2001).

4.2 LAND SYSTEMS

DPIRD undertakes land system mapping for WA using a nesting soil-landscape mapping hierarchy (Schoknecht & Payne 2011). While the primary purpose of the mapping is to inform pastoral and agricultural land capability, it is also useful for informing biological assessments. Under this hierarchy, land systems are defined as areas with recurring patterns of landforms, soils, vegetation and drainage (Payne & Leighton 2004).

The study area intersects eight land systems (Table 4-1; Figure 4-2). The Jundee System dominates the study (44.4%), followed by the Violet System (25.8%). The other six systems comprise the remaining 29.8% of the area.

Table 4-1 Land systems and extent in study area

Land system	Description	Area (ha)	% of study area
Bevon System	Irregular low ironstone hills with stony lower slopes supporting mulga shrublands.	144.4	8.3
Bullimore System	Gently undulating sandplain with occasional linear dunes and stripped surfaces supporting spinifex grasslands with mallees and acacia shrubs.	27.7	1.6
Desdemona System	Plains with deep sandy or loamy soils supporting mulga tall shrublands and wanderrie grasses.	30.0	1.7
Jundee System	Hardpan plains with variable gravelly mantles and minor sandy banks supporting weakly groved mulga shrublands.	768.4	44.4
Monk System	Hardpan plains with occasional sandy banks supporting mulga tall shrublands and wanderrie grasses.	245.3	14.2
Nubev System	Gently undulating stony plains, minor limonitic low rises and drainage floors supporting mulga and halophytic shrublands.	35.4	2.0
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.	446.7	25.8
Wyarri System	Granite domes, hills and tor fields with gritty-surfaced fringing plains supporting mulga and granite wattle shrublands.	32.7	1.9
Total		**1,730.6**	**100**

Dacian Gold Limited
Redcliffe Gold Project

Project No	1441-RGP-DGL-SUB
Date	25/11/2021
Drawn by	IN
Map author	CN

0 10 20
Kilometers

1:900,000 (at A4) GDA 1994 MGA Zone 50

Study area

IBRA region and subregion

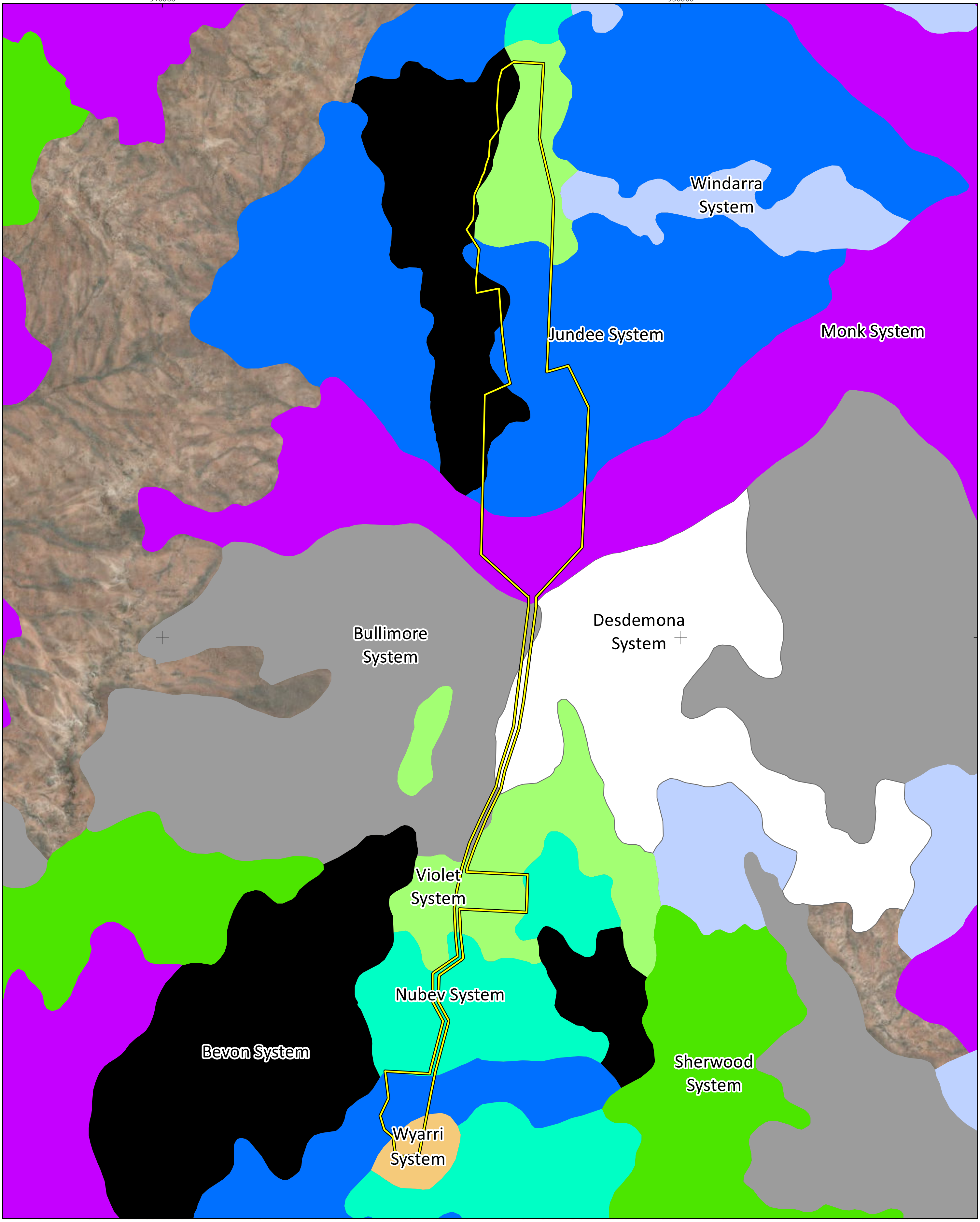
Murchison, Eastern Murchison

Great Victoria Desert, Shield

Figure 4-1

Study area in relation to IBRA bioregions and subregions

PHOENIX ENVIRONMENTAL SCIENCES



Dacian Gold Ltd
Redcliffe Gold Project

Project No	1441-RGP-DGL-SUB
Date	14-Dec-21
Drawn by	IN
Map author	CN

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Study area

Land system

- Bevon System
- Bullimore System
- Desdemona System
- Jundee System
- Monk System
- Nubev System
- Sherwood System
- Violet System
- Windarra System
- Wyarri System

Figure 4-2

Land systems in the study area

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4.3 CLIMATE AND WEATHER

The climate of the Eastern Murchison subregion is described as arid with mainly winter rainfall (Cowan 2001). The nearest Bureau of Meteorology (BoM) weather station with comprehensive data collection and recent historic climate data is Leonora (no. 012241), (Latitude: 28.89°S, Longitude 121.33°E), located 52km SW of the study area.

Leonora records the highest mean maximum monthly temperature is in January (37°C) and the lowest mean maximum monthly temperature in July (18.5°C). The lowest mean minimum monthly temperature in in July (6.1°C) and the highest mean minimum monthly temperature is in January (21.8°C) (BoM 2021b) (Figure 4-3). Average annual rainfall is 236.4 mm with February and March recording the highest monthly averages (30.9 and 29 mm respectively; Figure 4-3). Rainfall is highly variable between seasons and years, influenced by northwest cloud-bands in the winter months, and occasionally by tropical cyclones (BoM 2021a).

Daily mean temperatures at Leonora preceding the survey were generally warmer than long-term averages, however January, February and June were cooler than expected. In the three months prior to the survey, the mean maximum and minimum temperature was higher than the average for July and August. Temperatures were likely slightly warmer than expected during the month of the survey (Figure 4-3).

Records from Leonora show rainfall levels were much lower than average for most months. February experienced the highest rainfall levels at 49.6mm (18.7mm above the long-term average). September, April and January received the lowest amounts of rain throughout the year (0, 1.4 and 2mm respectively). Even though June had low levels of rain, July received higher than average rainfall, 7.9mm above average (Figure 4-3).

4.4 LAND USE

The dominant land use of the East Murchison subregion is grazing, UCL and Crown Reserves, mining and conservation (Cowan 2001). The study area includes disused mine pits, and extends across two pastoral stations, Mertondale and Nambi (DAFWA 2019).

4.5 CONSERVATION RESERVES AND ESAS

The nearest Environmentally Sensitive Areas, Lake Marmion and Lake Ballard, are located approximately 107 km SW of the study area. The study area does not intersect any current or proposed conservation reserves (Figure 1-1).

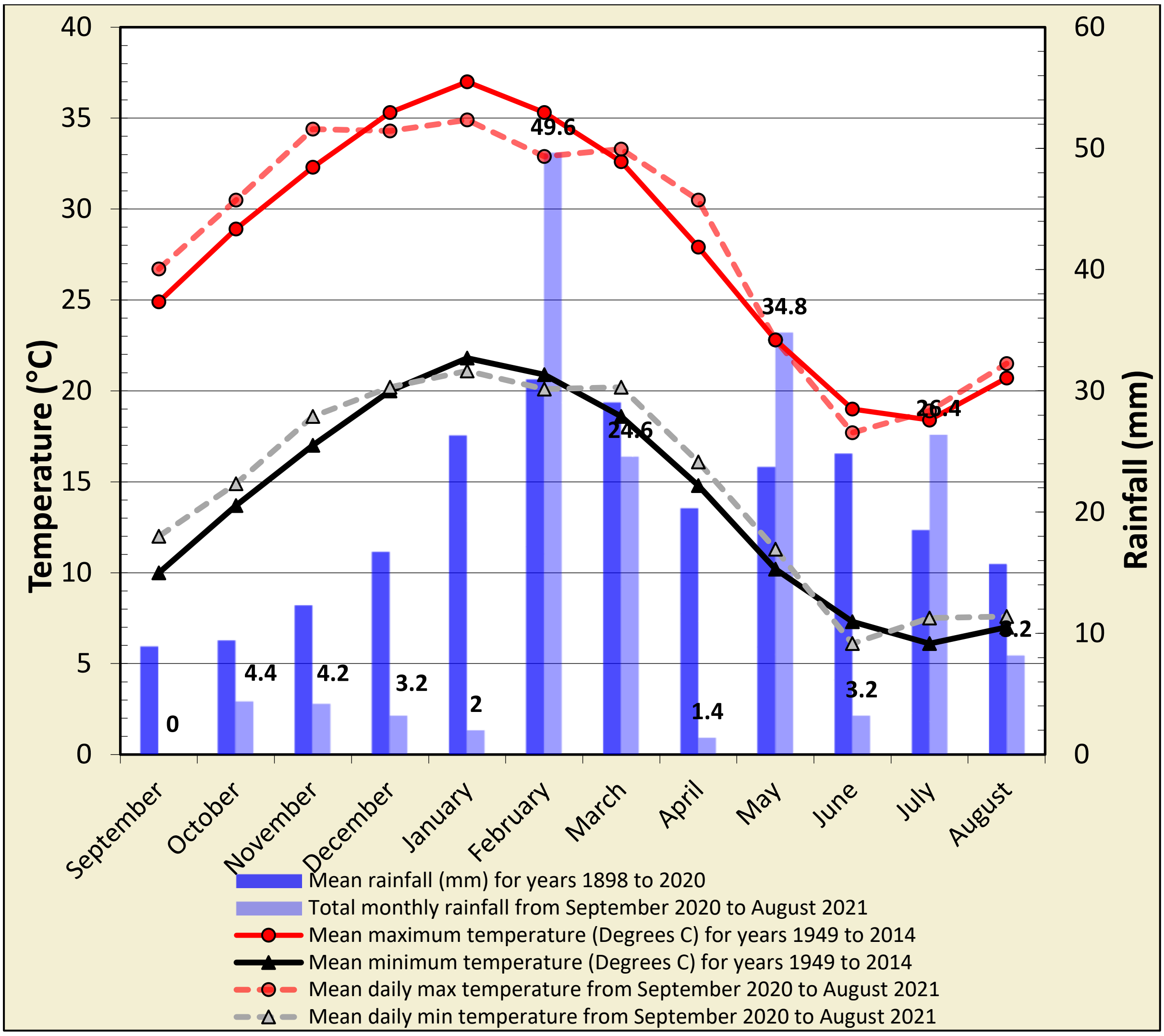


Figure 4-3 **Annual climate and weather data for Leonora (no. 012241) and mean monthly data for the 12 months preceding the survey (BoM 2021b)**

5 METHODS

The survey was conducted in accordance with relevant survey guidelines and guidance, including:

- EPA Environmental Factor Guideline. Subterranean fauna (EPA 2016a)
- EPA Technical Guidance. Sampling methods for subterranean fauna (EPA 2016c)
- EPA Technical Guidance. Subterranean fauna survey (EPA 2016e).

5.1 DESKTOP REVIEW

Searches of several biological databases were undertaken to identify and prepare lists of subterranean fauna and subterranean fauna habitat that may occur within the study area (Table 5-1). A literature search was conducted for accessible reports for biological surveys conducted within 100 km of the study area to build on the lists developed from the database searches (Table 5-2). As there were few reports available within 100 km of the study area, reports from further afield (up to 150 km from the study area) were also reviewed to identify any widespread species that may be present in the region. Species lists from these reports were not included in the desktop species list for this report.

Table 5-1 Database searches conducted for the desktop review

Database	Target group/s	Search coordinates and extent
DBCA Threatened and Priority Ecological Communities Database (DBCA 2021b)	TECs and PECs	Approximate centre point of study area (-28.462, 121.559) with 55 km buffer
WA Museum Arachnid and Myriapod Database, Crustacea Database, Insect Database	Arachnid, myriapod, crustacea and insects	Study area plus a 100 km buffer
Phoenix invertebrate fauna database	Arachnid, myriapod, crustacea and insects	Study area plus a 150 km buffer
Surface Geology of Australia, Western Australia Database (Stewart *et al.* 2008)	Surface geology	Study area

Table 5-2 Survey reports included in the desktop review

Report author	Survey description	Project
Javidkar *et al.* (2016); (2017)	Subterranean fauna survey	-
Phoenix (2010)	Stygofauna survey	Golden Terrace North and 727 prospects
Phoenix (in prep)	Stygofauna survey	Irwin Hills
Stantec (2017)	Stygofauna survey	Mount Keith Satellite Operations
Outback Ecology (2012)	Stygofauna survey	Lake Maitland Uranium Project
Aquaterra (2010)	Hydrogeological assessment	Golden Terrace South

In terms of the habitat review, three main factors were considered:

1. water quality (stygofauna)
    a. pH (5.0 – 8.0)
    b. Electrical Conductivity (EC) - <70,000 µs/cm and salinity - <60,000 mg/L
2. hydrogeology (stygofauna) – presence of saturated geologies that contains voids, are perched, or exist as fractured rock aquifers, or in the case of colluvial aquifers, support strong groundwater transmission

3. geology (troglofauna) – presence of unsaturated geologies that contain caves, fractures, voids, pisolitic voids or calcrete formations.

5.2 FIELD SURVEY

The field survey was undertaken between 27-30 September 2021 by two experienced zoologists.

5.2.1 Stygofauna sampling

A total of 26 locations were sampled for stygofauna across the study area. Of these, ten samples were taken from Nambi, ten from Hub and six from GTS (Table 5-3; Figure 5-1). There was not a sufficient number of suitable bores at GTS to allow for sampling of ten bores, however A Level 2 subterranean fauna survey had already been conducted in this area previously (Figure 5-1). A predicted cone of drawdown was not available at the time of sampling. As such, bores located within approximately 100m of the proposed pit locations were prioritised for sampling as these were deemed most likely to be located within the area to be affected by dewatering.

Stygofauna net hauls are used to survey for stygofauna. This comprises of taking six hauls per bore, three with a 250 µm and three with a 50 µm weighted nets. After the net was lowered to the bottom of each bore, it was used to briefly stir up sediments and their benthic inhabitants. Obstructions such as tree roots or partial bore collapse prevented six hauls being conducted at some bores due to nets becoming stuck or tangled. Of the 25 bores sampled using the haul method, 21 had six hauls completed. Four of the remaining bores had four hauls completed and one bore only had one haul completed.

After each haul, the strained content was rinsed into a 120 ml plastic vial by squirting 100% ethanol down the sides of the net and around the rim of the weight, washing the sample contents into the vial. If not already full, the sample vial was topped up with 100% ethanol.

One sample was taken using the Karaman-Chappuis (KC) method. KC sampling is used to provide regional data for interstitial fauna. These samples help to evaluate the habitat constraints of fauna that were collected from bores in the 'impact area', and therefore provide regional context. The method targets interstitial fauna beneath gravel banks of rivers, streams and pools. Some of these fauna are also likely to be present within the superficial aquifer and therefore appear in bore samples. A hole was dug into the gravel bank of a historic mining pit that's base sits below ground water level. The hole was excavated until the water table was reached. Then, as water flowed into the hole, it was scooped out and filtered through a 50 µm stygofauna net. Approximately 6L of ground water was filtered through the net. The sample from the net was then processed in the same method as the haul samples.

The net was thoroughly rinsed in freshwater after each sample to avoid cross-contamination of samples.

At conclusion of the survey, samples were stored in a refrigerator in the laboratory, where they were sorted, and specimens identified using high-magnification stereo-microscopes.

Table 5-3 Location of bores sampled during field survey

Location	Bore	Latitude	Longitude	Samples taken	Date bore est. (age at time of sampling)
GTS	20RRC030	-28.4627	121.5635	6 x stygo haul	13/09/2020
GTS	20RRC051D	-28.4573	121.5649	6 x stygo haul	11/10/2020
GTS	GTR045	-28.4610	121.5632	6 x stygo haul	Date unknown (1+ years old)
GTS	GTRC210	-28.4607	121.5642	6 x stygo haul	Date unknown (1+ years old)
GTS	GTS op hole	-28.4577	121.5627	4 x stygo haul	Date unknown (1+ years old)
GTS	MSWB8	-28.4560	121.5628	6 x stygo haul	Date unknown (1+ years old)
Hub	19RRC016	-28.4588	121.5631	6 x stygo haul	10/02/2019
Hub	19RRC025	-28.3947	121.5575	6 x stygo haul	6/05/2019
Hub	19RRC042	-28.4584	121.563	4 x stygo haul	31/07/2019
Hub	19RRC062	-28.4566	121.5636	6 x stygo haul	17/09/2019
Hub	20RRC061	-28.4595	121.5642	6 x stygo haul	11/11/2020
Hub	20RRC094	-28.3966	121.5559	6 x stygo haul	2/12/2020
Hub	20RRC100	-28.5735	121.544	6 x stygo haul	4/12/2020
Hub	20RRC104	-28.5728	121.5444	6 x stygo haul	5/12/2020
Hub	20RRC116	-28.3943	121.5577	6 x stygo haul	7/12/2020
Hub	20RRC129	-28.5737	121.5426	6 x stygo haul	11/12/2020
Nambi	Nambi pit	-28.4003	121.5555	6L Karaman-Chappuis	N/A
Nambi	Nambiunknown1	-28.5747	121.5437	1 x stygo haul	Date unknown (1+ years old)
Nambi	Nambiunknown2	-28.5771	121.5447	6 x stygo haul	Date unknown (1+ years old)
Nambi	NBRC010	-28.4000	121.5557	4 x stygo haul	Date unknown (1+ years old)
Nambi	NBRC101	-28.3962	121.5568	6 x stygo haul	Date unknown (1+ years old)
Nambi	NBRC102	-28.5701	121.5433	6 x stygo haul	Date unknown (1+ years old)
Nambi	NBRC103	-28.4005	121.5554	6 x stygo haul	Date unknown (1+ years old)
Nambi	NBRC105	-28.4005	121.5558	6 x stygo haul	Date unknown (1+ years old)
Nambi	NBRC107	-28.4004	121.5557	6 x stygo haul	Date unknown (1+ years old)
Nambi	NBRC109	-28.4007	121.5553	6 x stygo haul	Date unknown (1+ years old)

5.2.2 Bore and water quality data

At each bore, total depth and depth to groundwater were measured using an electronic dipper. A bailer was then sent down to collect a sample of the water to retrieve water quality of each bore. The following water quality parameters were measured in-situ with a YSP multiprobe:

- temperature (°C)
- dissolved Oxygen (%)
- dissolved Oxygen (mg/L)

- conductivity (µs/cm)
- pH
- oxygen reduction potential (mV).

5.2.3 Specimen identification

Morphological identifications of specimens were identified to the lowest taxonomic level where possible. If specimens could not be identified morphologically identified, molecular sequencing was conducted. The molecular identification of species based on comparisons between the mitochondrial gene COI (Cytochrome OxidaseI) is referred to as DNA barcoding.

DNA was extracted from each specimen and the 658 base pair COI gene was amplified by Genotyping Australia using universal COI primers (Folmer *et al.* 1994). The data was subsequently compared to previously published sequences uploaded into Genbank using the BLAST function in Geneious Prime v11.1.5. Sequences were also compared inhouse, to Phoenix's molecular database. The top blast hits for each major taxon were reported, the sequences from the survey were added, duplicate sequences were removed, and remaining sequences then analysed with a Maximum Likelihood phylogenetic analysis using a GTR+G model of evolution and 100 bootstraps (RAxML). Distances were calculated via tree-based estimates of identical bases in Geneious Prime. Species delineation was determined through analysis of pairwise similarity matrices and RAxML trees showing clusters of specimens with similar DNA between those from the current survey and Genbank, and if other clusters were present but clearly forming a separate species.

A total of four specimens were sequenced, comprising three syncarids and one isopod. All produced successful sequences and were able to be analysed against the publicly available molecular data.

4.3.4.3 Nomenclature

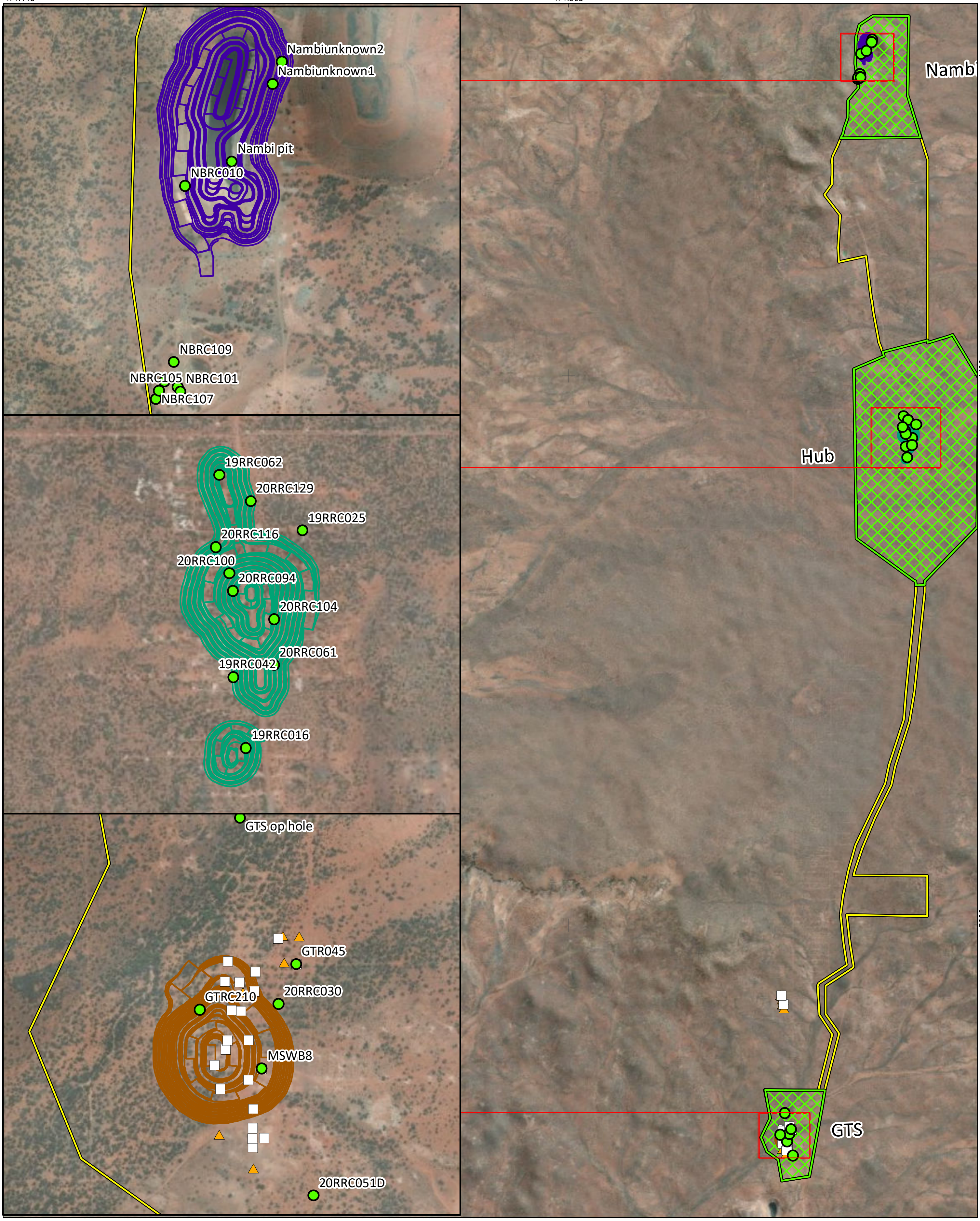
Nomenclature followed a number of taxon-specific references; however some species are currently unnamed and required morphospecies designation as listed in this report. These are adopted from the respective taxonomic authorities. Interim Phoenix specific codes are used for some of the species identified using molecular tools pending a code-designation by the WA Museum. Reference collections for these morphospecies generally reside with the WA Museum, as expected by the EPA (EPA 2016d).

5.2.4 Survey personnel

The personnel involved in the surveys are listed in Table 5-4. All survey work was carried out under relevant licences issued by DBCA under the BC Act.

Table 5-4 Survey personnel

Name	Permit	Qualifications	Role/s
Jarrad Clark	NA	BSc (Env. Mgt.)	Project oversight
Caitlin Nagle	Fauna taking (biological assessment) licence no. BA27000479-2	M. Sc. (Conservation Biology)	Project manager, field survey, reporting
Brendan Thomson		BSc (Env. Mgt. Planning)	Field survey, specimen processing
Anna Jacks	NA	BSc Hons (Env. Sci)	Invertebrate taxonomy



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Study area
Deposit areas
Proposed pits
GTS pit
Hub pit
Nambi pit

Survey sites
Previous stygofauna survey sites (Phoenix 2010)
Previous troglofauna survey sites (Phoenix 2010)

Figure 5-1

Bores sampled during field survey

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6 RESULTS

6.1 DESKTOP REVIEW

6.1.1 Subterranean fauna

The desktop review identified records of 34 stygofauna taxa and 17 troglofauna taxa. The stygofauna taxa were dominated by copepods, while the troglofauna were mostly isopods and pseudoscorpions (Table 6-1; Table 6-2).

Of the stygofauna taxa, none are confirmed SRE and 25 are potential SREs (Table 6-3; Figure 6-1). A further five stygofauna taxa of uncertain SRE status and four taxa known not be SREs were identified. Of the troglofauna taxa, none are confirmed SREs and 11 were potential SREs (Table 6-4; Figure 6-1). The remaining six taxa were all of uncertain SRE status.

The desktop records indicate one stygofauna species has previously been recorded within the study area (Figure 6-1):

- *Metacyclops* sp. – considered to be widespread over the study area and region in general

Of the 36 potentially restricted taxa, ten stygofauna taxa and five troglofauna taxa are named species. The remaining 15 stygofauna and 11 troglofauna potential SRE taxa are named only to morphospecies codes as applied by the WA Museum or are not identified to confirmed species level (i.e. "sp." or "cf."). The majority of records of uncertain SRE status are unidentifiable ("sp. indet.", i.e. female or juvenile specimens) or could not be identified to species or morphospecies and may represent new species or other species listed in the same genus where records exist (Table 6-3;Table 6-4).

Table 6-1 Summary of stygofauna identified in the desktop review

Higher order	Families	Genera	Taxa	% of taxa
Amphipoda	1	3	3	8.8
Copepod	2	11	15	44.1
Coleoptera	1	2	4	11.8
Isopod	2	2	4	11.8
Ostracod	1	1	1	2.9
Syncarid	2	4	7	20.6
Total	**9**	**23**	**34**	**100.0**

Table 6-2 Summary of troglofauna identified in the desktop review

Higher order	Families	Genera	Taxa	% of taxa
Isopod	5	5	8	47.1
Millipede	1	1	1	5.9
Pseudoscorpiones	2	3	7	41.2
Centiped	1	1	1	5.9
Total	**9**	**10**	**17**	**100.0**

Table 6-3 Stygofauna identified in the desktop review

Higher taxon, family	Species	SRE status	Proximity to study area (km)
Amphipoda			
Chiltoniidae	*Scutachiltonia axfordi*	Potential	Outside (63 - 65 km)
	Stygochiltonia bradfordae	Potential	Outside (65 - 70 km)
	Yilgarniella sturtensis	Potential	Outside (64 - 70 km)
Bathynellacea			
Bathynellidae	*Bathynella* \`sp. B27\`	Potential	Outside (69 km)
	Bathynellidae \`sp. OES28\`	Potential	Outside (25 km)
Parabathynellidae	*Atopobathynella* \`sp. B22\`	Potential	Outside (62 - 69 km)
	Atopobathynella \`sp. B23\`	Potential	Outside (59 - 66 km)
	Atopobathynella \`sp. OES2\`	Potential	Outside (22 - 27 km)
	Atopobathynella \`sp. OES29\`	Potential	Outside (23 km)
	Parabathynella sp. Indet.	Uncertain	Outside (95 km)
Coleoptera			
Dytiscidae (diving beetles)	*Limbodessus lapostaae*	Potential	Outside (54 - 57 km)
	Limbodessus windarraensis	Potential	Outside (54 - 55 km)
	Paroster darlotensis	Potential	Outside (80 km)
	Paroster melroseensis	Potential	Outside (80 km)
Cyclopoida			
Cyclopidae	Cyclopidae \`sp.\`	Uncertain	Outside (62 - 65 km)
	Dussartcyclops uniarticulatus	Not SRE	Outside (66 km)
	Fierscyclops fiersi	Not SRE	Outside (60 -70 km)
	Halicyclops eberhardi	Not SRE	Outside (79 - 142 km)
	Halicyclops kieferi	Potential	Outside (61 - 69 km)
	Mesocyclops brooksi	Not SRE	Outside (60 - 163 km)
	Metacyclops sp.	Uncertain	Inside
	Pescecyclops laurentiisae	Potential	Outside (64 km)
Harpacticoida	Ameiridae \`sp. B05\`	Potential	Outside (60 - 69km)
	Ameiridae \`sp. B06\`	Potential	Outside (61 - 67 km)
	Nitokra lacustris	Potential	Outside (62 - 80 km)
	Harpacticoida \`sp.\`	Uncertain	Outside (65 km)
	Schizopera \`sp. B18\`	Potential	Outside (62 - 64 km)
	Schizopera \`sp. B19\`	Potential	Outside (60 - 62 km)
	Schizopera \`sp. B20\`	Potential	Outside (62 km)
Isopoda			
Olibrinidae	?*Adoniscus* \`sp. B02\`	Potential	Outside (69 km)
Scyphacidae	*Haloniscus* \`sp.\`	Uncertain	Outside (60 - 67 km)

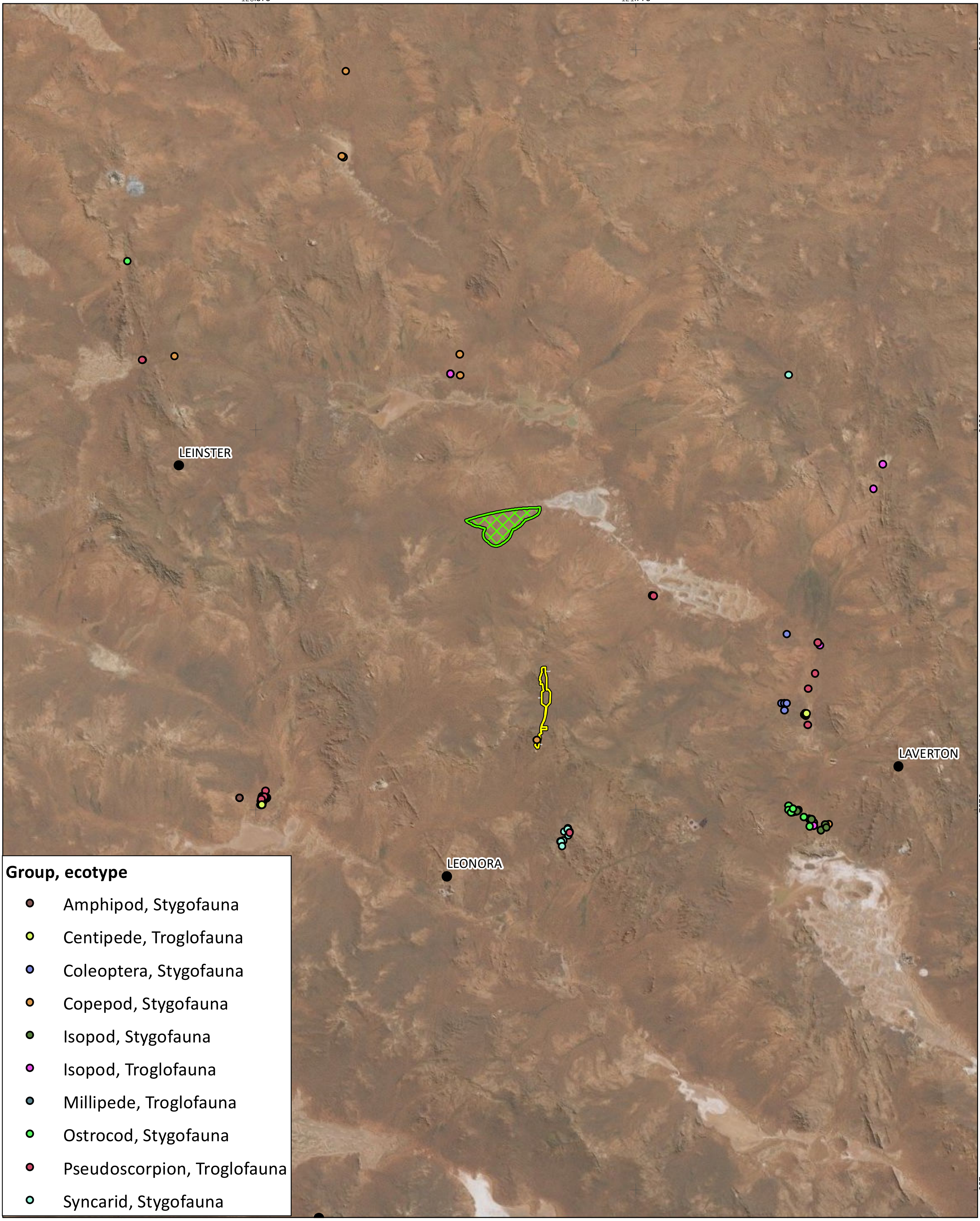
Higher taxon, family	Species	SRE status	Proximity to study area (km)
	Haloniscus `sp. B08`	Potential	Outside (61 - 69 km)
	Haloniscus `sp. B09`	Potential	Outside (64 - 70 km)
Podocopida			
Cyprididae	*Sarscypridopsis* `sp. BOS569`	Potential	Outside (60 - 66 km)

Table 6-4 Troglofauna identified in the desktop review

Higher taxon, family	Species	SRE status	Proximity to study area (km)
Isopoda			
Armadillidae	*Buddelundia* sp. Indet.	Unknown	Outside (64 km)
Microparasellidae	*Angeliera* \`sp. B01\`	Potential	Outside (69 km)
Paraplatyarthridae	*Paraplatyarthrus crebesconiscus*	Potential	Outside (31 - 80km)
	Paraplatyarthrus occidentoniscus	Potential	Outside (64 km)
	Paraplatyarthrus subterraneus	Potential	Outside (59 km)
Philosciidae	*Andricophiloscia* \`sp. B01\`	Potential	Outside (67 km)
	Andricophiloscia \`sp. B02\`	Potential	Outside (61 km)
Platyarthridae	*Trichorhina* \`sp. ISO021\`	Potential	Outside (89 - 95 km)
Polyxenida			
Polyxenidae	Polyxenidae sp. Indet.	Unknown	Outside (65 km)
Pseudoscorpiones			
Chthoniidae	*Lagynochthonius polydentatus*	Potential	Outside (65 km)
	Tyrannochthonius \`billhumphreysi?\`	Potential	Outside (31 - 123 km)
	Tyrannochthonius billhumphreysi	Potential	Outside (64 - 65 km)
	Tyrannochthonius \`Helens Bore\`	Potential	Outside (23 km)
	Tyrannochthonius \`sp. nov.?\`	Unknown	Outside (31 km)
Olpiidae	Olpiidae \`blind troglobite\`	Unknown	Outside (65 km)
	Olpiidae sp. Indet.	Unknown	Outside (64 - 65 km)
Scolopendrida			
Cryptopidae	Cryptopidae \`sp.\`	Unknown	Outside (60 - 65 km)

6.1.2 Threatened and Priority Ecological Communities

The desktop review identified one PEC within a 55 km radius of the study area, the Nambi calcrete groundwater assemblage type on Carey paleodrainage on Nambi Station. This PEC is a subterranean fauna community located approximately 34 km north of the study area. It is listed as Priority 1, hosting a unique assemblage of invertebrates in the groundwater calcretes. The primary threat to the Nambi calcrete groundwater assemblage is listed as mining (DBCA 2021a). None of the desktop records of subterranean fauna are located within the confines of the Nambi calcrete groundwater assemblage PEC.



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Study area

PEC: Nambi calcrete groundwater assemblage, P1

Figure 6-1

Desktop records of subterranean fauna and TEC PECS

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6.1.3 Geology and hydrology

6.1.3.1 Geology

According to the Surface Geology of Australia 1:1,000,000 scale, Western Australia database (Stewart *et al.* 2008), the study area intersects five geological formations (Table 6-5; Figure 6-2). Located at the northern end of the study area, Nambi is dominated by mafic extrusive rocks. Hub, which is located in the centre of the study area, is primarily characterised by Colluvium. At the southern end of the study area, GTS is dominated by sedimentary rocks.

6.1.3.1.1 Nambi

Weathering profiles vary across the area however at Nambi it is typically quite shallow (J Cooper 2021, pers. comm., 12 November). In some areas, fractured oxidized units are intercepted from near surface and continue through to fresh rock, while in other areas holes transition through weakly weathered mottled zones, to saprolite and saprock units. During construction of most bore holes, fresh rock was intercepted at a depth of roughly 40m. There is very little clay, laterite or residual soil coverage in most areas. Geology in this region is dominated by felsic schist, mafic basalt and shale units.

6.1.3.1.2 Hub

Hub has a much deeper and more ‘typical’ regolith and weathering profile than that seen at Nambi (J Cooper 2021, pers. comm., 12 November). Fresh rock is typically not intercepted in the top 100 m of rock. An extremely weathered, surficial laterite unit of varying thickness (3-8 m) covers the entire region. From ~3-40 m, lithology is dominated by clay and schist units. These units will transition through the mottled clay and upper saprolite zones. Bore logs indicate the presence of mafic layers below the clay in some areas. While these layers may be sufficiently fractured to provide suitable habitat for stygofauna, the thick layer of low permeability clay above would act as a barrier to nutrient filtration, likely rendering the habitat as unsuitable.

Weathering varies with depth, transitioning from extremely weather close to surface, through to highly weather and moderately weathered at depth.

6.1.3.1.3 GTS

According to the hydrogeological assessment conducted at GTS, the area consists mainly of a thin veneer of alluvial sand and clay overlying a profile of weathered basement rock comprising mostly low permeability clays (Aquaterra 2010).

Table 6-5 Surface geology by deposit area and suitability as subterranean fauna habitat

Surface geology	Abbreviation	Description	Extent Nambi (ha, % deposit area)	Extent Hub (ha, % deposit area)	Extent GTS (ha, % deposit area)	Total extent (ha, %)	Suitability for subterranean fauna
Colluvium 38491	Qrc	Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite	-	726.7 98.7%	7.3 5.9%	734.0 70.4%	Medium to high depending on degree of consolidation, interconnectivity of spaces and the depth from the surface
hi-Ca granite 74296	Agh	Monzogranite, granodiorite, tonalite, quartz monzonite; in places recrystallised and foliated; some mixed granite and country rock assemblages; high-Ca granite	3.4 1.9%	-	-	3.4 0.3%	Low to medium dependant on level of fracturing
mafic extrusive rocks 74248	Abe	Basalt, high-Mg basalt, minor mafic intrusive rocks; some andesite; agglomerate; mafic schist; amphibolite; dolerite; komatiitic basalt; carbonated basalt; basaltic andesite; mafic rock interleaved with minor granitic rock	180.2 98.1%	8.9 1.2%	3.5 2.9%	192.6 18.5%	Medium to high depending on degree of fracturing and porosity
mafic intrusive rocks 74263	Ade	Mafic intrusive rocks, medium to coarse-grained; layered mafic to ultramafic intrusions - dolerite, gabbro, olivine gabbro, peridotite, pyroxenite, leucogabbro, quartz dolerite, quartz gabbro, gabbronorite	-	1.0 0.1%	-	1.0 <0.1%	Medium to high depending on degree of fracturing and porosity
sedimentary rocks 74322	Ase	Phyllitic schist, siltstone, sandstone, greywacke, pelite, conglomerate, quartzite, phyllite, shale, slate, claystone, chert, minor felsic volcanic and volcaniclastic rocks; arkose, para- and orthoamphibolites; rare banded iron formation	-	-	111.2 91.1%	111.2 10.7%	Low to medium dependant on composition, degree of porosity and fracturing
		Total (ha)	**183.6**	**736.6**	**122.0**	**1042.2**	

6.1.3.2 Hydrology

The static water level (SWL) for the Project area sits between 7 m and 45m below ground level (BGL) indicating a hydraulic gradient running from north to south, with the SWL being further from the surface in the north where the ground level sits at a higher elevation.

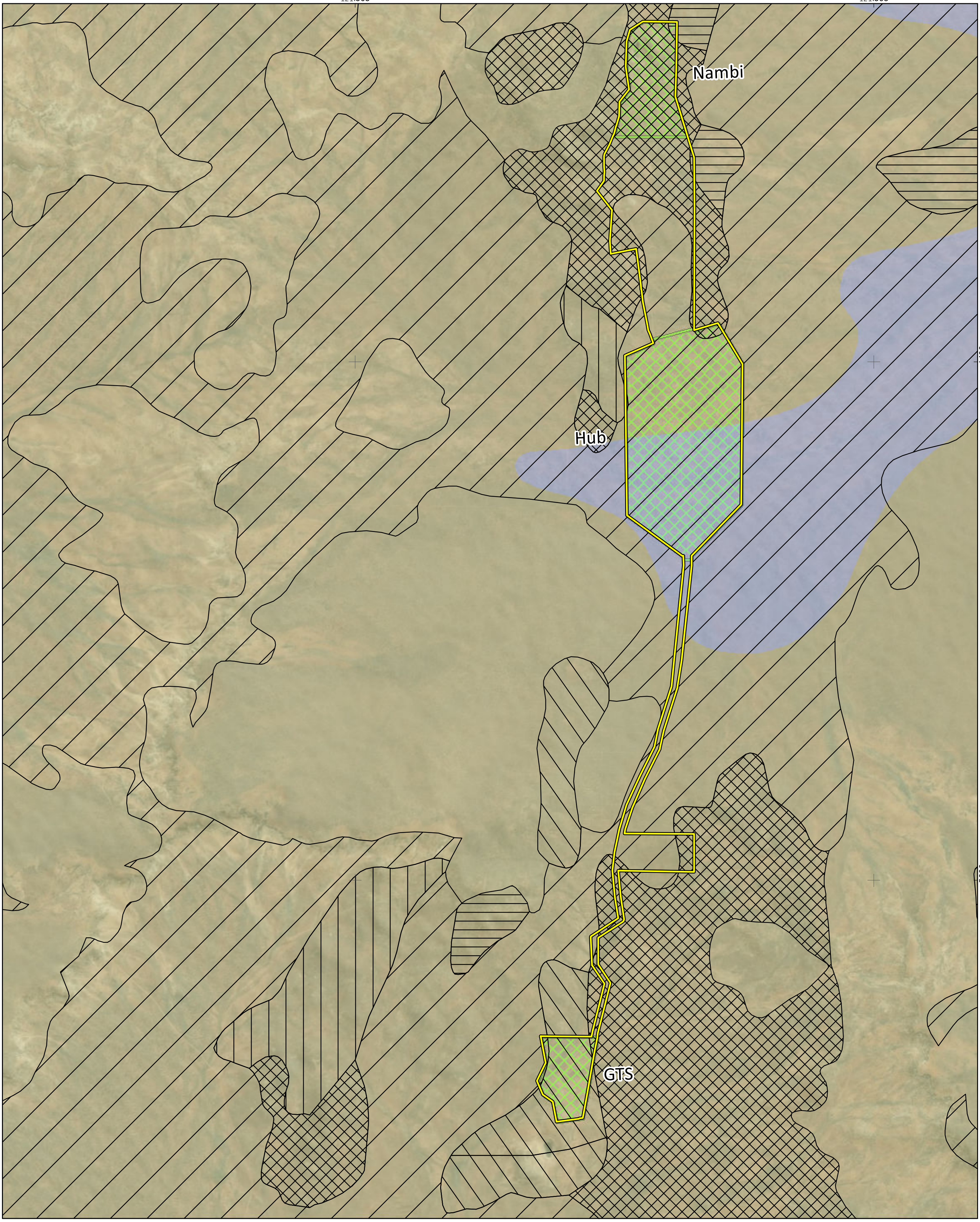
No detailed hydrological mapping was available for the Project at the time of writing. However, broadscale hydrogeological mapping indicates that the study area intersects two aquifer types (Table 6-6, Figure 6-2):

- fractured and deeply weather rocks – local aquifers, minor groundwater resources, locally large supplies from fracture zones and permeable horizons in weathering profile
- surficial deposits – local aquifers, minor to major groundwater resources.

The subterranean fauna survey previously conducted for the Project concluded that the Redcliffe area did not contain the substantial freshwater calcrete formations that are prevalent elsewhere in the Goldfields (Phoenix 2010).

Table 6-6 Aquifer types per deposit area

Deposit	Aquifer type	% of deposit area
Nambi	Fractured and deeply weathered rocks	100%
Hub	Surficial deposits	52.4%
	Fractured and deeply weathered rocks	47.6%
GTS	Fractured and deeply weathered rocks	100%



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1:95,000 (at A4) GCS WGS 1984

Study area
Deposit areas

Aquifer

Fractured and deeply weathered rocks
Surficial deposits

Surface

Agh
Qrc

Figure 6-2

Surface geology and hydrology in the study area

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6.2 Field survey

A total of 28 specimens from seven distinct stygofauna taxa were collected during the field survey (Table 6-7, Figure 6-3). Of these, two are previously unknown species:

- Parabathynellidae 'Phoenix0076' – A new species that has only been recorded from Hub. Three specimens were collected from two bores, located approximately 217 m apart.
- *Australoeucyclops* \`BCY089\` – A new species that has only been recorded from Nambi. One specimen was collected from the Nambi pit via the KC method.

Of the seven distinct taxa, six are cyclopoid copepods and one is a syncarid. One unidentifiable copepod specimen (juvenile) was also collected that may represent one of the other identified taxa recorded or a different taxa.

A total of five distinct species comprising of four copepods and one syncarid were collected Nambi, one species was collected from Hub and one species from GTS. There was no overlap in the taxa recorded between the three deposit areas.

Five of the copepods are named species and are all considered to be widespread. Of these, *Mesocyclops brooksi* is the only one recorded from within the desktop search area, and *Microcyclops varicans* was identified as likely to occur based on the literature review. All five widespread species were more than 150km away from the study area. The *Metacyclops* sp. collected during the Level 2 previously conducted at GTS was not collected during this survey (Phoenix 2010).

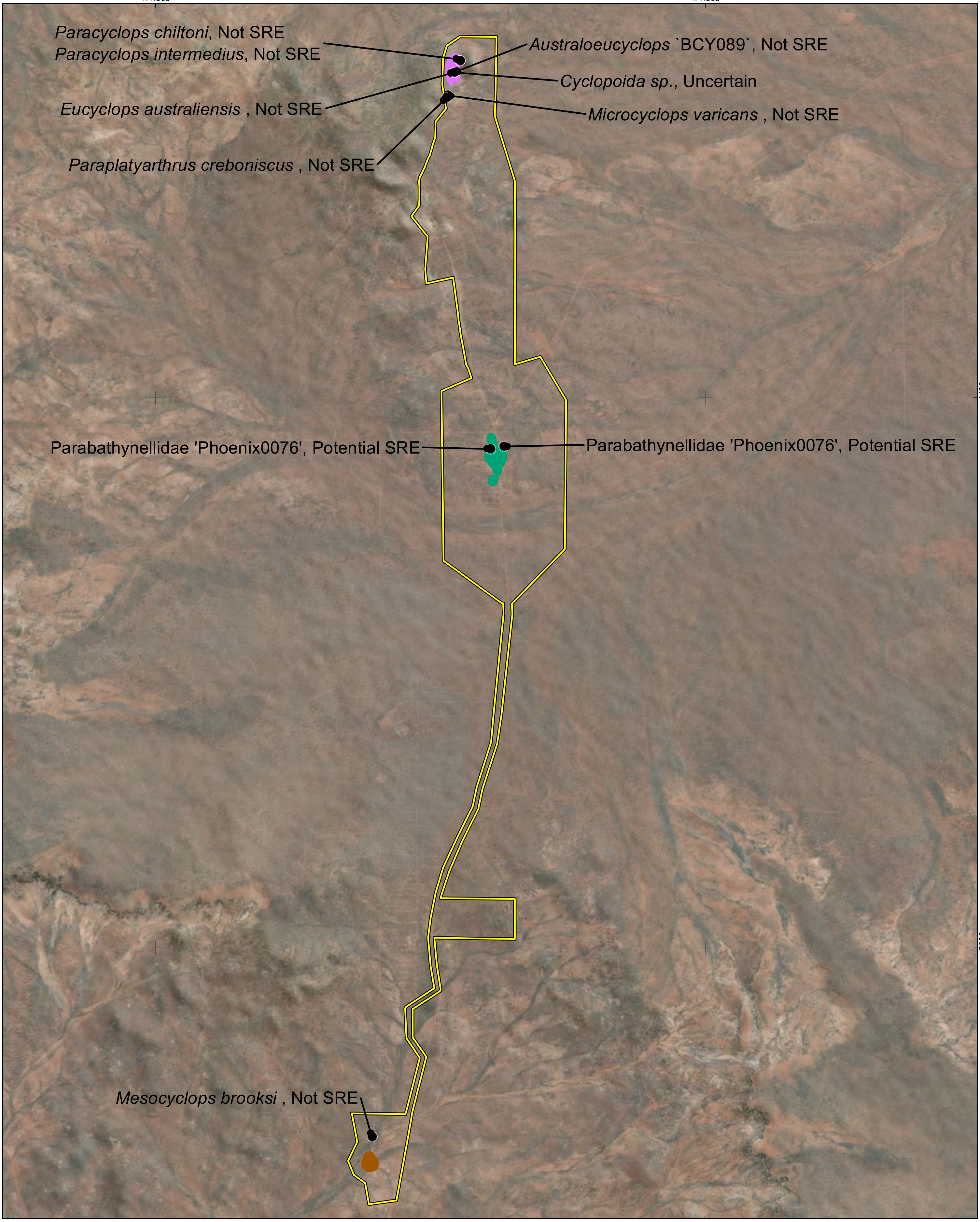
Table 6-7 Stygofauna recorded in the field survey

Higher order/ Family	Taxa	Site/s	No. specimens	SRE status	Comments
Parabathynellidae	Parabathynellidae 'Phoenix0076'	19RRC025, 20RRC116	3	Potential	This specimen is 14% divergent from MT782159 (*Atopobathynella* sp. B33 voucher BMR00584) and is therefore considered a new species.
Cyclopidae	*Australoeucyclops* \`BCY089\`	NambiPit	1	Not SRE	Does not fit any described species and is therefore considered a new species. Collected from the interstitial zone so has been deemed a stygophile.
	Eucyclops australiensis	NambiPit	2	Not SRE	Inhabits both surface and subterranean aquatic environments.
	Mesocyclops brooksi	GTS op hole	2	Not SRE	Inhabits both surface and subterranean aquatic environments.
	Microcyclops varicans	NBRC109	1	Not SRE	Inhabits both surface and subterranean aquatic environments.
	Paracyclops chiltoni	Nambiunkown2	12	Not SRE	Inhabits both surface and subterranean aquatic environments.
	Paracyclops intermedius	Nambiunkown2	6	Not SRE	Believed likely to only inhabit surface waters.
Cyclopoida	Cyclopoida sp.	NambiPit	1	Unknown	Juvenile, may represent a taxon already recorded.

One species of troglofauna, an isopod, was incidentally caught from Nambi (NBRC103) during the stygofauna survey (Figure 6-3). This specimen was 4.8% divergent from *Paraplatyarthrus crebroniscus* and is therefore considered as conspecific. *Paraplatyarthrus crebroniscus* was identified in the desktop review and is known from several records ranging from approximately 80 km north to 60 km east of Nambi, with a total linear range of over 100 km (Javidkar *et al.* 2016; Javidkar *et al.* 2017). It is a troglophile, inhabiting both surface and subterranean habitats and is therefore not considered to be restricted species. Its species name '*creboniscus*' is composed of the Latin word 'crebesco' (meaning widespread) and 'oniscus', referring to its comparatively widespread distribution in the calcrete aquifers (Javidkar *et al.* 2017).

6.2.1 Ground water quality

Ground water samples taken in the field indicate that the water is fresh (salinity of <0.5 ppt) to mildly brackish (salinity of 0.5 -2.9 ppt) and from circumneutral (pH 6.91 – 7.5) to slightly alkaline (pH 7.5 – 8.26) (Table 6-8). Dissolved oxygen ranged from hypoxic (<1 ppm) to moderate (8.11; Table 6-8), with low oxygen levels unlikely to be a limiting factor for stygofauna given that they have been recorded in waters with concentrations below 1mg/L (1 ppm) (Humphreys 2008).



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Date	14-Dec-21
Drawn by	IN
Map author	CN

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Kilometers

1:89,515 (at A4) GCS WGS 1984

Study area
Survey records

Proposed pits

GTS pit
Hub pit
Nambi pit

Figure 6-3

Subterranean fauna recorded in the field survey

PHOENIX ENVIRONMENTAL SCIENCES

Table 6-8 Ground water quality data for bore sampled for stygofauna

Bore	Area	Temperature (°C)	O^2 (%)	O^2 (ppm)	Specific conductivity (µS)	Conductivity (µS)	TDS	Salinity (ppt)	pH	ORP	SWL (mbgl)
19RRC016	Hub	23.9	36.1	2.79	1,816	1,779	1,183	0.92	6.91	99.1	10.0
19RRC025	Hub	23.5	64.1	5.12	5,300	5,143	3,445	2.85	7.76	103.0	7.0
19RRC042	Hub	24.3	30.8	2.42	2,626	2,590	1,709.5	1.36	7.45	99.4	9.4
19RRC062	Hub	23.3	49.6	3.99	3,906	3,770	2,535	2.06	7.81	85.5	10.0
20RRC061	Hub	24.4	75.2	5.87	1,962	1,940	1,274	1.00	7.90	95.9	9.5
20RRC094	Hub	22.3	53.8	4.46	1,702	1,604	1,105	0.86	8.13	95.3	9.3
20RRC100	Hub	23.2	54.2	4.32	2,478	2,387	1,612	1.28	7.80	109.1	8.4
20RRC104	Hub	24.0	27.5	2.19	2,336	2,284	1,514.5	1.20	7.85	85.8	9.1
20RRC116	Hub	23.1	69.1	5.57	2,202	2,122	1430	1.13	7.98	93.1	9.9
20RRC129	Hub	24.5	64.5	5.07	3,396	3,359	2,203.5	1.78	7.92	96.2	8.1
20RRC030	GTS	24.8	55.4	4.31	840	837	546	0.41	7.64	130.4	17.6
20RRC051D	GTS	21.5	17.8	1.42	11,535	10,740	7,501	6.59	7.43	-75.6	18.4
GTR045	GTS	24.3	76.3	6.00	1,498	1,477	975	0.75	7.82	90.9	18.8
GTRC210	GTS	23.6	54.5	4.44	1,988	1,935	1,293.5	1.01	7.72	99.2	18.3
GTS op hole	GTS	24.6	24.4	1.91	641	636	416	0.31	7.08	-47.4	19.2
MSWB8	GTS	23.7	43.6	3.41	6,544	4,290	3.59	7.79	8.26		15.9
Nambi pit	Nambi	17.8	91.7	8.11	2,886	2,488	1,878.5	1.51	8.26	79.5	NA
Nambiunknown1	Nambi	unable to collect water sample									37.0
Nambiunknown2	Nambi	24.5	23.2	1.82	993	984	643.5	0.49	7.47	48.0	unable to obtain reading
NBRC010	Nambi	24.2	44.9	3.57	1,030	1,015	669.5	0.51	7.67	75.6	38.8
NBRC101	Nambi	25.1	70.9	5.51	551	552	357.5	0.26	7.21	87.7	22.6

Bore	Area	Temperature (°C)	O^2 (%)	O^2 (ppm)	Specific conductivity (µS)	Conductivity (µS)	TDS	Salinity (ppt)	pH	ORP	SWL (mbgl)
NBRC102	Nambi	25.9	59.1	4.49	604	614	390	0.29	7.17	78.4	25.4
NBRC103	Nambi	24.0	51.2	4.02	583	572	377	0.28	7.34	NA	44.6
NBRC105	Nambi	24.0	75.7	5.78	370.1	378.9	239.85	0.17	6.97	80.8	11.7
NBRC107	Nambi	24.6	57.8	4.56	715	710	461.5	0.35	7.20	NA	24.2
NBRC109	Nambi	22.9	54.2	4.40	801	769	520	0.39	7.92	66.2	39.6

O^2 = dissolved oxygen

TDS = total dissolved solids

ORP = oxidation reduction potential

SWl = static water level (meters BGL)

6.3 SURVEY LIMITATIONS

The limitations of the survey have been considered in accordance with EPA (EPA 2016e, 2021) (Table 6-9).

Table 6-9 Consideration of potential survey limitations

Limitations	Constraint	Comments
Availability of contextual information at a regional and local scale	Slight	Pervious stygofauna surveys have been conducted over part of the Project area. However, limited surveys have been conducted regionally. No detailed geology/hydrology mapping available for much of the study area, limiting the ability to make inferences about the presence and extent of subterranean fauna habitat, as well as potential species distributions.
Competency/experience of the team carrying out the survey	No	Caitlin Nagle has extensive experience undertaking subterranean fauna surveys throughout Western Australia.
Scope and completeness	No	All survey areas were sampled to EPA guidelines (EPA 2016c). Only six bores were available to sample at GTS. However, a detailed stygofauna survey has been conducted at GTS previously and recorded only a *Metacyclops* copepod thought to be widespread (Phoenix 2010). The report determined there was not likely to be significant stygofauna habitat values in GTS area.
Proportion of fauna recorded and/or collected, any identification issues	No	Survey effort was sufficient to detect presence of stygofauna. All specimens collected, with the exception of one juvenile specimen, were able to be identified to species level.
Access within the study area	Slight	Bore access was constrained by the presence of swelling clays and tree roots. Samples taken from some bores may have only sampled the top portion of the aquifer if bores had closed over because of swelling clays. However clayey aquifers are considered unlikely to support stygofauna.
Timing, rainfall, season	No	The field survey was conducted in spring after adequate rainfall.
Disturbance that may have affected the results of the survey	No	No disturbances

7 Discussion

The EPA's objective for subterranean fauna is its protection so that biological diversity and ecological integrity are maintained (EPA 2016a). Subterranean communities are often restricted to very small areas and it is supposed this is based on the limited dispersal capabilities of the fauna, with short-range endemism interpreted at a much smaller scale than in terrestrial systems (Eberhard *et al.* 2009).

The Pilot study for the Redcliffe Gold Project recorded seven distinct stygofauna taxa across the Project area, with four known species and one previously unknown species being collected from Nambi, one previously unknown species from Hub and one known species from GTS. This indicates that the Project area supports a stygofaunal community.

7.1 Suitability of Redcliffe as subterranean fauna habitat

The water quality results indicate that the physico-chemical properties of the water within the study area are suitable for subterranean fauna. As such, the absence of subterranean fauna in any particular area is likely the result of unsuitable geology and/or hydrology.

7.1.1 Nambi

The Nambi deposit area features geology types that may be suitably porous or fractured to provide habitat for subterranean fauna. However, sampling only detected stygophiles and troglophiles from this area.

7.1.2 Hub

The thick layer of low permeability clay that dominates the surface at Hub is not only unsuitable habitat for subterranean fauna but would severely deplete nutrient filtration from the surface down to any more suitable habitat below. As such, it is believed unlikely that Hub hosts stygobitic or troglobitic communities.

7.1.3 GTS

The hydrogeological assessment of the GTS area indicates that its lithography is dominated by clay, which does not provide suitable habitat for troglofauna or stygofauna given its low permeability (Aquaterra 2010). This is supported by the lack of specimens collected in this Pilot study and the extensive Level 2 study previously conducted (Phoenix 2010). As such, it is considered unlikely that the GTS deposit area provides suitable habitat for subterranean fauna.

7.2 Subterranean fauna

One previously unknown stygofauna taxon, Parabathynellidae 'Phoenix0076' was collected from the Hub deposit area. This specimen is most closely related to a member of the *Atopobathynella* genus, in which there are widespread stygophile representatives (Cho & Humphreys 2010; Cho *et al.* 2006; Cho *et al.* 2005). Given the geology at Hub, it is unlikely that this species would be able to persist in an aquifer located below the low permeability clay. Additionally, the depth at which the samples were collected that contained these specimens did not exceed the depth of the clay layer, which suggests these specimens were collected from within the clay layer. Based on this, it is believed this species is likely to be a stygophile, and thus, unrestricted to the Project area. However, as the distribution and ecotype of *P*. 'Phoenix0076' is currently unknown and its classification within the Parabathynellidae family is unresolved, it is considered here to be a potential SRE.

Another previously unknown taxon, *Australoeucyclops* `BCY089`, was collected from Nambi pit. Given that this specimen was collected using the KC method, which only targets interstitial habitats, it has been designated a stygophile and is thus not considered to be of conservation significance. The remaining five stygofauna taxa recorded are all considered to be widespread, and most are known to inhabit both surface and subterranean water sources.

The troglofaunal isopod *Paraplatyarthrus creboniscus* incidentally collected is regarded as a troglophile and is also known from multiple locations outside the study area.

7.3 CONCLUSION

Despite the collection of two previously unknown species, it is believed to be unlikely that the Redcliffe Gold Project hosts significant subterranean fauna values. The geology of the study area is primarily low permeability clays that are considered unsuitable subterranean fauna habitat. No further surveys are recommended.

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APPENDIX 6: REDCLIFFE GOLD PROJECT BASELINE HYDRO-METEOROLOGICAL & SURFACE WATER MANAGEMENT STUDY (GRM 2021A)

GROUNDWATER

RESOURCE MANAGEMENT

REDCLIFFE GOLD PROJECT

BASELINE HYDRO-METEOROLOGICAL &

SURFACE WATER MANAGEMENT STUDY

Prepared for

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Report J2126R01 Final

6 December 2021

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Report Distribution

Revision	Date	Author	Reviewer	Issued to
V01	29 October 2021	A. Lowry	J. Vermaak	-
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EXECUTIVE SUMMARY

Dacian Gold Ltd (Dacian) plan to commence mining at their Redcliffe Gold Project (RGP) in mid-2022. The RGP currently comprises three deposits, namely Nambi, Hub and Golden Terrace South (GTS) situated along an approximately 20 km long north-south strike length, located about 50 km north-northeast of Leonora in the Goldfields Region of Western Australia.

Mining of each of the deposits will occur over a roughly eighteen month period with ore being shipped by road-train to Dacian's existing Mt Morgan's Operation for processing. Consequently landforms and infrastructure required for the proposed project will be restricted to pits, waste rock dumps, haul roads (including a section of modified public roadway at Redcliffe), a 100-man camp, limited mine services areas and other ancillary facilities.

Dacian has commissioned Groundwater Resource Management Pty Ltd (GRM) to complete the relevant hydrogeological (groundwater) and hydrological (surface water) assessments. This report presents the findings from a desktop study of regional hydro-meteorological data and a flood risk assessment site visit that was used in the preliminary design of surface water management measures for the RGP.

The following key findings were made:

- The regional climate is one of extremes and droughts and major floods can occur in the same area within a few years of each other. The climate in this region is highly variable, both spatially and temporally, and this can make hydrologic analysis and the design of water management measures difficult.
- Regional climatic conditions are arid with mean annual rainfalls of less than 250 mm. The rainfall that occurs during the early winter months of June and July tends to be more reliable and generally of a greater total amount than the less dependable, but more intense, summer rainfalls from January to March.
- Although remnant tropical cyclones and associated depressions may bring heavy rains to the region, they are erratic in nature and occur relatively infrequently. An analysis of cyclone data for the last 49 years shows that, on average, one cyclone will pass within 200 km of the RGP approximately every four years. Four cyclones have passed within 100 km of the RGP in the last 49 years or so, which included the significant TC Bobby in late February 1995.
- The Bureau of Meteorology (BoM) Leonora rainfall station (No. 12046) is located approximately 50 km south-southwest of the RGP and daily data are available from January 1907 to the present. Analysis of 107 complete years of data yield mean and median annual rainfalls of 239 and 221 mm. These values are considered to be representative of conditions at the RGP and their use is recommended for design purposes.
- Locally, maximum and minimum annual rainfalls of 626.1 mm and 54.0 mm have been recorded at Weebo in 1942 and 1969 respectively. Frequency analyses indicate that this maximum annual rainfall had an annual exceedance probability (AEP) of less than 1% (i.e. rarer than 1 in 100), while the 1962 minimum rainfall is representative of 1% AEP (1 in 100) drought conditions.
- Typically there are in the order of 37 rain days each year, although this may be as low as 7 days and as high as 81 days. Locally, the longest period without rain was 213 days and was recorded at Sturt Meadows between 29 July 1952 and 2 March 1953.
- The wettest day recorded locally occurred on 27 February 1995, when 186 mm was recorded at Sturt Meadows (Leonora recorded 105.9 mm on the same day). This rainfall was the result of a rain bearing system associated with TC Bobby which had an AEP of less than about 0.5% (i.e. rarer than 1 in 200).

- Short duration rainfall intensities due to remnant cyclones and other tropical depression related events can be significant. Maximum six minute intensities in excess of 150 mm/hr have been recorded regionally and are indicative of cyclonic rainfall intensities that could be experienced at the RGP.
- A rainfall intensity-frequency-duration (IFD) relationship was developed for the RGP using the latest available BoM dataset (2016). In summary, the 1%AEP intensities for 1, 3, 12, 24 and 72 hr duration events are 54.2, 25.0, 9.5, 5.9 and 2.8 mm/hr respectively (yielding equivalent storm depths of approximately 54, 75, 113, 143 and 201 mm).
- Application of BoM Probable Maximum Precipitation methods to the RGP location yield 24 and 72 hour rainfall depths of approximately 710 and 1,290 mm respectively.
- In the absence of a local evaporation record it is recommended that the average of pan evaporation data for the Yamarna and Kalgoorlie Airport stations be used for design purposes for the RGP. This gives a mean annual pan evaporation for the RGP of approximately 2,827 mm, some 65 to 70% of which can be expected to evaporate from shallow freshwater ponds at the RGP.
- A review of the BoM Leonora temperature data indicates that typically there are in the order of 25 days each year with daily maximum temperatures in excess of 40°C, the bulk of which occur during December, January and February. Conversely, each year, on average, 6 days can be expected during June, July and August with minimum night time temperatures of 2°C or less and light ground frosts are possible.
- All of the proposed RGP mining areas are located within DWER's vast, internally draining Salt Lake Basin (area = 441,000 km^2) which extends across much of central WA. The Nambi and Hub mining areas are located in the upper headwaters of the Lake Carey Catchment (area = 113,780 km^2), while the GTS mining area is located immediately to the south of the regional watershed divide with the Lake Raeside-Ponton Catchment (area = 115,965 km^2).
- Given their location in the upper headwaters of the regional catchments, catchment areas upstream of the RGP mining areas are relatively modest. There are no major river systems in the vicinity of the proposed mining areas and any watercourses or drainages that do exist are ephemeral and only convey flow periodically, following significant rainfall. Consequently only relatively minor surface water management measures will be required at each of the proposed RGP mining areas, as follows:
  - Nambi Mining Area – three floodways where drainage lines cross proposed roadways;
  - Hub Mining Area – an approximately 1,575 m long flood bund constructed along the western (upstream) side of the Hub North and South Pits, along with four floodway crossings where drainage lines cross proposed roadways; and,
  - GTS Mining Area – an approximately 1,000 m long diversion channel and approximately 725 m long flood bund constructed along the northern and western sides of the GTS Pit.

GLOSSARY OF HYDROLOGICAL TERMS

Annual Exceedance Probability (AEP)	The probability that a given rainfall total accumulated over a given duration will be exceeded in any one year.
Antecedent Soil Moisture	Water present in the soil prior to a rainfall event.
Average Recurrence Interval (ARI)	The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that the periods between exceedances are generally random.
Australian Rainfall and Runoff (ARR)	National guideline document, data and software suite that can be used for the estimation of design flood characteristics in Australia. Currently in its 4th edition it is commonly referred to as ARR2016.
Australian Hydrological Geospatial Fabric (AHGF)	The Australian Hydrological Geospatial Fabric (Geofabric) is a specialised Geographic Information System (GIS). It identifies and registers the spatial relationships between important hydrological features such as watercourses, water bodies, canals, aquifers, monitoring points and catchments
Backwater	Water backed-up or retarded in its course as compared with its normal or natural condition of flow
Baseflow	The component of streamflow supplied by groundwater discharge
Basin	A tract of country, generally larger catchment areas, drained by a river and its tributaries.
Catchment	The land area draining to a point of interest, such as a water storage or monitoring site on a watercourse.
Channel	An artificial or constructed waterway designed to convey water. Often described as open channels to distinguish them from pipes.
Control	Physical properties of a cross-section or a reach of an open channel, either natural or artificial, which govern the relationship between stage and discharge at a location in the open channel.
Dead Storage	In a water storage, the volume of water stored below the level of the lowest outlet (the minimum supply level). This water cannot be accessed under normal operating conditions.
Discharge	Volume of liquid flowing through a cross-section in a unit time.
Drainage Division	Representation of the catchments of the 12-major surface water drainage systems across Australia, generally comprising a number of river basins.
Endorheic Basin	A closed surface water drainage basin that retains water and has no outflow to the sea.
Environmental Flow	The streamflow required to maintain appropriate environmental conditions in a waterway or water body.
Ephemeral	Something which only lasts for a short time. Typically used to describe rivers, lakes and wetlands that are intermittently dry.
Evapotranspiration (ET)	The sum of evaporation and plant transpiration from the earth's land surface to the atmosphere.
Evaporation	A process that occurs at a liquid surface, resulting in a change of state from liquid to vapour.
Floodplain	Flat or nearly flat land adjacent to a stream or river that experiences occasional or periodic flooding
Full Supply Level (FSL)	The normal maximum operating water level of a water storage when not affected by floods. This water level corresponds to 100% capacity.

GLOSSARY OF HYDROLOGICAL TERMS

Generalised Short-Duration Method (GSDM)	Appropriate for estimating probable maximum precipitation for durations up to six hours and for an area of less than 1000 square kilometres.
Generalised Tropical Storm Method – Revised (GTSMR)	Appropriate for estimating probable maximum precipitation in regions of Australia affected by tropical storms.
Intensity-Frequency-Duration (IFD)	Design rainfall intensities (mm/h) or design rainfall depths (mm) corresponding to selected standard probabilities, based on the statistical analysis of historical rainfall.
Minimum Supply Level (MSL)	The lowest water level to which a water storage can be drawn down (0% full) with existing outlet infrastructure; typically, equal to the level of the lowest outlet, the lower limit of accessible storage capacity.
Precipitation	All forms in which water falls on the land surface and open water bodies as rain, sleet, snow, hail, or drizzle.
Probable Maximum Flood (PMF)	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation (PMP, and coupled with the worst flood producing catchment conditions.
Probable Maximum Precipitation (PMP)	The theoretically greatest depth of precipitation for a given duration under modern meteorological conditions for a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends.
Rainfall	The total liquid product of precipitation or condensation from the atmosphere, as received and measured in a rain gauge
Riparian	An area or zone within or along the banks of a stream or adjacent to a watercourse or wetland; relating to a riverbank and its environment, particularly to the vegetation.
Stage	The water level, typically measured at a water monitoring site
Storage	A pond, lake or basin, whether natural or artificial, for the storage, regulation and control of water.
Surface Runoff	Water from precipitation or other sources that flows over the land surface. Surface runoff is the fraction of precipitation that does not infiltrate at the land surface and may be retained at the surface or result in overland flow toward depressions, streams and other surface water bodies
Sustainable Yield	The level of water extraction from a particular system that would compromise key environmental assets, or ecosystem functions and the productive base of the resource, if it were exceeded.
Total Suspended Solids (TSS)	The sum of all particulate material suspended (i.e. not dissolved) in water. Usually expressed in terms of milligrams per litre (mg/L). It can be measured by filtering and comparing the filter weight before and after filtration.
Transpiration	Evaporative loss of water from the leaves of plants through the stomata; the flow of water through plants from soil to atmosphere.
Watercourse	A river, creek or other natural watercourse (whether modified or not) in which water is contained or flows (whether permanently or from time to time).
Wind Run	The product of the average wind speed and the period over which that average speed was measured

Ref: Australian Water Information Dictionary, Bureau of Meteorology, Commonwealth of Australia 2017 (http://www.bom.gov.au/water/awid/all.shtml)

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1.0 INTRODUCTION

Dacian Gold Ltd (Dacian) plan to commence mining at their Redcliffe Gold Project (RGP) in mid-2022. The RGP comprises three deposits; namely, Nambi, Hub and Golden Terrace South (GTS) situated along an approximately 20 km north-south strike length, located about 50 km north-northeast of Leonora in the north-eastern Goldfields Region of Western Australia.

Mining of each of the deposits will occur over a roughly twelve to eighteen month period with ore being shipped by road-train to Dacian's existing Mt Morgan's Operation for processing, some 70 km to the southeast. Consequently landforms and infrastructure required for the proposed project will be restricted to pits, waste rock dumps (WRDs), haul roads (including a section of realigned public roadway at the Hub mining area), limited mine services areas and other associated mine infrastructure. A 100-man camp will be required and a location for it has been identified some 4 km north of the GTS mining area.

Dacian has commissioned Groundwater Resource Management Pty Ltd (GRM) to complete the relevant hydrogeological (groundwater) and hydrological (surface water) assessments. This report deals with the surface water aspects of the project and presents GRM's completion of the following surface water tasks:

- Hydrological/meteorological Desktop Study – we obtained hydro-meteorological data and mapping information from Dacian and relevant State and Federal government bodies and completed a desktop review to define catchment areas, determine key catchment characteristics and summarise regional and local meteorological conditions. This study yielded pertinent meteorological information e.g. local rainfall intensity-frequency-duration (IFD), maximum daily rainfalls, tropical cyclone risk, critical historical wet and dry periods and preparation of PMP estimates.
- Flood Risk Assessment Site Visit – GRM's civil engineering hydrologist completed a site visit in October 2021 in order to assess the existing surface water regime in the vicinity of the proposed mining area and to evaluate potential flood risks and impacts from proposed mining infrastructure on the local environment. During the visit upstream catchment areas were inspected in order to gauge land cover, ground slope, drainage density etc. as well as noting evidence of previous flood events.
- Feasibility Level Surface Water Management Measure Design - we have developed feasibility level designs for the surface water management works required at each of the proposed mining areas including diversion channels, bunds, raised haul roads, floodways etc. The designs are summarised in the text and shown on preliminary design drawings and figures to a level consistent with a Feasibility Study (FS).

2.0 DESKTOP HYDRO-METEOROLOGICAL STUDY

2.1 Data Sources

No on-site rainfall or streamflow data are available for the proposed RGP. The hydro-meteorological desktop study therefore made use of local and regional data available from the public domain sources listed below. The data have been analysed in detail and the results are discussed in the following sections, with charts and additional information provided in Appendix A.

2.1.1 Bureau of Meteorology (BoM) Data

Data for the BoM stations listed in Tables 1-4 (and shown on Figures 1 and 2) were obtained and used in the completion of the desktop study. It should be noted that all stations are currently open, unless noted otherwise, and that all distances were measured from the centroid of the three proposed RGP mining areas at approximate coordinate 358,490 mE and 6,849,090 mN (GDA94/MGA Zone 51):

Table 1: Daily Rainfall Records for Local BoM Stations

BoM Station Name	Sta. No.	Data Period note1	% Complete notes2,3	Distance from Site (km)
Nambi	12062	Mar 1922 – Nov 2020	61.0	15 NE
Leonora	12046	Jan 1907 – Jul 2020	95.7	50 SSW
Minara	12061	Jan 1907 – May 2014	92.6	54 SSE
Sturt Meadows	12176	Jun 1909 – Dec 2021	99.9	61 WSW
Weebo	12082	May 1930 – May 2021	95.7	70 NW
Laverton	12045	Jan 1907 – May 2021	95.5	85ESE

Note 1: Data for Leonora, Minara and Laverton prior to January 1907 and for Sturt Meadows prior to Jun 1909 were discarded due to unacceptably high number of gaps.
Note 2: % Complete = No. of Daily Observations ÷ (End Date of Record - Start Date of Record).
Note 3: Nambi record spans 99 years, but includes 32 missing years & 16 incomplete years, hence lower overall completeness (61.0%). However the record also contains 51 years of high quality data (≥99% complete).

Table 2: Pluviograph Records for Regional BoM Stations

BoM Station Name	Station No.	Data Period	Distance from Site (km)
Cashmere Downs	12022	Dec 2002 - Dec 2015	202 WSW
Leonora	12046	Feb 1963 - Dec 2015	50 SSW
Kalgoorlie Airport	12038	Jul 1955 - Dec 2015	256 S

Table 3: Daily Evaporation for Regional BoM Stations

BoM Station Name	Station No.	Data Period	Distance from Site (km)
Kalgoorlie Airport	12038	Nov 1966 - Feb 2016	256 S
Yamarna closed	12219	Nov 1968 - May 1997	209 ENE

Table 4: Climate Summaries for Regional BoM Stations

BoM Station Name	Station No.	Recording Period[1]	Distance from Site
Leonora	12046	1897 – 2021	50 SSW
Laverton	12045	1899 – 2021	85 ESE
Leinster Aero	12314	1994 – 2021	110 NW
Menzies	12052	1896 – 2021	144 SSW
Bulga Downs	12239	1924 – 2021	177 W
Booylgoo Spring	12008	1922 – 2021	180 WNW
Yeelirrie	12090	1928 – 2021	195 NW
Cashmere Downs	12022	1919 – 2021	202 WSW
Yamarna [closed]	12219	1967 – 1998	209 ENE
Kalgoorlie Airport	12038	1939 – 2021	256 S

Note 1: Data not available for all climate parameters over entire recording period.

Swept path data from the BoM's Southern Hemisphere Tropical Cyclone Data Portal for Australian cyclones from 1969/1970 season to 2017/2018 season were also used in the study.

2.1.2 Department of Water and Environmental Regulation (DWER)

A request was made to the DWER for mean and maximum flow monitoring data. However, currently the Department has no flow gauging stations within either the Lake Carey or Raeside-Ponton Catchments of the Salt Lake Basin (Basin No. 024).

2.1.3 Department of Agriculture (DoA)

Data presented in the Department's Evaporation Data for Western Australia, Resource Management Technical Report No. 65, October 1987 were used in the completion of the study.

Reference was also made to the Department's Technical Bulletin No. 87 "An Inventory and Condition Survey of Rangelands in the North-Eastern Goldfields, Western Australia" (Pringle *et al*).

2.1.4 Mapping Data

The following mapping data were used in the completion of the desktop study (all data provided by Dacian unless noted otherwise):

- 1:250,000 scale electronic topographic mapping from Geoscience Australia.
- 1-second Hydro-Enforced SRTM data from Geoscience Australia.
- ESRI World Imagery.
- Digital Elevation Model (DEM) and imagery captured over Redcliffe mining area August 2021.
- Preliminary infrastructure layout information received October 2021.

2.2 Meteorological Conditions

2.2.1 General

The climate of the north-eastern Goldfields region is arid to semi-arid[1] and can be characterised by its relatively low annual rainfall and large temperature range.

The mean annual rainfall is typically less than about 250 mm, but may vary annually from less than one third to almost three times that amount. The rainfall that occurs during the autumn and early winter months of May to July tends to be more reliable though generally of a lesser total amount than the less dependable, but more intense summer cyclonic rainfall from December to March.

Temperature ranges of over 50°C have been recorded between summer maxima and winter minima. Annual pan evaporation rates typically exceed 2,500 mm/year and surpass rainfall by an order of magnitude.

The RGP is located within the "Desert: summer and winter rainfall[2]" bioclimatic category and as such none of the months of the year are reliably wet, and zero rainfall can be recorded in any month.

2.2.2 Regional Summer Climate

During the warmer months between November and April the region is influenced by anti-cyclonic systems to the southeast and as a result the climate is typified by easterly winds and hot days with clear skies. The area is also occasionally influenced by southern extensions of the Inter Tropic Convergence Zone (ITCZ) which may bring thunderstorm activity. Significant summer features are related to thermal lows over the region, which are associated with fine hot to very hot days, with little or no cloud, and easterly winds. Evening typically brings only slight decreases in temperature with an easing in wind velocity and direction change to the south-east.

Occasionally, remnant tropical cyclones, which have crossed the Pilbara coast, pass over the region. These proceed in a south-easterly direction weakening as they progress to become rain-bearing troughs or depressions between the usual anti-cyclone patterns. Strong wind gusts can be associated with these depressions that can occasionally cause wind erosion and dust storms.

During March to April, the surface winds become lighter and more variable. Typically by April the northward movement of the anti-cyclone belt has become very noticeable and the probability of tropical depression rain decreases.

Summer maximum temperatures commonly exceed 40°C. Evaporation levels are very high during the summer months, with Kalgoorlie averaging in excess of 300 mm/month. Humidity levels are low and dews are rare except during and immediately following periods of rain.

[1] In the temperate zones of Australia the classification of arid generally refers to areas with a mean annual rainfall of less than 250 mm.
[2] *Plant Life of Western Australia*, Beard, J.S., 1990.

2.2.3 Regional Winter Climate

Anti-cyclone systems reach their northern limit over Western Australia during the cooler half of the year, between May and October. Winter in the region is then characterised by a sequence of anti-cyclones moving from west to east, which distribute westerly winds and on occasions, north-westerly winds to the area.

Associated with these sequences of anti-cyclones are depressions bringing rain-bearing frontal systems through the region. Winds are usually moderate but occasionally westerly gales can extend into the area. Winter rains most often occur between late May and early August. When anti-cyclones are centred over the area, winds are frequently light and variable. Minimum temperatures may occasionally fall below freezing point for several successive days.

Between September and October the re-establishment of stable anti-cyclonic conditions is characterised by little to no rain in the region. Also during October, because of the southward movement of the ITCZ and the anti-cyclonic belt, the easterlies in the north and the westerlies in the south of the region both weaken, and light variable winds are a feature of the area.

Winter mean minimum temperatures range from 4.0 to -6.0°C. Evaporation levels are greatly reduced during the winter months with a mean monthly evaporation at Kalgoorlie of less than 100 mm/month. Generally the average rainfall during the wettest months of July to August does not exceed the evaporation rate throughout the region. Humidity levels are generally higher in winter than in summer, except during and immediately following summer rainfalls.

2.2.4 Local Rainfall

In order to analyse local rainfall conditions daily rainfall data were obtained for six BoM stations, all of which fall within an 85 km radius of the RGP (see Figure 2). All rainfall stations remain open and have records that span at least 90 years with varying degrees of completeness.

Annual Rainfall

An analysis of annual rainfall data for the local rainfall stations was carried out. Table 5 gives the maximum, minimum, mean and median annual rainfalls for each of the stations, while Table 6 gives the minimum, maximum and mean number of rain days per year and maximum duration without rain.

Only complete years of data were used in the analysis which meant that the length of some of the data sets were reduced significantly, particularly the Nambi record which was reduced by about one half[3].

The annual rainfall data for all the local stations demonstrate the right-handed or positive skewness typical of the region (annual skewness values ranged from +0.65 at Nambi to +0.89 at Minara). Median annual rainfall was therefore also calculated as it is generally considered to be a more representative reflection of rainfall central tendency for areas with skewed rainfall data than mean

[3] As a result annual rainfall values presented in this report may differ slightly with those presented elsewhere by BoM who do not necessarily remove incomplete years before summarising.

annual rainfall. This is the case in regions where exposure to a few, or even a single, extreme cyclonic rainfall event can have a disproportionate effect on the mean, but has much less effect on the median, given that it is based on ranked data.

Table 5: Local Rainfall Stations Annual Rainfall

Station Name	Maximum Annual Rainfall (mm)	Minimum Annual Rainfall (mm)	Mean Annual Rainfall (mm)	Median Annual Rainfall (mm)	No. of Complete Years
Nambi	541.4 (2000)	57.4 (1962)	226.6	204.0	51
Leonora	552.2 (1975)	57.8 (1936)	239.1	221.2	107
Minara	532.5 (2001)	88.6 (1969)	225.4	211.9	86
Sturt Meadows	561.1 (1975)	54.1 (1936)	221.5	210.4	109
Weebo	626.1 (1942)	54.0 (1969)	238.1	233.3	75
Laverton	525.6 (2000)	65.6 (1928)	230.6	206.6	103

Notes: All Annual Rainfall values above calculated using complete years of data only. Max/Min values shown in *bold italics*.

Table 6: Local Rainfall Stations Annual Rain Days and Duration Without Rain

Station Name	No. of Rain Days per Year			Periods Without Rain		
	Min.	Max.	Mean	Maximum Duration	From	To
Nambi	17	76	35.5	166	25 Feb 2020	8 Aug 2020
Leonora	16	***81***	44.8	127	22 Jan 1940	27 May 1940
Minara	14	74	39.3	149	19 Jul 1938	14 Dec 1938
Sturt Meadows	9	61	29.4	***217***	29 Jul 1952	2 Mar 1953
Weebo	***7***	57	30.3	172	8 Oct 1990	28 Mar 1991
Laverton	15	74	41.6	124	29 Jul 1923	29 Nov 1923

Notes: All Annual Rainfall values above calculated using complete years of data only. Max/Min values shown in *bold italics*.

Table 5 shows that the mean annual rainfall for the local stations range from approximately 221 to 239 mm, while the median values range from some 204 to 233 mm. However, given that the Leonora station remains open, is located some 50 km south-southwest of the RGP and has 107 years of complete data, its mean and median annual rainfall of 239 and 221 mm respectively are considered suitable for use in the design of the project[4].

Points of note from the analysis of the complete annual rainfall data sets for Leonora and the other local stations are as follows:

- Local annual rainfalls are highly variable with typically a one order of magnitude range between maximum and minimum values. Minimum and maximum annual rainfalls of 54.0

[4] Nambi despite being closer to the RGP (15 km NE) has less than half the number of complete years of data (51 years) compared to Leonora and has only one complete year of data in the last 20 years.

and 626.1 mm were recorded at Weebo in 1969 and 1942 respectively. There is no obvious spatial rainfall distribution between the local rainfall stations.

- Local annual rainfalls are also highly temporally variable and significantly wet and dry years can occur in consecutive years. This temporal variation is reflected in the data for Nambi with annual rainfalls of 447.1 mm in 1975, followed by 57.5 mm in 1976 i.e. a near eightfold year-on-year decrease. Nambi also recorded an annual rainfall of 57.4 mm in 1962, followed by 299.7 mm in 1963 i.e. greater than a fivefold year-on-year increase.
- Frequency analyses of the Weebo annual rainfall record was completed using a Generalised Extreme Value (GEV) distribution which indicates that the 626.1 mm recorded there in 1942 had an annual exceedance probability (AEP) of less than 1% (rarer than 1 in 100). The 1% AEP annual rainfall is in the order of 605 mm. The 54.0 mm recorded there in 1969 is equal to the 1% AEP (1 in 100) annual drought for the local area.
- The local annual maximum of 626.1 mm recorded at Weebo in 1942 was due largely to heavy rainfalls associated with Tropical Cyclone (TC) Unnamed No. 7 1941/42[5] when a ten-day rainfall total of 269.4 mm was recorded at Weebo and TC Unnamed No. 2 1941/42 when a two-week total rainfall of 2235.5 mm was recorded. It should be noted that 1942 was a significantly wet year locally and ranked second wettest at Leonora (524.4 mm) and third at Minara (464.3 mm).
- Significantly wet years also occurred locally in 1975 and 2000 with several of the local stations recording their highest or second highest annual rainfalls. Rainfalls in 1975 were attributable to TC Trixie in late February and to depressions related to TC's Beverley, Clara and Joan later that year. In March 2000 TC Steve re-crossed the WA coast at Carnarvon and continued in a south-easterly direction bringing rainfalls of between 50 and 100 mm to inland parts from the West Gascoyne to the South Coast near Esperance.
- The local minimum annual rainfall of 54.0 mm, which was recorded at Weebo in 1969, was as a result of only 11 days of rainfall that year. It is interesting to note that Weebo recorded fewer days of rain (7 days) in 2005, but recorded a total annual rainfall of 76.7 mm that year.
- The longest continuously dry period was 213 days long and was recorded at Sturt Meadows between 29 July 1952 and 2 March 1953 inclusive. This event was due to the absence of late winter rains and Tropical Cyclone or depression related rainfall for that entire summer.
- The average number of rain days per year recorded locally ranges from between about 29 and 45 days, with an overall average of some 37 days. However as many as 81 rain days per year (Leonora in 1992) and as few as 7 rain days per year (Weebo in 2005) have been recorded locally.

Monthly Rainfall

Mean, median, maximum and minimum monthly rainfall values were determined for all six local rainfall stations using only complete months of data (refer to Appendix A for results). The monthly values for Leonora using all 1,300 complete months within the data set are shown in Table 7.

[5] Prior to 1964 Tropical Cyclones were unnamed and were instead assigned a sequential number by BoM according to the season of their occurrence.

Table 7 shows that the six months of the year between January and June are the wettest based on mean monthly values and from February to July are the wettest based on median monthly values. The wettest month at Leonora based on mean monthly values is February with 31.0 mm. However, June has the maximum median monthly value of 19.4 mm. This bi-modal distribution is caused in late summer by tropical cyclones and associated depressions, while the increase in rainfall in early winter tends to be due to low-pressure trough systems acting in conjunction with large southerly frontal systems.

The results show the positive skewing effect that extreme cyclonic rainfall events can have on the mean rainfall values compared to median values, especially during the summer months. The difference between the mean and median monthly rainfall amounts is significantly less during the drier winter months. September and October are the driest months of the year based on both mean and median values. Rainfall was only recorded on about 8% days of September and October over the entire 114 year long record.

Table 7: Leonora Monthly Rainfall

Month note2	Mean Monthly Rainfall note1 (mm)	Median Monthly Rainfall note1 (mm)	Maximum Monthly Rainfall and Year (mm)	Minimum Monthly Rainfall (mm)	No. of Complete Months
January	26.2	11.5	172.0	0	108
February	31.0	12.6	284.6	0	109
March	30.6	12.5	273.9	0	109
April	20.5	13.9	135.4	0	109
May	23.5	17.3	158.6	0	107
June	24.1	19.4	144.0	0	108
July	18.7	14.8	101.6	0	109
August	15.6	11.0	85.2	0	107
September	8.5	5.1	49.9	0	108
October	9.5	3.6	73.0	0	109
November	12.4	7.0	61.2	0	108
December	17.5	10.8	94.0	0	109
Total No. of complete months in data set					1,300

Notes

1. For the same data set, the sum of median monthly rainfalls does NOT equal the median annual rainfall, unlike the sum of mean monthly rainfalls, which does equal the mean annual rainfall. This is due to ranking of data required to obtain the median, rather than simple addition and division required for the mean.

2. Data for all months are positively skewed with an average skewness of +2.2.

The maximum monthly rainfalls for each of the local stations are presented in Table 8. The results show that TC Bobby in late February 1995 was a very significant event in the vicinity of the RGP as it gave rise to the wettest month on record at five of the local rainfall stations. Sturt Meadows recorded the local maximum monthly rainfall of 386.6 mm, with some 270 mm being recorded over a two day period between 26 and 27 February 1995.

The wettest month recorded at Weebo of 318.0 mm as a result of the passage of TC Trixie was recorded over an eight day period between 19 and 26 February 1975 and included a three day total of 264.0 mm. The frequency of cyclones in the local area is discussed further later in this report.

Table 8: Local Rainfall Stations Maximum Monthly Rainfall

Station Name	Maximum Monthly Rainfall (mm)	Date	Event (if known)
Nambi	213.0	Feb 1995	TC Bobby
Leonora	284.6	Feb 1995	TC Bobby
Minara	256.1	Feb 1995	TC Bobby
Sturt Meadows	386.6	Feb 1995	TC Bobby
Weebo	318.0	Feb 1975	TC Trixie
Laverton	233.6	Feb 1995	TC Bobby

Note: Only months with complete data were used in the analysis.

Zero precipitation or dry months have been recorded at Leonora (and all of the other local rainfall stations considered) throughout the year. Approximately 13% of the usually wetter months of January and February recorded no rainfall, while only about 5% of June monthly records were completely dry. A plot of the mean and median monthly rainfall data for the Leonora station is included in Appendix A, along with those for the other five local BoM rainfall stations.

Daily Rainfall

A frequency analysis was carried out using Leonora daily data to assess the typical duration of local rainfall events. As only daily data were available, a multiple day duration event was assumed to comprise two or more consecutive days of rainfall, resulting in 3,048 discrete rainfall events, comprising 4,834 rain days during the 114 year span of the Leonora rainfall dataset. The results of the frequency analysis are presented in Table 9.

Table 9: Rainfall Duration Frequency Analysis for Leonora

Event Duration (days)	Frequency (No. of Events)	Frequency (%)	Cumulative Frequency (%)
1	1,898	62.27%	62.27%
2	748	24.54%	86.81%
3	243	7.97%	94.78%
4	106	3.48%	98.26%
5	38	1.25%	99.51%
6	10	0.33%	99.84%
7	4	0.13%	99.97%
8	0	0.00%	99.97%
9	1	0.03%	100.00%
Total	**3,048**	**100.00**	-

A review of the results of the rainfall duration frequency analysis shows that approximately two thirds (62.3%) of rainfall events are discrete, single-day events. Two and three-day events represent about 24.5% and 8% of all rainfall events. The longest period of consecutive daily rainfall was found to be 9 days and occurred between 19 and 27 February 1975 and was likely related to the remnant TC Trixie which was active in the north-eastern Goldfields at that time.

An analysis of maximum daily rainfall data was carried out for all six local BoM stations. The top ten wettest days are shown in Table 10 along with the recording station, date and tropical cyclone name where related. It should be noted that the highest daily rainfall is more than three times the minimum annual rainfall and is almost of a similar order as the mean annual rainfall at some of the local stations.

Table 10: Local Rainfall Stations Maximum Daily Rainfall

Station Name	Date	Daily Precipitation to 9 am (mm)	Rank	Event Name [note1]
Sturt Meadows	27 Feb 1995	185.6	1st	TC Bobby
Sturt Meadows	23 Jan 2014	161.0	2nd	Tropical Low 06U
Laverton	17 Feb 2011	120.2	3rd	TC Dianne
Weebo	23 Jan 2000	117.0	4th	Unknown
Leonora	23 Jan 2014	109.2	5th	Tropical Low 06U
Weebo	23 Feb 1975	108.2	6th	TC Trixie
Leonora	27 Feb 1995	105.9	7th	TC Bobby
Weebo	31 Jan 1960	104.9	8th	Unknown
Weebo	1 Jan 1955	104.6	9th	Unknown
Leonora	21 Mar 1927	103.4	10th	TC Unnamed #4 1926/27

Note 1: Prior to 1964 Tropical Cyclones were unnamed and were instead assigned a sequential number by BoM according to the season of their occurrence.

Frequency analyses were carried out on the annual daily maxima for the local BoM rainfall stations. The analyses showed that the 185.6 mm event recorded at Sturt Meadows on 27 February 1995 as a result of TC Bobby has an AEP of less than about 0.5% (i.e. rarer than 1 in 200).

A listing of the ten wettest days at each of the local stations is provided in Appendix A and is presented by individual station, by total rainfall depth and chronologically.

Maximum two and three day rainfalls recorded at each of the local rainfall stations are shown in Table 11. The local maximum two and three-day rainfall depths of 270.6 and 279.6 mm respectively were recorded at Sturt Meadows in late February 1995 as a result of TC Bobby. All of the two and three day maxima were related to significant tropical cyclones and other depression type events including TC Trixie (February 1975) and TC Dianne (February 2011).

Table 11: Local Stations Maximum Two and Three Day Rainfalls

Station Name	Maximum Two-Day Rainfall (mm)	Date of Maximum Two-Day Rainfall	Maximum Three-Day Rainfall (mm)	Date of Maximum Three-Day Rainfall
Nambi	113.2	22-23 Feb 1975	152.2	21-23 Feb 1975
Leonora	173.5	21-22 Mar 1927	216.2	26-28 Feb 1995
Minara	128.5	1-2 Jan 1955	134.2	21-23 Feb 1975
Sturt Meadows	270.6	26-27 Feb 1995	279.6	25-27 Feb 1995
Weebo	204.4	22-23 Feb 1975	264.0	21-23 Feb 1975
Laverton	153.2	17-18 Feb 2011	153.4	16-18 Feb 2011

Sub-Daily Rainfall

Pluviograph data from the three closest stations at Leonora (50 km SSW), Kalgoorlie Airport (256 km S) and Cashmere Downs (202 km WSW) were assessed. Maximum daily rainfalls of 109.2, 177.8 and 149.8 mm have been recorded at these three stations respectively and they therefore sit well within the range of maximum daily values for the stations local to the RGP. Table 12 shows the maximum six-minute duration rainfall intensities recorded at each of the pluviograph stations.

Table 12: Regional Stations Maximum Recorded Six Minute Rainfall Intensity

Station Name	Record Length	Max. Six-Minute Intensity	Date
Leonora	46.9 years	141.3 mm/hr	19 Dec 2006
Kalgoorlie Airport	54.4 years	152.6 mm/hr	4 Mar 2005
Cashmere Downs	7.1 years	167.5 mm/hr	20 Feb 2004

The maximum recorded six-minute intensities shown above compare well with the calculated 2% and 1% AEP Intensity-Frequency-Duration (IFD) values shown in the following section.

Intensity-Frequency-Duration Relationship

Table 13 shows the point rainfall IFD relationship developed for the RGP using the data set updated by BoM in 2016. The full IFD relationship is presented in Appendix B of this report.

Table 13: RGP Point Rainfall IFD Relationship (mm/hr)

Duration	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
6 mins	49.4	78.6	101	126	162	193
30 mins	21.8	34.7	44.6	55.3	71.2	84.9
1 hour	13.7	21.7	28.0	34.9	45.2	54.2
3 hours	6.41	10.1	13.0	16.1	20.9	25.0
6 hours	4.05	6.32	8.08	10.0	12.8	15.3
12 hours	2.58	4.02	5.12	6.30	8.01	9.45
24 hours	1.62	2.55	3.24	3.98	5.05	5.94
72 hours	0.70	1.12	1.45	1.79	2.33	2.79

Probable Maximum Precipitation

In order to estimate the probable maximum rainfall (PMP) that might be experienced at the RGP the BoM GSDM and GTSMR Coastal/GSAM Inland methods were applied at the centroid of the proposed mining areas (refer to Appendix C). The resulting PMP rainfall depths are summarised in Table 14.

Table 14: PMP Rainfall Depth Estimates

Duration (hours)	PMP Depth (mm)	Duration (hours)	PMP Depth (mm)
1	340	12	600
2	440	24	710
3	500	36	880
4	530	48	1,020
5	540	72	1,290
6	550	96	1,450

Cyclone Swept Path Analysis

As discussed earlier, the RGP is located within part of the north-eastern Goldfields that is subject to tropical cyclones, thunderstorms and related events. Of particular note in recent times was TC Bobby which crossed the western Pilbara coast near Onslow on 25 February 1995 as a Category 4 event, before continuing southwards across the Gascoyne as a Category 2 event and then the Goldfields as a rain bearing depression. Intense rainfall accompanied Bobby, with Onslow recording more than 400 mm over the duration of the cyclone. Many centres in the Goldfields recorded their maximum daily, monthly and annual rainfalls as presented in the preceding sections. Sturt Meadows and Leonora recorded some 289 and 233 mm of rainfall respectively in the four days to 28 February 1995. The resulting runoff closed roads and flooded many open pit and underground mines across the region. It was estimated to have caused more than a $50 million loss in gold output alone[6].

In more recent times, Tropical Low 06U crossed the Northern Territory coast east of Darwin on 14 January 2014 and moved inland causing significant rainfall across vast swathes of inland Australia including the Kimberley, Pilbara, Mid-West and Goldfields regions of Western Australia. Sturt Meadows and Leonora received some 161 mm and 109 mm respectively to 9 a.m. on 23 January 2014 (these amounts are equivalent to approximately the 0.5% and 2% AEP 24 hour duration rainfall amounts respectively). Parts of the arid Nullarbor Plain received more than an entire summer's worth of rain in 24 hours, with Eyre receiving over 106 mm. While this event brought much needed rainfall and alleviated drought conditions over north-west Australia, it also caused widespread flooding and inundation of mines and cattle stations in the Goldfields.

Photograph 1 on the following page shows runoff overtopping a public road in the north-eastern Goldfields on 23 January 2014 during Tropical Low 06U.

[6] "*Report on a Survey of the Effects of Cyclone Bobby on Western Australian Mines*", Dept. of Minerals and Energy, October 1995.

Photograph 1: Runoff overtopping road on 23 January 2014 during Tropical Low 06U

In order to estimate the frequency that cyclones might be expected in the region, the swept paths of all Australian cyclones from the 1969/70 season to the 2017/18 season were examined and those that passed within a 200 km radius of the RGP were noted. This radius of influence was arbitrarily chosen as the width within which a cyclone would cause some operational impact to the RGP, even if only minor. This initial assessment showed that some twelve tropical cyclones entered the 200 km radius during the approximately 49-year period of record, or that the long-term regional average is approximately one cyclone within 200 km every four years.

A second assessment was carried out to determine the number of cyclones crossing closer to or within 100 km of the RGP. It was considered that cyclones crossing within this tighter radius would have more significant impacts on the RGP, likely leading to lost time and possible asset damage or loss. This assessment showed that four cyclones (TC's Connie, Orson, Bobby and Olivia) crossed within a 100 km radius over the approximately 49-year period of record, or one every 12 years or so.

A final assessment showed that two cyclones (TC's Connie and Orson) crossed within a 50 km radius of the RGP site over the approximately 49-year period of record, or one every 25 years or so.

The results of the cyclone swept path analyses are provided in Appendix D.

It should be noted that the above analyses are somewhat subjective as it only considers the cyclone frequency and not its intensity. Cyclone intensity varies from a gale force Category 1 with wind speeds up to 125 km/hr to severe category 5 cyclones with gusts of more than 280 km/hr. Obviously a more intense cyclone passing further away may cause greater damage than a less intense cyclone in the immediate vicinity of the RGP.

2.2.5 Evaporation

The mean monthly Class A bird-guarded pan evaporation measured at Yamarna and Kalgoorlie Airport is listed in Table 15 (these stations are the closest reliable evaporation gauging sites, with the former located some 256 km south and the latter located some 209 km east-northeast of the RGP).

Table 15: Mean Monthly Pan Evaporation

Month	Mean Monthly Pan Evaporation (mm)		
	Yamarna note 1	Kalgoorlie Airport note 1	Redcliffe Gold Project note 3
January	434	388	411
February	342	305	323
March	313	267	290
April	213	174	194
May	136	112	124
June	96	78	87
July	99	87	93
August	133	118	126
September	204	174	189
October	288	260	274
November	345	309	327
December	406	372	389
Mean Annual Pan Evaporation (mm)	**3,010**	**2,643**	**2,827**

Notes:
1. Yamarna values based on BoM's analysis of 24 years of data collected between 1968 and 1997.
2. Kalgoorlie Airport values based on BoM's analysis of 50 years of data collected between 1966 and 2016.
3. Assumed mean pan evaporation based on average of other two stations.

The mean annual pan evaporation measured at Yamarna and Kalgoorlie Airport is 3,010 mm and 2,643 mm respectively, both of which are one order of magnitude greater than the mean annual rainfall for the region. It should also be noted that mean monthly evaporation exceeds mean monthly rainfall throughout the year.

The evaporation data show that evaporation is highest in the summer months from December to February, with January having the highest values.

Given that the RGP is located roughly midway between the Yamarna and Kalgoorlie Airport stations and in the absence of any local evaporation data, the average of pan evaporation data for both stations shown in the table above is considered suitable for current design purposes for the project. This indicates that the annual evaporation rates at the RGP will be in the order of 2,827 mm/year.

The DoA's Technical Report No. 65 (referenced earlier) states that a 7% coefficient of variation can be applied to mean annual evaporation rates in WA. Applying this coefficient to the project mean annual evaporation of 2,827 mm gives a standard deviation of 198 mm. Assuming that evaporation data are normally distributed, estimates of annual pan evaporation with 10, 50 and 100 year Average Recurrence Interval (ARI) will be in the order of 3,155 mm, 3,225 mm and 3,425 mm respectively.

The DoA report also states that a "pan to dam" coefficient in the order of 65-70% is appropriate for use for shallow dams and ponds (less than 4 m deep) storing freshwater in the north-eastern Goldfields. Consequently mean annual evaporative rates in the order of 1,840 mm to 1,980 mm might be expected from freshwater storage ponds at the RGP.

2.2.6 Temperature

The climate summary data for the Leonora station, situated some 50 km south-southwest of the RGP are shown in Table 16 below.

Table 16: Leonora Monthly Temperature (°C)

Month	Mean daily maximum Temp	Mean daily minimum Temp	Highest daily Max Temp	Lowest daily Min Temp	Mean no. of days where Max Temp ≥ 40.0°C	Mean no. of days where Min Temp ≤ 2.0°C
Jan	37.0	21.8	49.0	12.6	9.9	0
Feb	35.3	20.9	46.7	10.6	5.6	0
Mar	32.6	18.6	45.2	8.4	2.2	0
Apr	27.9	14.8	41.7	3.1	0.1	0
May	22.8	10.2	35.6	0.7	0	0.2
Jun	19.0	7.3	30.2	-2.8	0	1.3
Jul	18.4	6.1	28.9	-1.7	0	3.2
Aug	20.7	7.0	33.0	0.3	0	1.3
Sep	24.9	10.0	37.7	1.8	0	0.1
Oct	28.9	13.7	40.8	3.6	0.2	0
Nov	32.3	17.0	44.4	4.0	1.9	0
Dec	35.3	20.0	47.8	9.5	5.2	0

Note: Leonora mean maximum and minimum temperature values based on approximately 64 years of data recorded between 1900 and 2014. All other values based on approximately 57 years of data recorded between 1957 and 2014.

The monthly temperature data for Leonora provided the following information:

- Mean daily maximum temperatures range from 37.0 °C in January to 18.4°C in July.
- Mean daily minimum temperatures range from 21.8°C in January to 6.1°C in July.
- Highest and lowest daily temperatures of 49.0°C and -2.8°C have been recorded in January (2013) and June (1981) respectively.
- Typically there will be in the order of 25 days each year with daily maximum temperatures in excess of 40°C, approximately 21 of which will occur in December, January and February.
- On average 6 days each year can be expected when minimum temperatures will be 2°C or less and light ground frosts are possible. The bulk of such days will occur in June, July and August.

2.2.7 Wind Speed and Direction

Wind speed and direction data are available for Leonora, situated 50 km south-southwest of the RGP and Kalgoorlie Airport, some 256 km south. Although the Leonora station is closer, the Kalgoorlie Airport station has the advantage of not only recording wind speed and direction at three-hourly intervals, but also records the instantaneous wind gust speed. The 9 am and 3 pm mean monthly wind speeds for both stations and maximum wind gusts for Kalgoorlie Airport are shown in Table 17 and annual wind roses are provided in Appendix A.

Table 17: Mean Monthly 9 am and 3 pm Wind Speed for Kalgoorlie Airport and Leonora Stations and Maximum Wind Gusts for Kalgoorlie Airport

Month and Station Name	Mean 9 am Wind Speed (km/h)		Mean 3 pm Wind Speed (km/h)		Highest Recorded Wind Gust (km/h)	
	Kal. Airport	Leonora	Kal. Airport	Leonora	Kal. Airport	
Jan	16.6	10.8	15.1	8.6	141	14-Jan-94
Feb	16.4	10.2	15.1	8.7	118	16-Feb-70
Mar	15.7	10.3	14.2	8.6	118	28-Mar-71
Apr	14.4	8.8	13.7	8.1	104	24-Apr-73
May	11.8	7.6	14.1	8.1	122	5-May-75
Jun	11.8	7.5	15.7	9.6	102	4-Jun-74
Jul	12.4	8.1	16.6	10.4	97	30-Jul-48
Aug	14.3	9.1	17.2	11.1	108	12-Aug-64
Sep	16.2	10.7	17.8	11.2	109	13-Sep-65
Oct	17.1	11.8	17.6	11.7	117	3-Oct-50
Nov	17.1	12.1	17.2	11.5	139	7-Nov-79
Dec	16.3	10.7	16.0	9.6	122	10-Dec-46

Note: Leonora mean wind values based on approximately 53 years of data (1957-2010). Kalgoorlie Airport mean wind and gust values based on approximately 72 years of data (1939-2010) and 74 years (1939-2015) respectively.

Mean wind speeds at Kalgoorlie Airport are consistently fresher than those at Leonora in both the mornings and afternoons. Given that the RGP is significantly closer to Leonora, it is likely that it will encounter mean monthly wind speeds similar to those shown above for that station.

The highest instantaneous wind gust recorded at Kalgoorlie Airport was 141 km/hr which occurred on 14 January 1994 and may have been associated with TC Pearl which was passing along the Pilbara coast at that time.

Inspection of the wind roses for both the Leonora and Kalgoorlie Airport stations show that easterly's of up to 30 km/hr predominate in the morning, but by the afternoon somewhat weaker westerly's are equally likely to occur.

Calm conditions are roughly similar with morning calms recorded at Leonora about 9% of the year and afternoons calms about 8% of the time, compared to 9% and 6% respectively for Kalgoorlie Airport.

2.3 Hydrological Conditions

2.3.1 Regional Hydrological Setting

All of the proposed RGP mining areas are located within DWER's vast, internally draining Salt Lake Basin (area = 441,000 km^2) which extends across much of central WA. The Nambi and Hub mining areas are located within the Lake Carey Catchment (area = 113,780 km^2), while the GTS mining area is located immediately to the south of the regional watershed divide within the Lake Raeside-Ponton Catchment (area = 115,965 km^2), as shown in Figure 3.

The Salt Lake Basin comprises several large and broad, sub-parallel, southeast trending salt-lake drainage systems that extend from a regional divide to the west of Wiluna/Sandstone and either drain into Ponton Creek (Raeside and Rebecca system) or terminate at the edge of sand plains (Carey/Minigwal system). These drainages have very low gradients and contain small to very large playa lakes, some with surface areas in excess of 1,000 km^2. Following occasional intense rainfall as a result of tropical cyclones or depression related events the lakes may fill and, following very rare events, some may overflow, link-up and discharge onto the Nullarbor Plain through Ponton Creek, as last occurred following TC Bobby in February 1995.

Currently there are no DWER flow gauging stations within the Lake Carey or Lake Raeside-Ponton Catchments, or the much larger Salt Lake Basin. It was therefore not possible to review local or regional flow data.

2.3.2 Local Hydrological Setting

The three proposed RGP mining areas are located in the upper headwaters of the regional catchments and, consequently, their upstream catchment areas are relatively modest. There are no major river systems in the vicinity of the proposed mining areas and any watercourses or drainages that do exist are ephemeral and only convey flow periodically, following significant rainfall.

Hydrological conditions and catchment delineations for each of the proposed mining areas are presented in the following sections, along with selected photographs (all photographs from the recent site visit have been provided in Appendix E). It should be noted that the catchment delineations were developed using GIS spatial analysis tools applied to DEM data provided by Dacian over the mining areas and blended with Geoscience Australia's 1-second SRTM hydro-enforced data more broadly. Peak flow estimates are presented later in this report.

Nambi Catchment Delineation

The Nambi mining area is located within DWER's Lake Carey Catchment approximately 14 km north of the regional watershed divide with the Lake Raeside-Ponton Catchment.

The most significant feature at the proposed Nambi mining area is the breakaway aligned in a roughly north-south direction along the west side of the open pit (refer to Photograph Nos 1 and 2). This breakaway is typical of several in the region that typically comprise gently undulating plateaux with scarp faces of about 5 to 10 m high and footslopes of up to approximately 200 m long. This breakaway forms a local catchment divide and provides significant flood protection to the proposed

Nambi Pit from several ephemeral drainage lines that report in a generally southwest to northeast direction towards lake Irwin, located about 35 km to the northeast.

Photograph No. 1 – View North over Existing Nambi Pit Void with Breakaway to West (LHS)

Photograph No. 2 – View South over Existing Nambi Pit Void with Breakaway to West (RHS)

When combined with the fact that the local topographic high (Mount Redcliffe 553 mAHD) is located immediately to the south of the proposed Nambi mining area, the resulting upstream catchment area is very limited at approximately 0.655 km^2, comprising the following (refer to Figure 4):

- Nambi North = 0.137 km^2;
- Nambi Central = 0.151 km^2; and,
- Nambi South = 0.367 km^2.

Consequently surface water management measures required for the proposed Nambi mining area will be relatively modest, as described later in this report.

Hub Catchment Delineation

The Hub mining area is located within DWER's Lake Carey Catchment approximately 8 km north of the regional watershed divide with the Lake Raeside-Ponton Catchment. The catchment physiography in the vicinity of the proposed Hub mining area can be generally described as comprising low hills and rises with limonitic duricrust and stony plains that support mulga and halophytic shrubs.

The following two catchment areas were delineated upstream of the proposed Hub mining area (refer to Figure 5 and typical catchment conditions shown in Photograph Nos. 3 and 4):

- Hub North = 2.807 km^2; and,
- Hub South/Dillon Creek = 43.776 km^2.

Photograph No. 3 – View of typical sheet wash area in Hub North Catchment Area

Photograph No. 4 – View West from Leonora-Nambi Road of Hub South/Dillon Creek Channel

The drainages within the Hub North catchment area rise about 2 km to the northwest and drain towards the proposed Hub Pit mostly by sheet wash. Dillon Creek drains the Hub South catchment and is a much more significant watercourse with a channel of up to about 10 m wide and 1 m deep. It rises at the regional watershed divide some 10 km to the west and reports to the southern part of the proposed mining area, crossing the Leonora-Nambi Road before continuing for about 23 km in a north-easterly direction towards Lake Irwin.

GTS Catchment Delineation

The GTS mining area is located within DWER's Lake Raeside-Ponton Catchment approximately 5 km south of the regional watershed divide with the Lake Carey Catchment. There are several unnamed drainages that rise at the watershed divide and cross the proposed mining area in a roughly northeast to south west direction before terminating in a number of poorly defined soaks and claypans about 10 km to the southwest.

The GTS has an upstream catchment area of approximately 28.330 km^2 which reports to the northeast corner of the proposed WRD, as shown in Figure 6. There are two main channels; one from the eastern half of the catchment which crosses the Leonora-Nambi Road via an existing floodway and a second channel which drains the northern half of the catchment and joins the eastern channel about 450 m west of the Leonora Nambi Road. Downstream of the confluence the channels continue in a westerly direction for a further 300 m or so before turning towards the south and flowing away from the proposed GTS mining area. Both of these channels are between 5-10 m wide and 1-2 m deep and have a good deal (>0.5 m thick) of sand-gravel sized sediment deposited along their bases, indicating previous slow moving floodwater (refer to Photograph Nos 5 and 6).

Photograph No. 5 – View West (Downstream) from Leonora-Nambi Road Floodway of Eastern Channel

Photograph No. 6 – View South (Downstream) of Northern Channel

Surface elevations in the vicinity of the proposed GTS mining area are approximately 485 mAHD, while the local topographic high located on the terrace feature some 6.5 km to the east has an elevation of about 560 mAHD. Natural ground gradients in the immediate vicinity of the RGP are relatively flat, sloping towards the southwest at about 0.5%.

The catchment physiography in the vicinity of the proposed GTS mining area is similar to that at the Hub and is typified by low hills and rises with limonitic duricrust and stony plains that support mulga and halophytic shrubs.

The diversion of flows along these channels will require careful management and will be the main focus of surface water management measures at the GTS as discussed later in this report.

Camp & Magazine Hydrological Setting

Both the proposed RGP Camp and Magazine facilities have been situated to lessen potential impacts on the local hydrological regime and also to require minimal, if any, significant surface water management measures.

The proposed Camp is located about 4.5 km north of the GTS mining area immediately to the south of the regional watershed boundary between DWER's lake Carey catchment to the north and Lake Raeside-Ponton to the south, as shown in Figure 7. As such the proposed Camp area has essentially no upstream catchment area and drainage measures for roads, carparks, building pads etc. need only to take direct precipitation into consideration and therefore no specific surface water management measures are required.

The proposed Magazine facility is located about 2.5 km north of the Hub mining area and some 4 km south of the Nambi mining area. It has been situated at the eastern end of a small ridge that forms the local topographical high with a minor ephemeral drainage aligned some 150 m to the north as shown in Figure 8. The proposed Magazine has also been situated on the east (downstream) side of the Hub-Nambi Road which will serve to direct runoff to the north and south and away from the facility. As a result the proposed Magazine has a minimal upstream catchment area and requires no specific surface water management measures.

2.3.3 Peak Flow Estimates

Generally flow statistics at any location of interest can be generated using three different approaches (in order of preference):

- *Site Measured Streamflow Analysis* - from long-term streamflow records collected at the location of interest;
- *Regional Hydrological Analysis* - from streamflow records collected at the nearby watersheds with similar hydrological characteristics (e.g., similar drainage area, soils, vegetation and slopes); or,
- *Hydrological Calculation/Modelling* – using published regional methods applied to site specific rainfall and catchment characteristics.

Due to the absence of local or regional streamflow data, it was necessary to carry out hydrological calculations using published methods in order to estimate peak runoff values for the catchments upstream of the proposed RGP mining areas. The catchment areas were therefore applied to the "Arid Interior Rational Method" as presented in Australian Rainfall and Runoff (AR&R)[7] using the rainfall IFD data developed earlier. The resulting peak flow estimates are presented in Table 18 (calculation worksheets are presented in Appendix F).

Table 18: RGP Catchments - Peak Flow Estimates

Catchment Name	Area (km^2)	Length (km)	Slope (m/km)	Peak Flow Estimate (m^3/s)			
				10% AEP	5% AEP	2% AEP	1% AEP
Nambi North	0.137	0.425	59.6	1.1	1.7	2.7	3.8
Nambi Central	0.151	0.594	52.5	1.0	1.6	2.5	3.6
Nambi South	0.367	0.643	46.3	1.9	3.0	4.8	6.9
Hub North	2.807	2.430	7.8	4.9	7.8	12.8	18.3
Hub South	43.776	11.850	2.6	18.7	29.7	48.8	69.5
GTS	28.330	7.020	10.7	17.1	27.2	44.7	63.8

The peak flow estimates presented above are used in the design of surface water management measures presented in Section 4.0 of this report.

[7] *"Australian Rainfall and Runoff – Book 4, Estimation of Design Peak Discharges",* Institution of Engineers Australia, 1987.

3.0 SURFACE WATER MANAGEMENT

3.1 Surface Water Management Objectives

The following three goals define the objectives for surface water management for the RGP:

Reduce Potential Risk of Loss of Life, Health Hazards or Property Damage:

- provide protection for life, livelihood, and property;
- control the incidence of nuisance or damage related to flooding, poor drainage and sedimentation to an acceptable level; and,
- protect project infrastructure.

Preserve the Environment

- minimise the potential project impacts such as changes in the stream-flow regime, alteration of habitat, pollution or increased erosion and sedimentation;
- where feasible, maintain the shape and composition (geomorphology) of the natural watercourse geometry, natural biological indicator conditions and flow conditions;
- employ protection measures to prevent adverse hydrological and water quality impacts for all recognised watercourses within the site limits;
- promote sound development that respects the natural environment; and,
- rehabilitate any watercourses that are impacted as soon as practicable.

Conserve Social and Financial Resources

- treat water as a resource, ensuring that water management facilities are functional and integrate multi-use objectives where possible;
- provide a system of infrastructure that enhances site personnel convenience and safety, and allows development to proceed according to the mine plan;
- sustain future mine development, support orderly and managed development of resources and integration of land uses within the site limits;
- use best management water and sediment practices where feasible; and,
- encourage economic design of drainage systems.

These objectives are intended to ensure a consistent approach to:

- planning and analyses required for surface water management;
- constructing new operational phase surface water management works; and,
- installing future closure phase surface water management works.

The design philosophy and design criteria for floodwater protection and surface water management are presented in this section. The preliminary level design of the various water management facilities is presented in Section 4.0.

3.2 Flood Risk

All the watercourses in the vicinity of the RGP are ephemeral and are dry for many months and possibly even years at a time. However, flows can occur periodically, particularly during the summer months from January to March, when the potential exposure to high intensity rainfall from remnant tropical cyclones, depressions and lows is greatest. Consequently flows may, on occasion, be significant and may cause flooding and asset damage or loss if appropriate measures are not in place.

The hazard that such flooding poses to on-site facilities depends, amongst other things, on the following:

- the magnitude of the flood event;
- the proximity of the facility to the watercourse in flood;
- the sensitivity of the facility to flooding; and,
- the level of protective flood measures provided to the facility.

While the latter three factors can be controlled or engineered to some degree, the magnitude of the naturally occurring rainfall-runoff events may lead to flooding that cannot be controlled.

Although significant rainfall-runoff events do not occur cyclically, especially in a climatic region as variable as this, their probability of occurrence within any given period can be estimated. This probability is typically expressed as an annual exceedance probability (AEP) and is the probability that a given rainfall total accumulated over a given duration will be exceeded in any given year.

Table 19 shows the percentage probability for a range of different ARI flood events that could occur during an assumed two year maximum operational life at each of the proposed RGP mining areas.

Table 19: Percentage Probability of N-Year AEP Flood Event Occurring During Operational Life

Average Recurrence Interval (ARI)	5 yr	10 yr	20 yr	50 yr	100 yr	200 yr
Probability of Occurrence	36.0%	19.0%	9.8%	4.0%	2.0%	36.0%

Typically a range of AEP events are used for the design of various mine facilities, depending on their sensitivity to flooding and the period of exposure. For example a temporary drain around a laydown area used during construction may be designed for a 50% AEP event, while culverts below a main access road might be designed for the 10% or 5% AEP event, depending on the consequences of failure. Good practice suggests that when preparing earthworks pads for mine facilities that they be kept above the 5% AEP flood level as minimum[8].

For the RGP it is recommended that a 1% AEP (1 in 100) design criterion be applied to the pit flood protection measures during Operations, while it has been assumed that a 10% AEP criterion is

[8] Water and Rivers Commission, Western Australia, 2000, *Water Quality Protection Guidelines No. 6, Mining and Mineral Processing Minesite Stormwater*

suitable for the design of all other on-site drainage measures. It should be noted that the probabilities of occurrence of the 1% or 10% events occurring during the envisaged two year operational life of each of the RGP mining areas are roughly 2% and 19% respectively.

3.3 Pit Flood Protection Design Philosophy

The site visit findings and inspection of the available topographical mapping and aerial photography indicate that the greatest flood risk for the proposed RGP pits relates to their proximity to the upstream catchment areas delineated earlier and shown in Figures 4 to 6.

Flood risks to the proposed open pits should be minimised by a combination of the following measures:

- Construction of flood protection bunds during Operations and set back sufficiently to also serve as abandonment bunds at cessation of mining;
- Placement of waste rock dumps on the upstream side of pits where possible (applies to GTS mining area only);
- Diversion channels constructed around mine facilities to divert flows from upstream areas downstream;
- "Roll-over" at the top of pit ramps to minimise volume of runoff reporting in-pit;
- Facility grading and roadside drains to direct runoff away from the pits; and,
- Provision of in-pit storm runoff temporary storage sumps and pumping systems;

Runoff that reports in-pit as a result of direct precipitation within the pit crest should report to sump pumps on the floor of the pit.

3.4 In-Pit Runoff Volume Estimate

Even with the provision of the ex-pit surface water management measures identified above some runoff will report in-pit from direct precipitation and runoff from minor adjacent areas. An estimate of the anticipated rainfall-runoff volume from a range of events is presented in Table 20.

Table 20: In-Pit Runoff Volume Estimates

Rainfall Event	In-Pit Runoff Volume (m^3)[see note]			
	Nambi Pit	Hub North Pit	Hub South Pit	GTS Pit
2 year-72 hour	5,900	6,800	900	6,700
5 year-72 hour	9,400	10,700	1,300	10,600
10 year-72 hour	12,000	13,800	1,700	13,600
20 year-72 hour	14,900	17,100	2,100	16,800
50 year-72 hour	19,300	22,200	2,700	21,900
100 year-72 hour	23,100	26,600	3,200	26,200

Note: Pit crest areas of 104,412, 119,879, 14,322 and 118,227 m^2 respectively for Nambi, Hub North, Hub South and GTS respectively. Assumes pits are empty at start of rainfall event.

GROUNDWATER RESOURCE MANAGEMENT

The volumes presented in the table above are based upon pit crest areas with a 10% allowance for adjacent areas, 100% runoff coefficient and the following Rainfall IFD values (refer to Appendix B):

- 2 year-72 hour duration = 51 mm;
- 5 year-72 hour duration = 81 mm;
- 10 year-72 hour duration = 104 mm;
- 20 year-72 hour duration = 129 mm;
- 50 year-72 hour duration = 168; and,
- 100 year-72 hour duration = 201 mm.

Despite the fact that there is sufficient storage capacity with the various RGP pit voids to store all the rainfall events considered, it is important that pit flood bunding and all other necessary surface water management measures are installed and maintained in order to minimise runoff from ex-pit areas reporting in-pit. This will be even more critical should Dacian decide to develop underground workings at any of the RGP mining areas.

3.5 Stormwater and Sediment Management Philosophy

In addition to protecting the proposed pit and mine facilities against flooding from low frequency flood events such as the 1% AEP event discussed above, it will also be necessary to manage runoff from more common rainfall events. Although such events give rise to much lower runoff rates and volumes they should be managed appropriately in order to protect project infrastructure, minimise erosion and reduce the potential loss of sediment laden or other contaminated runoff from the RGP mining areas.

For the management of stormwater the various project facilities should therefore be segregated as follows:

- Mine Service/Workshops Areas.
- Hazardous Material Storage Areas.
- Disturbed Areas.
- Undisturbed Areas.

3.5.1 Mine Service/Workshops Areas

Mine Service/Workshop Areas should include surface water runoff and wash-down water drainage and recovery systems. Rainfall runoff from the Mine Service/Workshops Areas including roads, building roofs, laydown yards etc. should be captured in open drains that report to Water Management/Sedimentation Ponds where water should be temporarily stored prior to reuse.

To aid management of runoff from areas likely to be impacted by hydrocarbons, e.g. fuel storage and dispensing areas, truck wash and workshops, runoff should be captured using open drains that report to an oily water separator (OWS) provided upstream of Water Management/Sedimentation Ponds.

Mine Service/Workshops Area drains should be sized for the peak of the 10%AEP event as a minimum, with a minimum freeboard of 250 mm. Flow velocities along such drains should be limited to minimise erosion and the generation of sediment.

3.5.2 Hazardous Materials Storage Areas

All chemical, oil and other hazardous material storage areas should be enclosed within bunds in accordance with the relevant codes and standards. Water collected within the bunds should be assessed and, if suitable, discharged to the proposed Water Management/Sedimentation Pond.

Water collected within the bund that is found to be impacted should be disposed of appropriately.

3.5.3 Disturbed Areas

Outside the Mine Services/Workshops Areas the mine facilities will comprise open pits, ROM pads, waste rock dumps, access and haul roads and various topsoil stockpiles. Source controls should be used to improve the quality of runoff from these facilities, with runoff directed to Water Management/Sedimentation Ponds where possible.

For runoff within the proposed pits, in-pit sumps should be used to settle out sediment from collected runoff prior to pumping to surface for re-use or discharge off-site (if suitable).

3.5.4 Undisturbed Areas

Run-off from undisturbed areas within the project boundaries should be diverted around proposed project facilities into existing natural watercourses or drainage lines by providing diversion channels typically sized for the 10% AEP event with a minimum 250 mm freeboard. Flow velocities along all diversion channels should be limited to minimise erosion and the generation of sediment.

Where active mining areas or other sensitive facilities require protection from runoff from undisturbed areas, the 1% AEP event should typically be used for the design of pit flood diversion channels and bunds.

3.6 Drainage and Sediment Control Design Criteria

The following design criteria should be applied to drainage measures for the project facilities:

3.6.1 Peak Flow Estimation

Peak discharges from catchment areas of less than 10 hectares should be estimated using the Rational Method (i.e. Q = CIA). The average run-off coefficient (C) should be based on the values presented in Table 21.

Table 21: Run-off Coefficients

Catchment Type	Run-off Coefficient
Undisturbed areas	0.20
Gravel roads and yard areas	0.50
Asphalt, concrete and roof areas	0.90

Rainfall intensity (I) for the event duration should be interpolated from the rainfall Intensity Duration Frequency (IDF) relationship developed for the RGP provided in Appendix B. The time of concentration of each catchment area should be determined in accordance with the Kirpich Equation as follows:

$T_c = 0.00032 \times L^{0.77} \div S^{0.385}$

Where:

T_c = Time of concentration (hours).

L = Maximum length of water travel (m).

S = Average Slope (m/m).

The minimum time of concentration to be used for design purposes should be 5 minutes. Catchment areas (A) should either be measured directly in the field or calculated using CAD tools and the latest field survey data.

Peak discharge estimates from areas larger than 10 hectares should be obtained by using hydrologic modelling methods such as those presented in Books 4 and 5 of ARR97.

3.6.2 Channel Design

Channel design parameters should be determined using Manning's Equation as follows:

$Q = (A\ R^{2/3}\ S^{1/2})/n$

Where:

Q = flow rate (m^3/sec).

A = cross-sectional area of channel (m^2).

n = roughness coefficient, as per values presented below (dimensionless).

R = hydraulic radius, i.e. cross-sectional area, A, divided by wetted perimeter, P (m)

S = channel slope (m/m).

Roughness coefficients should be based on the values presented in Table 22:

Table 22: Roughness Coefficients

Channel Type	Roughness Coefficient
Unlined Earth, Clean, recently completed	0.016-0.018
Unlined Earth, With short grass, few weeds	0.022-0.027
Unlined Rock, Smooth and uniform	0.035-0.040
Unlined Rock, Jagged and irregular	0.040-0.045
Lined, Formed concrete	0.017-0.020
Lined, Random stone mortar	0.020-0.023
Lined, Dry rubble (rip-rap)	0.023-0.033

3.6.3 Drainage Design

Open Drain Construction

Open drain construction should maintain based upon the following criteria:

- Minimum self-cleansing velocity of 0.7 m/sec for a 50% AEP event;
- Maximum velocity of 1.0 m/sec for a 10% AEP event for unlined earth channels with no specific erosion protection;
- Maximum velocity of 1.5 m/sec for 10% AEP event for grassed channels with no specific erosion protection;
- Minimum 250 mm freeboard on open drains; and,
- Channel erosion control protection in the form of appropriate drop structures, rock check dams, rock-lined channels or concrete lined channels.

Culvert Installation

The minimum culvert diameter should be 450 mm. Culverts and underground stormwater pipes should be installed at slopes that should provide self-cleansing minimum velocities of 0.7 m/s for one-third depth of full-flow wherever possible.

Hardstand Area Drainage

Hardstand area drainage should be designed with a minimum surface grade of 0.5% in open yard areas and a minimum grade of 2% for a distance of 25 m away from structures.

Hardstand areas with finished elevations 1 m or greater above natural surface elevations should have a safety berm constructed along their outside edge. Suitably spaced breaks should be placed along the berm to allow runoff to escape. Rock or geomembrane lined slope drains should be constructed at these breaks to minimise erosion of fill material.

3.6.4 Water Management/Sedimentation Pond Design

For current preliminary design purposes water management/sedimentation ponds should be designed to store runoff from the 10%AEP-24-hour rainfall event i.e. 78 mm rainfall, without discharge.

The future detailed design of sedimentation ponds should be based on removing the settleable fraction down to a selected minimum design particle size based on an analysis of the sediment particle size distribution reporting to the pond. The adopted design particle size should correspond to 25% of the sample passing by weight or an absolute minimum particle size of 20 micron (unless chemical coagulant dosing is used). The required pond surface area should be estimated using the peak inflow rate and design particle settling velocity according to Stokes Law and applying published sedimentation efficiency factors[9].

Sedimentation ponds should have a minimum live settling depth of 1 m and an aspect ratio (length: width) of not less than 3:1 and preferably 5:1. Sufficient provision for dead (sediment) storage and freeboard should also be made.

3.6.5 Oily Water Separator Design

All potentially hydrocarbon impacted water from wash-down and re-fuelling facilities should be directed to a suitable gravity type OWS prior to collection and re-use.

[9] *The Constructed Wetlands Manual (Volumes 1 & 2)*, Department of Land and Water Conservation, New South Wales, 1998.

4.0 PRELIMINARY DESIGN

The accompanying Drawing Nos. J2126-D01 to -D03 show the preliminary layout of the proposed surface water facilities for each of the Redcliffe mining areas, as described in the following sections. This layout has been based on Dacian's aerial photography, topographical data set and preliminary project infrastructure design (October 2021).

4.1 Nambi Mining Area

The existing breakaway located immediately to the west of the proposed Nambi Pit forms the local catchment divide and effectively reduces the catchment area upstream of the pit to about 0.14 km^2 (delineated earlier as Nambi North Catchment). It is not practical to divert runoff from this area due to the steepness of the terrain and proximity to the existing pit void. The relatively limited amount of runoff from this area will therefore be dealt with in-pit as required.

Three floodways with low-flow culverts will be used to direct runoff from the Nambi Central and Nambi South Catchments (0.15 and 0.37 km^2 respectively) across the proposed Hub-Nambi Road and the eastern HV road at the locations shown in Dwg. No. –D01. For preliminary design purposes these crossings have been assumed to comprise depressed or lowered section of roadway to contain flows that, on occasion, may overtop the roadway, with low-flow culverts underneath the roadway.

Given the relatively short operational life at the proposed Nambi Mining area (~2 years) the floodways were designed to convey the 10% AEP peak flow (1.0 and 1.9 m^3/s from Central and South Catchments respectively), while the low-flow culverts were sized to pass events up to 50% AEP peak flow (0.2 and 0.3 m^3/s from Central and South Catchments respectively) with acceptable head build-up at inlet.

In accordance with current design guidelines[10] the required floodway widths were calculated using the broad crested weir equation applied to the 10% AEP peak flow with a 200 mm maximum water depth over the road surface, assuming the road would be closed for depths greater than this. This resulted in 10 and 15 m long lowered central road sections with 7.5 m long entry and exit slopes (assuming 25H:1V slope), yielding overall minimum floodway lengths of 25 and 30 m for the Central, South and Southeast floodways respectively. A single 450 mm diameter low-flow corrugated metal pipe culvert will be required to pass the 50% AEP peak flow at the Central floodway, while a single 600 mm barrel will be used at both the South and Southeast floodways.

Broken rock (riprap) lining will be constructed at the outlets from the floodway culverts and the downstream face of the floodway road embankment to minimise potential erosion of the natural channel.

4.2 Hub Mining Area

Primary flood protection will be provided to the Hub North and South Pits by the provision of two sections of flood protection bund constructed around the northern and western perimeter of the proposed pits as shown in Dwg. No. –D02. The minimum height of the flood protection bunds has

[10] *"Floodway Design Guide"*, Main Roads Western Australia, 2006 and *"Waterway Design"*, AUSTROADS, 1994.

been set at 2 m above existing ground starting at a high point of approximately 496 mAHD near the northeast crest of the Hub North Pit and sloping southwards and eastwards. The bunds have been placed outside the zones of influence and set back from the proposed pit crests in accordance with current design guidelines[11] so that they may also serve as abandonment bunds at the end of operations if necessary (alternatively Dacian may decide to construct the bunds as a raised LV roadway along the same alignment).

The flood bunds will not be constructed by end dumping of waste materials in piles, but instead the bund footprints will be cleared and the surficial material removed to a suitable formation depth (approximately 0.5 m minimum). They will be built from select waste material placed and compacted in controlled layers using dozers and construction traffic. The upstream face of the flood bund will be armoured with suitable, graded broken rock (riprap).

The key specifications for the flood bund are as follows:

- Maximum side slopes = 2:1 (H:V);
- Minimum height above existing ground = 2 m;
- Minimum crest width = 3 m;
- Minimum base width = 11 m;
- Maximum compacted layer thickness = 1 m;
- Minimum compaction standard = 95% Standard Maximum Dry Density;
- Moisture conditioning = ± 2% optimum moisture content;
- Bund fill material to be select graded clayey gravel material from pit excavation with maximum particle size of 350 mm; and,
- Riprap specification to have D_{max}= 550 mm, D_{50}= 375 mm and thickness = 800 mm.

A nominal diversion drain will be formed along the upstream toe of the flood protection bund to permit the passage of runoff and minimise standing water.

Four floodways with low-flow culverts will also be constructed to direct runoff from the Hub North and Hub South Catchments (2.81 and 43.78 km^2 respectively) across the existing and diverted Leonora-Nambi Roads at the locations shown in Dwg. No. –D02. For preliminary design purposes these crossings have been assumed to comprise depressed or lowered section of roadway to contain flows that, on occasion, may overtop the roadway, with low-flow culverts underneath the roadway.

Given the relatively short operational life at the proposed Hub Mining area (~2 years) the floodways were designed to convey the 10% AEP peak flow (4.9 and 18.7 m^3/s from North and South Catchments respectively), while the low-flow culverts were sized to pass events up to 50% AEP peak flow (0.8 and 3.1 m^3/s from North and South Catchments respectively) with acceptable head build-up at inlet.

[11] "*Safety Bund Walls around Abandoned Open Pit Mines – Guideline*", DoIR Western Australia, December 1997.

In accordance with current design guidelines[12] the required floodway widths were calculated using the broad crested weir equation applied to the 10% AEP peak flow with a 200 mm maximum water depth over the road surface, assuming the road would be closed for depths greater than this. This resulted in 35 and 125 m long lowered central road sections with 7.5 m long entry and exit slopes (assuming 25H:1V slope), yielding overall minimum floodway lengths of 50 and 140 m for the Northern and Southern floodways respectively. Twin 600 mm diameter low-flow corrugated metal pipe culverts will be required to pass the 50% AEP peak flow at both of the Northern floodways, while twin 900 mm barrels will be used at both of the Southern floodways.

Broken rock (riprap) lining will be constructed at the outlets from the floodway culverts and the downstream face of the floodway road embankment to minimise potential erosion of the natural channel.

4.3 GTS Mining Area

As discussed earlier it will be necessary to manage periodic flow from the 28.33 km^2 catchment located on the eastern side of the Leonora-Nambi Road and direct it around the proposed GTS mining area. In order to do so, an approximately 1,000 m long diversion channel will be constructed, starting about 300 m west (downstream) of the existing Leonora-Nambi Road floodway and aligned around the northern side of the WRD and proposed GTS Pit (outside zone of exclusion), terminating at the existing watercourse on the western side of the site, as shown on Dwg. No. –D03.

In order to convey flows of up to 1% AEP a channel with the preliminary design parameters shown in Table 23 will be required (refer to calculations in Appendix F).

Table 23: GTS Diversion Channel – Preliminary Design Parameters

Design Parameter	Units	Ch 0 – Ch 1,000
10% AEP Peak Flow	m^3/sec	17.1
1% AEP Peak Flow	m^3/sec	63.8
Average Gradient	%	0.3
Length	m	1,000
Base Width	m	10.0
Side Slopes	H:V	2H:1V (26.6°)
Channel Maximum Depth	m	2.0
Channel Maximum Top Width	m	18.0
10% AEP Peak Flow Depth	m	1.0
10% AEP Freeboard Allowance	m	1.0
1% AEP Peak Flow Depth	m	2.0
1% AEP Freeboard Allowance	m	0

Note: Channel design assumes Manning's Roughness (n value) = 0.030

[12] *"Floodway Design Guide"*, Main Roads Western Australia, 2006 and *"Waterway Design"*, AUSTROADS, 1994.

A rock lined apron will be provided at the diversion channel outlet to minimise potential erosion.

In addition, an approximately 725 m long section of dual purpose flood protection/abandonment bund will be constructed around the western perimeter of the proposed GTS Pit as shown in Dwg. No. –D03. The minimum height of the bund has been set at 2 m above existing ground and has been placed outside the zone of influence and set back from the proposed pit crest in accordance with current design guidelines[13] so that it may also serve as abandonment bunds at the end of operations if necessary. At start-up of mining Operations a toe-bund and raised haul and LV roads will be used temporarily to provide protection the northern and eastern side of the GTS Pit until the WRD is established.

The bund will not be constructed by end dumping of waste materials in piles, but instead its footprint will be cleared and the surficial material removed to a suitable formation depth (approximately 0.5 m minimum). It will be built from select waste material placed and compacted in controlled layers using dozers and construction traffic. The upstream face of the flood bund will be armoured with suitable, graded broken rock (riprap).

The key specifications for the flood bund are as follows:

- Maximum side slopes = 2:1 (H:V);
- Minimum height above existing ground = 2 m;
- Minimum crest width = 3 m;
- Minimum base width = 11 m;
- Maximum compacted layer thickness = 1 m;
- Minimum compaction standard = 95% Standard Maximum Dry Density;
- Moisture conditioning = ± 2% optimum moisture content;
- Bund fill material to be select graded clayey gravel material from pit excavation with maximum particle size of 350 mm; and,
- Riprap specification to have D_{max}= 550 mm, D_{50}= 375 mm and thickness = 800 mm.

[13] "*Safety Bund Walls around Abandoned Open Pit Mines – Guideline*", DoIR Western Australia, December 1997.

5.0 CLOSING REMARKS

A desktop study and site visit was completed to develop hydro-meteorological information that was subsequently used in the preliminary analyses and design of water management measures at the proposed Redcliffe Gold Project.

The fact that the three proposed mining areas are located in the upper headwaters of the regional catchments means that upstream catchment areas are relatively modest and the resulting surface water management measures are therefore relatively minimal. The detailed design and appropriate construction of the surface water management measures presented in this report will help ameliorate potential flood risks at the Redcliffe Gold Project.

We trust that this report satisfies Dacian Gold Limited's current requirements and we look forward to discussing the future development of the project with you.

Groundwater Resource Management Pty Ltd

Alistair Lowry

CIVIL ENGINEERING HYDROLOGIST

Jan Vermaak

PRINCIPAL HYDROGEOLOGIST

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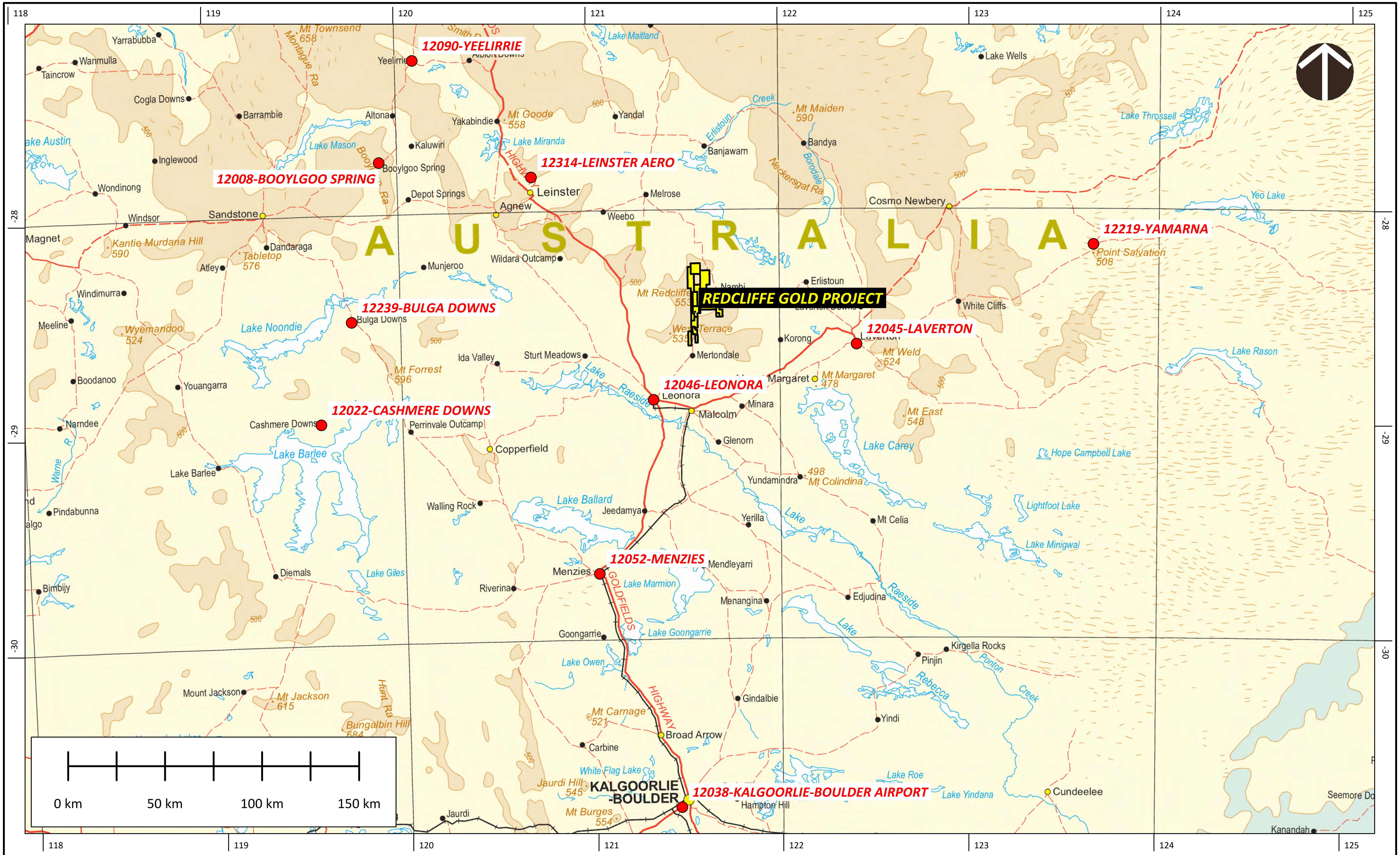


GROUNDWATER RESOURCE MANAGEMENT

FIGURE 1
REDCLIFFE GOLD PROJECT
LOCATION PLAN WITH
BoM REGIONAL SYNOPTIC STATIONS

Date July 21
Client Dacian Gold Ltd
Project Redcliffe Gold Project
Document J2126R01

Notes
1. Figure scale = 1:1,750,000 @ A3.
2. Coordinates to WGS84/Lat-Lon.

Sources
1. Climate stations Regional from BoM
www.bom.gov.au/climate/data/
2. Topo mapping Geoscience Australia
https://ecat.ga.gov.au/geonetwork

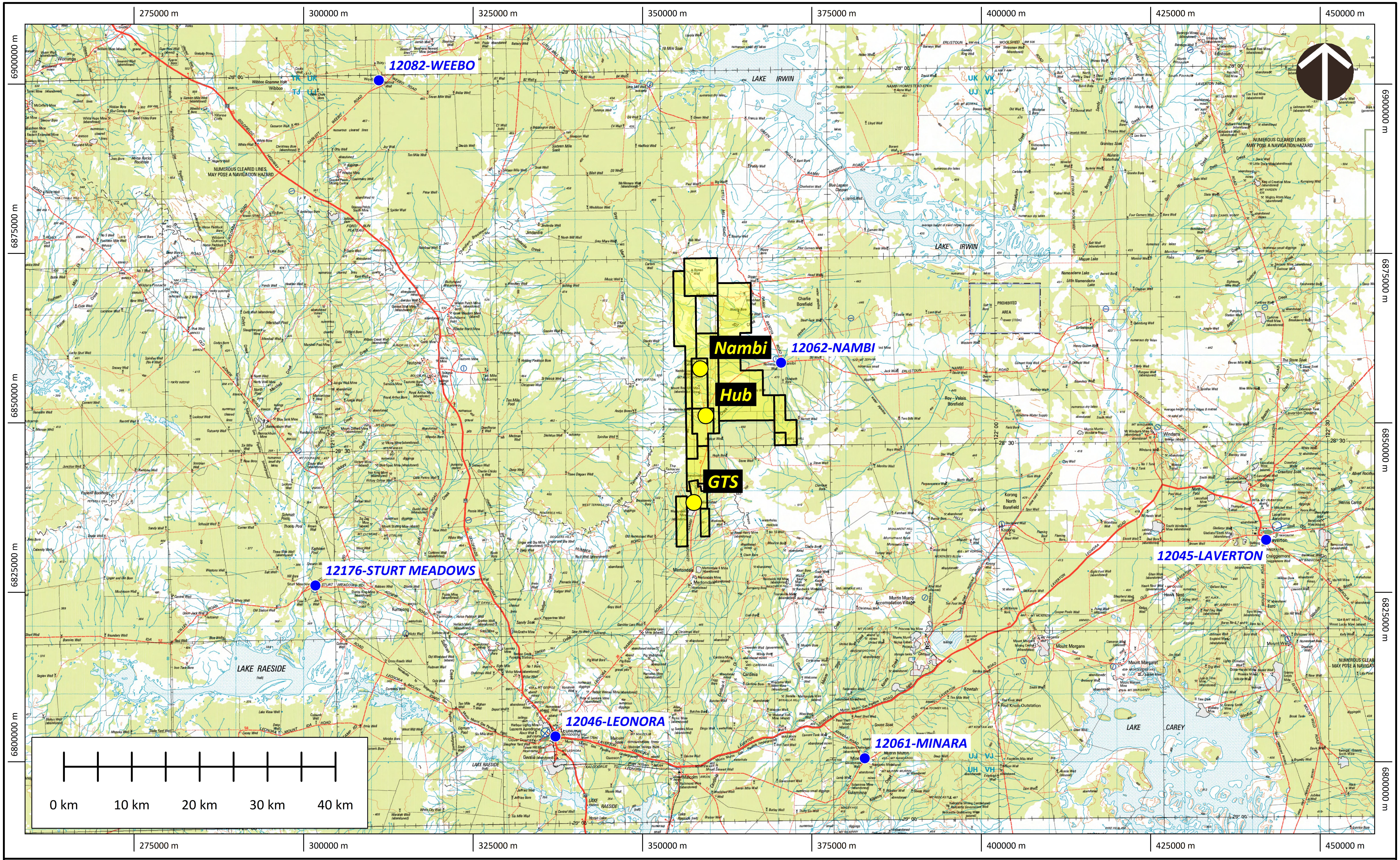


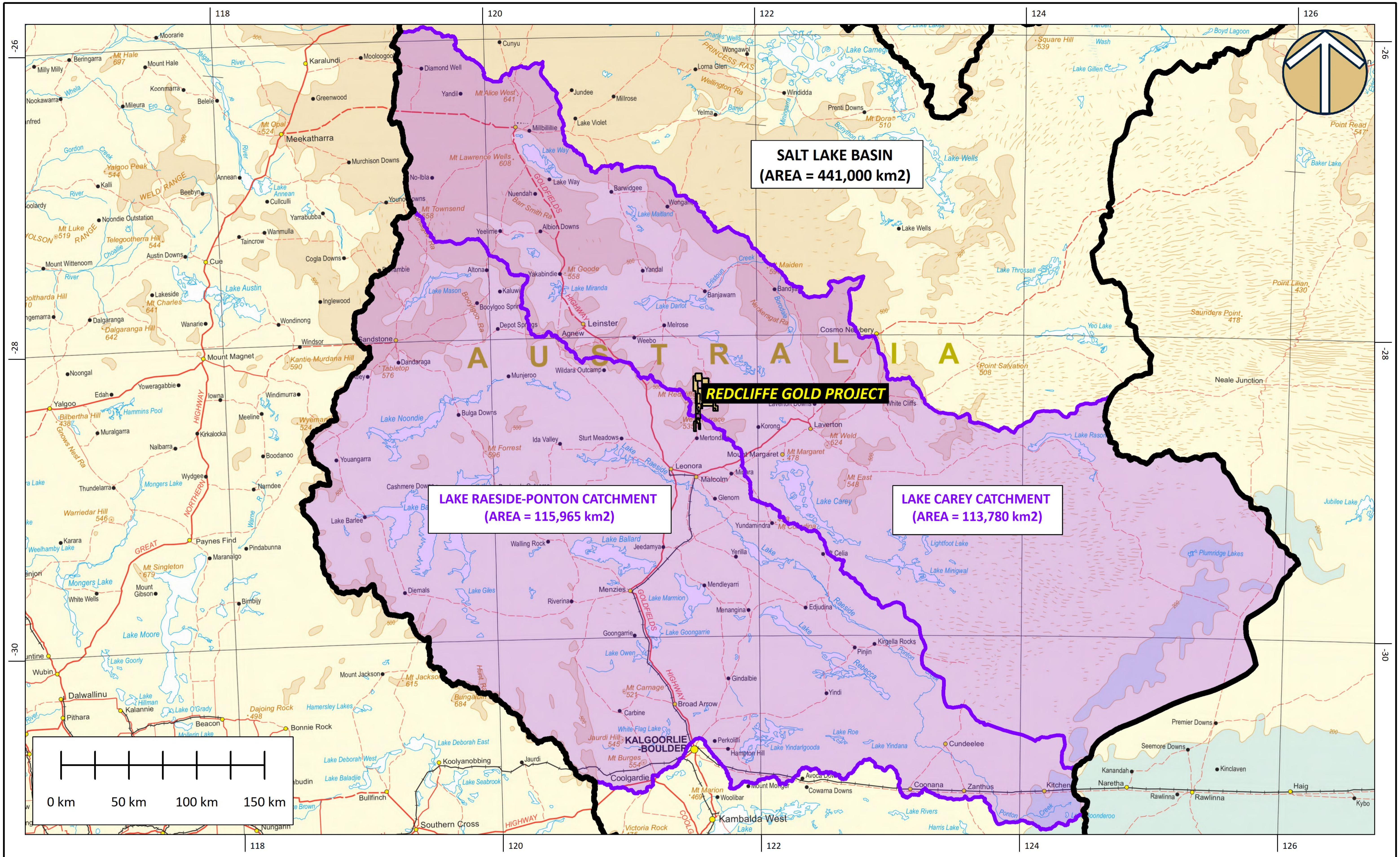
FIGURE 2
REDCLIFFE GOLD PROJECT
LOCATION PLAN WITH
BoM LOCAL RAINFALL STATIONS

GROUNDWATER RESOURCE MANAGEMENT

Date July 21
Client Dacian Gold Ltd
Project Redcliffe Gold Project
Document J2126R01

Notes
1. Figure scale = 1:500,000 @ A3.
2. Coordinates to GDA94/MGA 51.

Sources
1. Climate stations Regional from BoM
www.bom.gov.au/climate/data/
2. Topo mapping Geoscience Australia
https://ecat.ga.gov.au/geonetwork



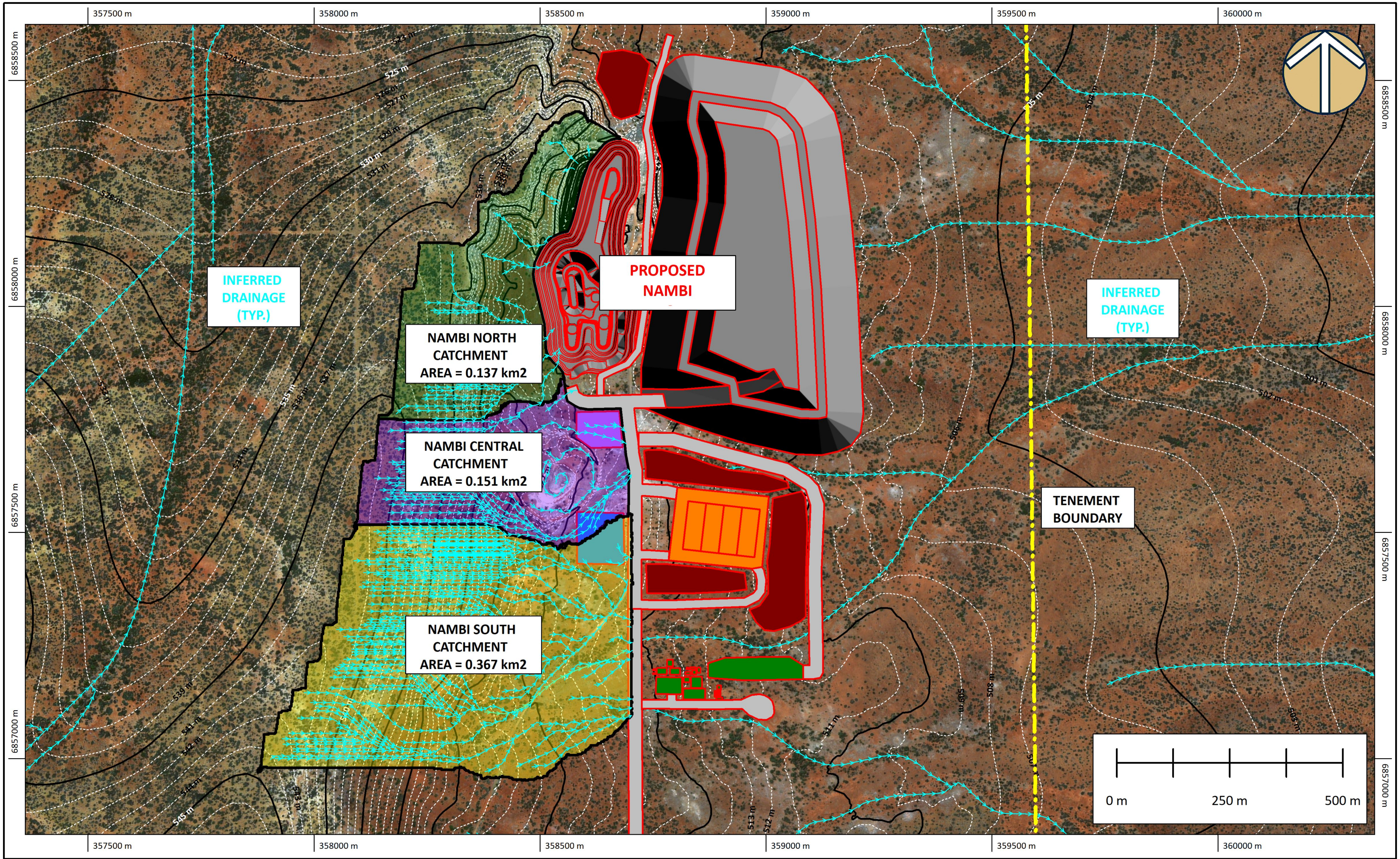
GROUNDWATER
RESOURCE MANAGEMENT

FIGURE 3
REDCLIFFE GOLD PROJECT
LOCATION PLAN WITH REGIONAL
DWER BASINS & CATCHMENTS

Date October 21
Client Dacian Gold Ltd
Project Redcliffe Gold Project
Document J2126R01

Notes
1. Figure scale = 1:2,500,000 @ A3.
2. Coordinates to WGS84/Lat-Lon.

Sources
1. Regional Basins & Catchments from DWER https://www.water.wa.gov.au/maps-and-data/monitoring/spatial-data-download
2. Topo mapping Geoscience Australia https://ecat.ga.gov.au/geonetwork



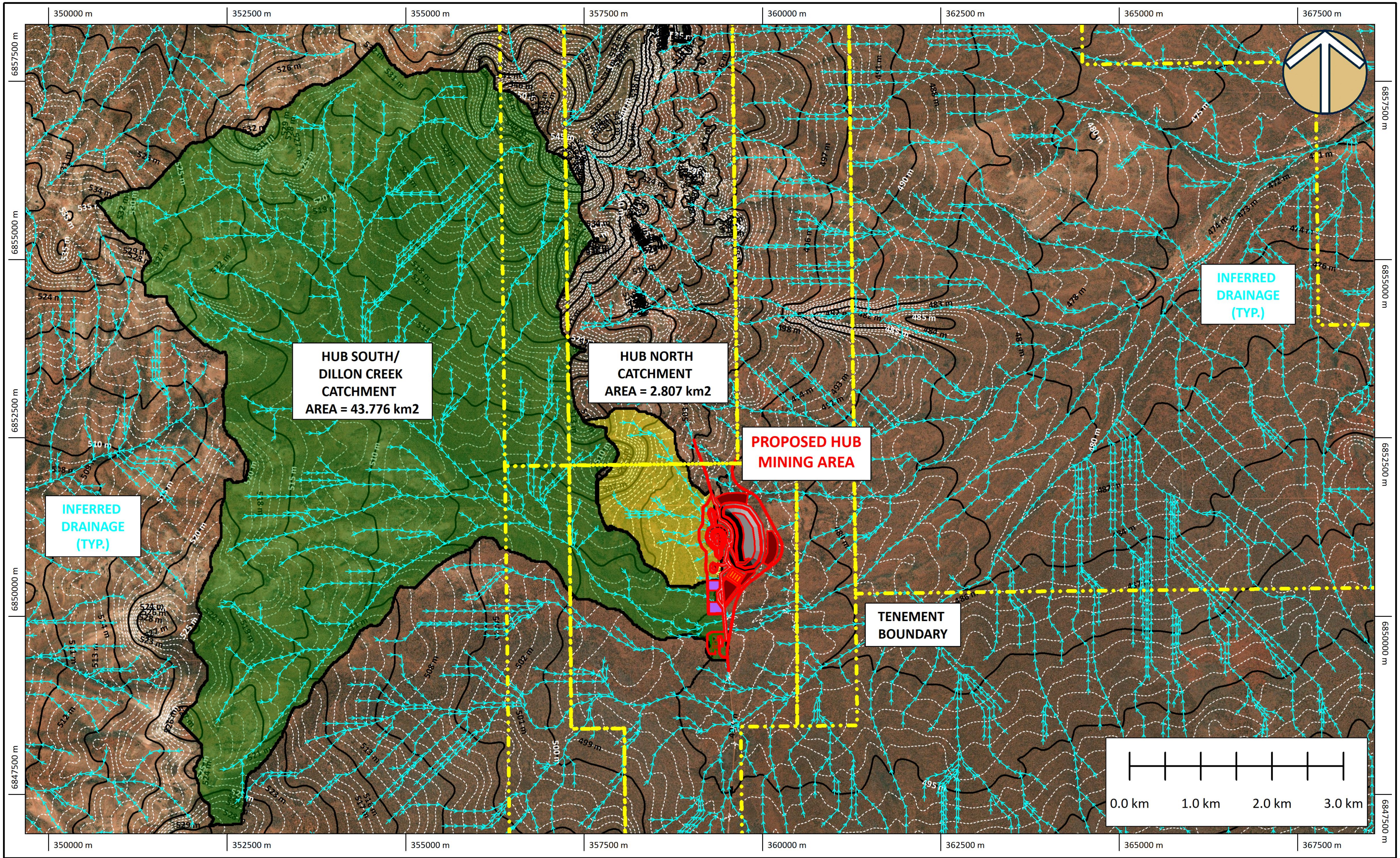
GROUNDWATER RESOURCE MANAGEMENT

FIGURE 4
REDCLIFFE GOLD PROJECT
NAMBI MINING AREA
LOCAL CATCHMENT DELINEATION

Date October 21
Client Dacian Gold Ltd
Project Redcliffe Gold Project
Document J2126R01

Notes
1. Figure scale = 1:7,500 @ A3.
2. Coordinates to GDA94/MGA 51.
3. Major/minor contour interval is 5m/1m.

Sources
1. Imagery from ESRI World Imagery.
2. Contours and catchment boundaries developed from Geoscience Australia's 1-sec SRTM dataset using GIS spatial anlayis tools.



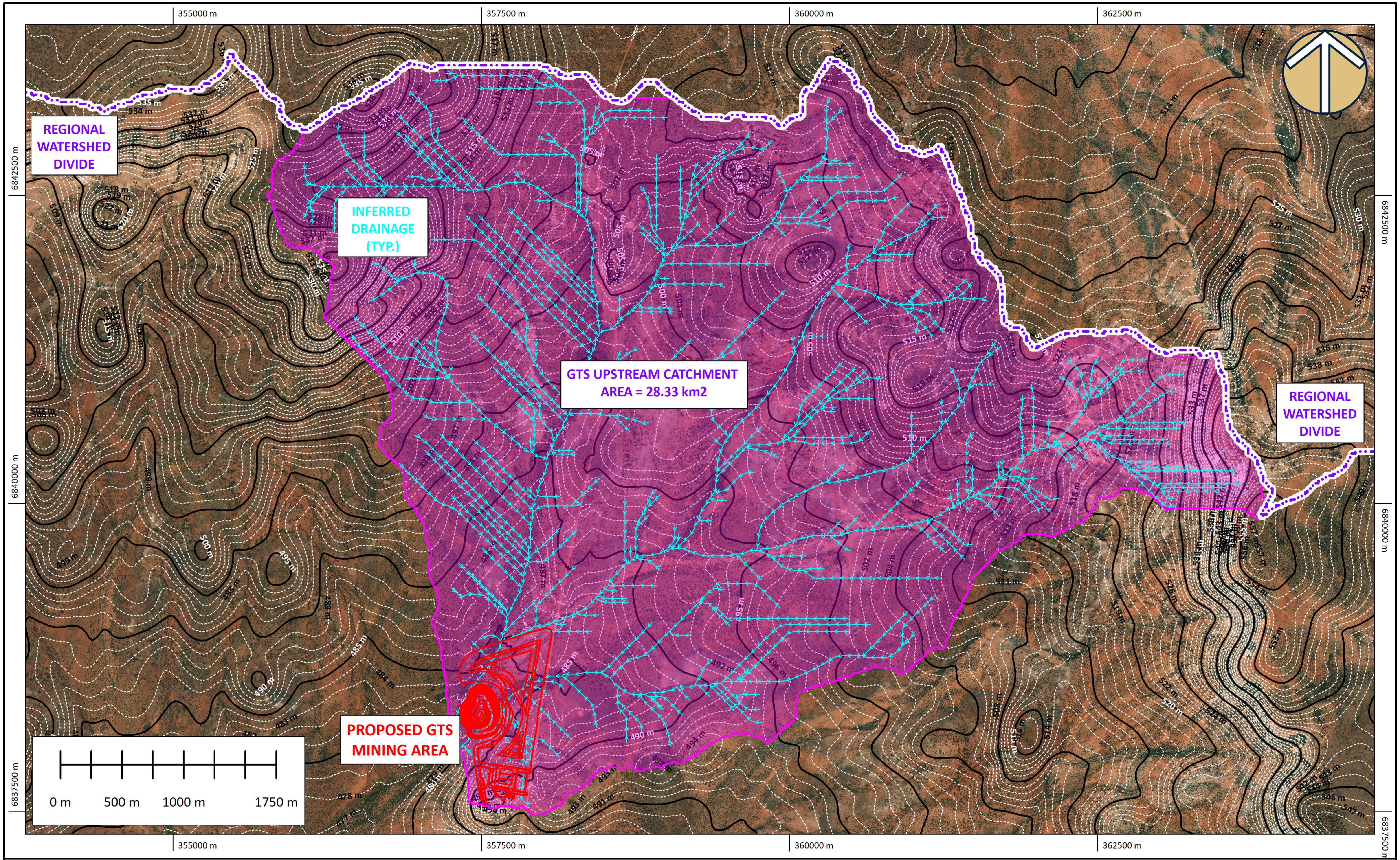
GROUNDWATER
RESOURCE MANAGEMENT

FIGURE 5
REDCLIFFE GOLD PROJECT
HUB MINING AREA
LOCAL CATCHMENT DELINEATION

Date October 21
Client Dacian Gold Ltd
Project Redcliffe Gold Project
Document J2126R01

Notes
1. Figure scale = 1:47,500 @ A3.
2. Coordinates to GDA94/MGA51.

Sources
1. Imagery from ESRI World Imagery.
2. Contours and catchment boundaries developed from Geoscience Australia's 1-sec SRTM dataset using GIS spatial anlayis tools.



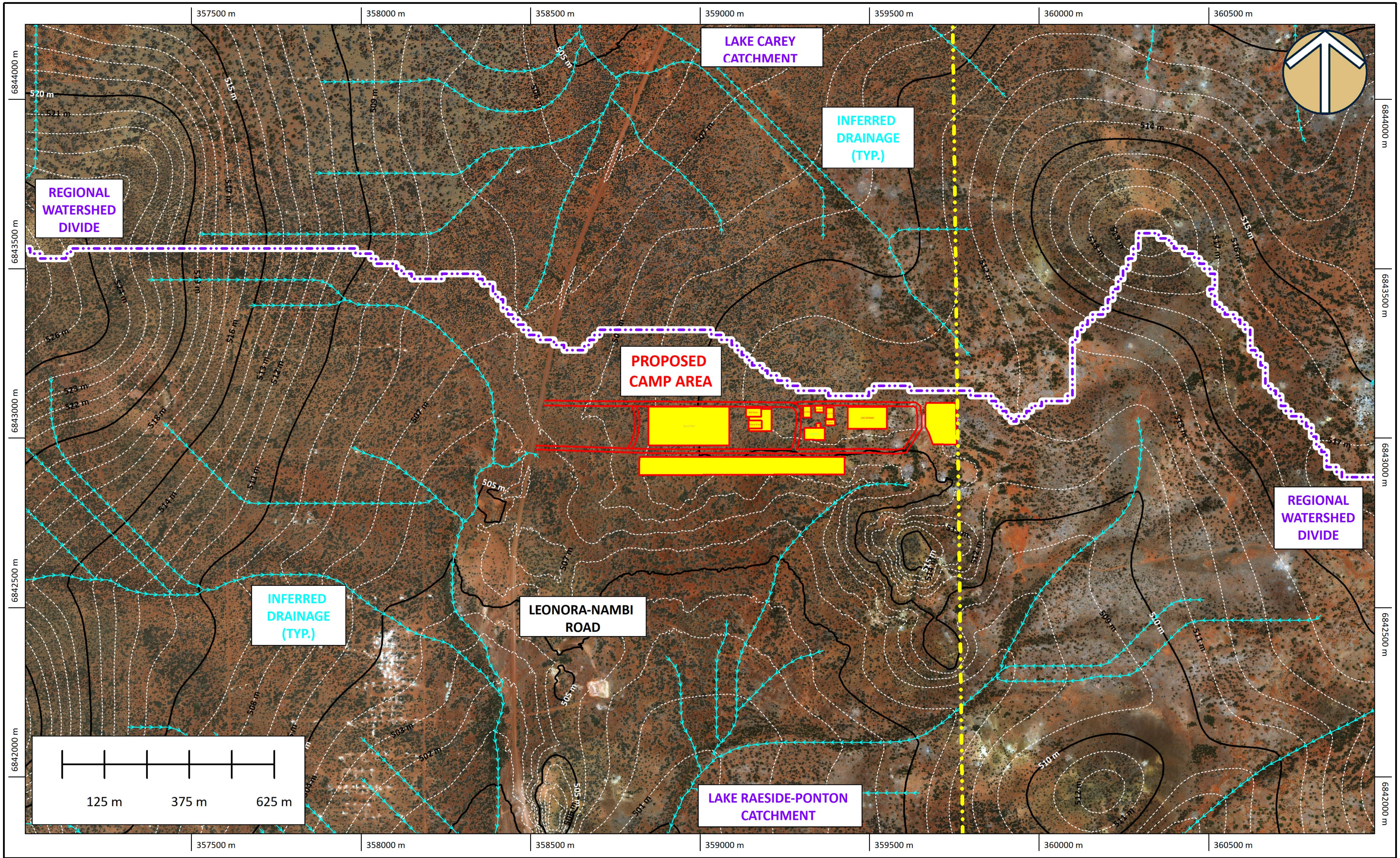
GROUNDWATER
RESOURCE MANAGEMENT

FIGURE 6
REDCLIFFE GOLD PROJECT
GTS MINING AREA
LOCAL CATCHMENT DELINEATION

Date October 21
Client Dacian Gold Ltd
Project Redcliffe Gold Project
Document J2126R01

Notes
1. Figure scale = 1:27,500 @ A3.
2. Coordinates to GDA94/MGA 51.
3. Major/minor contour interval is 5m/1m.

Sources
1. Aerial imagery from ESRI World Imagery.
2. Contours and catchment boundaries developed from Geoscience Australia's 1-sec SRTM dataset using GIS spatial anlaysis tools.



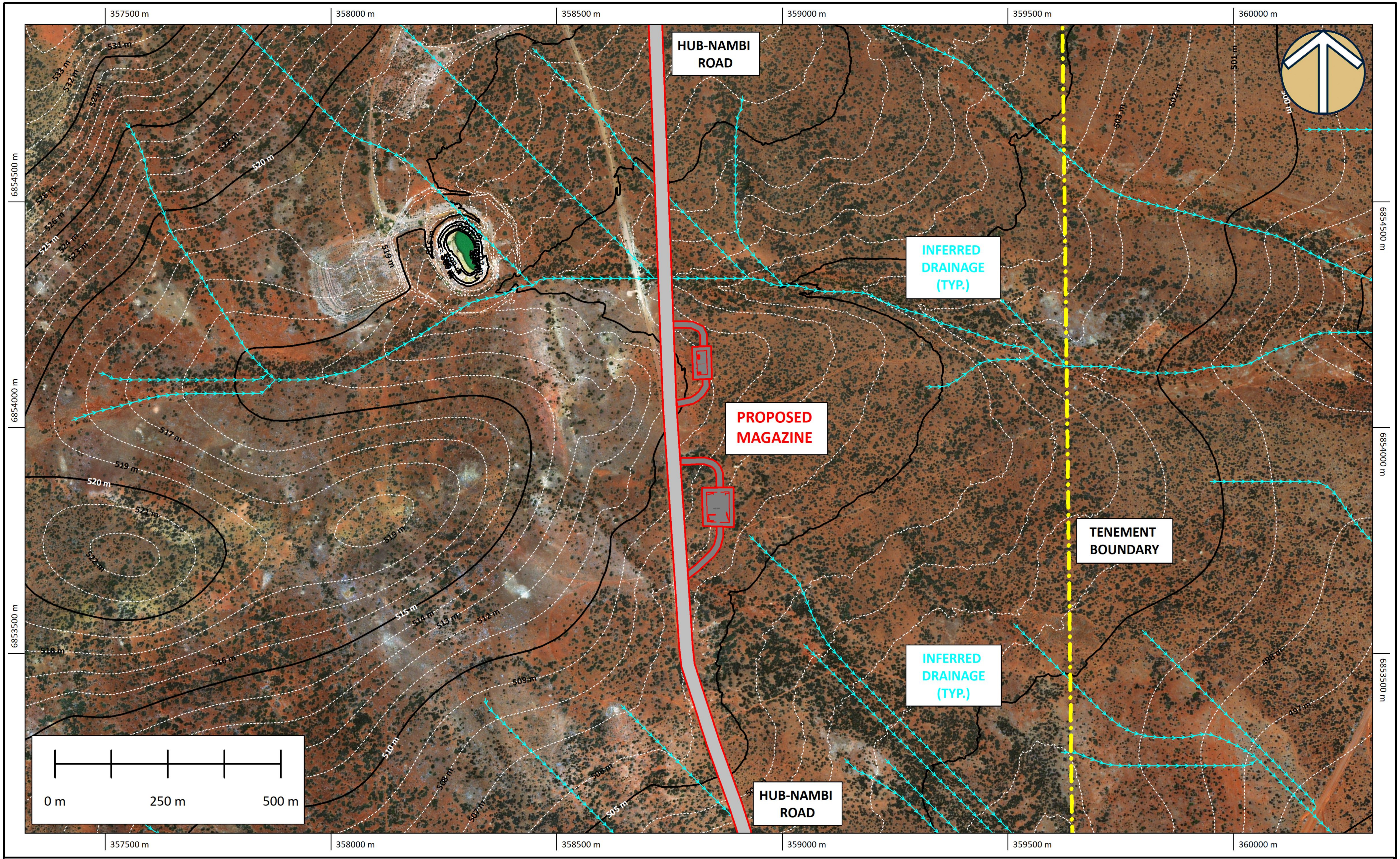
GROUNDWATER RESOURCE MANAGEMENT

FIGURE 7
REDCLIFFE GOLD PROJECT
CAMP AREA
LOCAL CATCHMENT DELINEATION

Date October 21
Client Dacian Gold Ltd
Project Redcliffe Gold Project
Document J2126R01

Notes
1. Figure scale = 1:10,000 @ A3.
2. Coordinates to GDA94/MGA 51.
3. Major/minor contour interval is 5m/1m.

Sources
1. Imagery from ESRI World Imagery.
2. Contours and catchment boundaries developed from Geoscience Australia's 1-sec SRTM dataset using GIS spatial anlayis tools.



GROUNDWATER RESOURCE MANAGEMENT

FIGURE 8
REDCLIFFE GOLD PROJECT
MAGAZINE FACILITY
LOCAL CATCHMENT DELINEATION

Date October 21
Client Dacian Gold Ltd
Project Redcliffe Gold Project
Document J2126R01

Notes
1. Figure scale = 1:7,500 @ A3.
2. Coordinates to GDA94/MGA 51.
3. Major/minor contour interval is 5m/1m.

Sources
1. Imagery from ESRI World Imagery.
2. Contours and catchment boundaries developed from Geoscience Australia's 1-sec SRTM dataset using GIS spatial anlayis tools.

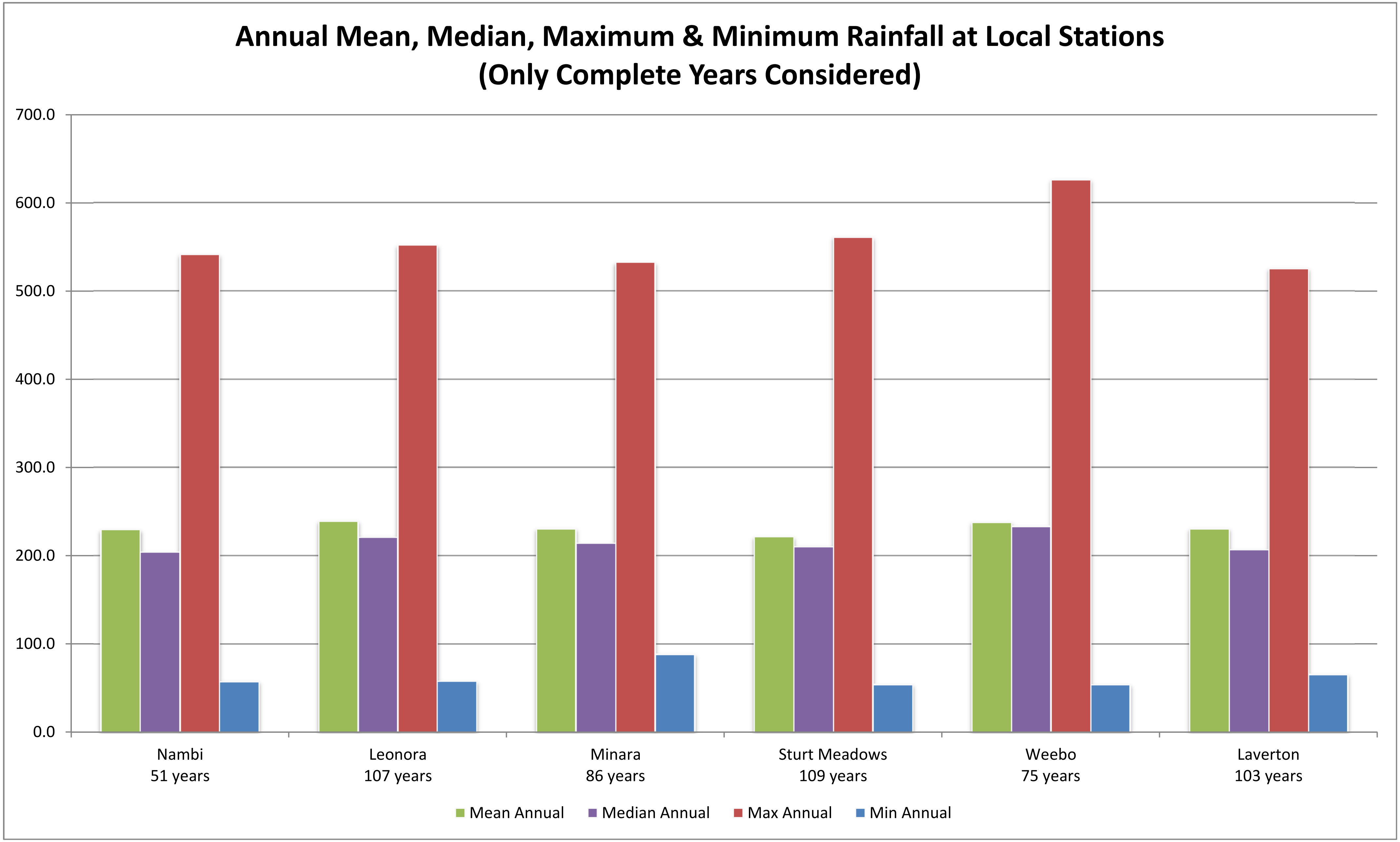
APPENDIX A

Hydro-meteorological Data

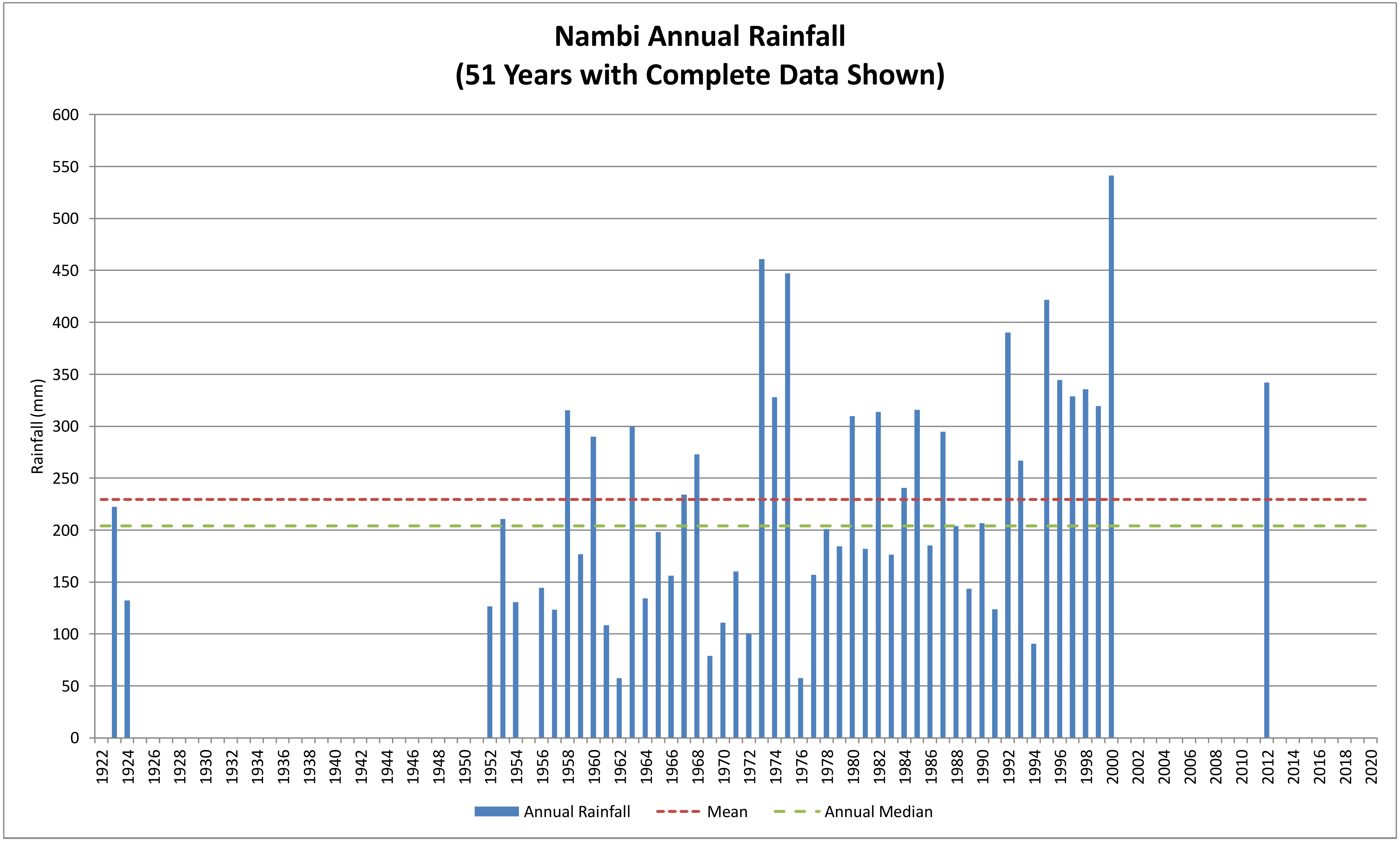
Monthly and Annual Rainfall Values
for Local Rainfall stations (all within 85 km of Redcliffe Project Centroid)

	Local BoM Rainfall Stations[1,2]																							
	Nambi				**Leonora**				**Minara**				**Sturt Meadows**				**Weebo**				**Laverton**			
	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max	Min	Mean	Median	Max	Min
Jan	33.3	13.0	173.1	0	26.2	11.5	172.0	0	23.3	9.6	152.1	0	26.0	10.9	229.2	0	33.3	14.4	209.9	0	25.7	8.4	179.0	0
Feb	30.6	14.1	213.0	0	31.0	12.6	284.6	0	26.2	10.2	256.1	0	28.6	9.1	386.6	0	37.9	16.4	318.0	0	31.6	18.1	233.6	0
Mar	29.8	9.5	204.8	0	30.6	12.5	273.9	0	30.9	12.9	175.8	0	30.7	14.5	229.2	0	31.5	13.5	223.5	0	31.3	16.0	181.0	0
Apr	22.7	13.2	129.6	0	20.5	13.9	135.4	0	21.4	13.2	94.0	0	18.7	13.2	111.0	0	23.5	17.8	197.5	0	20.6	12.4	108.5	0
May	24.4	20.6	113.4	0	23.5	17.3	158.6	0	23.4	15.0	174.6	0	22.3	16.4	146.6	0	22.5	15.0	111.3	0	21.6	15.0	123.8	0
Jun	23.8	14.0	121.2	0	24.1	19.4	144.0	0	23.3	18.5	107.6	0	20.1	15.0	103.8	0	22.9	16.0	115.6	0	22.2	15.8	126.2	0
Jul	16.6	10.2	84.8	0	18.7	14.8	101.6	0	15.0	12.4	72.6	0	16.7	11.7	95.2	0	15.0	9.2	64.0	0	15.5	11.8	66.1	0
Aug	12.7	6.9	62.2	0	15.6	11.0	85.2	0	14.3	9.3	59.7	0	14.0	8.6	85.6	0	11.6	5.6	66.5	0	12.7	8.7	84.8	0
Sep	8.3	5.5	38.4	0	8.5	5.1	49.9	0	7.8	3.8	58.5	0	6.7	2.6	55.1	0	5.5	1.0	47.6	0	8.0	3.0	53.5	0
Oct	8.7	3.2	51.0	0	9.5	3.6	73.0	0	9.3	3.8	76.4	0	8.1	2.5	65.6	0	7.7	3.6	59.9	0	10.0	5.9	67.0	0
Nov	11.5	10.0	71.1	0	12.4	7.0	61.2	0	14.4	9.1	109.1	0	11.3	5.8	90.1	0	11.2	5.2	87.7	0	14.3	8.5	152.0	0
Dec	16.0	9.4	103.8	0	17.5	10.8	94.0	0	17.5	11.2	104.1	0	15.1	7.6	101.0	0	18.4	9.0	84.0	0	18.2	11.4	134.6	0
Mean Annual	229.3				239.1				230.7				221.5				238.1				230.6			
Median Annual	204.0				221.2				214.1				210.4				233.3				206.6			
Max Annual	541.4				552.2				532.5				561.1				626.1				525.6			
Min Annual	57.4				57.8				88.6				54.1				54.0				65.6			

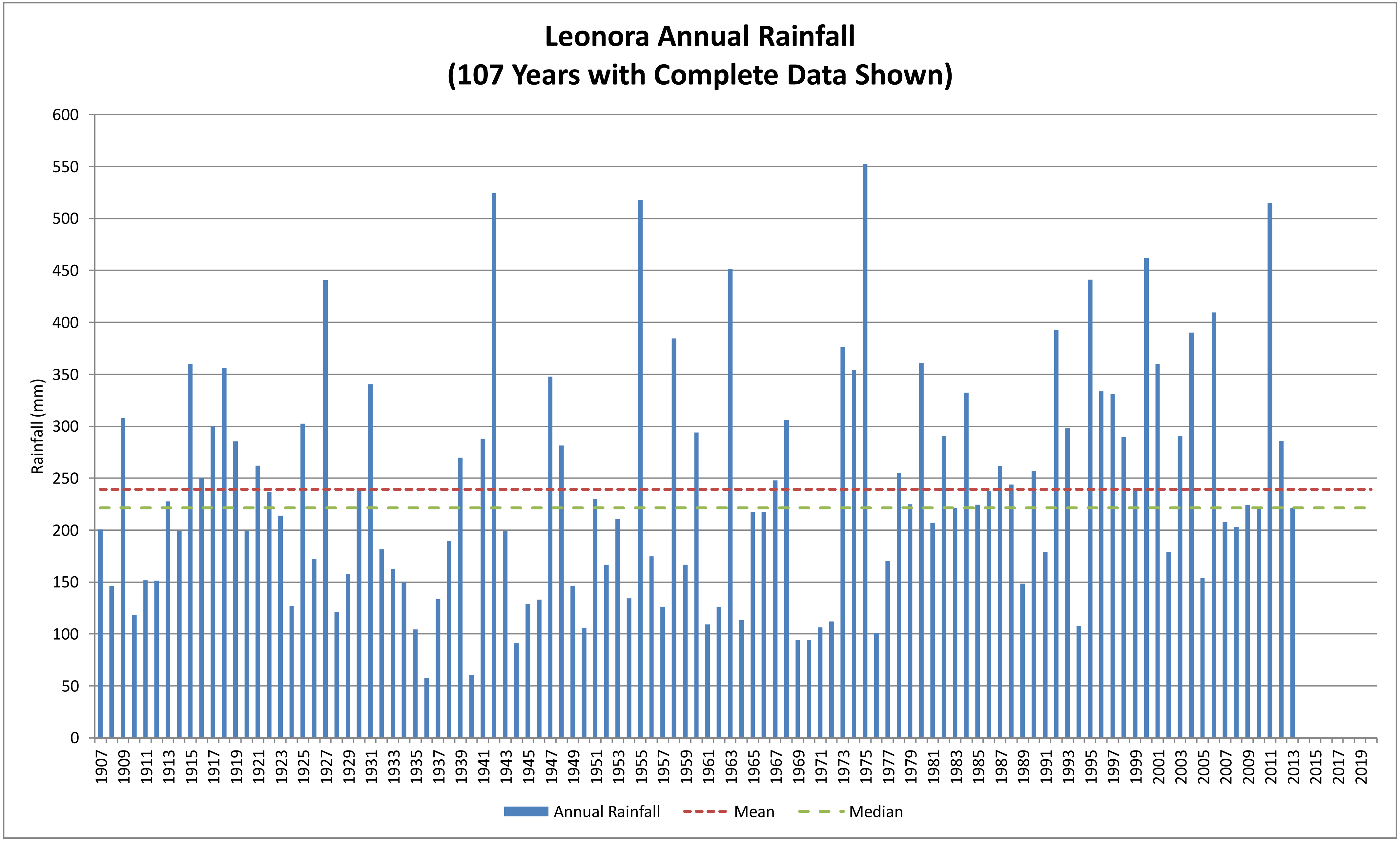
Notes:
1. Monthly values based on complete months only (slight differences may exist with published BoM values).
2. Annual values based on complete years only (slight differences may exist with published BoM values).

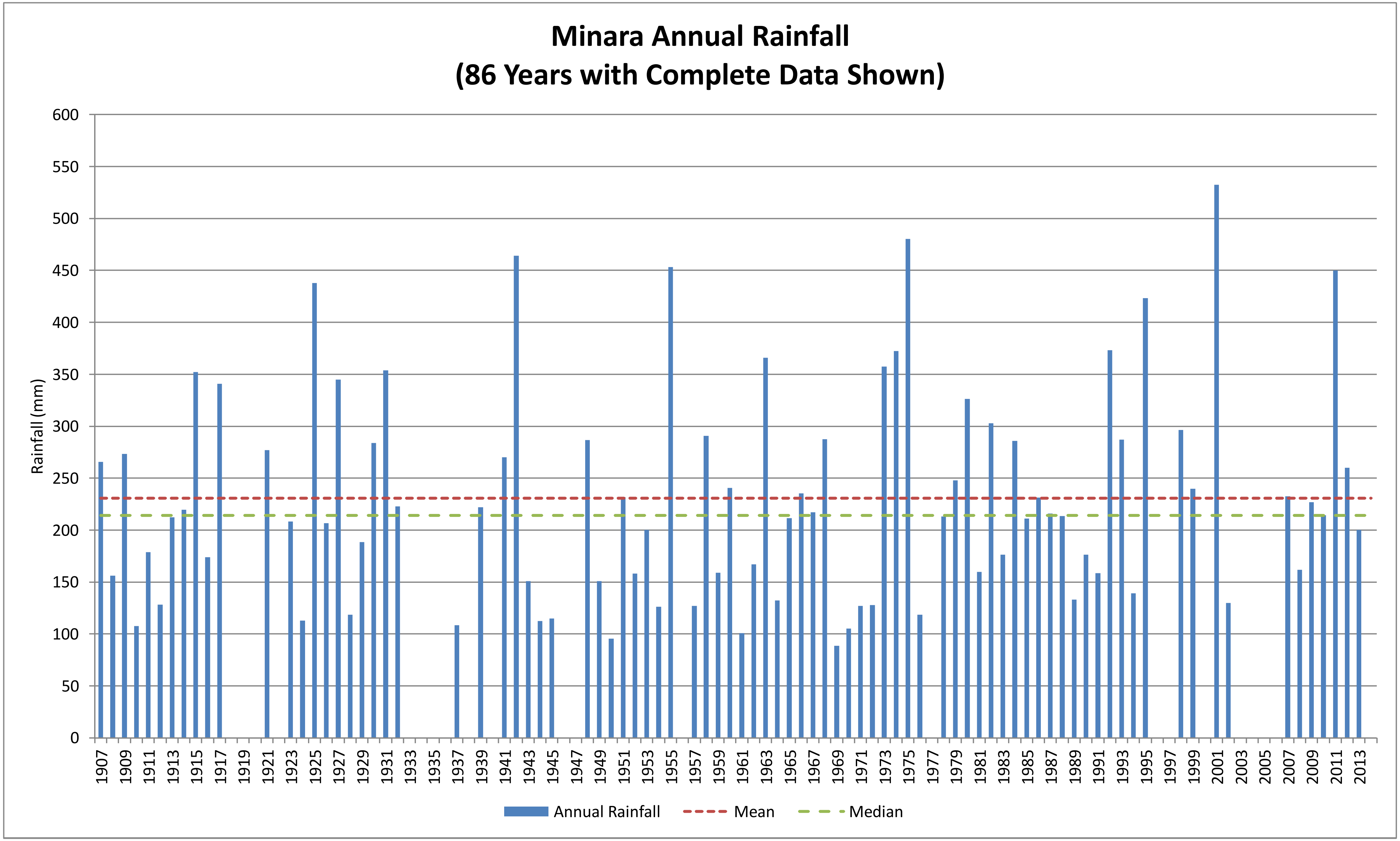


Annual Mean, Median, Maximum & Minimum Rainfall at Local Stations
(Only Complete Years Considered)
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
Nambi
51 years
Leonora
107 years
Minara
86 years
Sturt Meadows
109 years
Weebo
75 years
Laverton
103 years
Mean Annual
Median Annual
Max Annual
Min Annual

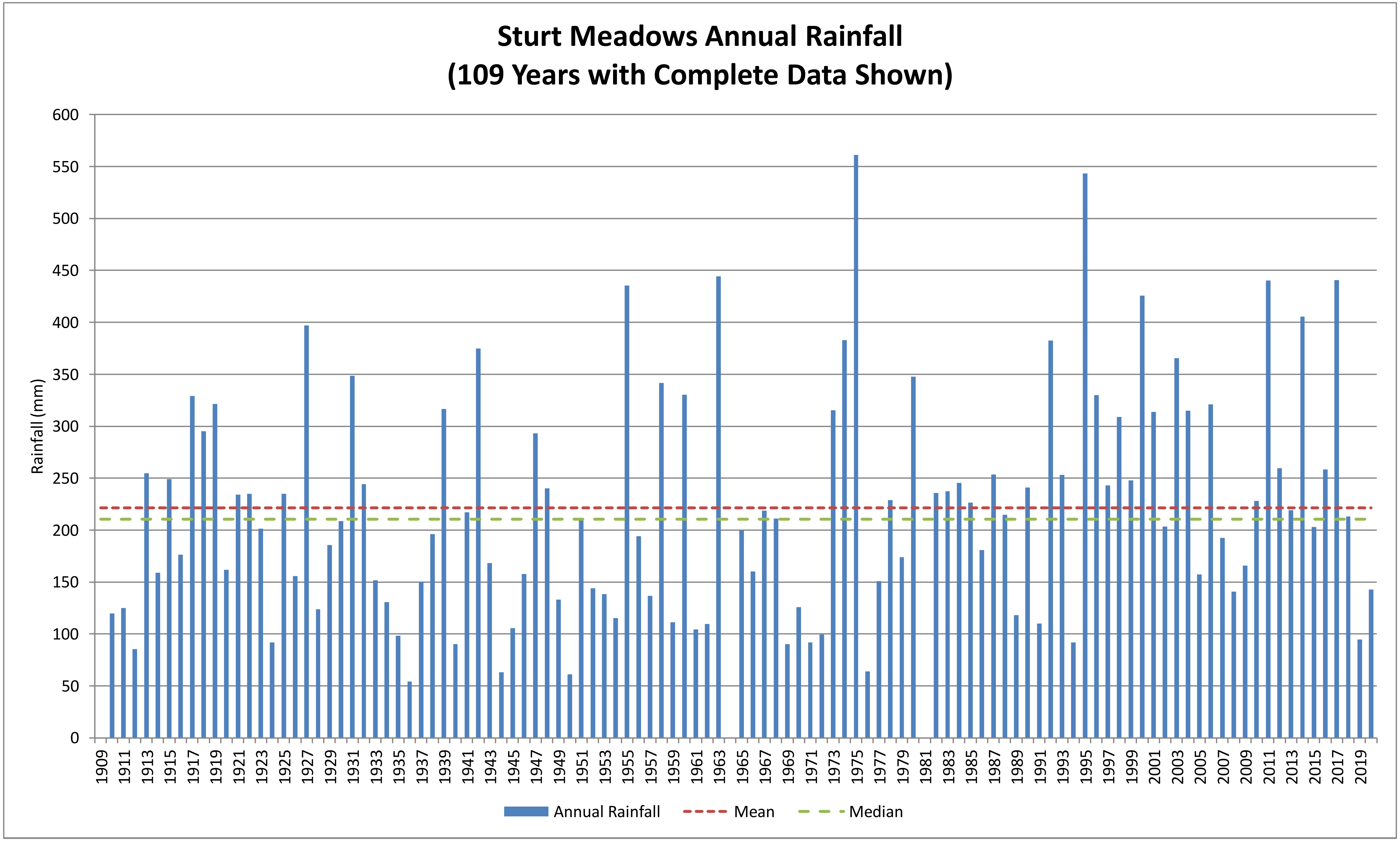


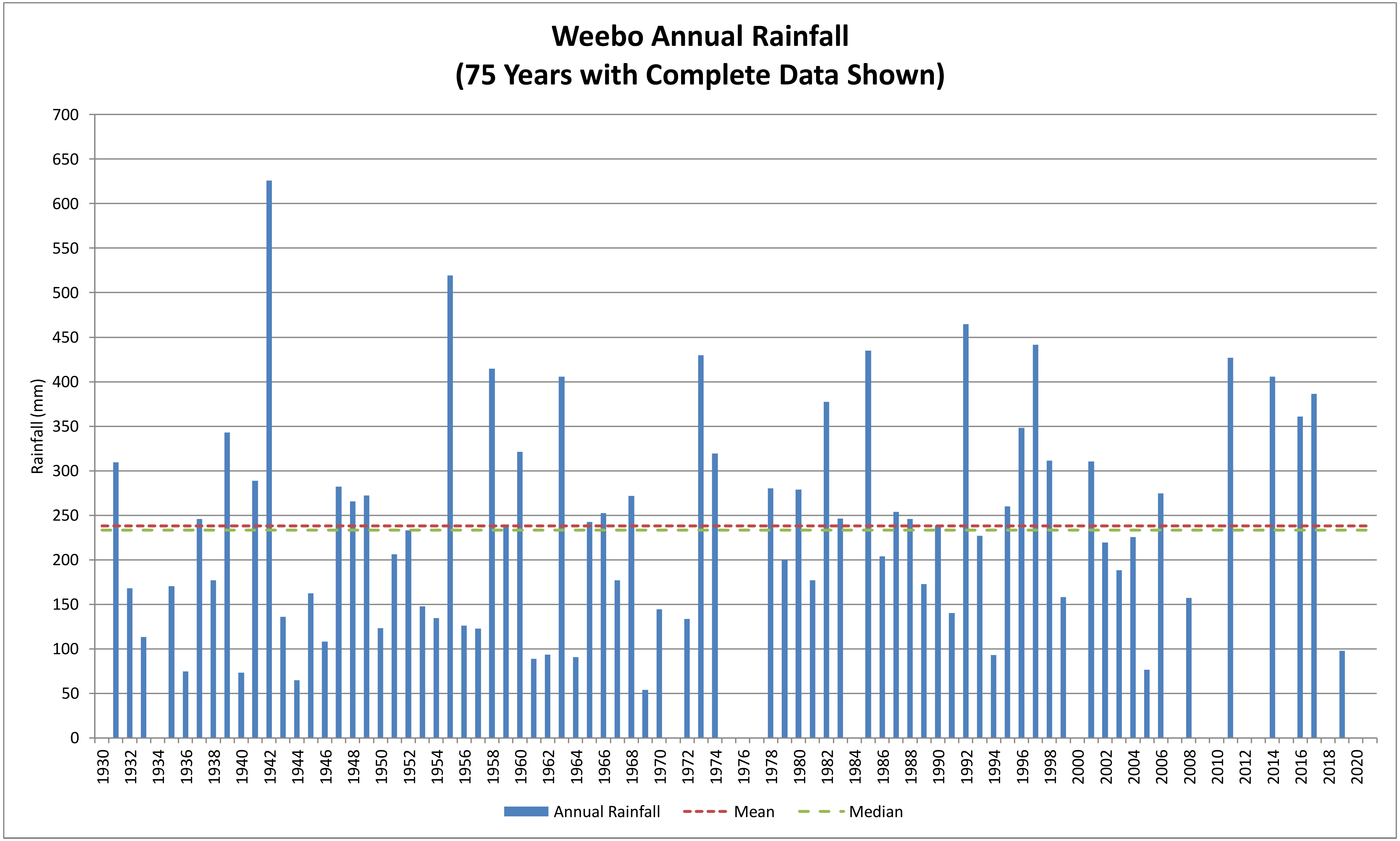
Nambi Annual Rainfall
(51 Years with Complete Data Shown)
Rainfall (mm)
600
550
500
450
400
350
300
250
200
150
100
50
0
1922
1924
1926
1928
1930
1932
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Annual Rainfall
Mean
Annual Median

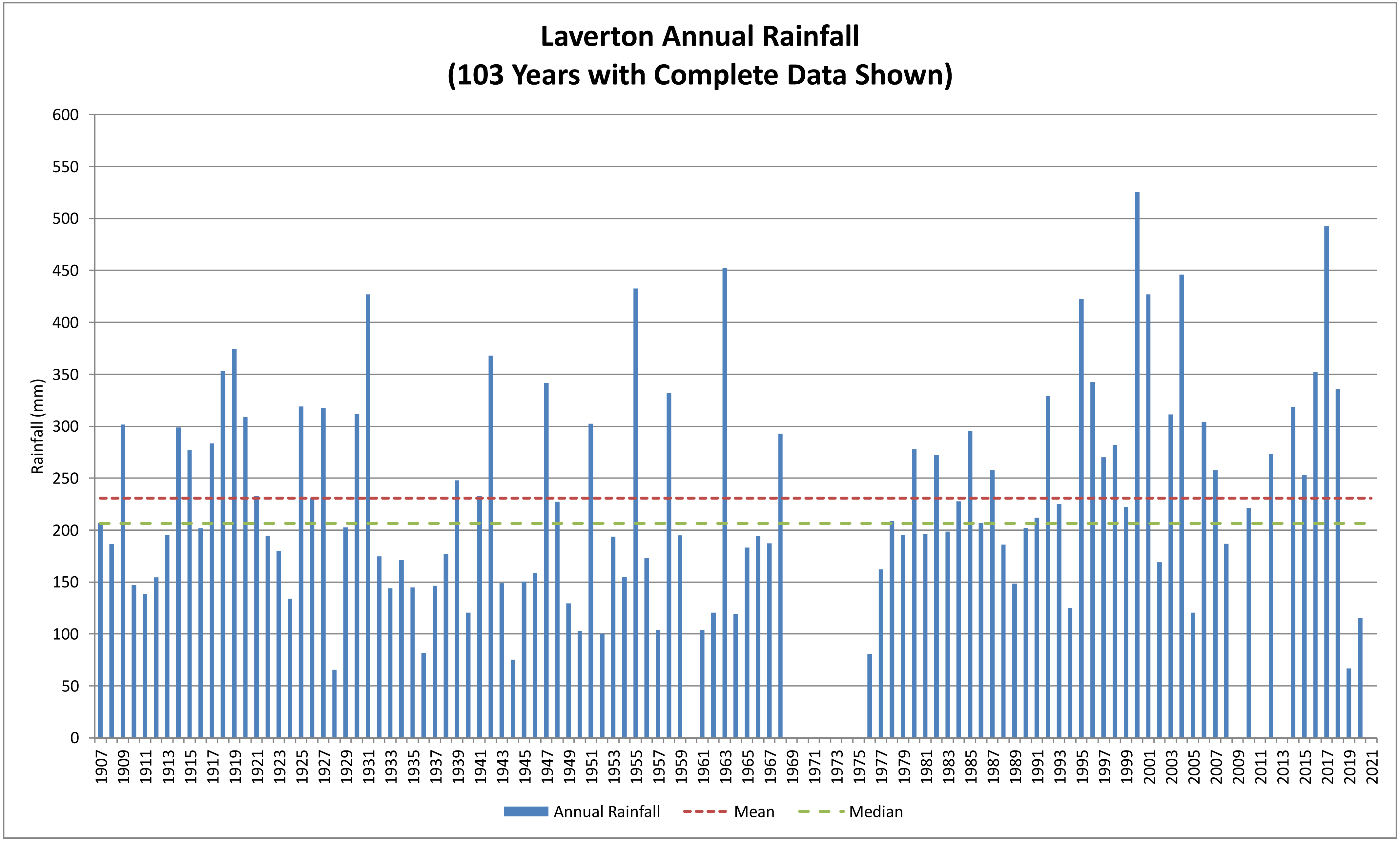

Leonora Annual Rainfall
(107 Years with Complete Data Shown)
Rainfall (mm)
0
50
100
150
200
250
300
350
400
450
500
550
600
1907
1909
1911
1913
1915
1917
1919
1921
1923
1925
1927
1929
1931
1933
1935
1937
1939
1941
1943
1945
1947
1949
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
Annual Rainfall
Mean
Median



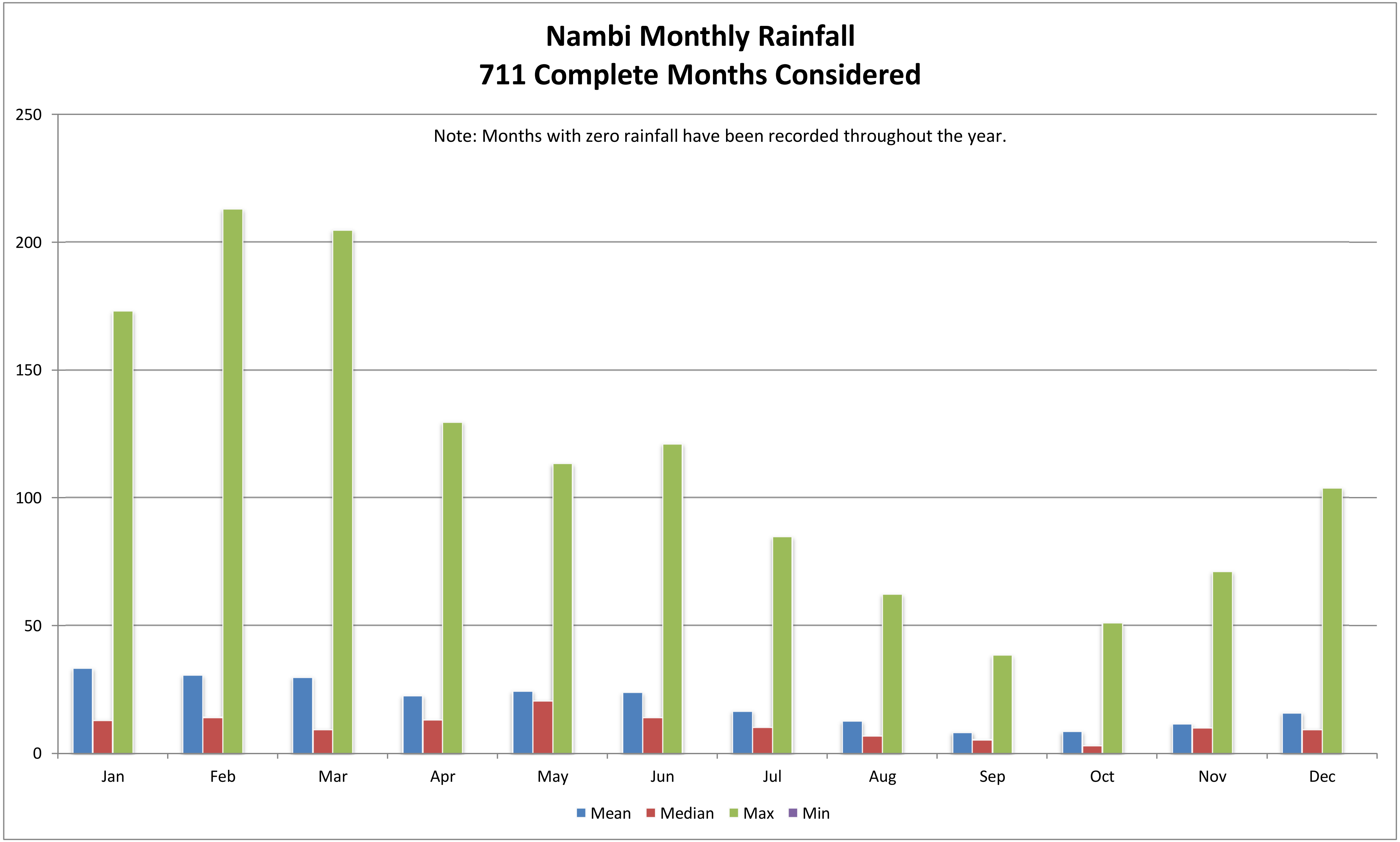
Minara Annual Rainfall
(86 Years with Complete Data Shown)
Rainfall (mm)
600
550
500
450
400
350
300
250
200
150
100
50
0
1907
1909
1911
1913
1915
1917
1919
1921
1923
1925
1927
1929
1931
1933
1935
1937
1939
1941
1943
1945
1947
1949
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
Annual Rainfall
Mean
Median

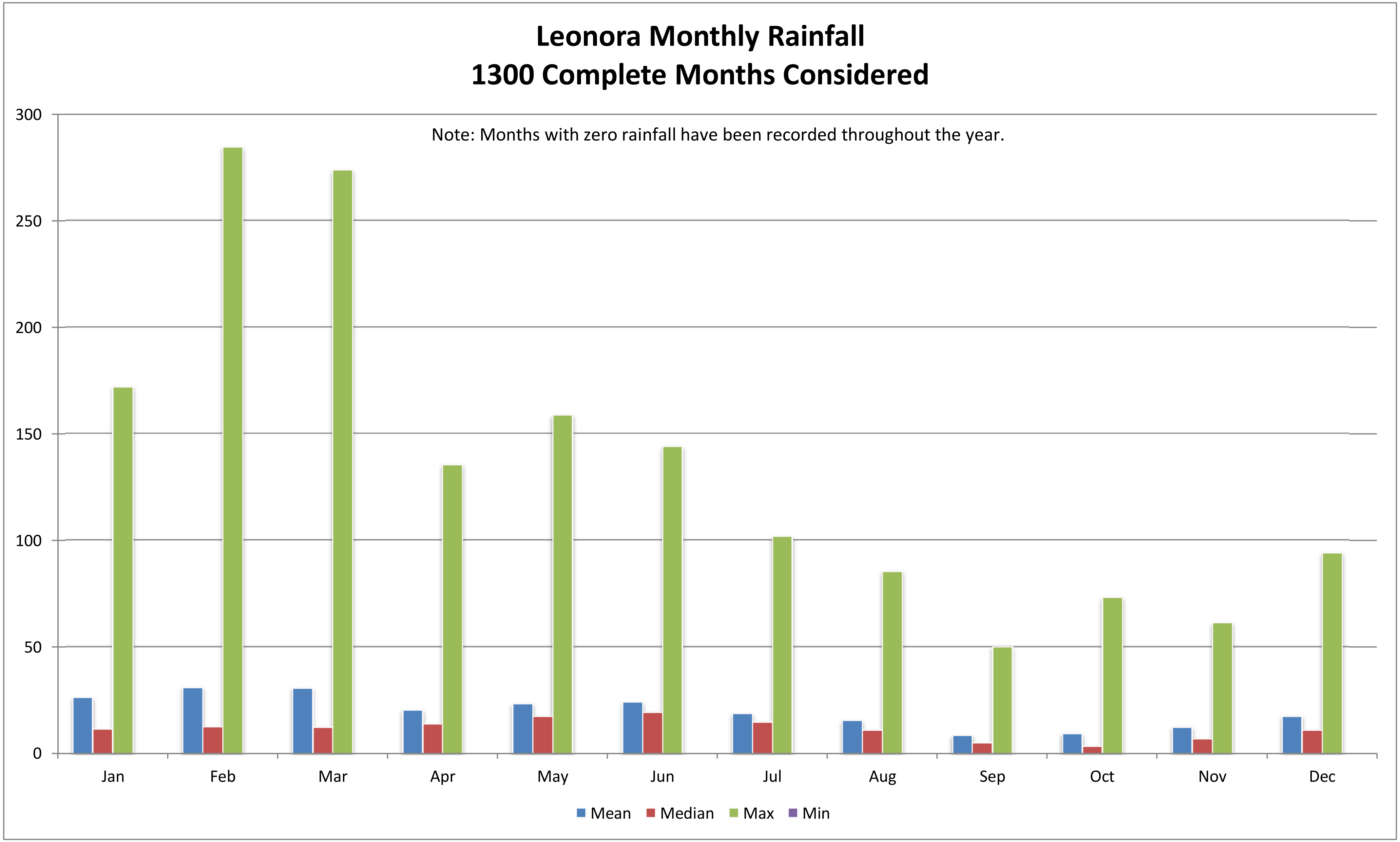

Sturt Meadows Annual Rainfall
(109 Years with Complete Data Shown)
Rainfall (mm)
600
550
500
450
400
350
300
250
200
150
100
50
0
1909 1911 1913 1915 1917 1919 1921 1923 1925 1927 1929 1931 1933 1935 1937 1939 1941 1943 1945 1947 1949 1951 1953 1955 1957 1959 1961 1963 1965 1967 1969 1971 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017 2019
Annual Rainfall
Mean
Median

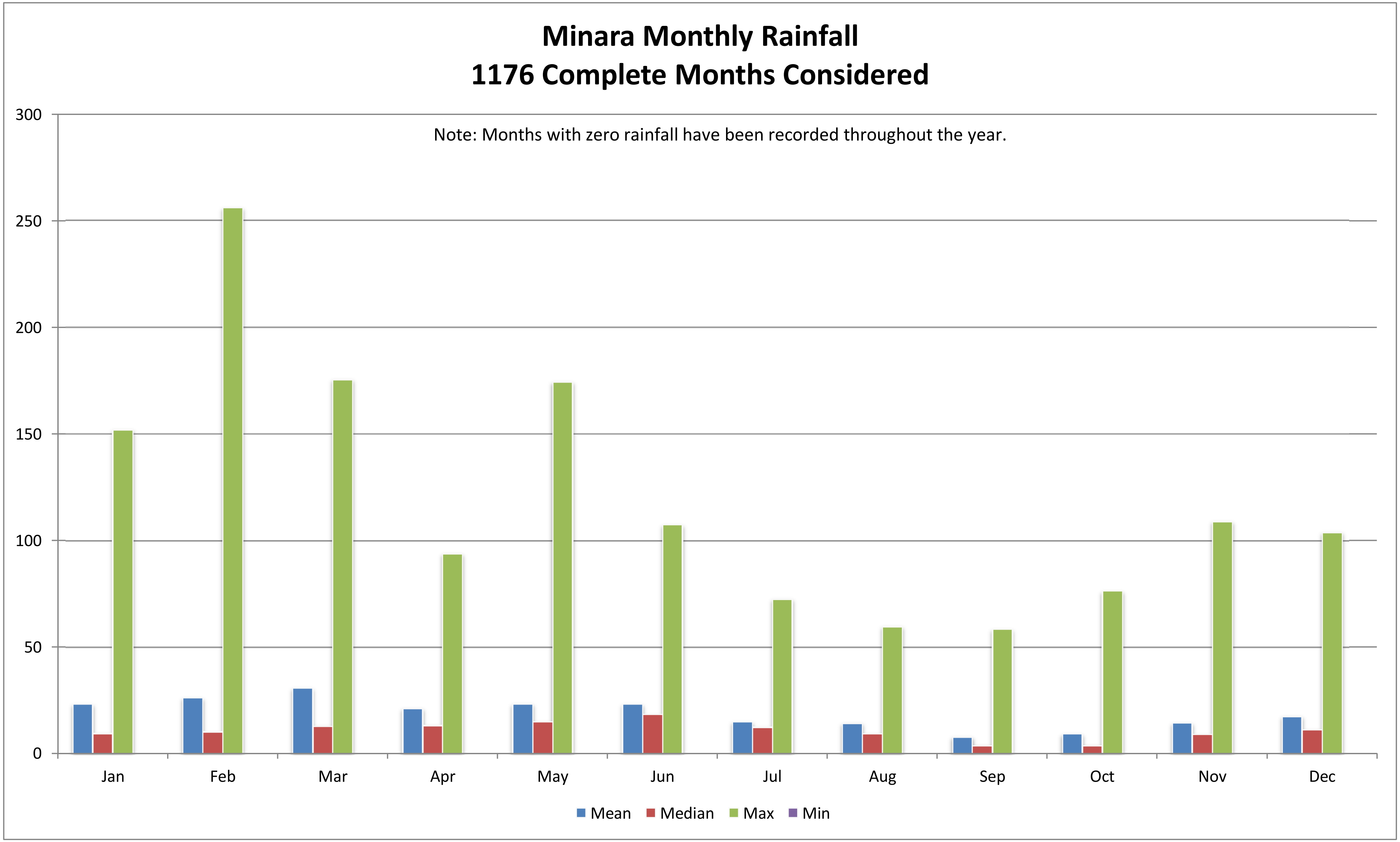

Weebo Annual Rainfall
(75 Years with Complete Data Shown)
Rainfall (mm)
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
1930
1932
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Annual Rainfall
Mean
Median

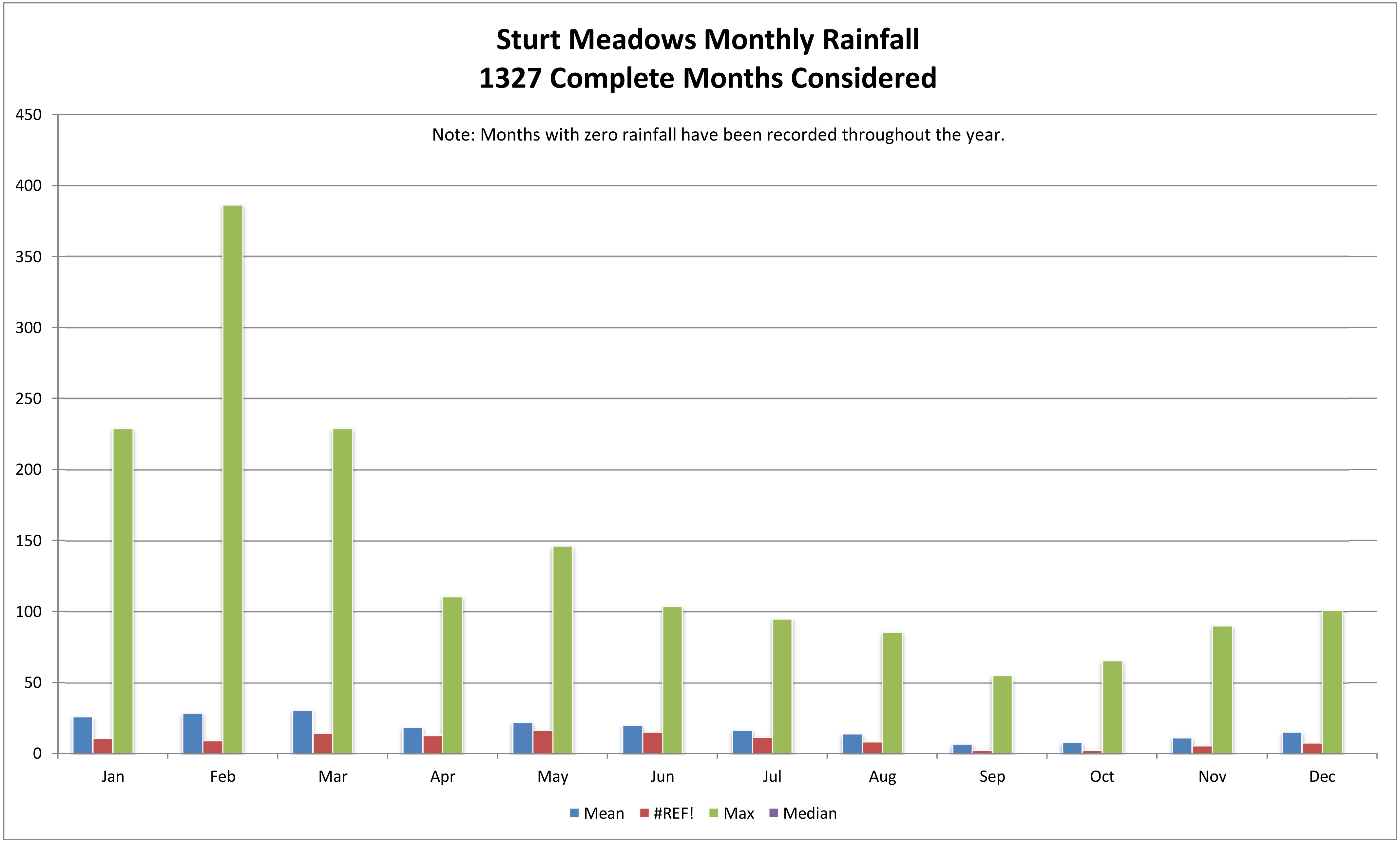


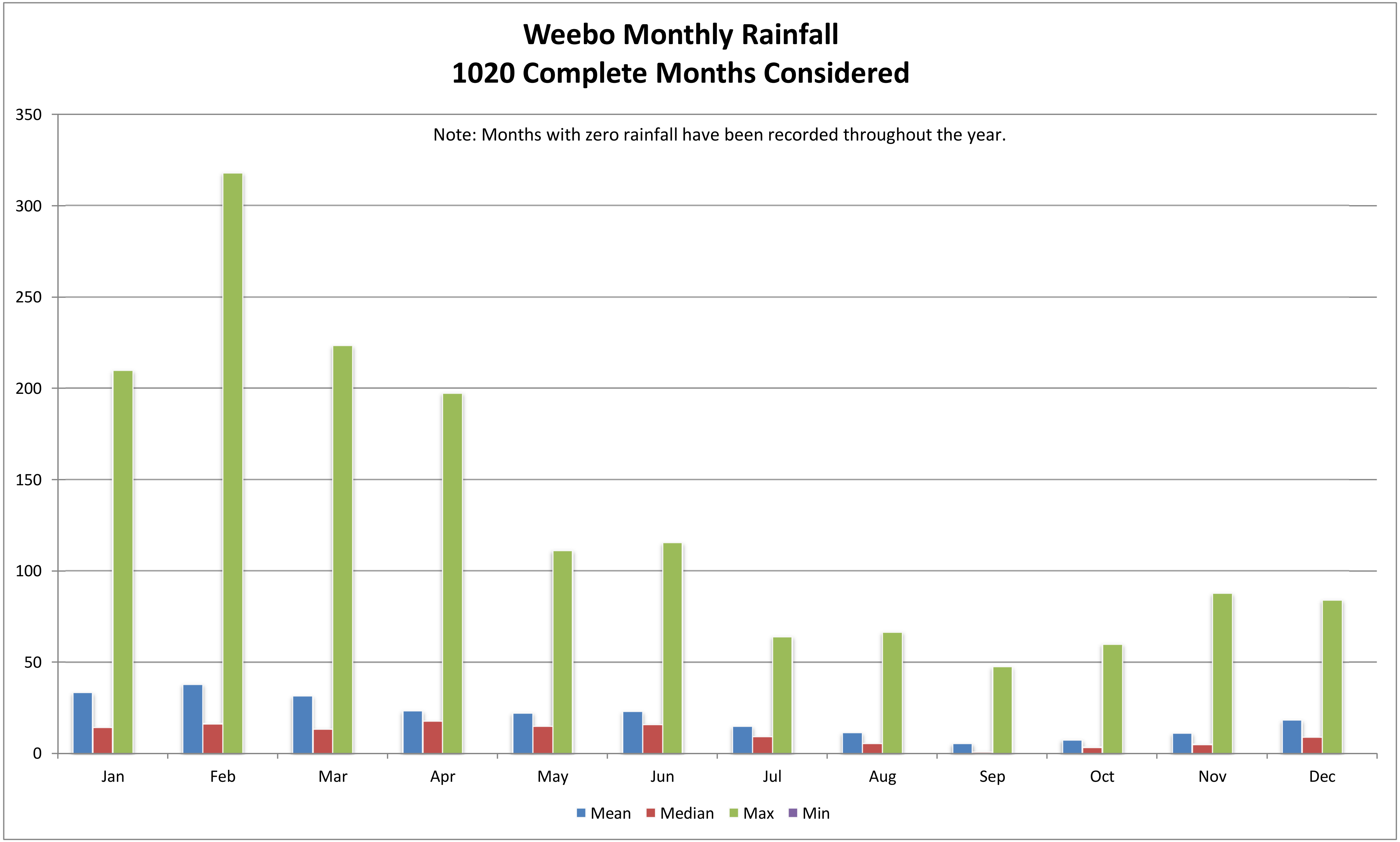
Laverton Annual Rainfall
(103 Years with Complete Data Shown)
Rainfall (mm)
600
550
500
450
400
350
300
250
200
150
100
50
0
1907
1909
1911
1913
1915
1917
1919
1921
1923
1925
1927
1929
1931
1933
1935
1937
1939
1941
1943
1945
1947
1949
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021
Annual Rainfall
Mean
Median

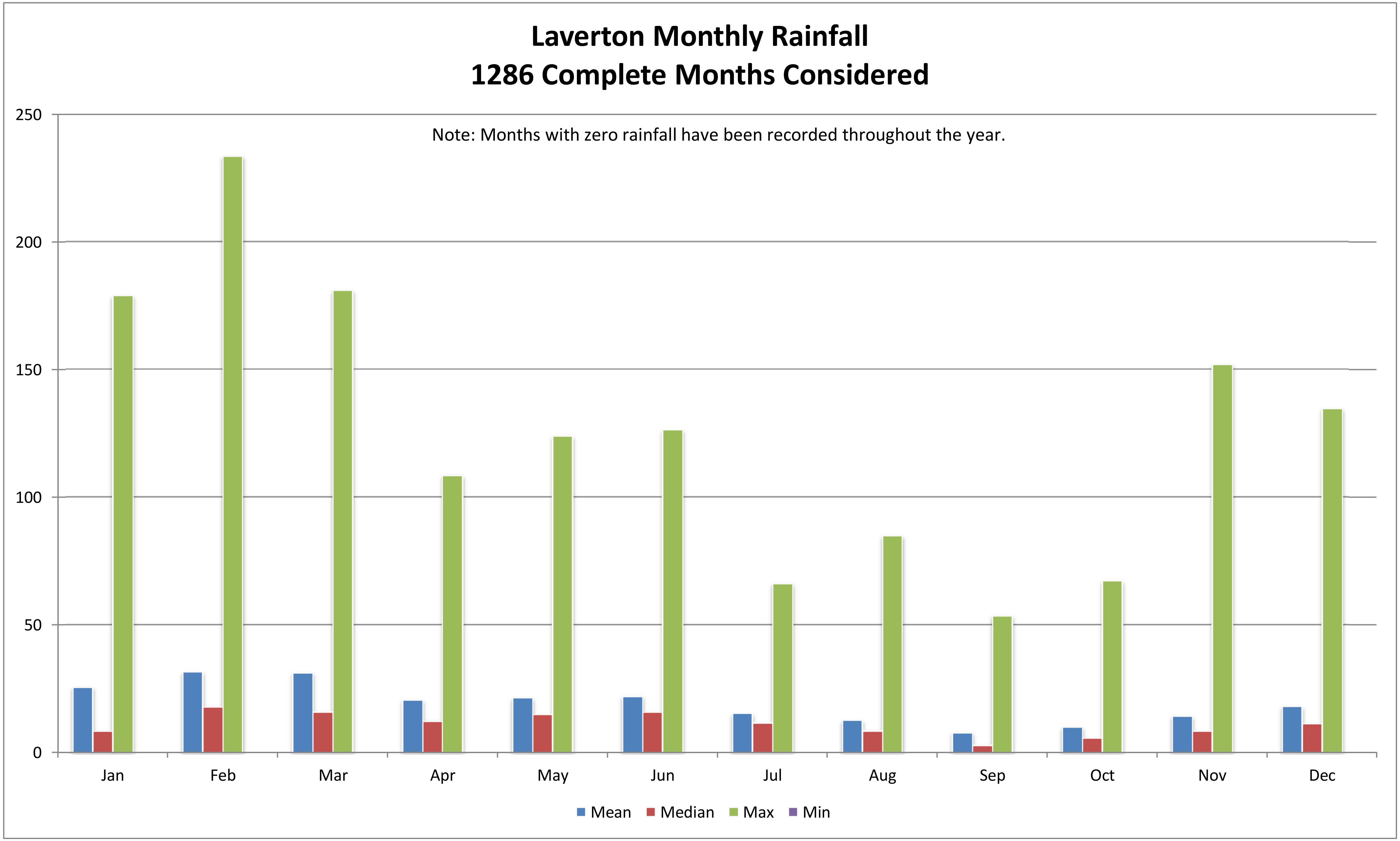

Nambi Monthly Rainfall
711 Complete Months Considered
Note: Months with zero rainfall have been recorded throughout the year.
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Mean
Median
Max
Min


Leonora Monthly Rainfall
1300 Complete Months Considered
Note: Months with zero rainfall have been recorded throughout the year.
300
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Mean
Median
Max
Min


Minara Monthly Rainfall
1176 Complete Months Considered
Note: Months with zero rainfall have been recorded throughout the year.
300
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Mean
Median
Max
Min


Sturt Meadows Monthly Rainfall
1327 Complete Months Considered
Note: Months with zero rainfall have been recorded throughout the year.
450
400
350
300
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Mean
#REF!
Max
Median


Weebo Monthly Rainfall
1020 Complete Months Considered
Note: Months with zero rainfall have been recorded throughout the year.
350
300
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Mean
Median
Max
Min


Laverton Monthly Rainfall
1286 Complete Months Considered
Note: Months with zero rainfall have been recorded throughout the year.
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Mean
Median
Max
Min

Top 10 Wettest Days at Each Local BoM Station

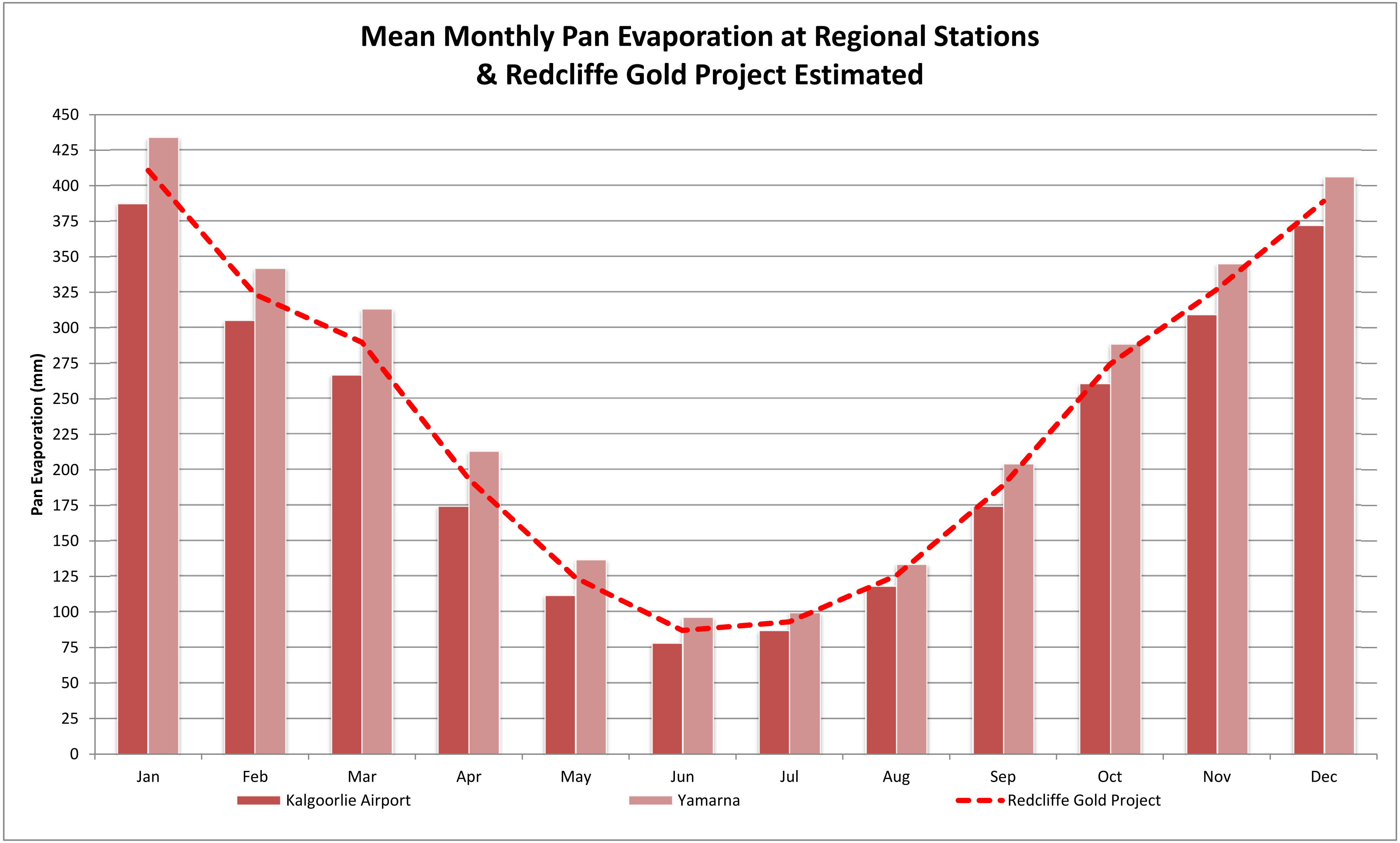
Station No.	Rainfall Station	Year	Month	Day	Precipitation to 9am (mm)	Rank
12062	Nambi	2000	1	23	94.6	1
12062	Nambi	1923	4	9	93.2	2
12062	Nambi	1925	2	26	79.5	3
12062	Nambi	1997	1	10	76.0	4
12062	Nambi	1987	1	22	70.6	5
12062	Nambi	2013	3	1	66.0	6
12062	Nambi	1987	1	20	63.0	7
12062	Nambi	1975	2	23	62.0	8
12062	Nambi	1927	3	22	61.0	9
12062	Nambi	2001	2	17	60.2	10
12046	Leonora	2014	1	23	109.2	1
12046	Leonora	1995	2	27	105.9	2
12046	Leonora	1927	3	21	103.4	3
12046	Leonora	2006	1	10	98.2	4
12046	Leonora	1909	1	22	84.6	5
12046	Leonora	1942	1	29	82.8	6
12046	Leonora	1939	1	14	82.6	7
12046	Leonora	1975	2	21	75.6	8
12046	Leonora	1975	2	22	75.6	9
12046	Leonora	2000	3	26	75.6	10
12061	Minara	1955	1	1	100.6	1
12061	Minara	1948	2	22	90.9	2
12061	Minara	1925	2	17	86.4	3
12061	Minara	1927	3	22	86.4	4
12061	Minara	1907	3	16	82.6	5
12061	Minara	1942	1	29	78.7	6
12061	Minara	1995	2	1	76.4	7
12061	Minara	1942	3	17	63.5	8
12061	Minara	1919	12	10	62.2	9
12061	Minara	1979	2	13	60.0	10
12176	Sturt Meadows	1995	2	27	185.6	1
12176	Sturt Meadows	2014	1	23	161.0	2
12176	Sturt Meadows	1975	2	22	96.8	3
12176	Sturt Meadows	2017	3	25	96.2	4
12176	Sturt Meadows	1927	3	22	92.7	5
12176	Sturt Meadows	1995	2	26	85.0	6
12176	Sturt Meadows	1960	2	1	79.0	7
12176	Sturt Meadows	1952	1	23	78.7	8
12176	Sturt Meadows	1975	2	21	77.2	9
12176	Sturt Meadows	1931	3	30	73.7	10
12082	Weebo	2000	1	23	117.0	1
12082	Weebo	1975	2	23	108.2	2
12082	Weebo	1960	1	31	104.9	3
12082	Weebo	1955	1	1	104.6	4
12082	Weebo	1939	1	13	102.4	5
12082	Weebo	1975	2	22	96.2	6
12082	Weebo	1997	2	19	93.0	7
12082	Weebo	1978	2	6	88.6	8
12082	Weebo	1985	1	31	87.0	9
12082	Weebo	1942	3	27	84.6	10
12045	Laverton	2011	2	17	120.2	1
12045	Laverton	2000	1	24	92.6	2
12045	Laverton	1914	11	11	90.9	3
12045	Laverton	2007	1	4	90.0	4
12045	Laverton	1918	2	3	86.6	5
12045	Laverton	1975	2	23	78.0	6
12045	Laverton	1995	2	26	78.0	7
12045	Laverton	1915	2	24	75.2	8
12045	Laverton	1939	1	14	74.7	9
12045	Laverton	2017	1	17	73.0	10

Top 60 Wettest Days at Local BoM Stations

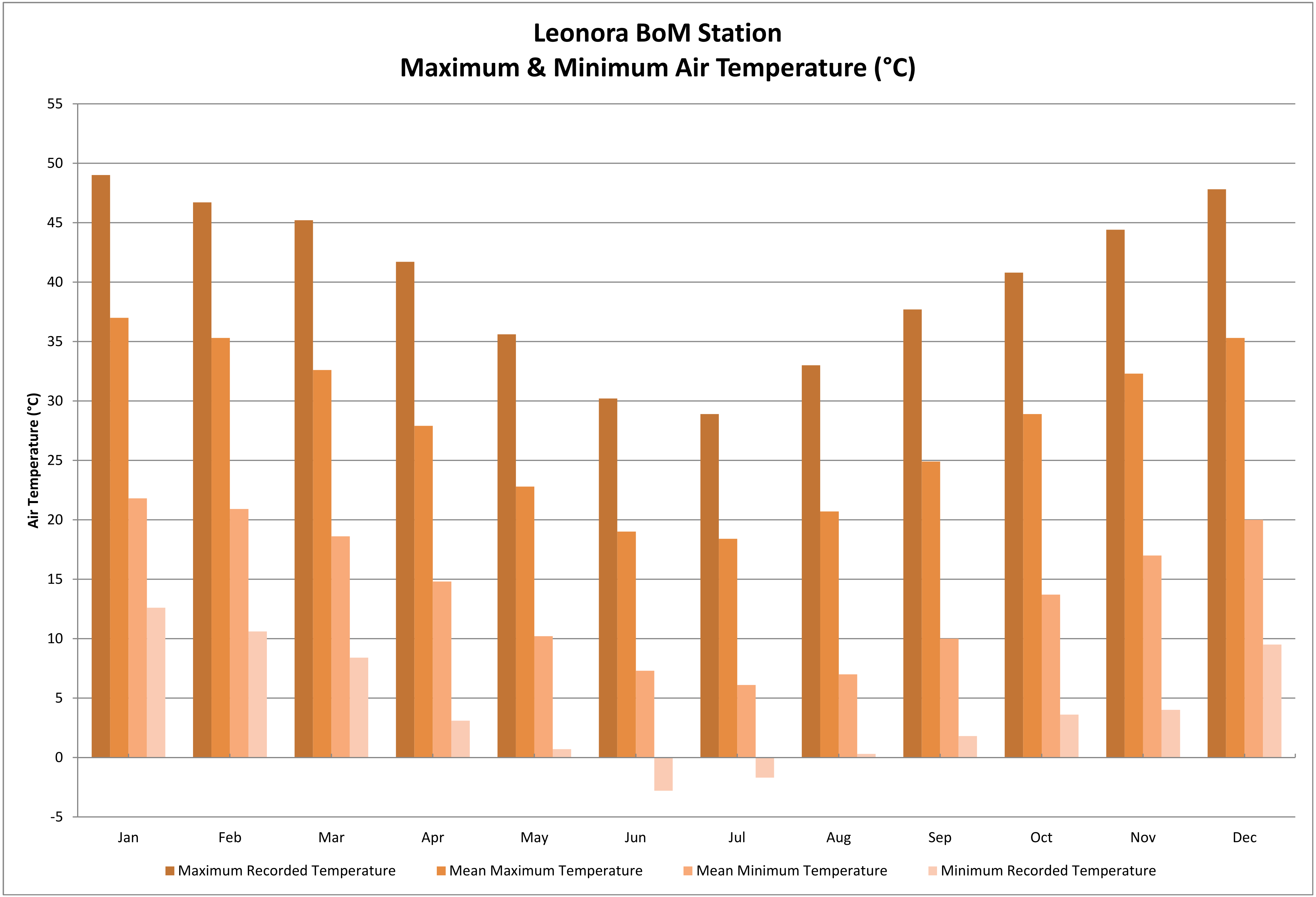
Station No.	Rainfall Station	Year	Month	Day	Precipitation to 9am (mm)	Rank
12176	Sturt Meadows	1995	2	27	185.6	1
12176	Sturt Meadows	2014	1	23	161.0	2
12045	Laverton	2011	2	17	120.2	3
12082	Weebo	2000	1	23	117.0	4
12046	Leonora	2014	1	23	109.2	5
12082	Weebo	1975	2	23	108.2	6
12046	Leonora	1995	2	27	105.9	7
12082	Weebo	1960	1	31	104.9	8
12082	Weebo	1955	1	1	104.6	9
12046	Leonora	1927	3	21	103.4	10
12082	Weebo	1939	1	13	102.4	11
12061	Minara	1955	1	1	100.6	12
12046	Leonora	2006	1	10	98.2	13
12176	Sturt Meadows	1975	2	22	96.8	14
12176	Sturt Meadows	2017	3	25	96.2	15
12082	Weebo	1975	2	22	96.2	16
12062	Nambi	2000	1	23	94.6	17
12062	Nambi	1923	4	9	93.2	18
12082	Weebo	1997	2	19	93.0	19
12176	Sturt Meadows	1927	3	22	92.7	20
12045	Laverton	2000	1	24	92.6	21
12061	Minara	1948	2	22	90.9	22
12045	Laverton	1914	11	11	90.9	23
12045	Laverton	2007	1	4	90.0	24
12082	Weebo	1978	2	6	88.6	25
12082	Weebo	1985	1	31	87.0	26
12045	Laverton	1918	2	3	86.6	27
12061	Minara	1925	2	17	86.4	28
12061	Minara	1927	3	22	86.4	29
12176	Sturt Meadows	1995	2	26	85.0	30
12046	Leonora	1909	1	22	84.6	31
12082	Weebo	1942	3	27	84.6	32
12046	Leonora	1942	1	29	82.8	33
12046	Leonora	1939	1	14	82.6	34
12061	Minara	1907	3	16	82.6	35
12062	Nambi	1925	2	26	79.5	36
12176	Sturt Meadows	1960	2	1	79.0	37
12061	Minara	1942	1	29	78.7	38
12176	Sturt Meadows	1952	1	23	78.7	39
12045	Laverton	1975	2	23	78.0	40
12045	Laverton	1995	2	26	78.0	41
12176	Sturt Meadows	1975	2	21	77.2	42
12061	Minara	1995	2	1	76.4	43
12062	Nambi	1997	1	10	76.0	44
12046	Leonora	1975	2	21	75.6	45
12046	Leonora	1975	2	22	75.6	46
12046	Leonora	2000	3	26	75.6	47
12045	Laverton	1915	2	24	75.2	48
12045	Laverton	1939	1	14	74.7	49
12176	Sturt Meadows	1931	3	30	73.7	50
12045	Laverton	2017	1	17	73.0	51
12062	Nambi	1987	1	22	70.6	52
12062	Nambi	2013	3	1	66.0	53
12061	Minara	1942	3	17	63.5	54
12062	Nambi	1987	1	20	63.0	55
12061	Minara	1919	12	10	62.2	56
12062	Nambi	1975	2	23	62.0	57
12062	Nambi	1927	3	22	61.0	58
12062	Nambi	2001	2	17	60.2	59
12061	Minara	1979	2	13	60.0	60

Top 60 Wettest Days at Local BoM Stations in Date Order

Station No.	Rainfall Station	Year	Month	Day	Precipitation to 9am (mm)
12061	Minara	1907	3	16	82.6
12046	Leonora	1909	1	22	84.6
12045	Laverton	1914	11	11	90.9
12045	Laverton	1915	2	24	75.2
12045	Laverton	1918	2	3	86.6
12061	Minara	1919	12	10	62.2
12062	Nambi	1923	4	9	93.2
12061	Minara	1925	2	17	86.4
12062	Nambi	1925	2	26	79.5
12046	Leonora	1927	3	21	103.4
12176	Sturt Meadows	1927	3	22	92.7
12061	Minara	1927	3	22	86.4
12062	Nambi	1927	3	22	61.0
12176	Sturt Meadows	1931	3	30	73.7
12082	Weebo	1939	1	13	102.4
12046	Leonora	1939	1	14	82.6
12045	Laverton	1939	1	14	74.7
12046	Leonora	1942	1	29	82.8
12061	Minara	1942	1	29	78.7
12061	Minara	1942	3	17	63.5
12082	Weebo	1942	3	27	84.6
12061	Minara	1948	2	22	90.9
12176	Sturt Meadows	1952	1	23	78.7
12082	Weebo	1955	1	1	104.6
12061	Minara	1955	1	1	100.6
12082	Weebo	1960	1	31	104.9
12176	Sturt Meadows	1960	2	1	79.0
12176	Sturt Meadows	1975	2	21	77.2
12046	Leonora	1975	2	21	75.6
12176	Sturt Meadows	1975	2	22	96.8
12082	Weebo	1975	2	22	96.2
12046	Leonora	1975	2	22	75.6
12082	Weebo	1975	2	23	108.2
12045	Laverton	1975	2	23	78.0
12062	Nambi	1975	2	23	62.0
12082	Weebo	1978	2	6	88.6
12061	Minara	1979	2	13	60.0
12082	Weebo	1985	1	31	87.0
12062	Nambi	1987	1	20	63.0
12062	Nambi	1987	1	22	70.6
12061	Minara	1995	2	1	76.4
12176	Sturt Meadows	1995	2	26	85.0
12045	Laverton	1995	2	26	78.0
12176	Sturt Meadows	1995	2	27	185.6
12046	Leonora	1995	2	27	105.9
12062	Nambi	1997	1	10	76.0
12082	Weebo	1997	2	19	93.0
12082	Weebo	2000	1	23	117.0
12062	Nambi	2000	1	23	94.6
12045	Laverton	2000	1	24	92.6
12046	Leonora	2000	3	26	75.6
12062	Nambi	2001	2	17	60.2
12046	Leonora	2006	1	10	98.2
12045	Laverton	2007	1	4	90.0
12045	Laverton	2011	2	17	120.2
12062	Nambi	2013	3	1	66.0
12176	Sturt Meadows	2014	1	23	161.0
12046	Leonora	2014	1	23	109.2
12045	Laverton	2017	1	17	73.0
12176	Sturt Meadows	2017	3	25	96.2



Mean Monthly Pan Evaporation at Regional Stations
& Redcliffe Gold Project Estimated
Pan Evaporation (mm)
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Kalgoorlie Airport
Yamarna
Redcliffe Gold Project


Leonora BoM Station
Maximum & Minimum Air Temperature (°C)
Air Temperature (°C)
55
50
45
40
35
30
25
20
15
10
5
0
-5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Maximum Recorded Temperature
Mean Maximum Temperature
Mean Minimum Temperature
Minimum Recorded Temperature

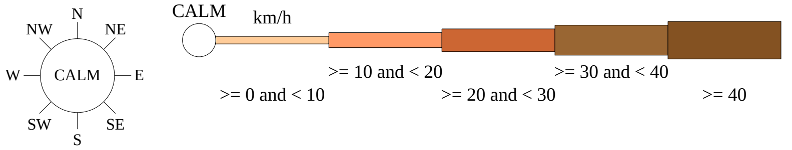
Rose of Wind direction versus Wind speed in km/h (22 Mar 1939 to 11 Aug 2020)

Custom times selected, refer to attached note for details

KALGOORLIE-BOULDER AIRPORT

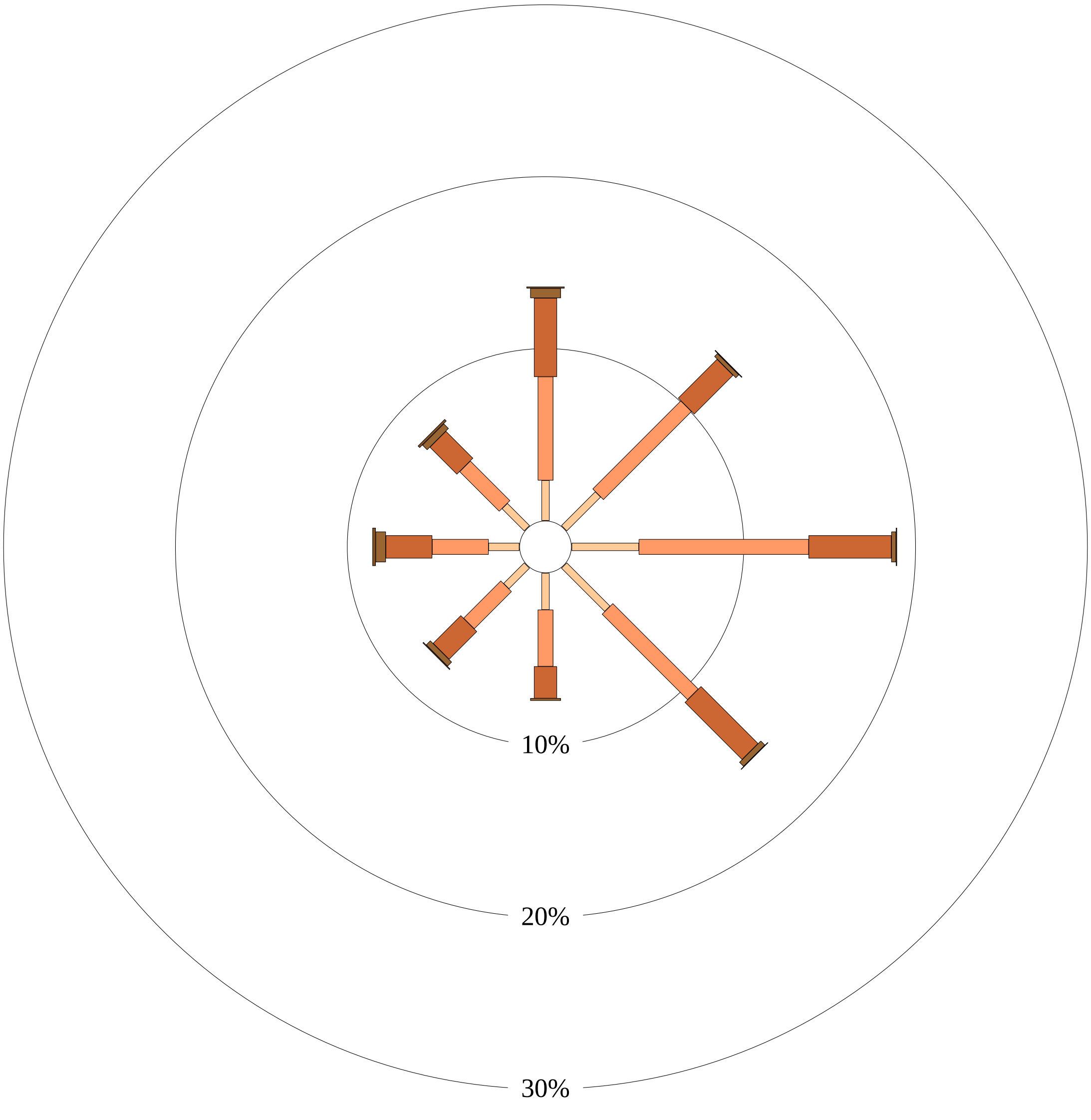
Site No: 012038 • Opened Feb 1939 • Still Open • Latitude: -30.7847° • Longitude: 121.4533° • Elevation 365.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



9 am
29639 Total Observations

Calm 8%



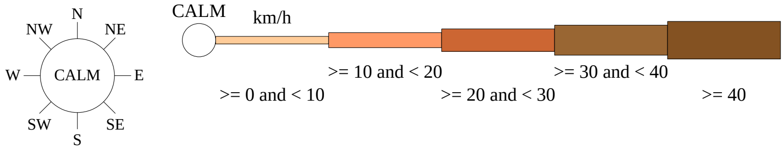
Rose of Wind direction versus Wind speed in km/h (22 Mar 1939 to 11 Aug 2020)

Custom times selected, refer to attached note for details

KALGOORLIE-BOULDER AIRPORT

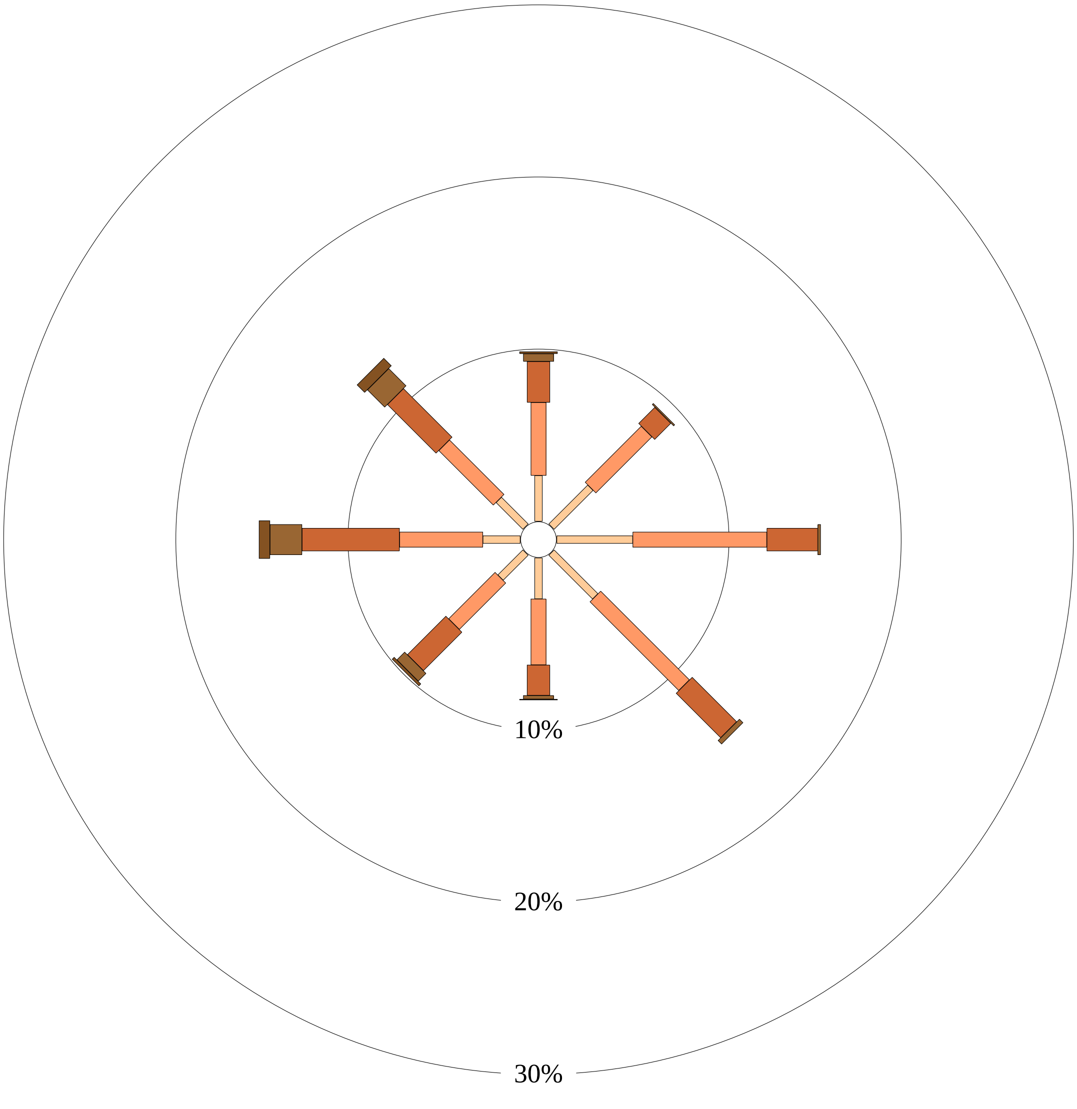
Site No: 012038 • Opened Feb 1939 • Still Open • Latitude: -30.7847° • Longitude: 121.4533° • Elevation 365.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm
29580 Total Observations

Calm 5%



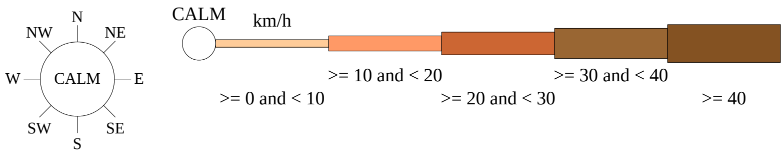
Rose of Wind direction versus Wind speed in km/h (01 Jan 1957 to 01 May 2014)

Custom times selected, refer to attached note for details

LEONORA

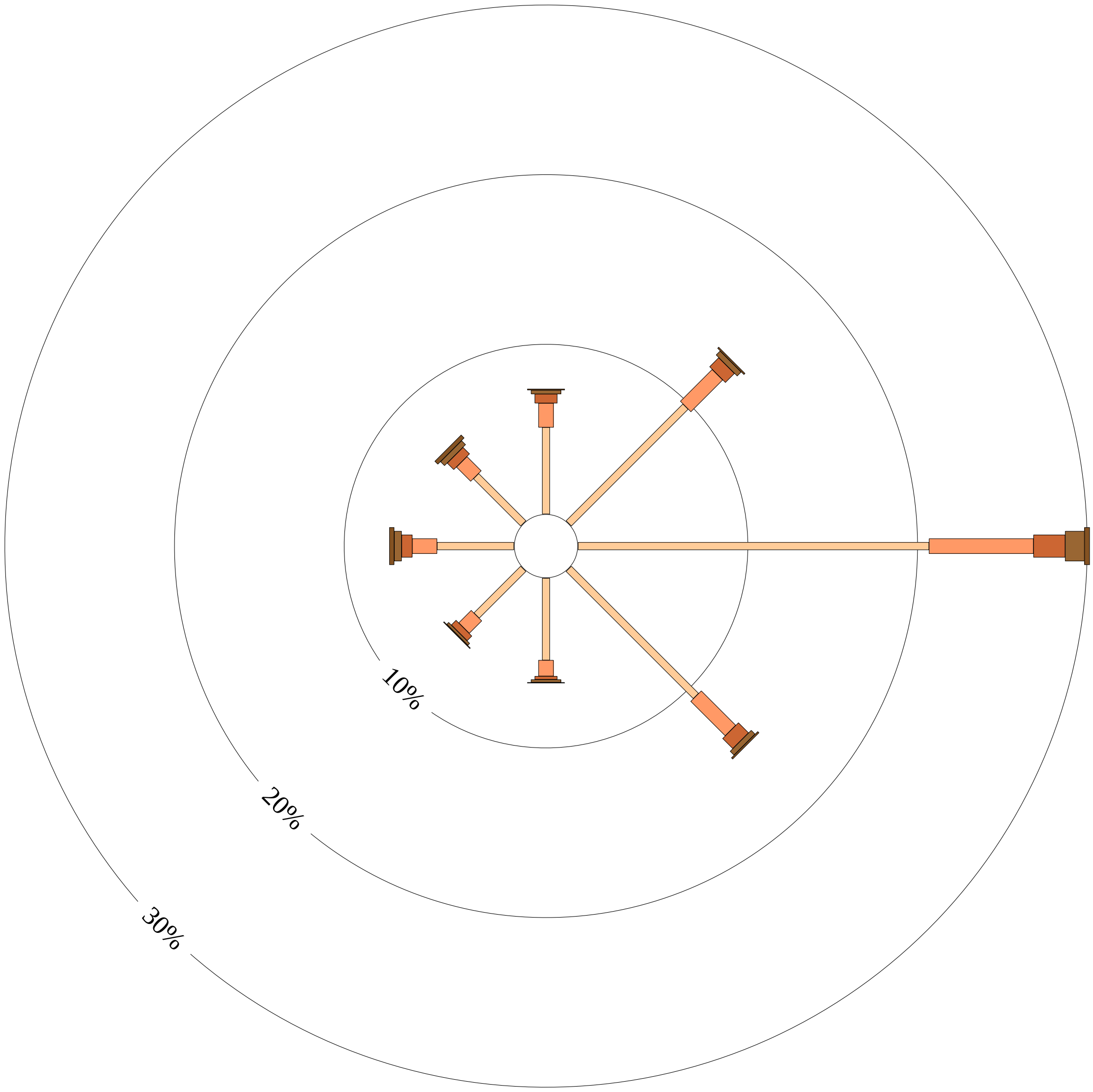
Site No: 012046 • Opened Jan 1898 • Still Open • Latitude: -28.8879° • Longitude: 121.3302° • Elevation 376m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



9 am
20770 Total Observations

Calm 9%



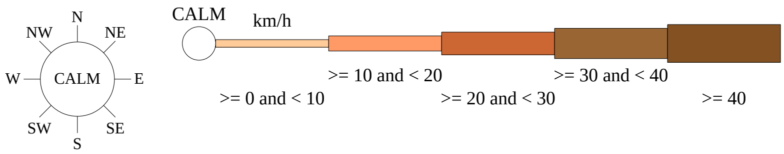
Rose of Wind direction versus Wind speed in km/h (01 Jan 1957 to 01 May 2014)

Custom times selected, refer to attached note for details

LEONORA

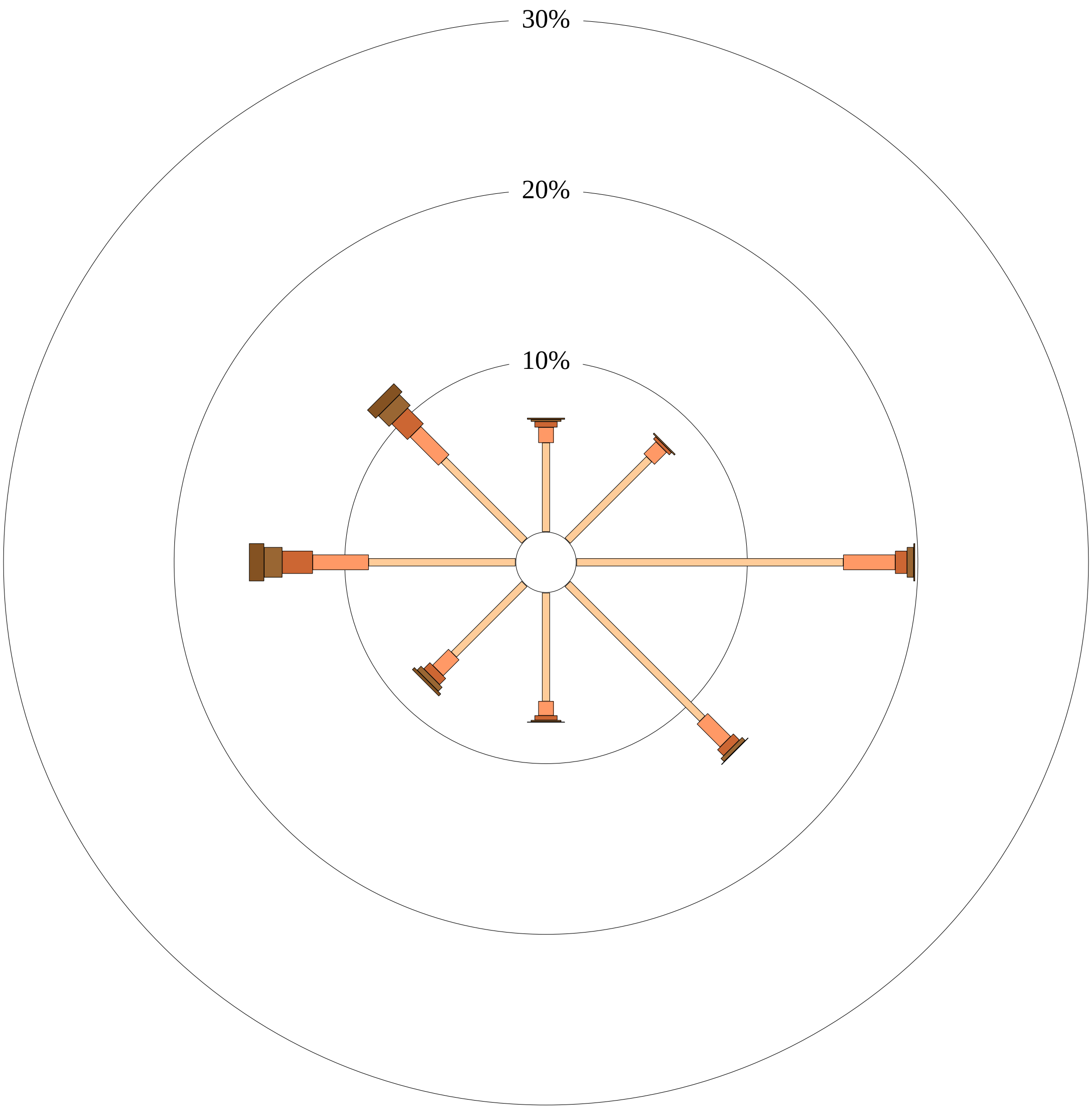
Site No: 012046 • Opened Jan 1898 • Still Open • Latitude: -28.8879° • Longitude: 121.3302° • Elevation 376m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



3 pm
20623 Total Observations

Calm 9%



Monthly Climate Statistics for 'LEONORA' [012046]
Created on [07 Jul 2021 14:34:58 GMT+00:00]

012046 LEONORA
Commenced: 1898
Last Record: 2020
Latitude: 28.89 Degrees South
Longitude: 121.33 Degrees East
Elevation: 376 m
State: WA

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Number of Years	Start Year	End Year
Mean maximum temperature (Degrees C) for years 1949 to 2014	37	35.3	32.6	27.9	22.8	19	18.4	20.7	24.9	28.9	32.3	35.3	27.9	64	1949	2014
Highest temperature (Degrees C) for years 1957 to 2014	49	46.7	45.2	41.7	35.6	30.2	28.9	33	37.7	40.8	44.4	47.8	49	57	1957	2014
Date of Highest temperature for years 1957 to 2014	9-Jan-13	12-Feb-91	6-Mar-61	4-Apr-57	3-May-90	13-Jun-61	31-Jul-69	30-Aug-06	28-Sep-80	31-Oct-88	17-Nov-59	17-Dec-57	9-Jan-13	N/A	1957	2014
Lowest maximum temperature (Degrees C) for years 1957 to 2014	18	18.3	16.2	14.4	12.2	9.8	10	9	11.7	11.2	14.5	17.5	9	57	1957	2014
Date of Lowest maximum temperature for years 1957 to 2014	30-Jan-06	1-Feb-68	19-Mar-84	24-Apr-66	10-May-97	20-Jun-68	11-Jul-11	12-Aug-86	5-Sep-64	13-Oct-78	14-Nov-08	4-Dec-88	12-Aug-86	N/A	1957	2014
Decile 1 maximum temperature (Degrees C) for years 1957 to 2014	30.5	27.4	25.1	21.6	17.8	15	14.4	15.9	19	22.6	25.9	28.9		58	1957	2014
Decile 9 maximum temperature (Degrees C) for years 1957 to 2014	43	41.7	39.1	34.1	28.8	23.3	23	26.3	30.9	35.8	38.7	41.1		58	1957	2014
Mean number of days >= 30 Degrees C for years 1957 to 2014	28.2	23.3	20.3	10.8	1.9	0	0	0.5	4.4	13.6	19.8	26.4	149.2	57	1957	2014
Mean number of days >= 35 Degrees C for years 1957 to 2014	20.9	15.5	10.4	2.1	0.1	0	0	0	0.3	4.5	9.4	17.1	80.3	57	1957	2014
Mean number of days >= 40 Degrees C for years 1957 to 2014	9.9	5.6	2.2	0.1	0	0	0	0	0	0.2	1.9	5.2	25.1	57	1957	2014
Mean minimum temperature (Degrees C) for years 1949 to 2014	21.8	20.9	18.6	14.8	10.2	7.3	6.1	7	10	13.7	17	20	14	64	1949	2014
Lowest temperature (Degrees C) for years 1957 to 2014	12.6	10.6	8.4	3.1	0.7	-2.8	-1.7	0.3	1.8	3.6	4	9.5	-2.8	57	1957	2014
Date of Lowest temperature for years 1957 to 2014	20-Jan-76	28-Feb-94	24-Mar-01	26-Apr-60	17-May-62	23-Jun-81	12-Jul-69	20-Aug-68	12-Sep-04	8-Oct-92	7-Nov-97	2-Dec-73	23-Jun-81	N/A	1957	2014
Highest minimum temperature (Degrees C) for years 1957 to 2014	33.5	32.2	30.6	25.9	21.7	19.8	17.3	24	24.9	27.8	27.2	30.4	33.5	57	1957	2014
Date of Highest minimum temperature for years 1957 to 2014	2-Jan-04	20-Feb-10	10-Mar-58	9-Apr-91	3-May-02	6-Jun-65	24-Jul-88	31-Aug-60	14-Sep-81	24-Oct-08	13-Nov-03	19-Dec-05	2-Jan-04	N/A	1957	2014
Decile 1 minimum temperature (Degrees C) for years 1957 to 2014	17.4	16.3	14	10	5.6	3	2	2.9	5.6	9	12.7	15.4		58	1957	2014
Decile 9 minimum temperature (Degrees C) for years 1957 to 2014	26.4	25.6	23.3	19.6	15.4	12.1	10.7	11.4	14.4	18.9	22.2	25		58	1957	2014
Mean number of days <= 2 Degrees C for years 1957 to 2014	0	0	0	0	0.2	1.3	3.2	1.3	0.1	0	0	0	6.1	57	1957	2014
Mean number of days <= 0 Degrees C for years 1957 to 2014	0	0	0	0	0	0.1	0.4	0	0	0	0	0	0.5	57	1957	2014
Mean daily ground minimum temperature Degrees C for years null to null																
Lowest ground temperature Degrees C for years null to null																
Date of Lowest ground temperature for years null to null														N/A		
Mean number of days ground min. temp. <= -1 Degrees C for years null to null																
Mean rainfall (mm) for years 1898 to 2020	26.3	30.9	29	20.3	23.7	24.8	18.5	15.7	8.9	9.4	12.3	16.7	236.4	116	1898	2020
Highest rainfall (mm) for years 1898 to 2020	172	284.6	273.9	135.4	158.6	144	101.6	85.2	83.3	73	61.2	94	552.2	118	1898	2020
Date of Highest rainfall for years 1898 to 2020	2014	1995	1927	1918	1921	1955	1980	1958	1904	2011	1914	1988	1975	N/A	1898	2020
Lowest rainfall (mm) for years 1898 to 2020	0	0	0	0	0	0	0	0	0	0	0	0	57.8	118	1898	2020
Date of Lowest rainfall for years 1898 to 2020	2019	2019	2019	2020	2020	2019	2020	2018	2019	2019	2019	2018	1936	N/A	1898	2020
Decile 1 monthly rainfall (mm) for years 1898 to 2020	0	0	0	0	0	3.5	2.4	1	0	0	0	0	112.7	110	1898	2020
Decile 5 (median) monthly rainfall (mm) for years 1898 to 2020	11.4	13	11.2	13.2	17.8	19.9	15	11	5	3.7	7	10.4	221.1	110	1898	2020
Decile 9 monthly rainfall (mm) for years 1898 to 2020	82.2	81.2	68.3	51.8	53.8	52.8	35.6	37.5	24	30.2	31.1	39.5	380.6	110	1898	2020
Highest daily rainfall (mm) for years 1898 to 2020	109.2	105.9	103.4	54.6	56	39.9	70	37.3	32.6	34.4	44.4	51.8	109.2	110	1898	2020
Date of Highest daily rainfall for years 1898 to 2020	23-Jan-14	27-Feb-95	21-Mar-27	8-Apr-20	1-May-88	15-Jun-55	19-Jul-80	23-Aug-58	28-Sep-84	27-Oct-11	24-Nov-02	30-Dec-91	23-Jan-14	N/A	1898	2020
Mean number of days of rain for years 1898 to 2020	3.3	3.6	3.8	3.5	4.2	5.4	5.1	3.9	2.6	2.5	2.8	3.1	43.8	110	1898	2020
Mean number of days of rain >= 1 mm for years 1898 to 2020	2.3	2.4	2.6	2.5	2.9	3.5	3.2	2.5	1.5	1.5	1.8	2.2	28.9	110	1898	2020
Mean number of days of rain >= 10 mm for years 1898 to 2020	0.6	0.9	0.8	0.5	0.6	0.6	0.4	0.4	0.2	0.2	0.3	0.5	6	110	1898	2020
Mean number of days of rain >= 25 mm for years 1898 to 2020	0.2	0.3	0.3	0.1	0.1	0.1	0	0.1	0	0	0	0.1	1.3	110	1898	2020
Mean daily wind run (km) for years null to null																
Maximum wind gust speed (km/h) for years null to null																
Date of Maximum wind gust speed for years null to null														N/A		
Mean daily sunshine (hours) for years null to null																
Mean daily solar exposure (MJ/(m*m)) for years 1990 to 2021	27.7	24.4	20.9	16.8	13.5	11.5	12.7	16.1	20.6	24.7	27.4	28.6	20.4	32	1990	2021
Mean number of clear days for years 1957 to 2010	16.1	13.3	13.8	11.7	13.1	12.3	14.3	17.2	17.9	17.9	14.8	15.8	178.2	54	1957	2010
Mean number of cloudy days for years 1957 to 2010	6.2	7.4	7.5	8.9	9.1	9.7	7.7	5.8	4.7	4.7	5.9	5.4	83	54	1957	2010
Mean daily evaporation (mm) for years null to null																
Mean 9am temperature (Degrees C) for years 1949 to 2010	27.7	26.2	24.1	20.4	15.5	11.8	10.9	13	17	20.9	24	26.5	19.8	61	1949	2010
Mean 9am wet bulb temperature (Degrees C) for years 1949 to 2010	17.7	17.7	16.7	14.6	11.5	9.2	8.1	9.1	11.3	13.1	15.1	16.8	13.4	52	1949	2010
Mean 9am dew point temperature (Degrees C) for years 1957 to 2010	9.5	11.2	10.6	9.3	7.1	6	4.6	4.3	4.9	5.1	6.7	8.2	7.3	45	1957	2010
Mean 9am relative humidity (%) for years 1949 to 2010	36	43	46	52	61	70	68	59	48	39	36	34	49	52	1949	2010
Mean 9am cloud cover (okas) for years 1949 to 2010	2.5	2.8	2.9	3.3	3.1	3.4	2.7	2.3	2.2	2.1	2.3	2.3	2.7	61	1949	2010
Mean 9am wind speed (km/h) for years 1957 to 2010	10.8	10.2	10.3	8.8	7.6	7.5	8.1	9.1	10.7	11.8	12.1	10.7	9.8	53	1957	2010
Mean 3pm temperature (Degrees C) for years 1949 to 2010	35.8	34.2	31.8	26.9	21.8	18.2	17.6	19.7	23.9	27.8	31	34.1	26.9	61	1949	2010
Mean 3pm wet bulb temperature (Degrees C) for years 1949 to 2010	20.2	20.3	19.1	16.9	14	12	11.2	11.9	13.8	15.4	17.2	19	15.9	52	1949	2010
Mean 3pm dew point temperature (Degrees C) for years 1957 to 2010	7.8	9.8	9.2	8.1	6.1	5.1	3.5	2.9	2.8	2.7	4.2	5.9	5.7	45	1957	2010
Mean 3pm relative humidity (%) for years 1949 to 2010	21	27	28	34	39	45	43	36	28	22	21	20	30	52	1949	2010
Mean 3pm cloud cover (oktas) for years 1949 to 2010	3	3.2	3.1	3.7	3.6	3.7	3.3	2.7	2.1	2.4	3	2.9	3.1	61	1949	2010
Mean 3pm wind speed (km/h) for years 1957 to 2010	8.6	8.7	8.6	8.1	8.1	9.6	10.4	11.1	11.2	11.7	11.5	9.6	9.8	53	1957	2010

Monthly Climate Statistics for 'LAVERTON' [012045]
Created on [07 Jul 2021 14:33:58 GMT+00:00]

012045 LAVERTON
Commenced: 1899
Last Record: 2021
Latitude: 28.63 Degrees South
Longitude: 122.41 Degrees East
Elevation: 461 m
State: WA

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Number of Years	Start Year	End Year
Mean maximum temperature (Degrees C) for years 1900 to 1971	35.8	34.8	31.9	27.2	22.1	18.5	17.8	20	24.5	28	32.1	34.9	27.3	68	1900	1971
Highest temperature (Degrees C) for years 1957 to 1971	46.1	45	42.8	40	33.3	30.2	28.4	31.4	35.6	40	43.3	44.4	46.1	12	1957	1971
Date of Highest temperature for years 1957 to 1971	14-Jan-57	17-Feb-71	1-Mar-65	4-Apr-57	14-May-57	13-Jun-61	31-Jul-69	31-Aug-62	28-Sep-61	28-Oct-65	28-Nov-62	17-Dec-57	14-Jan-57	N/A	1957	1971
Lowest maximum temperature (Degrees C) for years 1957 to 1971	21.1	18.3	16.6	13.9	12.3	10.5	10	10.7	14.7	16.1	16.5	22.2	10	12	1957	1971
Date of Lowest maximum temperature for years 1957 to 1971	22-Jan-58	1-Feb-63	29-Mar-67	24-Apr-66	20-May-68	20-Jun-68	11-Jul-62	8-Aug-65	15-Sep-65	5-Oct-58	2-Nov-66	2-Dec-66	11-Jul-62	N/A	1957	1971
Decile 1 maximum temperature (Degrees C) for years 1957 to 1971	29.7	27.7	25.2	21.2	17.2	14.5	13.9	15.5	18.3	21.7	26.1	27.8		13	1957	1971
Decile 9 maximum temperature (Degrees C) for years 1957 to 1971	41.7	40.3	38.3	34.5	28.3	23.5	22	24.9	30	35	38.9	39.9		13	1957	1971
Mean number of days >= 30 Degrees C for years 1957 to 1971	27.8	22.4	20.2	10.9	1.6	0.1	0	0.4	3.4	12.9	19.9	25.1	144.7	12	1957	1971
Mean number of days >= 35 Degrees C for years 1957 to 1971	20	14	10	2.3	0	0	0	0	0.3	3.7	9.4	15.3	75	12	1957	1971
Mean number of days >= 40 Degrees C for years 1957 to 1971	7.5	3.6	1.8	0.1	0	0	0	0	0	0.1	2.1	3.1	18.3	12	1957	1971
Mean minimum temperature (Degrees C) for years 1900 to 1971	20.5	20	18	13.9	9.5	6.6	5.2	6.4	9.5	12.8	16.6	19.3	13.2	68	1900	1971
Lowest temperature (Degrees C) for years 1957 to 1971	7.2	7.5	9.8	4	-0.4	-0.6	-2.4	-1.7	1.1	2.8	7.7	9.4	-2.4	12	1957	1971
Date of Lowest temperature for years 1957 to 1971	22-Jan-58	2-Feb-63	31-Mar-68	25-Apr-71	31-May-64	18-Jun-69	12-Jul-69	10-Aug-68	6-Sep-57	2-Oct-57	2-Nov-64	6-Dec-59	12-Jul-69	N/A	1957	1971
Highest minimum temperature (Degrees C) for years 1957 to 1971	31.3	28.3	29.3	24.8	18.9	18.4	15.6	18.3	18.3	26.1	28.3	29.4	31.3	12	1957	1971
Date of Highest minimum temperature for years 1957 to 1971	26-Jan-65	23-Feb-68	8-Mar-61	7-Apr-69	18-May-69	6-Jun-65	15-Jul-64	29-Aug-65	23-Sep-61	30-Oct-65	30-Nov-57	26-Dec-61	26-Jan-65	N/A	1957	1971
Decile 1 minimum temperature (Degrees C) for years 1957 to 1971	16.5	15	13.9	9.8	5	2.8	1.1	1.7	5	8.2	11.8	14		13	1957	1971
Decile 9 minimum temperature (Degrees C) for years 1957 to 1971	25.7	24.9	22.6	19.4	15	11.7	10.6	10.6	13.8	18.9	22.3	23.9		13	1957	1971
Mean number of days <= 2 Degrees C for years 1957 to 1971	0	0	0	0	0.6	1.5	5.4	3.7	0.2	0	0	0	11.4	12	1957	1971
Mean number of days <= 0 Degrees C for years 1957 to 1971	0	0	0	0	0.2	0.2	1.6	0.8	0	0	0	0	2.8	12	1957	1971
Mean daily ground minimum temperature Degrees C for years 1965 to 1969														2	1965	1969
Lowest ground temperature Degrees C for years 1965 to 1969														2	1965	1969
Date of Lowest ground temperature for years 1965 to 1969														N/A	1965	1969
Mean number of days ground min. temp. <= -1 Degrees C for years 1965 to 1969														2	1965	1969
Mean rainfall (mm) for years 1899 to 2021	26.5	31.1	30.8	21.5	22.4	23	16.1	13	8.6	9.7	14.7	18.3	235.2	112	1899	2021
Highest rainfall (mm) for years 1899 to 2021	179	233.6	181	204.5	123.8	126.2	66.1	84.8	67.3	67	152	134.6	525.6	117	1899	2021
Date of Highest rainfall for years 1899 to 2021	2000	1995	2000	1900	1921	1955	1963	1958	1904	2011	1914	1930	2000	N/A	1899	2021
Lowest rainfall (mm) for years 1899 to 2021	0	0	0	0	0	0	0	0	0	0	0	0	65.6	117	1899	2021
Date of Lowest rainfall for years 1899 to 2021	2019	2019	2008	2021	2019	2017	1982	2013	2020	2013	1991	1985	1928	N/A	1899	2021
Decile 1 monthly rainfall (mm) for years 1899 to 2021	0	0	0	0	0.7	3	1.4	0.7	0	0	0	0	120.6	111	1899	2021
Decile 5 (median) monthly rainfall (mm) for years 1899 to 2021	8.6	18.4	16	11.8	15.4	16.8	11.9	8.6	3.3	5.6	8.9	12	215.4	111	1899	2021
Decile 9 monthly rainfall (mm) for years 1899 to 2021	83.6	85.5	86.2	55.4	49	53.9	38.7	28.6	25.5	26.2	32.8	41.7	366.6	111	1899	2021
Highest daily rainfall (mm) for years 1899 to 2021	92.6	120.2	67.1	54	51.6	40.4	32.5	40.6	53.5	49	90.9	70.6	120.2	110	1899	2021
Date of Highest daily rainfall for years 1899 to 2021	24-Jan-00	17-Feb-11	21-Mar-29	4-Apr-74	24-May-11	11-Jun-55	26-Jul-71	21-Aug-19	5-Sep-77	13-Oct-40	11-Nov-14	30-Dec-30	17-Feb-11	N/A	1899	2021
Mean number of days of rain for years 1899 to 2021	3.3	3.7	3.9	3.5	4.3	4.9	4.5	3.4	1.9	2.2	2.9	3.2	41.7	111	1899	2021
Mean number of days of rain >= 1 mm for years 1899 to 2021	2.5	2.8	2.8	2.5	3	3.4	3	2.4	1.4	1.5	2.1	2.4	29.8	110	1899	2021
Mean number of days of rain >= 10 mm for years 1899 to 2021	0.6	0.8	0.9	0.5	0.5	0.5	0.3	0.3	0.1	0.2	0.4	0.5	5.6	110	1899	2021
Mean number of days of rain >= 25 mm for years 1899 to 2021	0.2	0.3	0.3	0.1	0.1	0.1	0	0	0	0	0.1	0.1	1.3	110	1899	2021
Mean daily wind run (km) for years null to null																
Maximum wind gust speed (km/h) for years null to null																
Date of Maximum wind gust speed for years null to null														N/A		
Mean daily sunshine (hours) for years null to null																
Mean daily solar exposure (MJ/(m*m)) for years 1990 to 2021	27.1	24.2	20.8	16.8	13.6	11.7	12.9	16.4	20.9	24.6	27.2	28.2	20.4	32	1990	2021
Mean number of clear days for years 1957 to 1969	17.2	15.3	18.2	13.5	15.2	13.3	16.6	18.7	19.3	18.8	16.2	17	199.3	12	1957	1969
Mean number of cloudy days for years 1957 to 1969	5.1	5.6	5.9	7.8	7.1	8.8	6.8	4.4	3.4	3.3	4.5	4.9	67.6	12	1957	1969
Mean daily evaporation (mm) for years null to null																
Mean 9am temperature (Degrees C) for years 1900 to 1969	27.5	26.4	24.2	20.5	16.2	12.8	11.8	13.9	17.9	21.1	24.8	27	20.3	67	1900	1969
Mean 9am wet bulb temperature (Degrees C) for years 1900 to 1969	17.8	17.6	16.6	14.3	11.6	9.5	8.4	9.4	11.3	13.4	15.5	17.2	13.5	66	1900	1969
Mean 9am dew point temperature (Degrees C) for years 1957 to 1969	8.5	9.5	8.8	8	5.6	6.4	4.3	3.1	3.4	5.8	5.5	8	6.4	11	1957	1969
Mean 9am relative humidity (%) for years 1936 to 1969	34	39	43	48	57	65	63	53	42	37	34	33	46	31	1936	1969
Mean 9am cloud cover (okas) for years 1900 to 1969	2	2.2	2.4	2.7	2.7	3	2.5	2.1	1.5	1.7	1.9	1.9	2.2	60	1900	1969
Mean 9am wind speed (km/h) for years 1957 to 1969	13.1	12.3	12	10.9	9.8	9.5	9.4	11.2	12.4	11.7	13.1	12.6	11.5	12	1957	1969
Mean 3pm temperature (Degrees C) for years 1900 to 1969	34.6	33.7	30.9	26.4	21.3	17.7	17.1	19.4	23.7	27.1	30.7	33.6	26.4	68	1900	1969
Mean 3pm wet bulb temperature (Degrees C) for years 1900 to 1969	20.2	20	19	16.6	13.8	11.8	10.9	11.8	13.6	15.5	17.6	19.4	15.9	66	1900	1969
Mean 3pm dew point temperature (Degrees C) for years 1957 to 1969	7.1	7.7	7.1	7.1	4.6	5.6	3.5	1.9	1.8	4.3	4	6.4	5.1	11	1957	1969
Mean 3pm relative humidity (%) for years 1936 to 1969	21	23	26	32	40	47	43	35	26	24	21	20	30	31	1936	1969
Mean 3pm cloud cover (oktas) for years 1900 to 1969	2.4	2.6	2.7	2.8	2.8	3	2.6	2.1	1.7	2	2.4	2.4	2.5	60	1900	1969
Mean 3pm wind speed (km/h) for years 1957 to 1969	10.6	10.1	9.6	9.9	8.8	11.3	10.4	12	11.9	10.9	12	10.5	10.7	11	1957	1969

Monthly Climate Statistics for 'LEINSTER AERO' [012314]
Created on [07 Jul 2021 14:34:45 GMT+00:00]

012314 LEINSTER AERO
Commenced: 1994
Last Record: 2021
Latitude: 27.84 Degrees South
Longitude: 120.70 Degrees East
Elevation: 497 m
State: WA

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Number of Years	Start Year	End Year
Mean maximum temperature (Degrees C) for years 1994 to 2021	37.2	35.4	31.8	28.1	23.2	19.4	19	21.7	25.7	30.2	32.9	35.7	28.4	27	1994	2021
Highest temperature (Degrees C) for years 1994 to 2021	47.8	46.5	43.3	39.7	35.3	29.2	29.8	33.7	36.3	40.2	44.3	45.8	47.8	27	1994	2021
Date of Highest temperature for years 1994 to 2021	8-Jan-13	14-Feb-05	6-Mar-08	4-Apr-16	2-May-13	1-Jun-98	31-Jul-15	28-Aug-20	17-Sep-94	10-Oct-19	19-Nov-19	31-Dec-97	8-Jan-13	N/A	1994	2021
Lowest maximum temperature (Degrees C) for years 1994 to 2021	15.9	19	16.6	16.1	11.7	10.9	9.7	12.8	11.6	14	19.5	18.2	9.7	27	1994	2021
Date of Lowest maximum temperature for years 1994 to 2021	30-Jan-18	1-Feb-18	30-Mar-06	8-Apr-95	10-May-97	8-Jun-96	11-Jul-11	5-Aug-18	2-Sep-10	5-Oct-17	16-Nov-08	18-Dec-10	11-Jul-11	N/A	1994	2021
Decile 1 maximum temperature (Degrees C) for years 1994 to 2021	30.7	28.2	24.7	22.2	18.1	15.1	14.2	16.9	19.7	23.7	26.5	29.7		26	1994	2021
Decile 9 maximum temperature (Degrees C) for years 1994 to 2021	42.9	41.9	38.2	34.2	28.5	23.7	23.6	27.6	31.6	36.3	38.8	40.8		26	1994	2021
Mean number of days >= 30 Degrees C for years 1994 to 2021	27.6	23	19.7	10	1.2	0	0	1	6.1	15.6	20.5	26.4	151.1	27	1994	2021
Mean number of days >= 35 Degrees C for years 1994 to 2021	22.2	15.1	9.4	2	0.1	0	0	0	0.5	5.3	10.6	17.4	82.6	27	1994	2021
Mean number of days >= 40 Degrees C for years 1994 to 2021	10.3	5.4	1	0	0	0	0	0	0	0.1	1.7	4.9	23.4	27	1994	2021
Mean minimum temperature (Degrees C) for years 1994 to 2021	23.2	22.2	19.2	15.4	10.4	7.3	6.1	7.7	10.8	15.1	18.4	21.3	14.8	27	1994	2021
Lowest temperature (Degrees C) for years 1994 to 2021	12.5	13.5	8.7	5.3	1.4	-0.4	-1.6	-0.4	1.4	2.8	7.9	12.5	-1.6	27	1994	2021
Date of Lowest temperature for years 1994 to 2021	5-Jan-07	2-Feb-06	25-Mar-01	30-Apr-00	29-May-18	29-Jun-06	15-Jul-99	6-Aug-18	2-Sep-15	4-Oct-20	2-Nov-02	14-Dec-01	15-Jul-99	N/A	1994	2021
Highest minimum temperature (Degrees C) for years 1994 to 2021	33.1	32.9	29.4	25.7	22.6	16.8	16.1	18.4	20.9	26.3	28.7	30.1	33.1	27	1994	2021
Date of Highest minimum temperature for years 1994 to 2021	2-Jan-04	14-Feb-05	3-Mar-98	27-Apr-05	2-May-05	23-Jun-19	17-Jul-20	15-Aug-01	10-Sep-19	24-Oct-08	19-Nov-19	7-Dec-19	2-Jan-04	N/A	1994	2021
Decile 1 minimum temperature (Degrees C) for years 1994 to 2021	18.8	17.8	14.7	11	5.6	2.5	1.7	3	6	10	13.7	16.7		26	1994	2021
Decile 9 minimum temperature (Degrees C) for years 1994 to 2021	27.6	26.9	23.7	19.9	15.6	12.3	11	12.8	15.3	20	23.1	25.6		26	1994	2021
Mean number of days <= 2 Degrees C for years 1994 to 2021	0	0	0	0	0.1	2	3.8	1.5	0	0	0	0	7.4	27	1994	2021
Mean number of days <= 0 Degrees C for years 1994 to 2021	0	0	0	0	0	0.3	0.7	0.1	0	0	0	0	1.1	27	1994	2021
Mean daily ground minimum temperature Degrees C for years null to null																
Lowest ground temperature Degrees C for years null to null																
Date of Lowest ground temperature for years null to null														N/A		
Mean number of days ground min. temp. <= -1 Degrees C for years null to null																
Mean rainfall (mm) for years 1994 to 2021	37.7	41	36.2	23.7	15	14.1	16	8.9	3.6	11.8	15.7	24.6	253	25	1994	2021
Highest rainfall (mm) for years 1994 to 2021	133.4	128.4	193.8	74.2	94.8	64.4	72.8	45	26.8	69.4	77.2	125.8	439.4	26	1994	2021
Date of Highest rainfall for years 1994 to 2021	2000	2001	2017	1996	2005	1998	2004	1997	2010	2006	2008	1998	1997	N/A	1994	2021
Lowest rainfall (mm) for years 1994 to 2021	0	0	0	0.2	0	0	0	0	0	0	0	0.2	102.6	26	1994	2021
Date of Lowest rainfall for years 1994 to 2021	2015	1996	2008	2012	2018	2006	2020	2013	2020	2019	2020	2003	2020	N/A	1994	2021
Decile 1 monthly rainfall (mm) for years 1994 to 2021	0.6	1.6	2.6	2.4	0.1	1.2	0.2	0.1	0	0	0.1	3	142.1	26	1994	2021
Decile 5 (median) monthly rainfall (mm) for years 1994 to 2021	22	32	23.1	16.4	6.1	9.6	10.1	5.3	1.8	2.9	9.1	18.8	239.2	26	1994	2021
Decile 9 monthly rainfall (mm) for years 1994 to 2021	94.5	97	60.7	54.9	33.4	24.6	33.5	20.1	7.5	32.4	38.6	46.5	394.9	26	1994	2021
Highest daily rainfall (mm) for years 1994 to 2021	65	94	61	47	77.2	19	25	37	25.2	25.8	39.4	91	94	25	1994	2021
Date of Highest daily rainfall for years 1994 to 2021	23-Jan-00	23-Feb-01	11-Mar-00	12-Apr-96	6-May-05	11-Jun-96	14-Jul-98	5-Aug-97	1-Sep-10	26-Oct-06	17-Nov-08	7-Dec-98	23-Feb-01	N/A	1994	2021
Mean number of days of rain for years 1994 to 2021	5.1	6	5.6	4.6	4.1	4.6	4.6	3.4	2	2.8	4.3	4.1	51.2	26	1994	2021
Mean number of days of rain >= 1 mm for years 1994 to 2021	3.6	3.9	3.3	3.2	2.1	2.5	2.7	1.7	0.8	1.9	2.5	2.6	30.8	25	1994	2021
Mean number of days of rain >= 10 mm for years 1994 to 2021	1.2	1.5	0.9	0.6	0.4	0.4	0.3	0.1	0	0.4	0.4	0.7	6.9	25	1994	2021
Mean number of days of rain >= 25 mm for years 1994 to 2021	0.4	0.3	0.5	0.2	0	0	0	0	0	0	0.1	0.2	1.7	25	1994	2021
Mean daily wind run (km) for years 2003 to 2021	382	352	341	287	259	255	256	284	329	353	365	366	319	15	2003	2021
Maximum wind gust speed (km/h) for years 2003 to 2021	89	87	85	81	89	74	85	78	87	94	91	91	94	17	2003	2021
Date of Maximum wind gust speed for years 2003 to 2021	25-Jan-18	27-Feb-07	13-Mar-19	1-Apr-10	3-May-13	26-Jun-19	9-Jul-10	27-Aug-16	10-Sep-17	30-Oct-06	24-Nov-12	12-Dec-16	30-Oct-06	N/A	2003	2021
Mean daily sunshine (hours) for years null to null																
Mean daily solar exposure (MJ/(m*m)) for years 1990 to 2021	27.5	24.3	21.2	17.1	14.1	12.1	13.3	16.9	21.5	25.1	27.7	28.7	20.8	32	1990	2021
Mean number of clear days for years 2007 to 2010														3	2007	2010
Mean number of cloudy days for years 2007 to 2010														3	2007	2010
Mean daily evaporation (mm) for years null to null																
Mean 9am temperature (Degrees C) for years 1994 to 2010	28.8	27.3	24.2	20.9	16.7	12.8	12	14.2	17.9	22.1	24.7	27.2	20.7	16	1994	2010
Mean 9am wet bulb temperature (Degrees C) for years 1995 to 2010	17.8	18.1	16.3	14.9	11.7	9.4	8.6	9	11.2	12.8	15.2	16.6	13.5	13	1995	2010
Mean 9am dew point temperature (Degrees C) for years 1995 to 2010	9	11.1	9.9	9.6	6.8	5.1	4.1	2.5	3.4	3.5	5.7	7.3	6.5	16	1995	2010
Mean 9am relative humidity (%) for years 1995 to 2010	34	42	45	52	55	62	62	49	41	33	34	32	45	16	1995	2010
Mean 9am cloud cover (okas) for years 2005 to 2010														3	2005	2010
Mean 9am wind speed (km/h) for years 1994 to 2010	21.4	21	20.6	17.7	17.4	16.3	16	18	19.8	20.8	20.8	20.6	19.2	16	1994	2010
Mean 3pm temperature (Degrees C) for years 1994 to 2010	35.9	33.8	30.7	26.7	22.6	18.6	18	20.6	24.5	28.6	31.1	33.8	27.1	16	1994	2010
Mean 3pm wet bulb temperature (Degrees C) for years 1995 to 2010	19.7	20.1	17.9	16.5	13.5	11.5	10.8	11.2	13.3	14.8	16.4	18	15.3	14	1995	2010
Mean 3pm dew point temperature (Degrees C) for years 1995 to 2010	5.5	8.5	7.4	7.4	4.7	3.3	1.9	-0.5	-0.4	-0.3	1.8	3.5	3.6	16	1995	2010
Mean 3pm relative humidity (%) for years 1995 to 2010	20	27	28	34	34	40	38	28	22	18	19	18	27	16	1995	2010
Mean 3pm cloud cover (oktas) for years 2005 to 2010														4	2005	2010
Mean 3pm wind speed (km/h) for years 1994 to 2010	18	18.9	17.5	15.6	15.7	16.4	16.6	17.9	19.4	19.2	19.2	18.9	17.8	16	1994	2010

Monthly Climate Statistics for 'MENZIES' [012052]
Created on [07 Jul 2021 14:42:20 GMT+00:00]

012052 MENZIES
Commenced: 1896
Last Record: 2019
Latitude: 29.69 Degrees South
Longitude: 121.03 Degrees East
Elevation: 426 m
State: WA

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Number of Years	Start Year	End Year
Mean maximum temperature (Degrees C) for years 1898 to 1996	35.1	33.9	31.1	26.2	21.3	17.7	17	19	23.1	26.8	30.7	33.9	26.3	94	1898	1996
Highest temperature (Degrees C) for years 1957 to 1996	46.2	45.6	45	39.4	33.9	28.3	28.3	31.1	36.4	40.8	42.9	45.2	46.2	37	1957	1996
Date of Highest temperature for years 1957 to 1996	13-Jan-91	25-Feb-70	10-Mar-73	14-Apr-81	2-May-72	13-Jun-61	31-Jul-69	31-Aug-62	28-Sep-80	25-Oct-83	23-Nov-82	11-Dec-70	13-Jan-91	N/A	1957	1996
Lowest maximum temperature (Degrees C) for years 1957 to 1996	16.8	17.8	14.9	12.8	10.9	9.4	7.2	9.4	10.2	11.8	15.1	15	7.2	37	1957	1996
Date of Lowest maximum temperature for years 1957 to 1996	23-Jan-67	1-Feb-68	19-Mar-84	24-Apr-66	25-May-77	19-Jun-68	19-Jul-61	31-Aug-79	30-Sep-92	12-Oct-78	16-Nov-85	12-Dec-68	19-Jul-61	N/A	1957	1996
Decile 1 maximum temperature (Degrees C) for years 1957 to 1996	30	27	24.4	20	16.8	14	13.6	14.9	17.8	20.6	24.4	28.1		37	1957	1996
Decile 9 maximum temperature (Degrees C) for years 1957 to 1996	41.7	40.6	38.3	33.3	27.7	22.2	21.7	24.1	29.1	34.5	37.8	39.9		37	1957	1996
Mean number of days >= 30 Degrees C for years 1957 to 1996	27.4	21.6	17.9	8.3	1.2	0	0	0.2	2.3	10	16.9	24.3	130.1	37	1957	1996
Mean number of days >= 35 Degrees C for years 1957 to 1996	17.9	12.9	8.3	1.3	0	0	0	0	0.1	2.9	6.4	13.7	63.5	37	1957	1996
Mean number of days >= 40 Degrees C for years 1957 to 1996	6.2	3.8	1.5	0	0	0	0	0	0	0.1	1.1	2.9	15.6	37	1957	1996
Mean minimum temperature (Degrees C) for years 1897 to 1996	19.7	19.4	17.2	13.4	9.3	6.7	5.3	6.1	8.6	11.7	15.5	18.2	12.6	94	1897	1996
Lowest temperature (Degrees C) for years 1957 to 1996	11.7	10	7.6	1.1	-1.4	-4.8	-4	-3	-0.6	0.6	3.4	6.8	-4.8	36	1957	1996
Date of Lowest temperature for years 1957 to 1996	15-Jan-67	15-Feb-63	22-Mar-82	26-Apr-60	23-May-75	22-Jun-81	31-Jul-75	25-Aug-95	7-Sep-60	15-Oct-68	20-Nov-92	25-Dec-74	22-Jun-81	N/A	1957	1996
Highest minimum temperature (Degrees C) for years 1957 to 1996	31	28.9	30.3	24	20.2	18.9	14.5	17.9	23.3	25	27.2	29.4	31	36	1957	1996
Date of Highest minimum temperature for years 1957 to 1996	31-Jan-93	19-Feb-63	10-Mar-73	16-Apr-94	2-May-67	6-Jun-65	21-Jul-94	23-Aug-82	26-Sep-57	20-Oct-96	29-Nov-93	11-Dec-70	31-Jan-93	N/A	1957	1996
Decile 1 minimum temperature (Degrees C) for years 1957 to 1996	15.6	15	13	8.9	5	2.5	1.2	1.7	4	7	11.1	13.9		37	1957	1996
Decile 9 minimum temperature (Degrees C) for years 1957 to 1996	25	24.4	22	18.4	14.4	11.1	9.7	10.6	13	17.2	20.6	23.4		37	1957	1996
Mean number of days <= 2 Degrees C for years 1957 to 1996	0	0	0	0.1	0.5	2.1	4.8	3.6	0.7	0.1	0	0	11.9	36	1957	1996
Mean number of days <= 0 Degrees C for years 1957 to 1996	0	0	0	0	0.1	0.5	1.4	1	0.1	0	0	0	3.1	36	1957	1996
Mean daily ground minimum temperature Degrees C for years null to null																
Lowest ground temperature Degrees C for years null to null																
Date of Lowest ground temperature for years null to null														N/A		
Mean number of days ground min. temp. <= -1 Degrees C for years null to null																
Mean rainfall (mm) for years 1896 to 2019	23.1	32.5	26.7	20.9	25.2	27.4	22.6	19.5	10.4	11.3	14.7	15.4	254	104	1896	2019
Highest rainfall (mm) for years 1896 to 2019	175.6	351	154.4	110.6	150.5	113.2	91.4	105.1	78.9	88.1	76.8	67	721.8	117	1896	2019
Date of Highest rainfall for years 1896 to 2019	1942	1995	1992	1995	1921	1986	1980	1992	1955	1975	2003	1987	1995	N/A	1896	2019
Lowest rainfall (mm) for years 1896 to 2019	0	0	0	0	0	0	0	0	0	0	0	0	75.9	117	1896	2019
Date of Lowest rainfall for years 1896 to 2019	2015	1998	2009	2007	2018	2013	2008	2006	2015	2007	1994	2017	1950	N/A	1896	2019
Decile 1 monthly rainfall (mm) for years 1896 to 2019	0	0.2	0	0	0.5	4.8	3.9	2.3	0.2	0	0.2	0	128.2	108	1896	2019
Decile 5 (median) monthly rainfall (mm) for years 1896 to 2019	8.7	10.6	13	11.2	19	20.9	18.4	14.8	6	6.1	8.9	9.2	244.4	108	1896	2019
Decile 9 monthly rainfall (mm) for years 1896 to 2019	63.8	80.8	69.4	59.6	61.1	61	42.7	43.8	21.3	22.8	36.7	43.1	386.4	108	1896	2019
Highest daily rainfall (mm) for years 1898 to 2019	108.7	168.4	83	70.4	52.3	47.2	35.9	36.6	50.8	43.9	60	54	168.4	108	1898	2019
Date of Highest daily rainfall for years 1898 to 2019	29-Jan-42	27-Feb-95	2-Mar-13	5-Apr-34	14-May-21	9-Jun-57	19-Jul-80	2-Aug-92	20-Sep-55	19-Oct-09	29-Nov-98	25-Dec-87	27-Feb-95	N/A	1898	2019
Mean number of days of rain for years 1896 to 2019	2.9	3.4	3.6	3.5	4.7	5.9	6	5	3.1	2.8	3.1	3.1	47.1	108	1896	2019
Mean number of days of rain >= 1 mm for years 1898 to 2019	2.1	2.5	2.7	2.5	3.2	3.9	3.9	3.4	2	1.8	2.2	2.1	32.3	108	1898	2019
Mean number of days of rain >= 10 mm for years 1898 to 2019	0.6	0.8	0.8	0.6	0.6	0.7	0.5	0.4	0.2	0.3	0.4	0.4	6.3	108	1898	2019
Mean number of days of rain >= 25 mm for years 1898 to 2019	0.2	0.3	0.2	0.1	0.1	0.1	0	0.1	0	0	0.1	0.1	1.3	108	1898	2019
Mean daily wind run (km) for years null to null																
Maximum wind gust speed (km/h) for years null to null																
Date of Maximum wind gust speed for years null to null														N/A		
Mean daily sunshine (hours) for years null to null																
Mean daily solar exposure (MJ/(m*m)) for years 1990 to 2021	27.6	24.2	20.9	16.3	12.9	11	12.1	15.5	20.1	24.3	27.3	28.6	20.1	32	1990	2021
Mean number of clear days for years 1957 to 1996	16	12.7	13.3	10.9	11.8	9.8	11.3	13.9	14.8	16.1	13.4	15.1	159.1	39	1957	1996
Mean number of cloudy days for years 1957 to 1996	5.4	7	7.1	8.6	9.4	10.7	9.3	7.6	5.3	5.5	5.7	5.2	86.8	39	1957	1996
Mean daily evaporation (mm) for years null to null																
Mean 9am temperature (Degrees C) for years 1897 to 1996	26.2	25.1	22.9	19.2	14.9	11.7	10.7	12.4	16	19.3	22.9	25.4	18.9	98	1897	1996
Mean 9am wet bulb temperature (Degrees C) for years 1897 to 1996	17.1	17.1	15.9	13.7	10.9	8.9	7.9	8.7	10.6	12.3	14.5	16.4	12.8	90	1897	1996
Mean 9am dew point temperature (Degrees C) for years 1957 to 1996	9.2	10.8	9.8	8.7	6.7	5.9	4.8	4.4	4.5	4.7	6	8.1	7	31	1957	1996
Mean 9am relative humidity (%) for years 1938 to 1996	39	43	46	53	60	68	69	60	48	41	37	36	50	50	1938	1996
Mean 9am cloud cover (okas) for years 1897 to 1996	2	2.4	2.5	2.9	3	3.4	2.9	2.6	2.1	2.1	2.1	1.8	2.5	98	1897	1996
Mean 9am wind speed (km/h) for years 1957 to 1996	17.1	16.8	16.3	14.5	13.4	13	13.2	14.5	16.7	16.8	17	16.6	15.5	36	1957	1996
Mean 3pm temperature (Degrees C) for years 1897 to 1996	33.9	32.8	30.1	25.4	20.4	16.9	16.3	18.2	22.3	25.8	29.6	32.7	25.4	98	1897	1996
Mean 3pm wet bulb temperature (Degrees C) for years 1897 to 1996	19.5	19.5	18.3	16	13.2	11.2	10.5	11.1	12.9	14.5	16.5	18.4	15.1	90	1897	1996
Mean 3pm dew point temperature (Degrees C) for years 1957 to 1996	7.1	9.3	8.2	7.1	5.5	5	4	2.9	2.3	2.4	3.2	5.5	5.2	31	1957	1996
Mean 3pm relative humidity (%) for years 1938 to 1996	23	26	27	34	40	46	45	37	28	24	21	20	31	50	1938	1996
Mean 3pm cloud cover (oktas) for years 1897 to 1996	2.4	2.8	2.8	3.2	3.3	3.7	3.3	3	2.1	2.3	2.6	2.4	2.8	97	1897	1996
Mean 3pm wind speed (km/h) for years 1957 to 1996	15.3	15.5	13.7	13.1	13.5	14.4	15.5	16	17	16.8	16.2	15	15.2	35	1957	1996

Monthly Climate Statistics for 'BULGA DOWNS' [012239]
Created on [07 Jul 2021 13:47:20 GMT+00:00]

012239 BULGA DOWNS
Commenced: 1924
Last Record: 2021
Latitude: 28.50 Degrees South
Longitude: 119.74 Degrees East
Elevation: 439 m
State: WA

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Number of Years	Start Year	End Year
Mean maximum temperature (Degrees C) for years 2002 to 2021	37.8	36.6	32.9	28.9	23.9	20	19.5	22.1	25.6	30.6	33.3	36.3	29	19	2002	2021
Highest temperature (Degrees C) for years 2002 to 2021	48	46.5	44.5	39.6	35.1	28.9	29	34.3	37.5	41.2	45.2	45.5	48	19	2002	2021
Date of Highest temperature for years 2002 to 2021	21-Jan-15	10-Feb-15	6-Mar-08	10-Apr-19	1-May-13	1-Jun-17	26-Jul-11	28-Aug-20	26-Sep-10	19-Oct-04	18-Nov-19	26-Dec-13	21-Jan-15	N/A	2002	2021
Lowest maximum temperature (Degrees C) for years 2002 to 2021	18.8	18.2	16.1	17.3	14.6	12.6	8.9	13	11.6	15.5	14.2	20.6	8.9	19	2002	2021
Date of Lowest maximum temperature for years 2002 to 2021	31-Jan-06	20-Feb-08	5-Mar-15	20-Apr-19	31-May-13	8-Jun-16	11-Jul-11	5-Aug-18	2-Sep-10	4-Oct-17	15-Nov-08	18-Dec-10	11-Jul-11	N/A	2002	2021
Decile 1 maximum temperature (Degrees C) for years 2002 to 2021	31.4	30	26	23	18.9	16	15.5	17.3	20	24.3	26.5	30.2		17	2002	2021
Decile 9 maximum temperature (Degrees C) for years 2002 to 2021	43.5	42.7	38.7	35.2	28.5	24.8	24.2	28.4	32.2	36.9	39.5	41.7		17	2002	2021
Mean number of days >= 30 Degrees C for years 2002 to 2021	28.6	25.2	23.1	12.7	1.8	0	0	1.3	6.1	17.2	21.8	27.6	165.4	19	2002	2021
Mean number of days >= 35 Degrees C for years 2002 to 2021	22.7	18.7	11.9	3.4	0.1	0	0	0	0.7	5.7	12.1	18.6	93.9	19	2002	2021
Mean number of days >= 40 Degrees C for years 2002 to 2021	11.7	7.7	1.8	0	0	0	0	0	0	0.3	2.3	6.3	30.1	19	2002	2021
Mean minimum temperature (Degrees C) for years 2002 to 2021	22.3	21.6	18.6	14.4	9	6.3	4.8	6.2	9.1	14.1	17.4	20.3	13.7	19	2002	2021
Lowest temperature (Degrees C) for years 2002 to 2021	11.3	12.7	10.2	4.9	-0.4	-3.5	-4	-2.8	1.1	2.6	5.8	11.5	-4	19	2002	2021
Date of Lowest temperature for years 2002 to 2021	5-Jan-07	1-Feb-06	29-Mar-07	21-Apr-19	19-May-19	29-Jun-06	5-Jul-17	3-Aug-17	15-Sep-16	3-Oct-16	2-Nov-05	6-Dec-15	5-Jul-17	N/A	2002	2021
Highest minimum temperature (Degrees C) for years 2002 to 2021	30.5	30.3	28.4	23.1	18.4	15.5	15	15.8	18.8	25	26.2	29.2	30.5	19	2002	2021
Date of Highest minimum temperature for years 2002 to 2021	12-Jan-09	2-Feb-07	13-Mar-05	14-Apr-07	1-May-05	5-Jun-10	21-Jul-05	30-Aug-19	10-Sep-20	27-Oct-10	15-Nov-06	31-Dec-10	12-Jan-09	N/A	2002	2021
Decile 1 minimum temperature (Degrees C) for years 2002 to 2021	18	18	14.3	10.1	4.6	1.9	0.5	2.2	4.5	9.5	12.3	15.5		17	2002	2021
Decile 9 minimum temperature (Degrees C) for years 2002 to 2021	26.7	26	22.1	18.8	14	11.4	9.9	10.5	14	19.2	22.2	24.8		17	2002	2021
Mean number of days <= 2 Degrees C for years 2002 to 2021	0	0	0	0	0.7	3.1	6.9	2.9	0.2	0	0	0	13.8	19	2002	2021
Mean number of days <= 0 Degrees C for years 2002 to 2021	0	0	0	0	0.1	0.6	2.1	0.6	0	0	0	0	3.4	19	2002	2021
Mean daily ground minimum temperature Degrees C for years null to null																
Lowest ground temperature Degrees C for years null to null																
Date of Lowest ground temperature for years null to null														N/A		
Mean number of days ground min. temp. <= -1 Degrees C for years null to null																
Mean rainfall (mm) for years 1924 to 2021	30.1	30.5	26.6	20.2	24.8	26.5	23.3	15.3	7.4	8.1	11.1	12.8	234.1	95	1924	2021
Highest rainfall (mm) for years 1924 to 2021	229.8	464.2	193.4	143	147	106.8	97.2	92.4	52.6	88	112.8	88.4	688.4	97	1924	2021
Date of Highest rainfall for years 1924 to 2021	2014	1995	1992	1992	1980	1986	1996	1992	1955	1975	2008	2010	1995	N/A	1924	2021
Lowest rainfall (mm) for years 1924 to 2021	0	0	0	0	0	0	0	0	0	0	0	0	54.3	97	1924	2021
Date of Lowest rainfall for years 1924 to 2021	2015	2014	2008	2012	2017	2006	1994	1991	2019	2019	2019	2018	1926	N/A	1924	2021
Decile 1 monthly rainfall (mm) for years 1924 to 2021	0	0	0	0	0	3.4	3.4	1.6	0	0	0	0	112.1	96	1924	2021
Decile 5 (median) monthly rainfall (mm) for years 1924 to 2021	16.8	14.4	16.4	12.4	18.5	21.7	16.8	10.4	4	3	6	5.1	213.5	96	1924	2021
Decile 9 monthly rainfall (mm) for years 1924 to 2021	76.7	69.6	69.1	50.2	57.9	57.3	56.6	34.9	17.9	19.4	27.8	33.4	369.1	96	1924	2021
Highest daily rainfall (mm) for years 1924 to 2021	101	161.4	65.8	44.6	38.4	22	39	30	27	38	58.8	40.4	161.4	40	1924	2021
Date of Highest daily rainfall for years 1924 to 2021	23-Jan-14	27-Feb-95	1-Mar-06	17-Apr-92	2-May-93	8-Jun-98	10-Jul-09	2-Aug-92	27-Sep-95	31-Oct-01	16-Nov-08	19-Dec-10	27-Feb-95	N/A	1924	2021
Mean number of days of rain for years 1924 to 2021	2.4	2.8	2.9	2.6	2.8	4.8	4.3	3.5	1.5	1.3	1.6	2	32.5	96	1924	2021
Mean number of days of rain >= 1 mm for years 1924 to 2021	1	1.2	1.1	1	1	1.2	1.2	1	0.6	0.5	0.7	0.8	11.3	40	1924	2021
Mean number of days of rain >= 10 mm for years 1924 to 2021	0.4	0.5	0.4	0.3	0.2	0.2	0.3	0.1	0.1	0.1	0.2	0.2	3	40	1924	2021
Mean number of days of rain >= 25 mm for years 1924 to 2021	0.1	0.2	0.1	0	0.1	0	0	0	0	0	0	0.1	0.6	40	1924	2021
Mean daily wind run (km) for years null to null																
Maximum wind gust speed (km/h) for years null to null																
Date of Maximum wind gust speed for years null to null														N/A		
Mean daily sunshine (hours) for years null to null																
Mean daily solar exposure (MJ/(m*m)) for years 1990 to 2021	27.9	24.6	21.4	16.9	13.6	11.7	12.8	16.2	20.8	24.9	27.9	28.9	20.6	32	1990	2021
Mean number of clear days for years 2002 to 2010														8	2002	2010
Mean number of cloudy days for years 2002 to 2010														8	2002	2010
Mean daily evaporation (mm) for years null to null																
Mean 9am temperature (Degrees C) for years 2002 to 2010														8	2002	2010
Mean 9am wet bulb temperature (Degrees C) for years 2002 to 2010														8	2002	2010
Mean 9am dew point temperature (Degrees C) for years 2002 to 2010														8	2002	2010
Mean 9am relative humidity (%) for years 2002 to 2010														8	2002	2010
Mean 9am cloud cover (okas) for years 2002 to 2010														8	2002	2010
Mean 9am wind speed (km/h) for years 2002 to 2010														8	2002	2010
Mean 3pm temperature (Degrees C) for years 2002 to 2010														8	2002	2010
Mean 3pm wet bulb temperature (Degrees C) for years 2002 to 2010														8	2002	2010
Mean 3pm dew point temperature (Degrees C) for years 2002 to 2010														8	2002	2010
Mean 3pm relative humidity (%) for years 2002 to 2010														8	2002	2010
Mean 3pm cloud cover (oktas) for years 2002 to 2010														8	2002	2010
Mean 3pm wind speed (km/h) for years 2002 to 2010														8	2002	2010

Monthly Climate Statistics for 'BOOYLGOO SPRING' [012008]
Created on [07 Jul 2021 13:43:30 GMT+00:00]

012008 BOOYLGOO SPRING
Commenced: 1922
Last Record: 2013
Latitude: 27.72 Degrees South
Longitude: 119.91 Degrees East
Elevation: 610 m
State: WA

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Number of Years	Start Year	End Year
Mean maximum temperature (Degrees C) for years 1936 to 1975	36	35	32.5	27.1	21.8	18.2	17.6	19.7	24.1	27.7	31.6	34.8	27.2	32	1936	1975
Highest temperature (Degrees C) for years 1965 to 1975	43.6	42.8	42.8	38.9	34.2	28.3	27.9	30.3	34.3	38.9	40.8	43.5	43.6	11	1965	1975
Date of Highest temperature for years 1965 to 1975	8-Jan-67	6-Feb-75	9-Mar-73	1-Apr-65	4-May-67	5-Jun-65	31-Jul-69	30-Aug-67	30-Sep-67	20-Oct-67	22-Nov-69	31-Dec-72	8-Jan-67	N/A	1965	1975
Lowest maximum temperature (Degrees C) for years 1965 to 1975	21	21	18.1	15.7	12.5	10	10.7	11.6	14.6	17.2	15	22.2	10	11	1965	1975
Date of Lowest maximum temperature for years 1965 to 1975	26-Jan-71	26-Feb-75	23-Mar-68	24-Apr-66	6-May-70	20-Jun-68	30-Jul-74	25-Aug-73	19-Sep-74	15-Oct-74	3-Nov-75	12-Dec-68	20-Jun-68	N/A	1965	1975
Decile 1 maximum temperature (Degrees C) for years 1965 to 1975	31.2	28.1	25.7	20.3	16.8	14.3	14.2	15	18.4	21.7	25.6	29		11	1965	1975
Decile 9 maximum temperature (Degrees C) for years 1965 to 1975	41.1	40.3	37.9	34.2	27.8	22.8	21.9	24	29.5	34.4	37.7	39.7		11	1965	1975
Mean number of days >= 30 Degrees C for years 1965 to 1975	27.8	24.5	22.5	10.2	1.4	0	0	0.1	2.5	11.6	19.1	26.2	145.9	11	1965	1975
Mean number of days >= 35 Degrees C for years 1965 to 1975	22.5	16.3	10.4	1.8	0	0	0	0	0	2.4	8.7	16.2	78.3	11	1965	1975
Mean number of days >= 40 Degrees C for years 1965 to 1975	6.5	3.6	1.4	0	0	0	0	0	0	0	0.6	2.7	14.8	11	1965	1975
Mean minimum temperature (Degrees C) for years 1936 to 1975	21.5	20.9	18.5	13.6	8.5	5.9	4.4	5.5	8.6	12.3	16.3	19.7	13	32	1936	1975
Lowest temperature (Degrees C) for years 1965 to 1975	13.9	10.6	9.2	3.1	-1.5	-1.5	-6.7	-1.7	-0.3	3.9	7.8	9.2	-6.7	11	1965	1975
Date of Lowest temperature for years 1965 to 1975	24-Jan-67	24-Feb-67	28-Mar-68	19-Apr-70	23-May-75	19-Jun-74	12-Jul-69	23-Aug-70	4-Sep-70	7-Oct-68	6-Nov-68	3-Dec-66	12-Jul-69	N/A	1965	1975
Highest minimum temperature (Degrees C) for years 1965 to 1975	29.2	28.3	29.5	23.1	17.2	17.2	15.4	15.3	18.2	26.1	25.8	30.2	30.2	11	1965	1975
Date of Highest minimum temperature for years 1965 to 1975	1-Jan-73	10-Feb-72	10-Mar-73	3-Apr-69	3-May-67	6-Jun-65	24-Jul-73	26-Aug-70	18-Sep-74	30-Oct-67	15-Nov-65	31-Dec-72	31-Dec-72	N/A	1965	1975
Decile 1 minimum temperature (Degrees C) for years 1965 to 1975	18.3	16.9	14.2	9	3.3	2.1	0.4	1.1	4.4	8.6	11.7	15.7		11	1965	1975
Decile 9 minimum temperature (Degrees C) for years 1965 to 1975	25.6	25.2	23.2	19.6	13.3	10.8	9.8	10.5	13	18.3	21.8	24.4		11	1965	1975
Mean number of days <= 2 Degrees C for years 1965 to 1975	0	0	0	0	1.5	2.9	6.5	4.1	0.6	0	0	0	15.6	11	1965	1975
Mean number of days <= 0 Degrees C for years 1965 to 1975	0	0	0	0	0.3	0.6	2.5	1.6	0.2	0	0	0	5.2	11	1965	1975
Mean daily ground minimum temperature Degrees C for years null to null																
Lowest ground temperature Degrees C for years null to null																
Date of Lowest ground temperature for years null to null														N/A		
Mean number of days ground min. temp. <= -1 Degrees C for years null to null																
Mean rainfall (mm) for years 1922 to 2013	30.5	31.7	31.8	20.9	25.2	24.6	19.6	13.5	5.7	10.4	11.6	16.4	239	80	1922	2013
Highest rainfall (mm) for years 1922 to 2013	155.4	260	174	155.8	134.7	115.4	80.2	71.3	43.8	104	82	135	607.8	89	1922	2013
Date of Highest rainfall for years 1922 to 2013	1939	1975	2000	1992	1993	1986	2004	1947	1984	1975	1985	1998	1975	N/A	1922	2013
Lowest rainfall (mm) for years 1922 to 2013	0	0	0	0	0	0	0	0	0	0	0	0	63.5	89	1922	2013
Date of Lowest rainfall for years 1922 to 2013	2010	2013	2009	2012	2010	2010	2006	2012	2011	2010	2009	2008	1936	N/A	1922	2013
Decile 1 monthly rainfall (mm) for years 1922 to 2013	0	0.4	0.4	0	0.9	2.5	2.4	0.3	0	0	0	0	117	90	1922	2013
Decile 5 (median) monthly rainfall (mm) for years 1922 to 2013	18.6	14.9	16.3	16.6	20.4	17.2	14.4	7.5	2.3	3.8	5.6	8	214.6	90	1922	2013
Decile 9 monthly rainfall (mm) for years 1922 to 2013	91.5	89.3	82.6	48.8	56.1	63.3	50.7	34.5	12.2	36.3	27.4	43.5	378.9	90	1922	2013
Highest daily rainfall (mm) for years 1922 to 2013	109.2	140	65	48.8	78	38.4	56	33.6	27.1	35.2	57.2	60	140	90	1922	2013
Date of Highest daily rainfall for years 1922 to 2013	13-Jan-39	23-Feb-75	18-Mar-12	20-Apr-37	6-May-05	13-Jun-89	19-Jul-80	30-Aug-77	28-Sep-84	6-Oct-75	20-Nov-85	7-Dec-98	23-Feb-75	N/A	1922	2013
Mean number of days of rain for years 1922 to 2013	3.9	3.8	4.4	3.9	4.7	5.9	5.4	3.6	2.3	2.1	2.6	3.2	45.8	90	1922	2013
Mean number of days of rain >= 1 mm for years 1922 to 2013	3	2.8	3.1	2.8	3.2	3.7	3.4	2.4	1.3	1.4	1.7	2.3	31.1	90	1922	2013
Mean number of days of rain >= 10 mm for years 1922 to 2013	0.9	0.8	0.8	0.7	0.8	0.7	0.5	0.4	0.1	0.3	0.3	0.4	6.7	90	1922	2013
Mean number of days of rain >= 25 mm for years 1922 to 2013	0.3	0.4	0.3	0.1	0.2	0.1	0	0	0	0.1	0.1	0.1	1.7	90	1922	2013
Mean daily wind run (km) for years null to null																
Maximum wind gust speed (km/h) for years null to null																
Date of Maximum wind gust speed for years null to null														N/A		
Mean daily sunshine (hours) for years null to null																
Mean daily solar exposure (MJ/(m*m)) for years 1990 to 2021	27.6	24.4	21.3	17.2	14.1	12.2	13.3	16.9	21.4	25.2	28	29	20.9	32	1990	2021
Mean number of clear days for years null to null																
Mean number of cloudy days for years null to null																
Mean daily evaporation (mm) for years null to null																
Mean 9am temperature (Degrees C) for years 1936 to 1975	26.8	25.9	23.5	18.8	13.9	10.8	9.8	11.5	15.3	19.1	22.9	25.9	18.7	32	1936	1975
Mean 9am wet bulb temperature (Degrees C) for years 1937 to 1975	17.1	17.1	16	13.2	10.3	8.3	7.3	7.8	9.9	11.8	14	15.6	12.4	29	1937	1975
Mean 9am dew point temperature (Degrees C) for years 1975 to 1975														0	1975	1975
Mean 9am relative humidity (%) for years 1936 to 1975	33	36	42	49	60	70	70	58	44	37	31	29	47	21	1936	1975
Mean 9am cloud cover (okas) for years 1927 to 1975	2.5	2.5	2.8	3.3	3	3.2	2.6	2.2	1.9	2	2.1	1.9	2.5	32	1927	1975
Mean 9am wind speed (km/h) for years 1965 to 1975	14.9	14.2	12.7	10.1	7.7	9	8.9	10	12.5	14.1	14	14.2	11.9	10	1965	1975
Mean 3pm temperature (Degrees C) for years null to null																
Mean 3pm wet bulb temperature (Degrees C) for years null to null																
Mean 3pm dew point temperature (Degrees C) for years null to null																
Mean 3pm relative humidity (%) for years null to null																
Mean 3pm cloud cover (oktas) for years null to null																
Mean 3pm wind speed (km/h) for years null to null																

Monthly Climate Statistics for 'YEELIRRIE' [012090]
Created on [07 Jul 2021 15:38:24 GMT+00:00]

012090 YEELIRRIE
Commenced: 1928
Last Record: 2017
Latitude: 27.28 Degrees South
Longitude: 120.09 Degrees East
Elevation: 487 m
State: WA

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Number of Years	Start Year	End Year
Mean maximum temperature (Degrees C) for years 1973 to 2017	37.9	36	33.2	28.9	23.5	19.6	19.3	21.8	25.8	30.2	33.1	36.3	28.8	44	1973	2017
Highest temperature (Degrees C) for years 1973 to 2017	47.9	46	44	40.7	36.8	29.9	30.4	33.4	37.5	41.5	43.2	45.4	47.9	44	1973	2017
Date of Highest temperature for years 1973 to 2017	8-Jan-13	11-Feb-91	2-Mar-80	4-Apr-16	3-May-90	1-Jun-98	31-Jul-15	29-Aug-95	30-Sep-98	20-Oct-04	10-Nov-10	31-Dec-10	8-Jan-13	N/A	1973	2017
Lowest maximum temperature (Degrees C) for years 1973 to 2017	18.4	20.6	17.1	16	12.8	11.6	9	9.2	13.2	11.1	15.2	20	9	44	1973	2017
Date of Lowest maximum temperature for years 1973 to 2017	31-Jan-06	16-Feb-01	8-Mar-82	23-Apr-83	11-May-79	24-Jun-93	13-Jul-04	30-Aug-77	30-Sep-09	13-Oct-78	3-Nov-75	17-Dec-10	13-Jul-04	N/A	1973	2017
Decile 1 maximum temperature (Degrees C) for years 1973 to 2017	32.5	29.5	26.4	22.6	18.4	15.3	15	16.6	20	23.6	27.2	30.6		43	1973	2017
Decile 9 maximum temperature (Degrees C) for years 1973 to 2017	42.8	41.9	39	34.5	29.1	24	24	27.5	31.9	36.4	39	41		43	1973	2017
Mean number of days >= 30 Degrees C for years 1973 to 2017	28.7	24.4	22.7	12.7	1.8	0	0	0.7	6.2	15.8	21.9	27.4	162.3	44	1973	2017
Mean number of days >= 35 Degrees C for years 1973 to 2017	23.3	17.5	12	1.9	0	0	0	0	0.4	5.7	10.8	19.7	91.3	44	1973	2017
Mean number of days >= 40 Degrees C for years 1973 to 2017	11	6.2	1.9	0	0	0	0	0	0	0.1	1.8	5.8	26.8	44	1973	2017
Mean minimum temperature (Degrees C) for years 1973 to 2017	22.3	21.3	18.3	13.9	8.2	4.7	3.5	4.7	7.8	12.7	16.4	19.9	12.8	44	1973	2017
Lowest temperature (Degrees C) for years 1973 to 2017	12	10	6	3	-2.8	-5	-5.1	-4.8	-2.2	-0.4	1.9	7.6	-5.1	44	1973	2017
Date of Lowest temperature for years 1973 to 2017	8-Jan-89	17-Feb-90	29-Mar-07	30-Apr-99	27-May-77	23-Jun-81	27-Jul-00	2-Aug-93	5-Sep-99	7-Oct-94	2-Nov-99	1-Dec-87	27-Jul-00	N/A	1973	2017
Highest minimum temperature (Degrees C) for years 1973 to 2017	31.6	31.4	28.8	24.3	20.5	16.4	15.7	17.9	21.4	26	27.9	29.6	31.6	44	1973	2017
Date of Highest minimum temperature for years 1973 to 2017	20-Jan-91	14-Feb-07	10-Mar-79	4-Apr-87	2-May-05	7-Jun-87	24-Jul-73	29-Aug-98	14-Sep-81	27-Oct-10	30-Nov-98	1-Dec-94	20-Jan-91	N/A	1973	2017
Decile 1 minimum temperature (Degrees C) for years 1973 to 2017	17.8	16.7	13.2	9	2.5	-1	-2.1	-0.6	2.8	7	11.4	15		42	1973	2017
Decile 9 minimum temperature (Degrees C) for years 1973 to 2017	26.6	25.6	23.2	18.6	14.3	11	10.2	10.4	13	18.1	21.4	24.6		42	1973	2017
Mean number of days <= 2 Degrees C for years 1973 to 2017	0	0	0	0	2.3	9.3	12.7	8.6	2.1	0.1	0	0	35.1	44	1973	2017
Mean number of days <= 0 Degrees C for years 1973 to 2017	0	0	0	0	0.5	4.9	7.4	4.4	0.7	0	0	0	17.9	44	1973	2017
Mean daily ground minimum temperature Degrees C for years null to null																
Lowest ground temperature Degrees C for years null to null																
Date of Lowest ground temperature for years null to null														N/A		
Mean number of days ground min. temp. <= -1 Degrees C for years null to null																
Mean rainfall (mm) for years 1928 to 2017	30.2	31.2	34	24.1	24.7	22.6	17.2	12.3	4.7	9.4	10.4	19.9	240.5	86	1928	2017
Highest rainfall (mm) for years 1928 to 2017	159.9	166.2	155.1	211	89.4	146	101	80.3	39.2	90.4	63.6	102.4	506.8	90	1928	2017
Date of Highest rainfall for years 1928 to 2017	1955	2011	2017	1992	1982	1986	1974	1947	1984	2006	1975	1994	1975	N/A	1928	2017
Lowest rainfall (mm) for years 1928 to 2017	0	0	0	0	0	0	0	0	0	0	0	0	42.8	90	1928	2017
Date of Lowest rainfall for years 1928 to 2017	1998	2013	1989	1994	2017	1984	2017	2012	2015	2013	1997	2003	1950	N/A	1928	2017
Decile 1 monthly rainfall (mm) for years 1928 to 2017	0.7	0.3	0	0	0.5	1	1	0	0	0	0	0	121.8	90	1928	2017
Decile 5 (median) monthly rainfall (mm) for years 1928 to 2017	14.8	14.9	16.9	17.4	15	13.4	10.2	7.2	1.3	3.5	5.9	9.9	226.6	90	1928	2017
Decile 9 monthly rainfall (mm) for years 1928 to 2017	85.2	96	103.2	58.2	63.6	58.9	41.3	28.7	13.3	29.8	29	58.1	397	90	1928	2017
Highest daily rainfall (mm) for years 1928 to 2017	90.2	68.4	99.1	66.4	47	61.2	44	41.2	33.7	34.3	42	77	99.1	90	1928	2017
Date of Highest daily rainfall for years 1928 to 2017	23-Jan-52	2-Feb-85	30-Mar-31	16-Apr-92	1-May-30	13-Jun-89	19-Jul-80	30-Aug-77	1-Sep-10	25-Oct-06	15-Nov-17	19-Dec-94	30-Mar-31	N/A	1928	2017
Mean number of days of rain for years 1928 to 2017	4.1	4	4.2	3.9	4.1	5	4.4	3	1.6	2	2.5	3.1	41.9	90	1928	2017
Mean number of days of rain >= 1 mm for years 1928 to 2017	3.4	3.2	3.4	3.2	3	3.7	3.1	2.1	1.1	1.4	1.9	2.5	32	90	1928	2017
Mean number of days of rain >= 10 mm for years 1928 to 2017	0.9	0.8	0.9	0.7	0.8	0.6	0.5	0.3	0.1	0.3	0.2	0.6	6.7	90	1928	2017
Mean number of days of rain >= 25 mm for years 1928 to 2017	0.3	0.3	0.4	0.2	0.2	0.1	0	0	0	0.1	0.1	0.1	1.8	90	1928	2017
Mean daily wind run (km) for years null to null																
Maximum wind gust speed (km/h) for years null to null																
Date of Maximum wind gust speed for years null to null														N/A		
Mean daily sunshine (hours) for years null to null																
Mean daily solar exposure (MJ/(m*m)) for years 1990 to 2021	27.4	24.4	21.4	17.2	14.3	12.4	13.5	17.2	21.8	25.3	27.9	28.8	21	32	1990	2021
Mean number of clear days for years 1973 to 2010	15.2	11.2	13.7	11.1	14.1	13.3	16.1	17.7	18.8	18.2	15.9	15.4	180.7	37	1973	2010
Mean number of cloudy days for years 1973 to 2010	4.7	6.7	6.5	7.9	7.3	6.8	6.4	3.8	2.6	3	3.6	4.4	63.7	37	1973	2010
Mean daily evaporation (mm) for years 1982 to 1985														4	1982	1985
Mean 9am temperature (Degrees C) for years 1973 to 2010	29.7	27.8	25.4	21.3	16.1	11.9	11.1	13.7	17.9	22.1	25.2	28.2	20.9	37	1973	2010
Mean 9am wet bulb temperature (Degrees C) for years 1973 to 2010	18.8	18.6	17.2	15.2	11.8	9	8.2	9.4	11.4	13.4	15.4	17.5	13.8	34	1973	2010
Mean 9am dew point temperature (Degrees C) for years 1973 to 2010	10.5	11.6	10.6	9.9	7.5	5.7	4.5	4.2	4.4	4.6	6.5	8.5	7.4	34	1973	2010
Mean 9am relative humidity (%) for years 1973 to 2010	34	42	43	52	59	68	66	56	44	36	33	32	47	34	1973	2010
Mean 9am cloud cover (okas) for years 1973 to 2010	2.2	3	2.7	3.3	3	3	2.7	2.2	1.7	1.9	2.1	2.1	2.5	37	1973	2010
Mean 9am wind speed (km/h) for years 1973 to 2010	13.2	12.4	11.7	9.8	8.1	6.9	7.4	10.3	12.8	14	13.8	12.7	11.1	36	1973	2010
Mean 3pm temperature (Degrees C) for years 1973 to 2010	36.7	34.8	32.4	27.9	22.7	18.7	18.4	20.7	24.9	28.9	31.8	35	27.7	37	1973	2010
Mean 3pm wet bulb temperature (Degrees C) for years 1973 to 2010	20.7	20.5	19.2	17.3	14.3	11.9	11.4	12.2	13.8	15.4	17.2	19.2	16.1	34	1973	2010
Mean 3pm dew point temperature (Degrees C) for years 1973 to 2010	8.5	9.8	8.8	8.6	6	4.4	3.4	2.5	1.9	1.8	3.8	5.9	5.4	34	1973	2010
Mean 3pm relative humidity (%) for years 1973 to 2010	21	27	27	34	37	42	41	33	26	20	19	19	29	34	1973	2010
Mean 3pm cloud cover (oktas) for years 1973 to 2010	3.2	3.6	3.4	3.8	3.2	3.2	2.8	2.3	1.8	2.2	2.8	3.1	2.9	37	1973	2010
Mean 3pm wind speed (km/h) for years 1973 to 2010	10.7	11	10.1	8.9	9	9.3	10.6	12.5	13.8	14.3	13.2	11.4	11.2	35	1973	2010

Monthly Climate Statistics for 'CASHMERE DOWNS' [012022]
Created on [07 Jul 2021 13:55:43 GMT+00:00]

012022 CASHMERE DOWNS
Commenced: 1919
Last Record: 2002
Latitude: 28.97 Degrees South
Longitude: 119.57 Degrees East
Elevation: 450 m
State: WA

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Number of Years	Start Year	End Year
Mean maximum temperature (Degrees C) for years 1972 to 2002	36	34.3	31.4	26.9	21.8	18.1	17.4	19.1	23.2	26.9	30.5	33.9	26.6	31	1972	2002
Highest temperature (Degrees C) for years 1972 to 2002	45.5	44.6	44	36.8	35.2	27.4	28.4	31	36.5	40.7	41	45	45.5	31	1972	2002
Date of Highest temperature for years 1972 to 2002	20-Jan-91	14-Feb-98	4-Mar-73	8-Apr-91	2-May-90	7-Jun-98	29-Jul-01	28-Aug-95	28-Sep-73	25-Oct-83	23-Nov-96	30-Dec-72	20-Jan-91	N/A	1972	2002
Lowest maximum temperature (Degrees C) for years 1972 to 2002	18.4	19.2	15.3	15.7	10.4	10.3	9.2	9.6	10.2	10.7	14.7	18.4	9.2	31	1972	2002
Date of Lowest maximum temperature for years 1972 to 2002	21-Jan-87	23-Feb-75	19-Mar-84	29-Apr-00	25-May-77	28-Jun-72	5-Jul-86	12-Aug-86	30-Sep-92	27-Oct-83	16-Nov-85	19-Dec-88	5-Jul-86	N/A	1972	2002
Decile 1 maximum temperature (Degrees C) for years 1972 to 2002	30.4	27.8	24.9	21.2	16.8	14.1	13.5	14.4	17.7	20.7	24.6	27.8		31	1972	2002
Decile 9 maximum temperature (Degrees C) for years 1972 to 2002	41.3	40.5	38	32.6	27.5	22.3	22.1	24.4	29.4	33.8	37	39.6		31	1972	2002
Mean number of days >= 30 Degrees C for years 1972 to 2002	28.2	22.7	18.5	7.6	1	0	0	0.1	2.4	9.1	16.4	24.4	130.4	31	1972	2002
Mean number of days >= 35 Degrees C for years 1972 to 2002	19.4	13.1	8.4	0.9	0	0	0	0	0.1	1.7	5.5	13.7	62.8	31	1972	2002
Mean number of days >= 40 Degrees C for years 1972 to 2002	6.1	3.4	1.1	0	0	0	0	0	0	0	0.5	2.5	13.6	31	1972	2002
Mean minimum temperature (Degrees C) for years 1972 to 2002	20.9	20.4	17.8	14.1	9.7	6.8	5.9	6.5	8.9	12	15.7	18.9	13.1	31	1972	2002
Lowest temperature (Degrees C) for years 1972 to 2002	9.8	10.2	7.6	3.5	-1.4	-4.2	-2.6	-1.4	0.8	1.4	2.8	9.6	-4.2	31	1972	2002
Date of Lowest temperature for years 1972 to 2002	14-Jan-88	16-Feb-90	24-Mar-01	30-Apr-74	27-May-77	23-Jun-81	20-Jul-87	12-Aug-72	19-Sep-93	7-Oct-92	20-Nov-92	5-Dec-90	23-Jun-81	N/A	1972	2002
Highest minimum temperature (Degrees C) for years 1972 to 2002	29.1	30.5	28.2	23	20.7	16.2	17	17.5	20.5	24.1	27.2	29.2	30.5	31	1972	2002
Date of Highest minimum temperature for years 1972 to 2002	24-Jan-94	11-Feb-79	4-Mar-90	3-Apr-78	9-May-98	13-Jun-72	30-Jul-01	18-Aug-82	27-Sep-01	17-Oct-95	20-Nov-80	31-Dec-72	11-Feb-79	N/A	1972	2002
Decile 1 minimum temperature (Degrees C) for years 1972 to 2002	16.4	15.9	13.2	9.6	4.9	2.5	1.6	2.5	4.8	7.2	11.3	14.3		31	1972	2002
Decile 9 minimum temperature (Degrees C) for years 1972 to 2002	25.5	24.6	22.8	18.2	14.8	11	9.8	10.7	13.2	17.1	20.7	23.6		31	1972	2002
Mean number of days <= 2 Degrees C for years 1972 to 2002	0	0	0	0	0.3	2.3	3.8	2.3	0.4	0.1	0	0	9.2	31	1972	2002
Mean number of days <= 0 Degrees C for years 1972 to 2002	0	0	0	0	0	0.3	1	0.5	0	0	0	0	1.8	31	1972	2002
Mean daily ground minimum temperature Degrees C for years null to null																
Lowest ground temperature Degrees C for years null to null																
Date of Lowest ground temperature for years null to null														N/A		
Mean number of days ground min. temp. <= -1 Degrees C for years null to null																
Mean rainfall (mm) for years 1919 to 2002	22.5	29.9	28.8	22.7	27.9	29.4	25.5	18.9	9.5	9.9	11.9	15.6	253.2	71	1919	2002
Highest rainfall (mm) for years 1919 to 2002	133.2	367.6	196.4	125.4	132.8	123.1	119.6	81.4	69.6	70.2	85.9	85.6	616.3	73	1919	2002
Date of Highest rainfall for years 1919 to 2002	1942	1995	2000	1964	1921	1955	1996	1992	1974	1975	1931	1998	1975	N/A	1919	2002
Lowest rainfall (mm) for years 1919 to 2002	0	0	0	0	0	1.5	0	0.2	0	0	0	0	78.1	73	1919	2002
Date of Lowest rainfall for years 1919 to 2002	1997	1998	1988	1994	1983	1960	1937	1989	1988	1994	1994	2001	1936	N/A	1919	2002
Decile 1 monthly rainfall (mm) for years 1919 to 2002	0	0.2	0.4	0	0.4	5.4	4.5	2.1	0	0	0	0	126.6	73	1919	2002
Decile 5 (median) monthly rainfall (mm) for years 1919 to 2002	12	12.9	14.6	9.3	21.8	21.4	18	15.2	5.8	4.8	6.3	7.6	224	73	1919	2002
Decile 9 monthly rainfall (mm) for years 1919 to 2002	60.7	65.4	78.4	62.3	68.9	68.8	50.8	35.6	19.8	27.5	29.1	42.5	433.3	73	1919	2002
Highest daily rainfall (mm) for years 1919 to 2002	101.1	149.8	78.8	56.1	37.8	57.4	41	50	47	29.6	48.8	48.2	149.8	73	1919	2002
Date of Highest daily rainfall for years 1919 to 2002	13-Jan-39	27-Feb-95	23-Mar-99	28-Apr-64	29-May-62	14-Jun-55	15-Jul-96	16-Aug-78	20-Sep-55	31-Oct-01	3-Nov-99	6-Dec-98	27-Feb-95	N/A	1919	2002
Mean number of days of rain for years 1919 to 2002	2.9	3.4	4.1	4	5.1	6.4	6.1	5.2	3	2.4	2.5	2.8	47.9	73	1919	2002
Mean number of days of rain >= 1 mm for years 1919 to 2002	2	2.3	2.8	2.6	3.5	4.2	4	3.2	1.8	1.5	1.8	1.9	31.6	73	1919	2002
Mean number of days of rain >= 10 mm for years 1919 to 2002	0.5	0.7	0.8	0.5	0.7	0.7	0.6	0.3	0.2	0.2	0.3	0.4	5.9	73	1919	2002
Mean number of days of rain >= 25 mm for years 1919 to 2002	0.2	0.3	0.2	0.2	0.2	0.1	0.1	0	0	0	0.1	0.1	1.5	73	1919	2002
Mean daily wind run (km) for years null to null																
Maximum wind gust speed (km/h) for years null to null																
Date of Maximum wind gust speed for years null to null														N/A		
Mean daily sunshine (hours) for years null to null																
Mean daily solar exposure (MJ/(m*m)) for years 1990 to 2021	27.8	24.4	21.2	16.8	13.4	11.6	12.5	15.9	20.4	24.7	27.7	28.9	20.4	32	1990	2021
Mean number of clear days for years 1972 to 2002	17.1	13.5	13.6	11.7	12.6	13.1	13.5	15.8	17.1	18.2	15.4	16.5	178.1	31	1972	2002
Mean number of cloudy days for years 1972 to 2002	4.4	6	6.6	7.8	8.7	8.6	7.6	6.4	4.8	4.3	5.2	4.5	74.9	31	1972	2002
Mean daily evaporation (mm) for years null to null																
Mean 9am temperature (Degrees C) for years 1972 to 2002	27.3	25.7	23.3	19.5	15	11.5	10.7	12.3	15.7	19.3	22.8	25.7	19.1	31	1972	2002
Mean 9am wet bulb temperature (Degrees C) for years 1972 to 2002	17.4	17.7	16.1	14.2	11.4	9	8.2	8.9	10.8	12.4	14.6	16.5	13.1	30	1972	2002
Mean 9am dew point temperature (Degrees C) for years 1977 to 2002	9.6	11.2	10.5	10	8.4	6.5	5.3	4.7	5.4	5.1	6.8	8.9	7.7	16	1977	2002
Mean 9am relative humidity (%) for years 1977 to 2002	37	45	49	57	66	74	71	63	53	42	39	38	53	16	1977	2002
Mean 9am cloud cover (okas) for years 1972 to 2002	2.3	2.7	3.1	3.4	3.4	3.4	3.1	2.6	2.5	2.3	2.4	2.1	2.8	31	1972	2002
Mean 9am wind speed (km/h) for years 1972 to 2002	14	13.7	13.3	11.6	9.2	8.2	8.7	9.8	12.1	13.5	13.4	12.5	11.7	30	1972	2002
Mean 3pm temperature (Degrees C) for years 1972 to 2002	34.9	33.3	30.6	26.1	21	17.4	16.8	18.4	22.5	26	29.5	33	25.8	31	1972	2002
Mean 3pm wet bulb temperature (Degrees C) for years 1972 to 2002	19.3	19.6	18.3	16.3	13.7	11.5	10.8	11.3	12.9	14.5	16.2	18.3	15.2	30	1972	2002
Mean 3pm dew point temperature (Degrees C) for years 1977 to 2002	7.2	9.2	9	8.7	7.3	5.4	4.2	3.2	2.6	2.2	3.6	6.1	5.7	16	1977	2002
Mean 3pm relative humidity (%) for years 1977 to 2002	21	28	31	38	45	48	45	40	30	24	22	22	33	16	1977	2002
Mean 3pm cloud cover (oktas) for years 1972 to 2002	2.8	3.3	3.3	3.7	3.7	3.5	3.4	3	2.5	2.5	3.1	2.9	3.1	31	1972	2002
Mean 3pm wind speed (km/h) for years 1972 to 2002	11	10.9	10.7	9.9	9.5	9.8	10.9	11.8	12.4	12.6	12.5	11.1	11.1	30	1972	2002

Monthly Climate Statistics for 'YAMARNA' [012219]
Created on [07 Jul 2021 15:37:16 GMT+00:00]

012219 YAMARNA
Commenced: 1967
Last Record: 1998
Latitude: 28.17 Degrees South
Longitude: 123.66 Degrees East
Elevation: 442 m
State: WA

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Number of Years	Start Year	End Year
Mean maximum temperature (Degrees C) for years 1968 to 1997	35.9	34.2	32.4	27.7	22.4	19	18.8	20.8	24.7	28.9	32	34.6	27.6	26	1968	1997
Highest temperature (Degrees C) for years 1968 to 1997	46.6	45.6	43	39.2	37.2	29	28.4	33	36.7	41	43.4	44.5	46.6	26	1968	1997
Date of Highest temperature for years 1968 to 1997	15-Jan-93	12-Feb-91	1-Mar-88	9-Apr-85	3-May-90	4-Jun-95	31-Jul-69	29-Aug-95	16-Sep-81	17-Oct-95	28-Nov-93	24-Dec-86	15-Jan-93	N/A	1968	1997
Lowest maximum temperature (Degrees C) for years 1968 to 1997	18.8	15.4	17.6	15.5	11.1	11.3	10.8	10.4	11.4	11.9	13.9	18	10.4	26	1968	1997
Date of Lowest maximum temperature for years 1968 to 1997	16-Jan-78	3-Feb-80	19-Mar-84	13-Apr-87	20-May-68	20-Jun-68	26-Jul-74	7-Aug-90	30-Sep-92	13-Oct-78	3-Nov-75	12-Dec-75	7-Aug-90	N/A	1968	1997
Decile 1 maximum temperature (Degrees C) for years 1968 to 1997	30	26.7	25.4	21.1	17.2	15.1	14.2	15.8	19	22	25.8	28		27	1968	1997
Decile 9 maximum temperature (Degrees C) for years 1968 to 1997	42.2	41	38.5	34	28.4	23.1	23.2	26.7	31.4	35.9	38.3	40.5		27	1968	1997
Mean number of days >= 30 Degrees C for years 1968 to 1997	25.8	21.1	20.6	10.6	1.5	0	0	0.2	4.7	12.6	19.2	24.4	140.7	26	1968	1997
Mean number of days >= 35 Degrees C for years 1968 to 1997	17.3	13	10.2	1.7	0.1	0	0	0	0.2	4.1	8.2	15.8	70.6	26	1968	1997
Mean number of days >= 40 Degrees C for years 1968 to 1997	7	4.3	1.5	0	0	0	0	0	0	0.3	1.4	4	18.5	26	1968	1997
Mean minimum temperature (Degrees C) for years 1968 to 1997	20.6	19.8	18	13.7	8.9	5.7	4.2	5.9	9.1	12.8	16.2	19.1	12.8	27	1968	1997
Lowest temperature (Degrees C) for years 1968 to 1997	10.5	11.7	9.5	0.9	-1.9	-4.3	-4.8	-4	-0.5	2.9	2	6.8	-4.8	27	1968	1997
Date of Lowest temperature for years 1968 to 1997	31-Jan-97	22-Feb-72	26-Mar-84	21-Apr-92	23-May-75	23-Jun-81	12-Jul-69	3-Aug-75	3-Sep-92	2-Oct-68	21-Nov-92	7-Dec-92	12-Jul-69	N/A	1968	1997
Highest minimum temperature (Degrees C) for years 1968 to 1997	31	29.1	28	24.4	20.9	18.8	15.1	16.2	22.8	23.4	28.5	29.5	31	27	1968	1997
Date of Highest minimum temperature for years 1968 to 1997	9-Jan-80	1-Feb-79	8-Mar-90	8-Apr-69	4-May-90	2-Jun-88	30-Jul-96	18-Aug-75	15-Sep-81	31-Oct-88	28-Nov-79	9-Dec-77	9-Jan-80	N/A	1968	1997
Decile 1 minimum temperature (Degrees C) for years 1968 to 1997	16	15.4	13.6	9	4.2	1.1	-0.2	1.4	4.6	8	11.6	14.2		27	1968	1997
Decile 9 minimum temperature (Degrees C) for years 1968 to 1997	25.6	24.7	22.4	18	14.5	11	9.8	10.5	14	17.8	21.3	23.6		27	1968	1997
Mean number of days <= 2 Degrees C for years 1968 to 1997	0	0	0	0	1	5	9.6	4.5	0.3	0	0	0	20.4	27	1968	1997
Mean number of days <= 0 Degrees C for years 1968 to 1997	0	0	0	0	0.2	1.4	3.8	1.2	0.1	0	0	0	6.7	27	1968	1997
Mean daily ground minimum temperature Degrees C for years 1968 to 1994	19.6	18.8	16.8	12.1	7.5	4.2	2.7	4.4	7.6	11.2	14.7	17.9	11.5	23	1968	1994
Lowest ground temperature Degrees C for years 1968 to 1994	10.6	4.8	7.6	-1.6	-3.5	-5.7	-6.4	-5.3	-1.6	1	0.5	6.3	-6.4	23	1968	1994
Date of Lowest ground temperature for years 1968 to 1994	27-Jan-80	9-Feb-71	25-Mar-76	8-Apr-72	23-May-75	18-Jun-74	12-Jul-69	3-Aug-75	4-Sep-70	2-Oct-86	9-Nov-92	7-Dec-92	12-Jul-69	N/A	1968	1994
Mean number of days ground min. temp. <= -1 Degrees C for years 1968 to 1994	0	0	0	0	0.6	2.2	4.9	1.7	0.1	0	0	0	9.5	23	1968	1994
Mean rainfall (mm) for years 1967 to 1998	19.6	35.2	19.5	22.8	24.6	20.9	16	14.8	10.1	11.6	13	19.8	228.8	24	1967	1998
Highest rainfall (mm) for years 1967 to 1998	134.6	299.6	104.2	139	60	71.9	64.8	47	63.2	56.6	38.6	75.2	576.8	29	1967	1998
Date of Highest rainfall for years 1967 to 1998	1973	1980	1992	1992	1988	1968	1974	1978	1979	1976	1975	1984	1992	N/A	1967	1998
Lowest rainfall (mm) for years 1967 to 1998	0	0	0	0	0	0	0	0	0	0	0	0	78.7	29	1967	1998
Date of Lowest rainfall for years 1967 to 1998	1972	1998	1978	1994	1994	1984	1992	1995	1989	1995	1990	1985	1977	N/A	1967	1998
Decile 1 monthly rainfall (mm) for years 1967 to 1998	0.2	0.2	0.8	0	0	1.7	0.1	0.2	0.2	0	2	1.3	121.1	29	1967	1998
Decile 5 (median) monthly rainfall (mm) for years 1967 to 1998	7.5	21.8	6.8	8.5	23.3	14.7	9.8	8.6	5.4	6.1	9.8	9.6	201.9	29	1967	1998
Decile 9 monthly rainfall (mm) for years 1967 to 1998	50.2	70.5	57.6	58.6	52.9	56.2	38.3	39.7	23	33.6	31.8	44.6	301.6	29	1967	1998
Highest daily rainfall (mm) for years 1967 to 1998	81.3	125.8	44.4	39.9	36.2	31.6	39.4	24.2	37.4	38.2	21.8	31.2	125.8	29	1967	1998
Date of Highest daily rainfall for years 1967 to 1998	26-Jan-73	4-Feb-80	20-Mar-92	17-Apr-70	3-May-88	14-Jun-91	28-Jul-74	1-Aug-78	21-Sep-79	1-Oct-92	30-Nov-89	28-Dec-82	4-Feb-80	N/A	1967	1998
Mean number of days of rain for years 1967 to 1998	3.1	3.7	3.9	4.4	4.4	4.9	4.7	3.7	3	2.8	3.5	4.8	46.9	29	1967	1998
Mean number of days of rain >= 1 mm for years 1967 to 1998	1.9	2.5	2.7	2.5	3.2	3.1	2.8	2.4	1.8	1.7	2.1	3	29.7	29	1967	1998
Mean number of days of rain >= 10 mm for years 1967 to 1998	0.4	0.9	0.6	0.7	0.8	0.6	0.3	0.3	0.2	0.3	0.3	0.5	5.9	29	1967	1998
Mean number of days of rain >= 25 mm for years 1967 to 1998	0.3	0.3	0.1	0.2	0.1	0.1	0.1	0	0	0.1	0	0.1	1.4	29	1967	1998
Mean daily wind run (km) for years null to null																
Maximum wind gust speed (km/h) for years null to null																
Date of Maximum wind gust speed for years null to null														N/A		
Mean daily sunshine (hours) for years null to null																
Mean daily solar exposure (MJ/(m*m)) for years 1990 to 2021	26.7	24.3	21	17	13.8	12.1	13.2	16.8	21.1	24.8	27	27.9	20.5	32	1990	2021
Mean number of clear days for years 1968 to 1997	13.9	12.3	13.1	11.6	12	12.9	15	16.8	17.2	15.8	13.1	13.4	167.1	27	1968	1997
Mean number of cloudy days for years 1968 to 1997	5	6.4	6.8	7.3	8.1	8.2	7.1	5.6	4.1	4.7	6.2	6.3	75.8	27	1968	1997
Mean daily evaporation (mm) for years 1968 to 1997	14	12.1	10.1	7.1	4.4	3.2	3.2	4.3	6.8	9.3	11.5	13.1	8.3	24	1968	1997
Mean 9am temperature (Degrees C) for years 1968 to 1997	27.3	25.8	24.3	20.6	15.8	12.6	11.9	13.9	17.8	21.5	24.3	26.4	20.2	27	1968	1997
Mean 9am wet bulb temperature (Degrees C) for years 1968 to 1997	17.1	17.4	16.2	14	11.3	9.2	8.2	9.2	11.1	13	14.8	16.5	13.2	24	1968	1997
Mean 9am dew point temperature (Degrees C) for years 1968 to 1997	8.4	10.9	9.2	7.8	6.1	5	3.5	3.2	3.3	3.8	5.8	7.9	6.2	23	1968	1997
Mean 9am relative humidity (%) for years 1968 to 1997	35	46	43	48	56	63	60	52	42	36	35	35	46	23	1968	1997
Mean 9am cloud cover (okas) for years 1968 to 1997	2.8	3	3	3.3	3.5	3.4	2.8	2.5	2.2	2.3	2.7	2.7	2.8	27	1968	1997
Mean 9am wind speed (km/h) for years 1968 to 1997	16.2	16.2	13.9	12.5	10.5	8.8	9.8	12.4	14.2	15.5	15.5	14.9	13.4	26	1968	1997
Mean 3pm temperature (Degrees C) for years 1968 to 1997	34.7	33.1	31.1	26.6	21.4	18.1	17.9	19.9	23.9	27.7	30.6	33.3	26.5	27	1968	1997
Mean 3pm wet bulb temperature (Degrees C) for years 1968 to 1997	19.2	19.5	18.1	16	13.3	11.4	10.7	11.4	13.2	14.9	16.6	18.4	15.2	24	1968	1997
Mean 3pm dew point temperature (Degrees C) for years 1968 to 1997	6	9.1	7.3	6.3	4.7	3.6	1.8	1.1	1	1.2	3.4	5.7	4.3	23	1968	1997
Mean 3pm relative humidity (%) for years 1968 to 1997	20	28	27	32	37	42	38	32	25	22	21	21	29	23	1968	1997
Mean 3pm cloud cover (oktas) for years 1968 to 1997	3.2	3.6	3.4	3.5	3.7	3.5	2.9	2.6	2.5	2.9	3.3	3.4	3.2	27	1968	1997
Mean 3pm wind speed (km/h) for years 1968 to 1997	13.2	12.8	11.8	10.4	10.2	10.2	12	12.8	13.4	14.4	13.6	13	12.3	25	1968	1997

Monthly Climate Statistics for 'KALGOORLIE-BOULDER AIRPORT' [012038]

Created on [07 Jul 2021 14:27:43 GMT+00:00]

012038 KALGOORLIE-BOULDER AIRPORT

Commenced: 1939

Last Record: 2021

Latitude: 30.78 Degrees South

Longitude: 121.45 Degrees East

Elevation: 365 m

State: WA

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual	Number of Years	Start Year	End Year
Mean maximum temperature (Degrees C) for years 1939 to 2021	33.6	32.1	29.5	25.3	20.7	17.6	16.8	18.7	22.4	26	29.1	32.1	25.3	80	1939	2021
Highest temperature (Degrees C) for years 1939 to 2021	46.5	45.3	44.5	40.1	33.4	27.6	28.7	32	36.8	40.9	44.7	45	46.5	80	1939	2021
Date of Highest temperature for years 1939 to 2021	22-Jan-90	28-Feb-19	10-Mar-73	11-Apr-19	2-May-02	15-Jun-47	30-Jul-01	30-Aug-06	28-Sep-80	16-Oct-95	17-Nov-19	31-Dec-72	22-Jan-90	N/A	1939	2021
Lowest maximum temperature (Degrees C) for years 1939 to 2021	14.4	15	14.1	12.8	10.5	9.6	7.2	8.9	10.2	11.6	13.9	14.3	7.2	80	1939	2021
Date of Lowest maximum temperature for years 1939 to 2021	22-Jan-67	19-Feb-08	19-Mar-84	21-Apr-66	25-May-77	19-Jun-68	19-Jul-61	1-Aug-45	13-Sep-55	9-Oct-43	1-Nov-39	12-Dec-68	19-Jul-61	N/A	1939	2021
Decile 1 maximum temperature (Degrees C) for years 1939 to 2021	27.2	25.2	22.8	19.6	16	13.8	13	14.3	16.9	19.6	22.7	25.7		79	1939	2021
Decile 9 maximum temperature (Degrees C) for years 1939 to 2021	40.4	39.4	36.5	31.8	26	21.7	21	24	28.3	33	36	38.7		79	1939	2021
Mean number of days >= 30 Degrees C for years 1939 to 2021	23.3	17.9	13.9	5.4	0.4	0	0	0.1	1.8	7.2	12.8	20.5	103.3	80	1939	2021
Mean number of days >= 35 Degrees C for years 1939 to 2021	12.5	8.8	5	0.6	0	0	0	0	0.1	1.5	4.4	8.8	41.7	80	1939	2021
Mean number of days >= 40 Degrees C for years 1939 to 2021	3.6	2.3	0.6	0	0	0	0	0	0	0.1	0.5	2	9.1	80	1939	2021
Mean minimum temperature (Degrees C) for years 1939 to 2021	18.3	17.9	16.1	12.8	8.7	6.3	5.1	5.7	8.1	11.3	14.2	16.7	11.8	80	1939	2021
Lowest temperature (Degrees C) for years 1939 to 2021	8.8	8.5	5.7	1.7	-1.8	-3	-3.4	-2.4	-0.6	-1	3.1	5.5	-3.4	80	1939	2021
Date of Lowest temperature for years 1939 to 2021	31-Jan-90	16-Feb-90	24-Mar-01	26-Apr-60	31-May-64	23-Jun-81	12-Jul-69	9-Aug-68	2-Sep-56	4-Oct-42	9-Nov-92	2-Dec-73	12-Jul-69	N/A	1939	2021
Highest minimum temperature (Degrees C) for years 1939 to 2021	30.4	30.8	27.6	24.7	22.8	16.3	15.8	17.4	22	25.7	26.6	29.4	30.8	80	1939	2021
Date of Highest minimum temperature for years 1939 to 2021	24-Jan-94	24-Feb-91	6-Mar-90	1-Apr-89	3-May-47	5-Jun-57	30-Jul-16	28-Aug-50	28-Sep-44	28-Oct-09	27-Nov-17	7-Dec-19	24-Feb-91	N/A	1939	2021
Decile 1 minimum temperature (Degrees C) for years 1939 to 2021	14.1	13.8	11.8	7.9	4	1.7	0.7	1.4	3.7	6.4	9.8	12.3		80	1939	2021
Decile 9 minimum temperature (Degrees C) for years 1939 to 2021	23.1	22.5	20.4	17.2	13.5	10.8	9.4	10.4	12.6	15.9	19	21.7		80	1939	2021
Mean number of days <= 2 Degrees C for years 1939 to 2021	0	0	0	0	0.7	3.8	6.2	4.5	0.8	0.1	0	0	16.1	80	1939	2021
Mean number of days <= 0 Degrees C for years 1939 to 2021	0	0	0	0	0.1	0.7	1.8	1	0.1	0	0	0	3.7	80	1939	2021
Mean daily ground minimum temperature Degrees C for years 1965 to 2016	17	16.8	14.6	11	6.8	4	2.9	3.2	5.8	9.4	12.8	15.4	10	50	1965	2016
Lowest ground temperature Degrees C for years 1965 to 2016	7.7	4.6	2.3	-0.5	-3.7	-5.9	-8.3	-6.6	-4.9	-2.9	-0.9	2.8	-8.3	50	1965	2016
Date of Lowest ground temperature for years 1965 to 2016	31-Jan-90	23-Feb-67	26-Mar-72	30-Apr-00	28-May-72	19-Jun-66	13-Jul-69	7-Aug-66	4-Sep-70	2-Oct-66	1-Nov-68	2-Dec-73	13-Jul-69	N/A	1965	2016
Mean number of days ground min. temp. <= -1 Degrees C for years 1965 to 2016	0	0	0	0	0.5	2.4	5.2	4	0.8	0.1	0	0	13	50	1965	2016
Mean rainfall (mm) for years 1939 to 2021	27.2	32.4	25	20	24.8	27.1	24.1	21.2	13.5	15.7	18.9	16.3	264.9	80	1939	2021
Highest rainfall (mm) for years 1939 to 2021	185.9	307.8	197	98.6	110.2	185.7	82.6	74	98.3	84.4	115.4	88.6	530.8	82	1939	2021
Date of Highest rainfall for years 1939 to 2021	1967	1948	1999	1961	1963	1968	1960	1992	1955	1982	1981	1988	1992	N/A	1939	2021
Lowest rainfall (mm) for years 1939 to 2021	0	0	0	0	0	1.4	0.6	1.6	0	0	0	0	108.7	82	1939	2021
Date of Lowest rainfall for years 1939 to 2021	1977	1998	2019	2001	1948	2008	1994	1989	2020	1979	1994	1964	1940	N/A	1939	2021
Decile 1 monthly rainfall (mm) for years 1939 to 2021	0.6	1.3	0.6	1.2	2.4	5.3	5.4	4.2	0.8	1.1	0.5	1.3	150	82	1939	2021
Decile 5 (median) monthly rainfall (mm) for years 1939 to 2021	11	14.6	10.2	12.6	18.8	18.8	20	16	10.4	9.9	15.4	11.8	249.7	82	1939	2021
Decile 9 monthly rainfall (mm) for years 1939 to 2021	81.4	80.5	67.8	54.5	47.1	54.4	49	43.6	29.4	33.8	40.3	39.8	392.2	82	1939	2021
Highest daily rainfall (mm) for years 1939 to 2021	154.4	177.8	70	49.8	45.2	57.2	28.6	49.6	44.2	45.6	77	50.6	177.8	82	1939	2021
Date of Highest daily rainfall for years 1939 to 2021	23-Jan-67	22-Feb-48	2-Mar-74	16-Apr-61	24-May-80	6-Jun-57	26-Jul-85	11-Aug-94	13-Sep-54	4-Oct-82	6-Nov-81	13-Dec-16	22-Feb-48	N/A	1939	2021
Mean number of days of rain for years 1939 to 2021	4.1	4.6	4.4	5.2	6.8	8.5	9	7.7	5.3	4.4	4.2	3.9	68.1	82	1939	2021
Mean number of days of rain >= 1 mm for years 1939 to 2021	2.5	3.1	2.7	3.2	3.9	4.7	4.7	4	2.8	2.7	2.6	2.5	39.4	82	1939	2021
Mean number of days of rain >= 10 mm for years 1939 to 2021	0.7	0.9	0.7	0.6	0.7	0.7	0.6	0.5	0.3	0.4	0.5	0.5	7.1	82	1939	2021
Mean number of days of rain >= 25 mm for years 1939 to 2021	0.2	0.3	0.3	0.1	0.1	0.1	0	0.1	0	0.1	0.1	0	1.4	82	1939	2021
Mean daily wind run (km) for years 1994 to 2021	425	403	361	294	263	269	282	299	341	377	398	412	344	25	1994	2021
Maximum wind gust speed (km/h) for years 1939 to 2021	141	118	118	104	122	102	97	108	109	117	139	122	141	80	1939	2021
Date of Maximum wind gust speed for years 1939 to 2021	14-Jan-94	16-Feb-70	28-Mar-71	24-Apr-73	5-May-75	4-Jun-74	30-Jul-48	12-Aug-64	13-Sep-65	3-Oct-50	7-Nov-79	10-Dec-46	14-Jan-94	N/A	1939	2021
Mean daily sunshine (hours) for years null to null																
Mean daily solar exposure (MJ/(m*m)) for years 1990 to 2021	27.5	24	20.3	15.9	12.1	10.4	11.3	14.7	19.1	23.8	26.7	28.4	19.5	32	1990	2021
Mean number of clear days for years 1939 to 2010	15.7	13.1	13.4	10.2	10.3	9.1	10.1	12.8	14.1	13.9	12.9	15.5	151.1	72	1939	2010
Mean number of cloudy days for years 1939 to 2010	5.6	6.3	6.9	9.2	10.2	10.4	9.7	7	6.2	5.9	6.5	5.3	89.2	72	1939	2010
Mean daily evaporation (mm) for years 1966 to 2016	12.5	10.8	8.6	5.8	3.6	2.6	2.8	3.8	5.8	8.4	10.3	12	7.2	50	1966	2016
Mean 9am temperature (Degrees C) for years 1939 to 2010	23.8	22.8	21	17.9	13.9	11	9.9	11.6	14.8	17.9	20.6	22.7	17.3	72	1939	2010
Mean 9am wet bulb temperature (Degrees C) for years 1939 to 2010	16.4	16.4	15.4	13.4	10.8	8.7	7.7	8.6	10.3	12	13.8	15.4	12.4	71	1939	2010
Mean 9am dew point temperature (Degrees C) for years 1939 to 2010	10	11.2	10.4	9.2	7.4	6	4.9	4.6	4.9	5.5	6.9	8.6	7.5	65	1939	2010
Mean 9am relative humidity (%) for years 1939 to 2010	45	51	54	60	67	74	73	65	54	47	45	43	57	65	1939	2010
Mean 9am cloud cover (okas) for years 1939 to 2010	2.8	3.2	3.4	3.8	3.8	3.8	3.7	3.1	2.9	3	3.1	2.7	3.3	72	1939	2010
Mean 9am wind speed (km/h) for years 1939 to 2010	16.6	16.4	15.7	14.4	11.8	11.8	12.4	14.3	16.2	17.1	17.1	16.3	15	72	1939	2010
Mean 3pm temperature (Degrees C) for years 1939 to 2010	32.3	30.9	28.6	24.3	19.9	16.8	16	17.8	21.3	24.7	27.8	30.7	24.3	72	1939	2010
Mean 3pm wet bulb temperature (Degrees C) for years 1939 to 2010	18.8	18.9	17.8	15.6	13.1	11.2	10.4	10.9	12.5	14.1	15.9	17.7	14.7	71	1939	2010
Mean 3pm dew point temperature (Degrees C) for years 1939 to 2010	7.2	9	8.4	7.5	6	4.9	3.5	2.4	2	2.3	3.8	5.8	5.2	65	1939	2010
Mean 3pm relative humidity (%) for years 1939 to 2010	24	30	32	38	44	48	46	39	31	27	25	24	34	65	1939	2010
Mean 3pm cloud cover (oktas) for years 1939 to 2010	2.8	3	3.1	3.8	4	4.3	4.1	3.5	3	3.1	3.3	2.8	3.4	72	1939	2010
Mean 3pm wind speed (km/h) for years 1939 to 2010	15.1	15.1	14.2	13.7	14.1	15.7	16.6	17.2	17.8	17.6	17.2	16	15.9	72	1939	2010

APPENDIX B

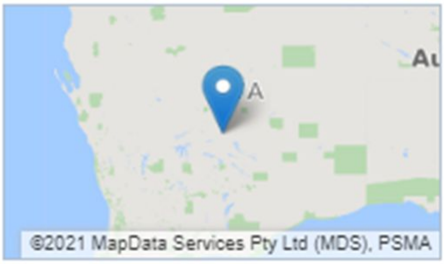
Point Rainfall Intensity Frequency Duration Relationship

Location

Label: REDCLIFFE GOLD PROJECT

Latitude: -28.4772 [Nearest grid cell: 28.4875 (S)]

Longitude: 121.5544 [Nearest grid cell: 121.5625 (E)]



IFD Design Rainfall Intensity (mm/h)

Issued: 09 July 2021

Rainfall intensity for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

Table | Chart

Unit: mm/h

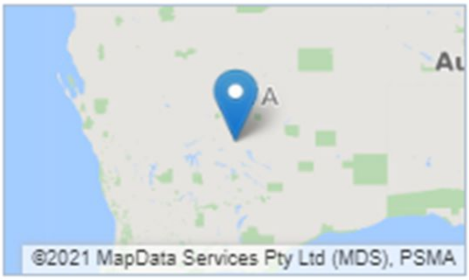
	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 min	65.5	78.9	125	161	200	258	307
2 min	54.6	65.4	104	136	170	224	272
3 min	50.0	60.0	95.6	124	155	203	245
4 min	46.6	55.9	89.0	115	143	186	224
5 min	43.6	52.5	83.5	108	134	173	207
6 min	41.1	49.4	78.6	101	126	162	193
10 min	33.4	40.3	64.1	82.3	102	131	155
15 min	27.3	33.0	52.4	67.2	83.2	107	126
20 min	23.2	28.0	44.5	57.2	70.8	90.9	108
25 min	20.3	24.5	38.9	50.0	62.0	79.7	94.7
30 min	18.1	21.8	34.7	44.6	55.3	71.2	84.9
45 min	13.9	16.7	26.5	34.1	42.4	54.8	65.6
1 hour	11.4	13.7	21.7	28.0	34.9	45.2	54.2
1.5 hour	8.65	10.3	16.3	21.1	26.3	34.1	41.0
2 hour	7.09	8.47	13.4	17.2	21.4	27.8	33.4
3 hour	5.38	6.41	10.1	13.0	16.1	20.9	25.0
4.5 hour	4.10	4.89	7.65	9.81	12.2	15.7	18.7
6 hour	3.39	4.05	6.32	8.08	10.0	12.8	15.3
9 hour	2.61	3.11	4.85	6.18	7.62	9.73	11.5
12 hour	2.16	2.58	4.02	5.12	6.30	8.01	9.45
18 hour	1.65	1.98	3.09	3.93	4.82	6.11	7.19
24 hour	1.35	1.62	2.55	3.24	3.98	5.05	5.94
30 hour	1.15	1.39	2.19	2.78	3.42	4.35	5.12
36 hour	1.01	1.22	1.92	2.45	3.01	3.84	4.54
48 hour	0.809	0.977	1.55	1.99	2.45	3.14	3.73
72 hour	0.578	0.701	1.12	1.45	1.79	2.33	2.79
96 hour	0.448	0.544	0.877	1.13	1.41	1.85	2.23
120 hour	0.363	0.442	0.715	0.927	1.16	1.53	1.85
144 hour	0.304	0.371	0.600	0.779	0.975	1.29	1.56
168 hour	0.261	0.318	0.514	0.668	0.837	1.11	1.34

Location

Label: REDCLIFFE GOLD PROJECT

Latitude: -28.4772 [Nearest grid cell: 28.4875 (S)]

Longitude: 121.5544 [Nearest grid cell: 121.5625 (E)]



IFD Design Rainfall Intensity (mm/h)

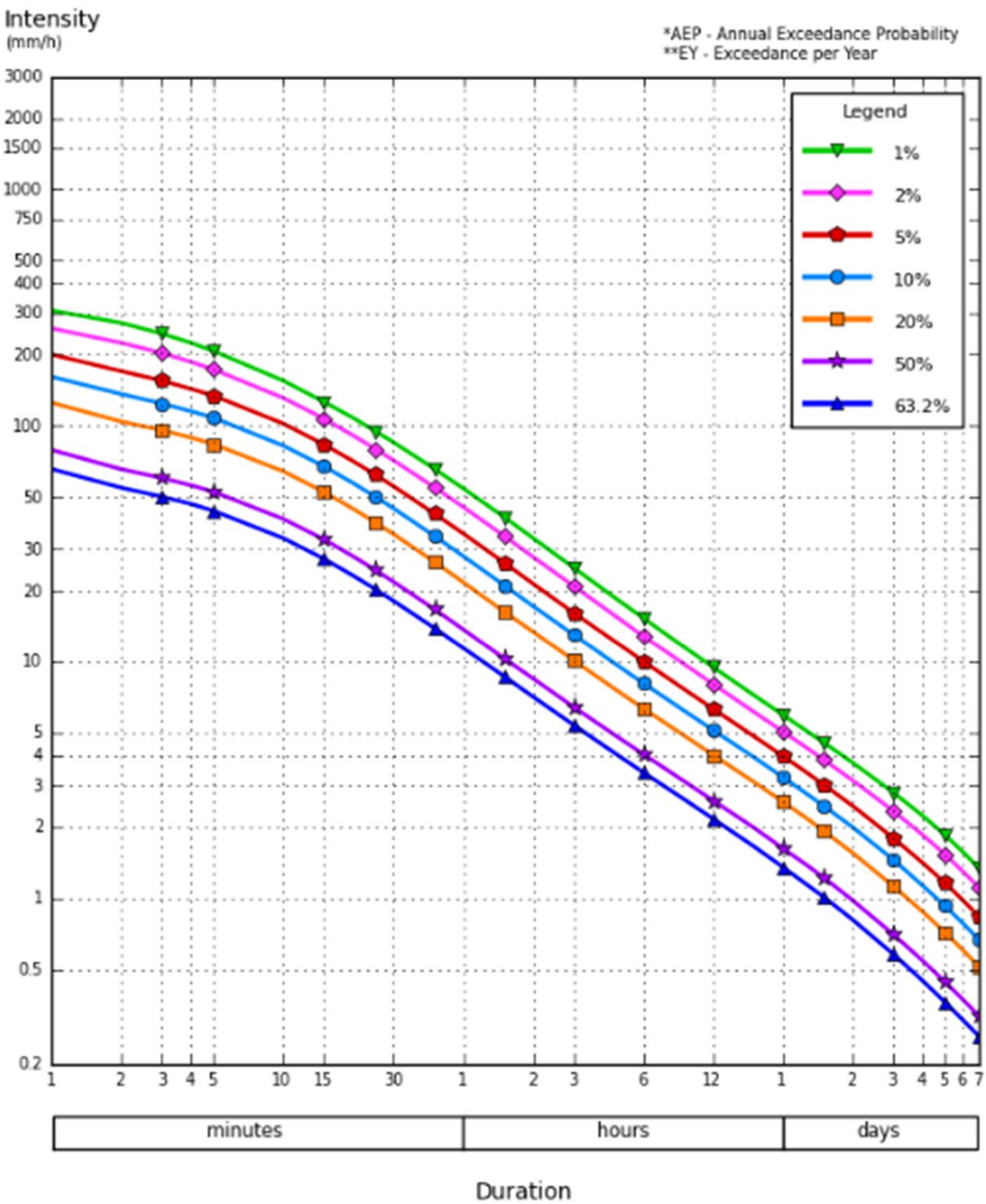
Issued: 09 July 2021

Rainfall intensity for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).

FAQ for New ARR probability terminology

Table | Chart

Unit: mm/h



GROUNDWATER RESOURCE MANAGEMENT

APPENDIX B2
REDCLIFFE GOLD PROJECT
POINT RAINFALL INTENSITY
FREQUENCY DURATION CHART

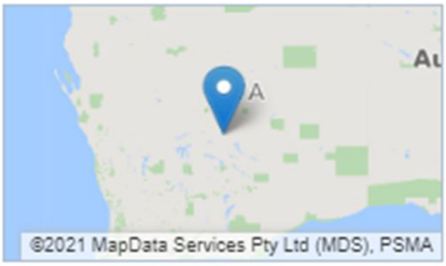
Date July 21
Client Dacian Gold Ltd
Project Redcliffe Gold Project
Document J2126R01

Location

Label: REDCLIFFE GOLD PROJECT

Latitude: -28.4772 [Nearest grid cell: 28.4875 (S)]

Longitude: 121.5544 [Nearest grid cell: 121.5625 (E)]



IFD Design Rainfall Depth (mm)

Issued: 09 July 2021

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

Table | Chart

Unit: mm

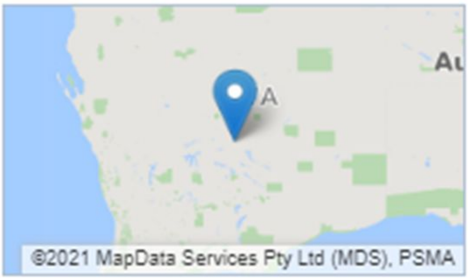
	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 min	1.09	1.32	2.09	2.69	3.34	4.29	5.11
2 min	1.82	2.18	3.48	4.52	5.67	7.46	9.07
3 min	2.50	3.00	4.78	6.19	7.75	10.1	12.3
4 min	3.10	3.73	5.93	7.66	9.56	12.4	14.9
5 min	3.64	4.37	6.96	8.96	11.2	14.4	17.3
6 min	4.11	4.94	7.86	10.1	12.6	16.2	19.3
10 min	5.57	6.72	10.7	13.7	17.0	21.8	25.8
15 min	6.83	8.24	13.1	16.8	20.8	26.6	31.6
20 min	7.75	9.34	14.8	19.1	23.6	30.3	35.9
25 min	8.47	10.2	16.2	20.8	25.8	33.2	39.5
30 min	9.07	10.9	17.3	22.3	27.7	35.6	42.4
45 min	10.4	12.5	19.9	25.6	31.8	41.1	49.2
1 hour	11.4	13.7	21.7	28.0	34.9	45.2	54.2
1.5 hour	13.0	15.5	24.5	31.6	39.4	51.1	61.4
2 hour	14.2	16.9	26.7	34.4	42.9	55.7	66.9
3 hour	16.1	19.2	30.2	38.9	48.4	62.6	75.1
4.5 hour	18.5	22.0	34.4	44.1	54.8	70.6	84.3
6 hour	20.4	24.3	37.9	48.5	60.0	77.1	91.7
9 hour	23.5	28.0	43.6	55.6	68.6	87.6	104
12 hour	25.9	31.0	48.3	61.4	75.6	96.2	113
18 hour	29.7	35.6	55.6	70.7	86.7	110	129
24 hour	32.5	39.0	61.1	77.8	95.5	121	143
30 hour	34.6	41.7	65.6	83.5	103	130	154
36 hour	36.3	43.8	69.1	88.2	108	138	163
48 hour	38.8	46.9	74.5	95.4	118	151	179
72 hour	41.6	50.4	81.0	104	129	168	201
96 hour	43.0	52.2	84.2	109	136	178	214
120 hour	43.6	53.0	85.8	111	139	183	222
144 hour	43.8	53.4	86.4	112	140	185	225
168 hour	43.9	53.5	86.4	112	141	186	225

Location

Label: REDCLIFFE GOLD PROJECT

Latitude: -28.4772 [Nearest grid cell: 28.4875 (S)]

Longitude: 121.5544 [Nearest grid cell: 121.5625 (E)]



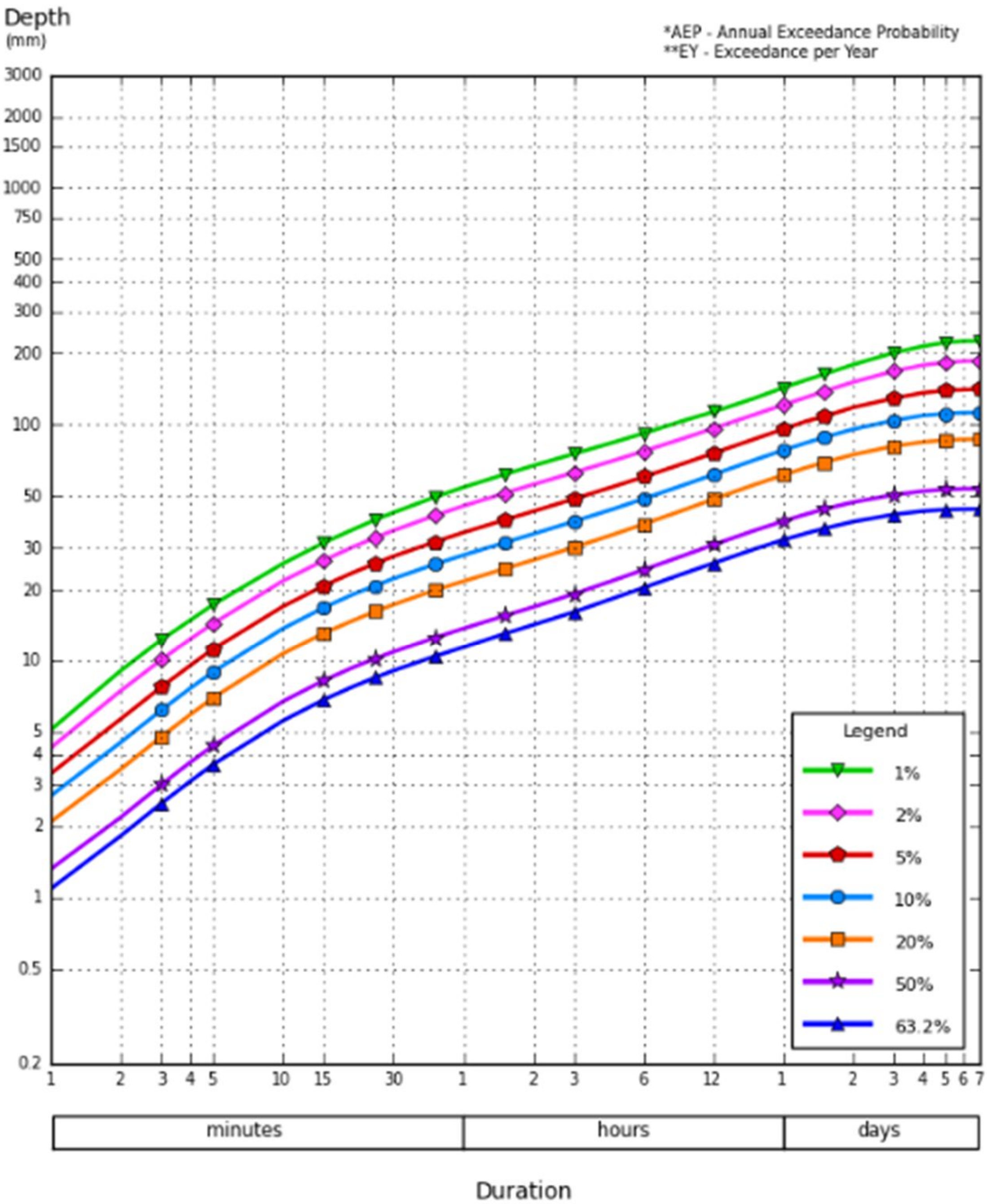
IFD Design Rainfall Depth (mm)

Issued: 09 July 2021

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
[FAQ for New ARR probability terminology]

Table | Chart

Unit: mm



Location

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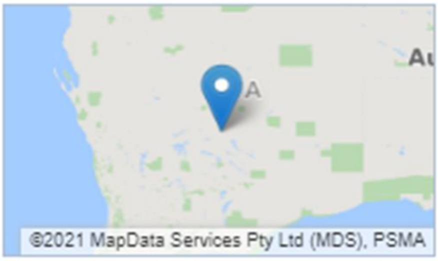


Rare Design Rainfall Intensity (mm/h)

Issued: 09 July 2021

Rainfall intensity for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

Table | Chart

Unit: mm/h

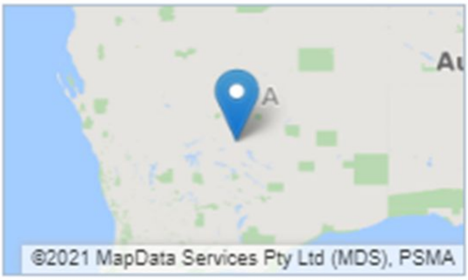
	Annual Exceedance Probability (1 in x)				
Duration	**1 in 100**	**1 in 200**	**1 in 500**	**1 in 1000**	**1 in 2000**
1 min	307	354	426	486	551
2 min	272	317	385	443	506
3 min	245	285	345	396	451
4 min	224	260	314	359	409
5 min	207	240	289	330	375
6 min	193	223	269	307	348
10 min	155	179	214	244	276
15 min	126	146	175	199	225
20 min	108	124	149	170	193
25 min	94.7	109	131	150	170
30 min	84.9	98.1	118	135	153
45 min	65.6	75.9	91.4	104	119
1 hour	54.2	62.7	75.6	86.4	98.2
1.5 hour	41.0	47.4	57.2	65.4	74.3
2 hour	33.4	38.7	46.7	53.3	60.5
3 hour	25.0	28.9	34.8	39.7	45.1
4.5 hour	18.7	21.6	25.9	29.6	33.5
6 hour	15.3	17.6	21.1	24.0	27.1
9 hour	11.5	13.2	15.8	18.0	20.3
12 hour	9.45	10.9	13.0	14.8	16.7
18 hour	7.19	8.28	9.93	11.3	12.8
24 hour	5.94	6.86	8.25	9.41	10.7
30 hour	5.12	5.92	7.11	8.10	9.21
36 hour	4.54	5.26	6.34	7.24	8.25
48 hour	3.73	4.36	5.31	6.11	7.00
72 hour	2.79	3.31	4.10	4.78	5.55
96 hour	2.23	2.67	3.34	3.93	4.60
120 hour	1.85	2.22	2.79	3.30	3.88
144 hour	1.56	1.88	2.37	2.81	3.32
168 hour	1.34	1.62	2.04	2.40	2.85

Location

Label: REDCLIFFE GOLD PROJECT

Latitude: -28.4772 [Nearest grid cell: 28.4875 (S)]

Longitude: 121.5544 [Nearest grid cell: 121.5625 (E)]



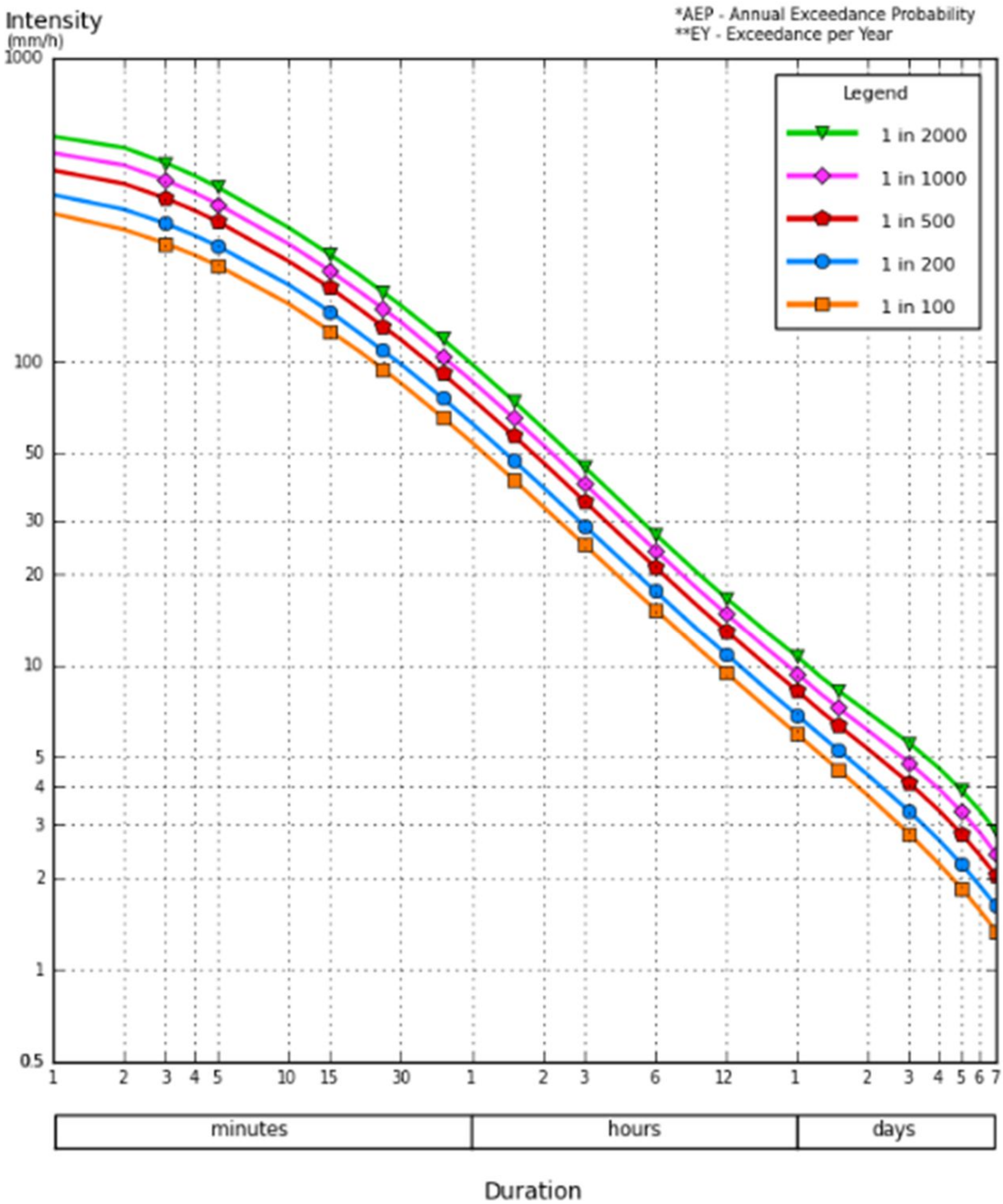
Rare Design Rainfall Intensity (mm/h)

Issued: 09 July 2021

Rainfall intensity for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

Table | Chart

Unit: mm/h



Location

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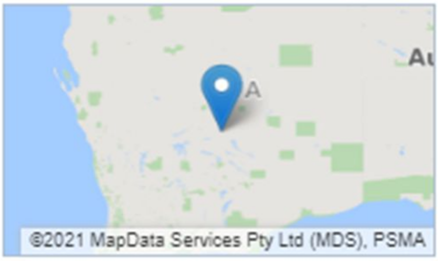

Rare Design Rainfall Depth (mm)

Issued: 09 July 2021

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

Table | Chart

Unit: mm

	Annual Exceedance Probability (1 in x)				
Duration	**1 in 100**	**1 in 200**	**1 in 500**	**1 in 1000**	**1 in 2000**
1 min	5.11	5.90	7.10	8.09	9.18
2 min	9.07	10.6	12.8	14.8	16.9
3 min	12.3	14.2	17.3	19.8	22.6
4 min	14.9	17.3	20.9	24.0	27.2
5 min	17.3	20.0	24.1	27.5	31.3
6 min	19.3	22.3	26.9	30.7	34.8
10 min	25.8	29.8	35.7	40.7	46.1
15 min	31.6	36.4	43.7	49.8	56.4
20 min	35.9	41.5	49.8	56.8	64.3
25 min	39.5	45.6	54.8	62.5	70.8
30 min	42.4	49.0	59.0	67.3	76.3
45 min	49.2	56.9	68.6	78.3	88.9
1 hour	54.2	62.7	75.6	86.4	98.2
1.5 hour	61.4	71.2	85.8	98.1	111
2 hour	66.9	77.4	93.3	107	121
3 hour	75.1	86.8	104	119	135
4.5 hour	84.3	97.2	117	133	151
6 hour	91.7	106	127	144	163
9 hour	104	119	143	162	183
12 hour	113	130	156	177	200
18 hour	129	149	179	203	230
24 hour	143	165	198	226	256
30 hour	154	177	213	243	276
36 hour	163	189	228	261	297
48 hour	179	209	255	293	336
72 hour	201	239	295	344	399
96 hour	214	256	321	377	441
120 hour	222	266	335	396	466
144 hour	225	271	341	404	478
168 hour	225	272	342	404	479

Location

Label: REDCLIFFE GOLD PROJECT

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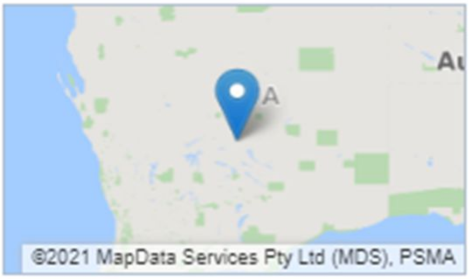


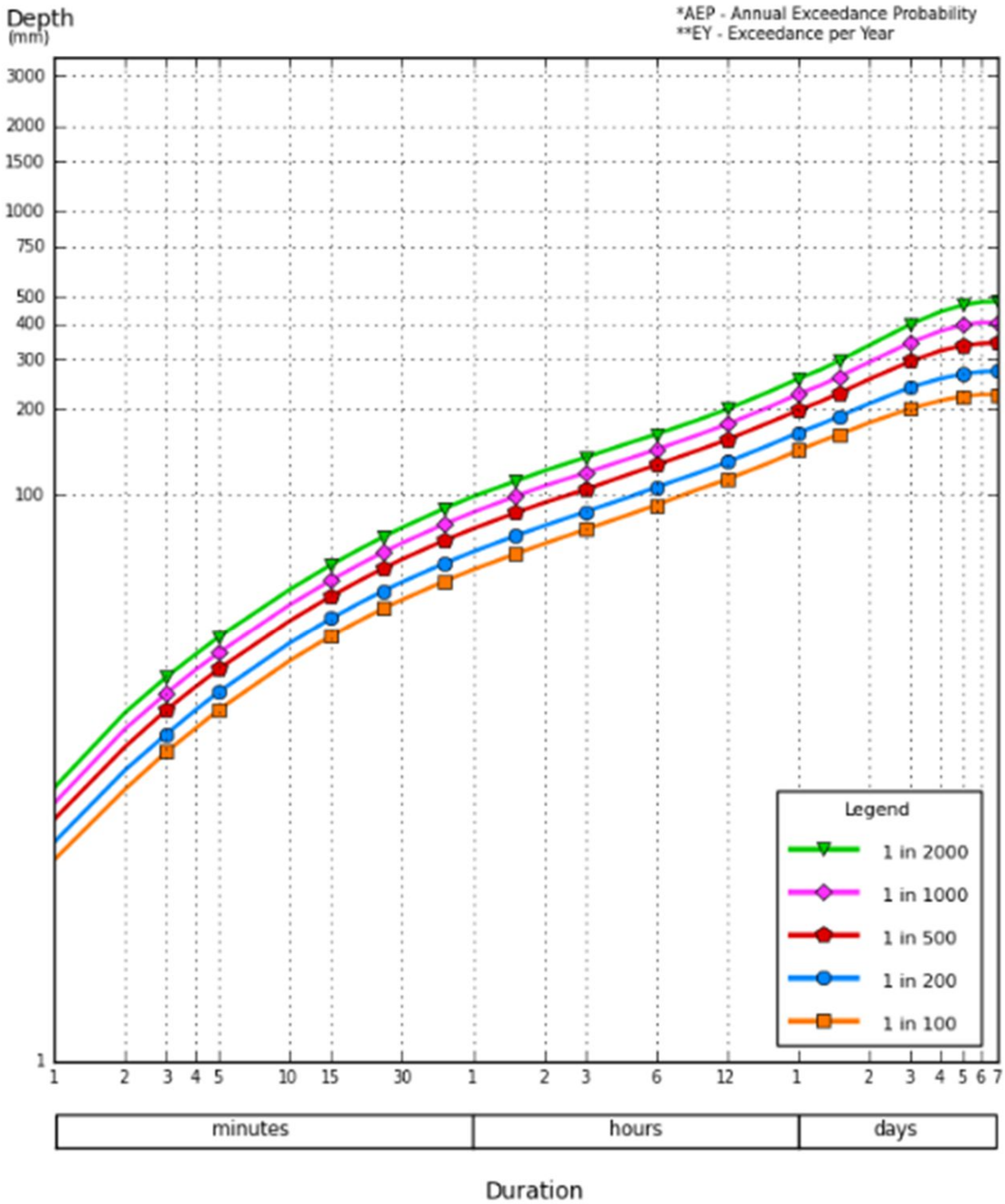
Rare Design Rainfall Depth (mm)

Issued: 09 July 2021

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).

FAQ for New ARR probability terminology

Table Chart Unit: mm



APPENDIX C

Probable Maximum Precipitation Estimate

APPENDIX C - MEMORANDUM

From: Alistair Lowry	Date: 12 July 2021	Project: J2126R01
To: Peter Dunstan	Company: Dacian Gold Ltd	
Re: Redcliffe Gold Project – Probable Maximum Precipitation Estimate		

INTRODUCTION

This memorandum has been prepared to support the ongoing Redcliffe Gold Project (RGP) Feasibility Study. An assessment of the Probable Maximum Precipitation (PMP) is typically required to identify potential impacts on the design of waste rock landforms and surface water management measures e.g. diversions, flood protection bunds, spillways etc. Pit hydrology modelling should also take PMP conditions into consideration post-closure.

The estimation of the PMP event for the RGP site has therefore been presented in the following sections. This memorandum builds on the hydro-meteorological information presented in the Hydro-Meteorological Study (GRM report J2126R01 *currently in preparation*). It is assumed that the reader is familiar with the content and findings of that report.

Background

At the outset it should be noted that the PMP has been defined by the World Meteorological Organisation as the "greatest depth of precipitation for a given duration, meteorologically possible for a given size storm area at a particular location at a particular time of year, with no allowance made for long-term climatic trends"[1]. It is a *conceptual event* based around the hypothesis that the rainfall results from the simultaneous occurrence of a storm of optimal efficiency together with maximum moisture availability which is approximated by assuming maximum moisture inflow to the storm.

As such, it can be thought of as an *upper limit **estimate*** of the rainfall depth that could occur in the future. The PMP is a key design rainfall input, along with spatial and temporal distributions and other factors, to the calculation of the probable maximum flood (PMF) which is often used as the design flood event for large dams and for other sensitive water management works and floodplain management studies.

A number of different methods have been used historically in Australia for PMP estimation including the in-situ maximisation of data recorded at a specific location and also storm transposition methods which allowed the displacement of a storm from the location where it occurred to a target location

[1] *"Manual for Estimation of Probable Maximum Precipitation"* Operational Hydrology Report No. 1, 2nd Edition (World Meteorological Organization, 1986).

assuming the storm could just as likely have occurred there. However since the mid 1970's generalised methods have been developed that allow rainfall from much wider geographical regions to be analysed and these are generally considered to be an improvement over the earlier transposition methods.

Successive revisions of these generalised methods have, in turn, brought progressively higher estimates of PMP depths for individual catchments as each revision has utilised a greater amount of data and better analytical techniques. Currently the Generalised Short Duration Method (GSDM[2], also known as the "Thunderstorm Method") is used to derive PMP estimates for durations less than six hours across all of Australia, while the Revised Generalised Tropical Storm Method (GTSMR[3]) is used for longer duration events and covers the majority of continental Australia affected by tropical storms. The Generalised Southeast Australia Method (GSAM) is used for longer-duration PMP estimates in south-east Australia[4].

Although, the WMO definition of PMP relates to the "theoretical" greatest rainfall depth of precipitation for a given duration that is physically possible, it is recognised that limitations in data and understanding of extreme meteorological conditions means that there is a finite probability, albeit small, of the PMP estimate being exceeded. In order to take into consideration the inability to accurately estimate the theoretical upper limit of rainfall, the term "*operational estimate of the PMP*" has been adopted[5]. This represents the best estimate of the PMP depth for a particular location that can currently be made using information obtained from observed large events and the generalised PMP methods. Therefore, it should be noted that the GSDM and GTSMR PMP estimates presented in this memorandum are the *operational estimates* of the PMP as opposed to the theoretical PMP. This distinction acknowledges the finite probability of occurrence of the PMP as discussed above.

The average recurrence interval (ARI) or annual exceedance probability (AEP) of the PMP is uncertain and results in much debate within the field of hydrology. However, it is considered to be an extremely rare event of at least 100,000 to 1 million year ARI (i.e. 0.001% to 0.0001% AEP). The PMF is considered to be an even more extreme event as it not only requires the PMP to occur, but also needs the most severe antecedent moisture and other hydrological conditions to prevail. Consequently the PMF is generally considered to be one or two orders of magnitude greater than the PMP (i.e. at least 1 million to 10 million year ARI or 0.0001% to 0.00001% AEP).

---

[2] "*The Estimation or Probable Precipitation in Australia: Generalised Short-Duration Method"* (BoM, 2003).
[3] *"Revision of the Generalised Tropical Storm Method for Estimating Probable Maximum Precipitation*", Hydrology Report Series No. 8, Hydrometeorological Advisory Service (BoM, 2003).
[4] "*Guidebook to the Estimation of Probable Maximum Precipitation: Generalised Southeast Australia Method"*, Hydrometeorological Advisory Service (BoM, 2006)
[5] "*PMP and Other Extreme Storms: Concepts and Probabilities*" (Schaefer, M.G., 1994).

PMP Estimation

The selection of the PMP estimation methods is summarised on the PMP Method Selection Worksheet (refer to Attachment 1). The RGP location within the "WA Transition Zone" means that the GSDM can be applied for events of up to three hours duration, while both the GTSMR Coastal/GSAM Inland methods should be applied for events of between 24 and 120 hour duration and the method generating the higher values adopted, as outlined below.

Generalised Short Duration Method (GSDM)

The upstream catchment areas reporting to the various mining areas at the RGP are relatively modest, with the largest (approximately 28.3 km^2) upstream of the Golden Terrace South (GTS) mining area. The GSDM has therefore been applied to this area in accordance with the published BoM method and accompanying datasets and is summarised in the GSDM Calculation Sheet (refer to Attachment 2). The key steps were as follows:

- *Selection of Terrain Category* – factors of 10% and 90% were applied to the RGP catchment falling within the "Rough" and "Smooth" categories respectively.
- *Adjustment for Catchment Elevation* – an Elevation Adjustment Factor (EAF) of 1.0 was adopted as the 500 mAHD mean elevation of the RGP is lower than 1,500 mAHD elevation above which the EAF requires adjustment.
- *Adjustment for Moisture* – the catchment average MAF of 0.78 was read directly from Figure 3 in the BoM text.
- *Initial PMP Rainfall Depth Estimates* – values for "Rough" and "Smooth" catchments for an area of 1 km^2 were read from the "Depth-Duration-Area Curves of Short Duration Rainfall" figure (refer to Attachment 3) to give initial rainfall depths for event durations of between 15 minutes (0.25 hours) and 3 hours.
- The initial PMP rainfall depth estimates were then multiplied by the EAF and MAF and rounded to the nearest 10 mm to yield the PMP depths summarised in Table 1.

Table 1: GSDM PMP Rainfall Depth Estimates

Duration (hours)	**0.25**	**0.5**	**0.75**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**
PMP Depth (mm)	150	220	280	340	390	440	470	500

Generalised Tropical Storm Method (GTSMR) - Coastal Zone

The GTSMR Coastal Zone method was applied for annual events in accordance with the published BoM method and accompanying datasets (referenced above) and is summarised in the GTSMR Calculation Sheet (refer to Attachment 4). The key steps were as follows:

- *Obtain Raw PMP Rainfall Depths* – were interpolated for the 28.3 km^2 GTS upstream catchment area using the depth-area data for the Coastal-Summer dataset for event durations of between 24 and 120 hours.
- *Adjustment for Moisture* – The MAF is the ratio of the extreme precipitable water at the catchment site ($EPW_{catchment}$) to the standard extreme precipitable water ($EPW_{standard}$) which

is 120.0 mm. The gridded EPW dataset was imported using GIS tools and an average $EPW_{catchment}$ value of 81.7 mm was obtained for the RGP, resulting in a MAF adjustment factor of 0.681.

- *Adjustment for Decay Amplitude* – the gridded decay amplitude factor (DAF) dataset was imported using GIS tools and a DAF factor of 0.74 was obtained.
- *Adjustment for Topography* – the gridded topographic adjustment factor (TAF) dataset was imported using GIS tools and a TAF factor of 1.05 was obtained.
- *Preliminary GTSMR PMP Rainfall Depths* – the raw depths for each standard duration were multiplied by the three catchment adjustment factors (i.e. PMP Estimate = Raw PMP depth × MAF × DAF × TAF) which were then rounded to the nearest 10 mm to yield the "Preliminary PMP Estimates" shown on the GTSMR calculation sheet. The GSDM values (estimated above) for event durations of between 1 and 3 hours were also added.
- *Final GTSMR PMP Rainfall Depths* – the PMP values were then graphically interpolated between the 3 hour GSDM and 24 hour GTSMR values.

The resulting combined GSDM and GTSMR depth estimates are summarised in Table 2.

Table 2: Combined GSDM & GTSMR PMP Rainfall Depth Estimates

Duration (hours)	**1**	**2**	**3**	**4**	**5**	**6**	**12**	**24**	**36**	**48**	**72**	**96**	**120**
PMP Depth (mm)	340	440	500	530	540	550	600	710	880	1020	1290	1450	1510

Generalised Southeast Australia Storm Method (GSAM) - Inland Zone

The GSAM Inland Zone method was applied in accordance with the published BoM method and accompanying datasets (referenced above) and is summarised in the GSAM Calculation Sheet (refer to Attachment 5). The key steps were as follows:

- *Obtain Raw PMP Rainfall Depths* – were interpolated for the assumed 28.3 km^2 GTS upstream catchment area using the depth-area data for the Inland dataset for event durations of between 24 and 96 hours.
- *Adjustment for Moisture* – The MAF is the ratio of the extreme precipitable water at the catchment site ($EPW_{catchment}$) to the standard extreme precipitable water ($EPW_{standard}$). The gridded EPW datasets were imported using GIS tools and average $EPW_{catchment}$ values of 81.7 and 60.7 mm were obtained for the RGP, resulting in MAF adjustment factors of 1.01 and 0.86 for Summer and Autumn events respectively. Given that the Autumn events were found to have higher rainfall depths, they were adopted for the PMP estimation.
- *Adjustment for Topography* – the gridded topographic adjustment factor (TAF) dataset was imported using GIS tools and a TAF factor of 1.04 was obtained.
- *Preliminary GSAM PMP Rainfall Depths* – the raw depths for each standard duration were multiplied by the two catchment adjustment factors (i.e. PMP Estimate = Raw PMP depth × MAF × TAF) which were then rounded to the nearest 10 mm to yield the "Preliminary PMP

Estimates" shown on the GSAM calculation sheet. The GSDM values (estimated above) for event durations of between 1 and 3 hours were also added.

- *Final GTSMR PMP Rainfall Depths* – the PMP values were then graphically interpolated between the 3 hour GSDM and 24 hour GTSMR values.

The resulting combined GSDM and GSAM depth estimates for durations between 1 and 96 hours are summarised in Table 3.

Table 3: Combined GSDM & GSAM PMP Rainfall Depth Estimates

Duration (hours)	**1**	**2**	**3**	**4**	**5**	**6**	**12**	**24**	**36**	**48**	**72**	**96**
PMP Depth (mm)	340	440	500	410	430	440	460	590	680	730	770	790

Comparison of GTSMR and GSAM Methods

Comparison of the resulting long duration PMP values i.e. PMP durations greater than 3 hours, shows that the GTSMR method reproduces significantly higher (more conservative) values and is therefore recommended for RGP design purposes.

The resulting GTSMR PMP depth estimates have been plotted along with the intensity-duration-frequency (IDF) and depth-duration-frequency (DDF) data developed previously for the RGP using the recently updated BoM 2016 dataset and shown in Figure 1 and 2 on the following pages.

Inspection of Figures 1 and 2 clearly demonstrates the extreme nature of the PMP event with rainfall intensities and depths, on average, some five to six times greater than the corresponding values for the 1% AEP event.

Figure 1: PMP Rainfall Intensity Estimates and Redcliffe Gold Project Rainfall Intensity-Duration-Frequency Relationship (BoM, 2016)

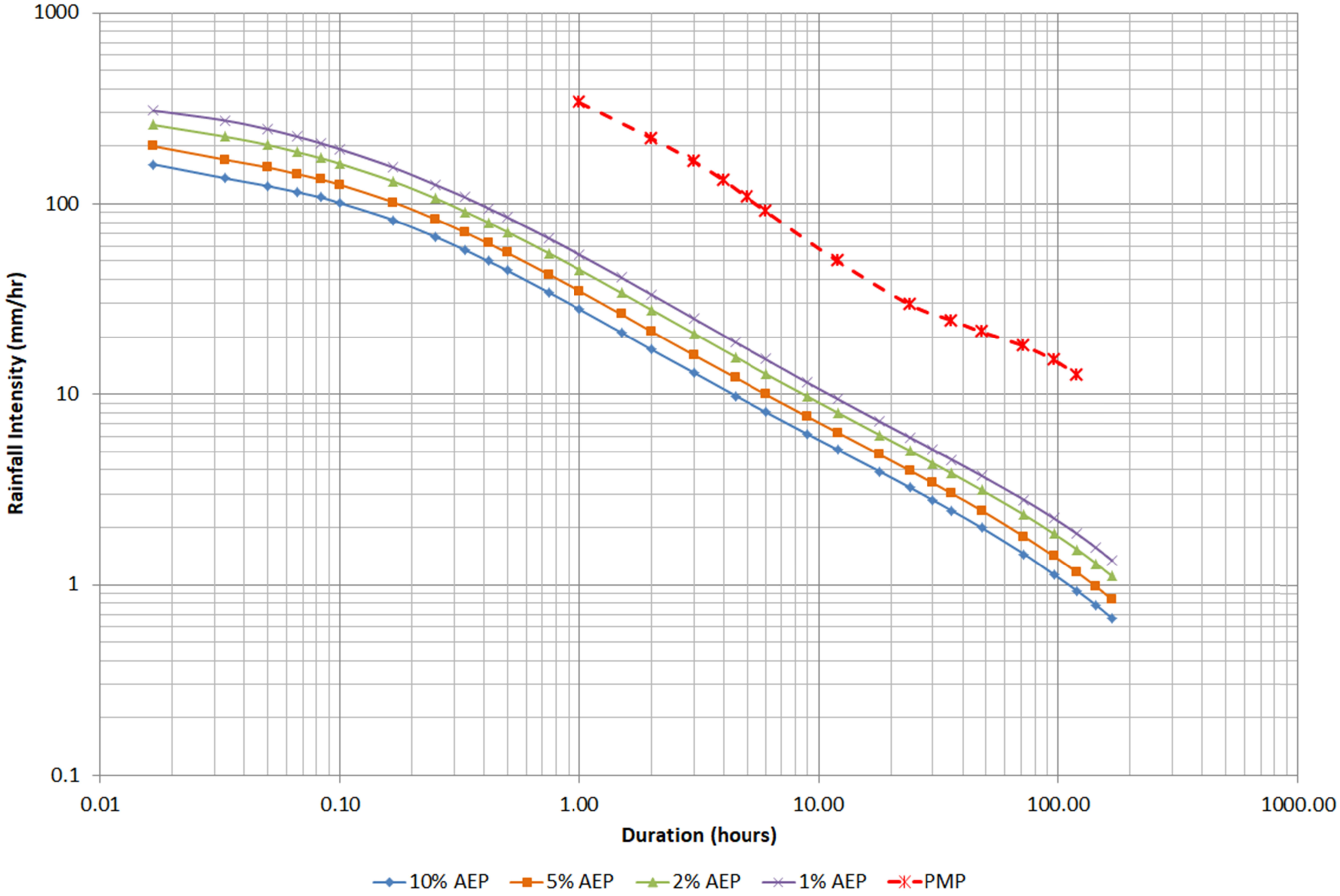
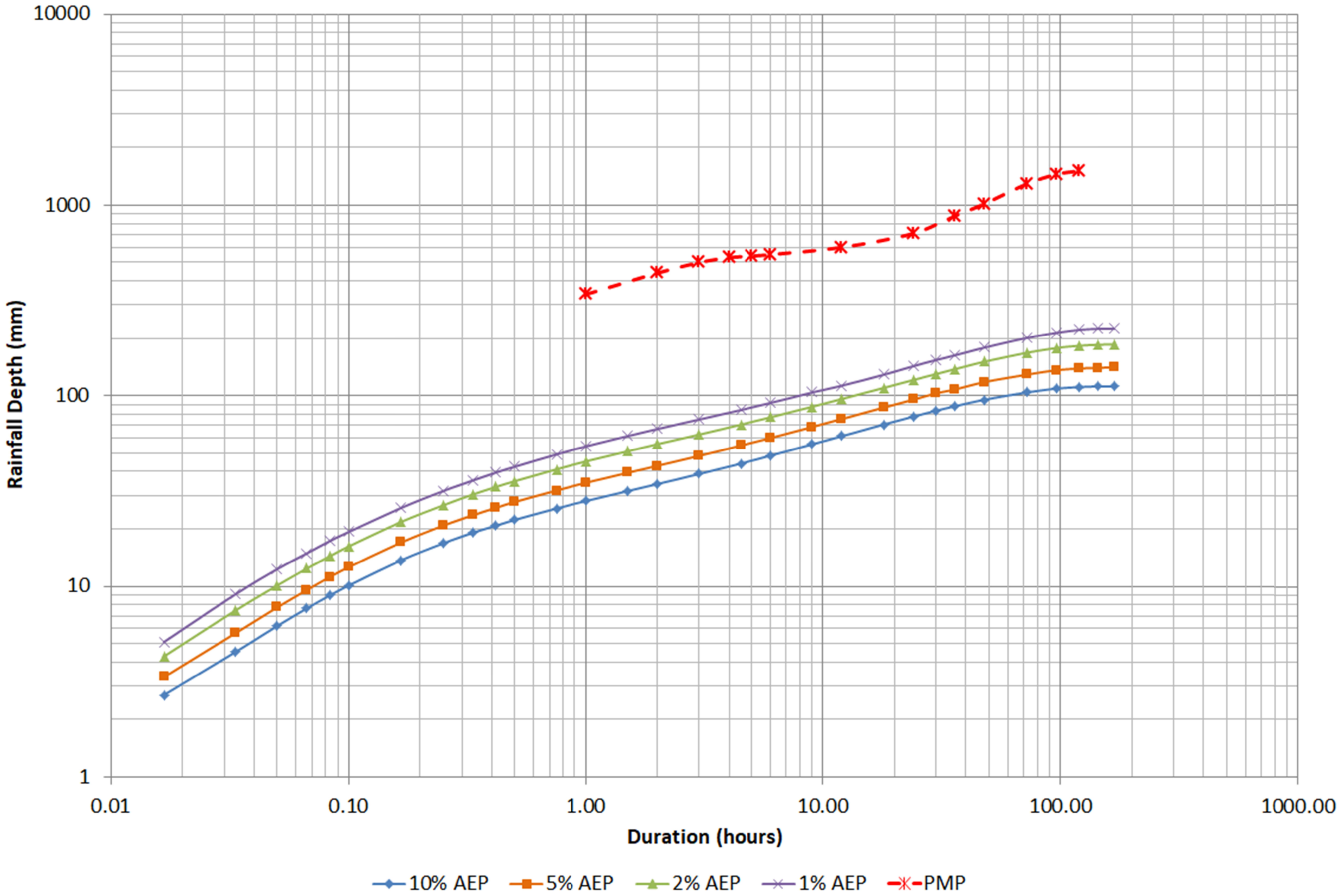


Figure 2: PMP Rainfall Depth Estimates and Redcliffe Gold Project Rainfall Depth-Duration-Frequency Relationship (BoM, 2016)



PMP Spatial Distribution

Given the limited upstream catchment areas that reports to the various RGP mining areas (<30 km^2), it can be assumed that there is no spatial distribution of the PMP and that, if it were to occur, it would be distributed uniformly across the site i.e. all parts would experience the same rainfall depth.

If a larger catchment area (say >200 km^2) was being considered, then it would be prudent to make allowances for the spatial distribution as it is unlikely that all parts of the catchment would record the same rainfall depth.

PMP Temporal Distribution

In order to transform the PMP into PMF design flood events of various durations it is necessary to consider the temporal distribution of the rainfall during the storm as it is highly unlikely that it will occur with the same intensity throughout the entire storm. Both the GSDM and GTSMR methodologies include design temporal patterns that have been based on temporal patterns of observed significant storms. These design patterns will be reviewed and adopted as necessary in the PMF estimates to be used for the project (to come).

Conclusion

PMP and PMF estimates have been developed for the proposed Redcliffe Gold Project site. These estimates show that PMP rainfall depths of approximately 340, 710 and 1,290 mm could occur over 1, 24 and 72 hour periods respectively.

Should you have any queries regarding the findings of this memorandum please do not hesitate to contact us.

Yours sincerely,

Alistair Lowry

Civil Engineering Hydrologist

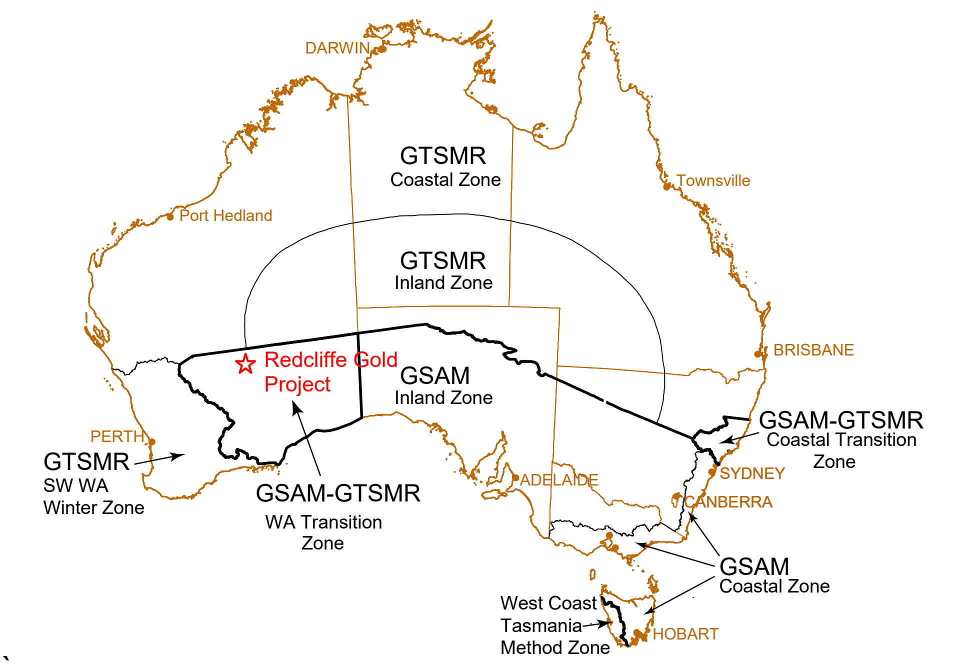
Attachments:

1. PMP Method Selection Worksheet
2. GSDM Calculation Sheet
3. GSDM Depth-Duration-Area Curves of Short Duration Rainfall
4. GTSMR Calculation Sheet
5. GSAM Calculation Sheet

ATTACHMENT No. 1 - PMP METHOD SELECTION WORKSHEET

Catchment Name: **Redcliffe Gold Project** Upstream Catchment Area: **28.3 km^2**

LONG DURATION PMP



Note: Not to Scale – Project location approximate.

CIRCLE THE ZONE IN WHICH THE CATCHMENT IS LOCATED:

~~GTSMR (Coastal)~~	~~GTSMR (Inland)~~
~~GTSMR (Coastal & SWWA)~~	~~Coastal Transition - GTSMR Coastal - GSAM Coastal~~
~~GSAM (Coastal)~~	WA Transition - GTSMR Coastal - GSAM Inland
~~GSAM (Inland)~~	~~WCTas~~

SHORT DURATION PMP (GSDM)

Is the catchment less than 1000km²? → NO → Short duration PMP estimates can **not** be calculated for the catchment

YES ↓

Is the catchment less than 500km² and south of 30°S?

NO → PMP estimates for up to 6 hours can be calculated using the **GSDM** for this catchment

YES → PMP estimates for up to 6 hours can be calculated using the **GSDM** for this catchment and can include **winter** estimates

PMP METHOD SUMMARY

Fill in the table below with the PMP method/s applicable to the catchment, referring to Table 1.1 for any additional information needed. NB: for the Transition zones, write separate entries for GTSMR and GSAM.

METHOD	ZONE	SEASON	DURATIONS
GSDM	3 hours	Monthly	1-3 hours
GTSMR	Coastal	Annual	24-120 hours
GSAM	Inland	Annual	24-72 hours

WHAT NEXT?

GTSMR: Calculate the PMP estimates for the catchment following the procedures in BoM guidebook

GSDM: Calculate the PMP estimates for the catchment following the procedures in BoM guidebook

GSAM: Calculate the PMP estimates for the catchment following the procedures in BoM guidebook

~~**WCTas:** Contact the Hydrometeorological Advisory Service, Bureau of Meteorology~~

ATTACHMENT No. 2 - GSDM CALCULATION SHEET

LOCATION INFORMATION	
Catchment: **Redcliffe Gold Project**	Area: **28.3 km^2**
State: **W.A.**	Duration Limit: **Three hours**
Latitude: **28.4772° S**	Longitude: **121.5544° E**
Portion of Area Considered:	
Smooth , **S** = **0.9** (0.0 - 1.0)	Rough , **R** = **0.1** (0.0 -1.0)

ELEVATION ADJUSTMENT FACTOR (EAF)
Mean Elevation: **500 m**
Adjustment for Elevation (-0.05 per 300 m above 1500 m): **Nil**
EAF = 1.0 (0.85 - 1.00)

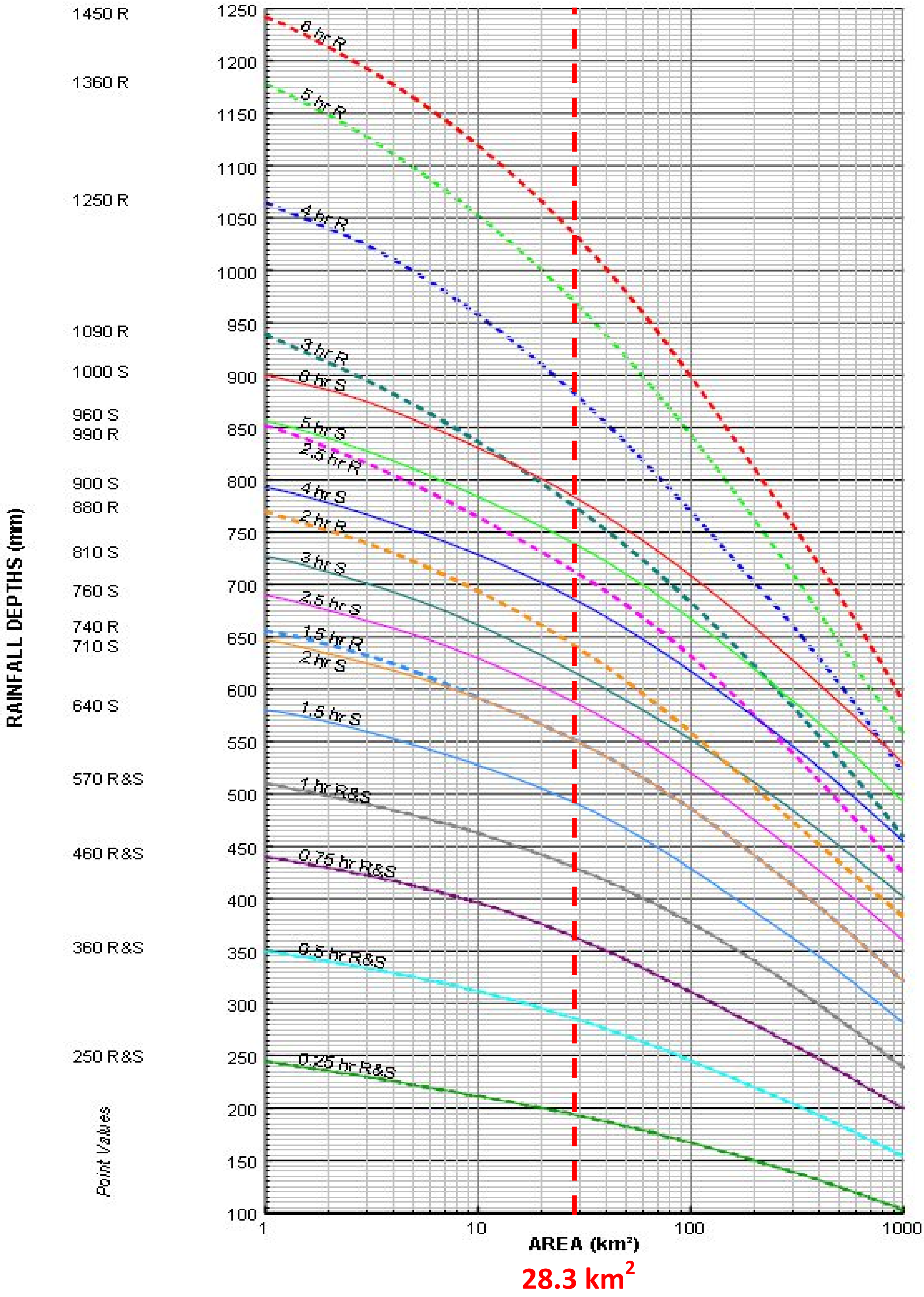
GSDM MOISTURE ADJUSTMENT FACTOR (MAF)
~~**EPW$_{catchment}$= XXX**~~
~~GSDM MAF=EPW$_{catchment}$/XXX~~
OR read directly off GSDM Moisture Adjustment Factor chart (Figure 3)
GSDM MAF = **0.78** (0.46-1.19)

PMP VALUES (mm)

Duration (hours)	**Initial Depth - Smooth (D_S)**	**Initial Depth - Rough (D_R)**	**PMP Estimate = (D_S×S + D_R×R) × MAF × EAF**	**Rounded PMP Estimate (nearest 10 mm)**
0.25	195	195	152.1	150
0.50	285	285	222.3	220
0.75	365	365	284.7	280
1.0	430	430	335.4	340
1.5	490	550	386.9	390
2.0	550	640	436.0	440
2.5	585	715	466.4	470
3.0	620	770	495.3	500
4.0	-	-	-	-
5.0	-	-	-	-
6.0	-	-	-	-

Prepared by: Alistair Lowry Date: 12 July 2021.

ATTACHMENT No. 3 - GSDM DEPTH-DURATION-AREA CURVES OF SHORT DURATION RAINFALL



ATTACHMENT No. 4: GTSMR CALCULATION WORKSHEET

LOCATION INFORMATION

Catchment Name: **Redcliffe Gold Project** State: **W.A.**

GTSMR zone(s): **Coastal Zone**

CATCHMENT FACTORS

Topographical Adjustment Factor	**TAF** = 1.048 (1.0 – 2.0)
Decay Amplitude Factor	**DAF** = 0.74 (0.7 – 1.0)
Annual Moisture Adjustment Factor	MAF_a = $EPW_{catchment}$/120.00
Extreme Precipitable Water ($EPW_{catchment}$) = 81.686	$\mathbf{MAF_a}$ = 0.681 (0.4 - 1.1)
~~**Winter Moisture Adjustment Factor** (where applicable)~~	~~MAF_w = $EPW_{catchment\_winter}$/82.30~~
~~Winter EPW ($EPW_{catchment\_winter}$) = …………~~	~~$\mathbf{MAF_w}$ = ………………. (0.4 – 1.1)~~

PMP VALUES (mm) – Annual

Duration (hours)	Initial Depth ($\mathbf{D_a}$)	PMP Estimate $=D_a$xTAFxDAFxMAF_a	Preliminary PMP Estimate (nearest 10mm)	Final PMP Estimate (from envelope)
1	Where applicable, calculate GSDM (Bureau of Meteorology, 2003) depths		340	340
2			440	440
3			500	500
4			-	530
5			-	540
6			-	550
12	(no preliminary estimates available)			650
24	1351.6	713.5	710	710
36	1659.5	876.0	880	880
48	1939.9	1024.1	1,020	1,020
72	2439.2	1287.7	1,290	1,290
96	2738.5	1445.7	1,450	1,450
120	2867.0	1513.5	1,510	1,510

~~PMP VALUES (mm) – Winter (where applicable)~~

~~Duration (hours)~~	~~Initial Depth ($\mathbf{D_w}$)~~	~~PMP Estimate $=D_w$xTAFxDAFxMAF_w~~	~~Preliminary PMP Estimate (nearest 10mm)~~	~~Final PMP Estimate (from envelope)~~
~~1~~	~~Where applicable, calculate GSDM (Bureau of Meteorology, 2003) depths~~			N/A
~~2~~				N/A
~~3~~				N/A
~~4~~				N/A
~~5~~				N/A
~~6~~				N/A
~~12~~	~~(no preliminary estimates available)~~			N/A
~~24~~				N/A
~~36~~				N/A
~~48~~				N/A
~~72~~				N/A
~~96~~				N/A

Prepared by: Alistair Lowry Date: 12 July 2021

ATTACHMENT 5: Generalised Southeast Australia Storm Method (GSAM)

LOCATION INFORMATION	
Catchment Name: **Redcliffe Gold Project**	State: **W.A.**
GSAM zone: **Inland**	Area: **28.3 km^2**

CATCHMENT FACTORS

Topographical Adjustment Factor	**TAF =**	**1.04**	(1.0 – 2.0)

Annual Moisture Adjustment Factor

$$\mathbf{MAF} = \frac{\mathbf{EPW}_{\text{seasonal catchment average}}}{\mathbf{EPW}_{\text{seasonal standard}}}$$

Season	$\mathbf{EPW}_{\text{seasonal catchment average}}$	$\mathbf{EPW}_{\text{seasonal standard}}$	MAF	
Summer (Annual)	81.686	80.80	**1.011**	(0.60 - 1.05)
Autumn	60.682	71.00	**0.855**	(0.56 - 0.91)

Summer PMP values (mm)			Autumn PMP values (mm)		
Duration (hours)	Initial Depth ($\mathbf{D}_{\text{summer}}$)	PMP Estimate ($\mathbf{D_s xTAFxMAF_s}$)	Duration (hours)	Initial Depth ($\mathbf{D}_{\text{autumn}}$)	PMP Estimate ($\mathbf{D_a xTAFxMAF_a}$)
24	469	493	24	667	593
36	501	526	36	768	683
48	522	548	48	823	732
72	565	594	72	871	775
96	589	619	96	887	789

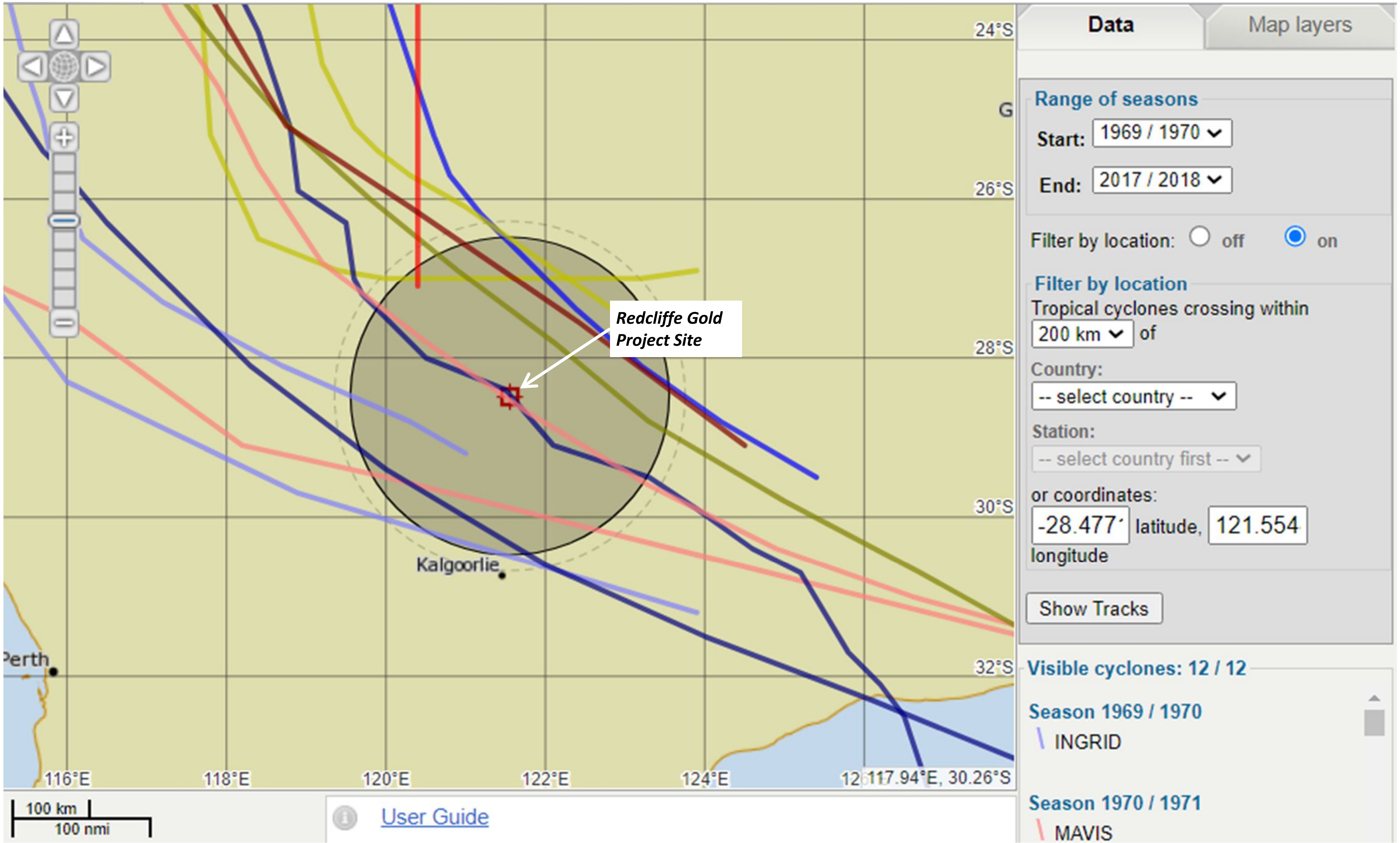
Final GSAM PMP Estimates

Duration (hours)	Maximum of the Seasonal Depths	Preliminary PMP Estimate (nearest 10mm)	Final PMP Estimate (from envelope)
1	Where applicable, calculate GSDM depths (Bureau of Meteorology, 2003)	340	**340**
2		440	**440**
3		500	**500**
4		-	**410**
5		-	**430**
6		-	**440**
12	(no preliminary estimates available)		**630**
24	667	590	**590**
36	768	680	**680**
48	823	730	**730**
72	871	770	**770**
96	887	790	**790**

Prepared by: Alistair Lowry Date: 12 July 2021

APPENDIX D

Cyclone Swept Path Analysis

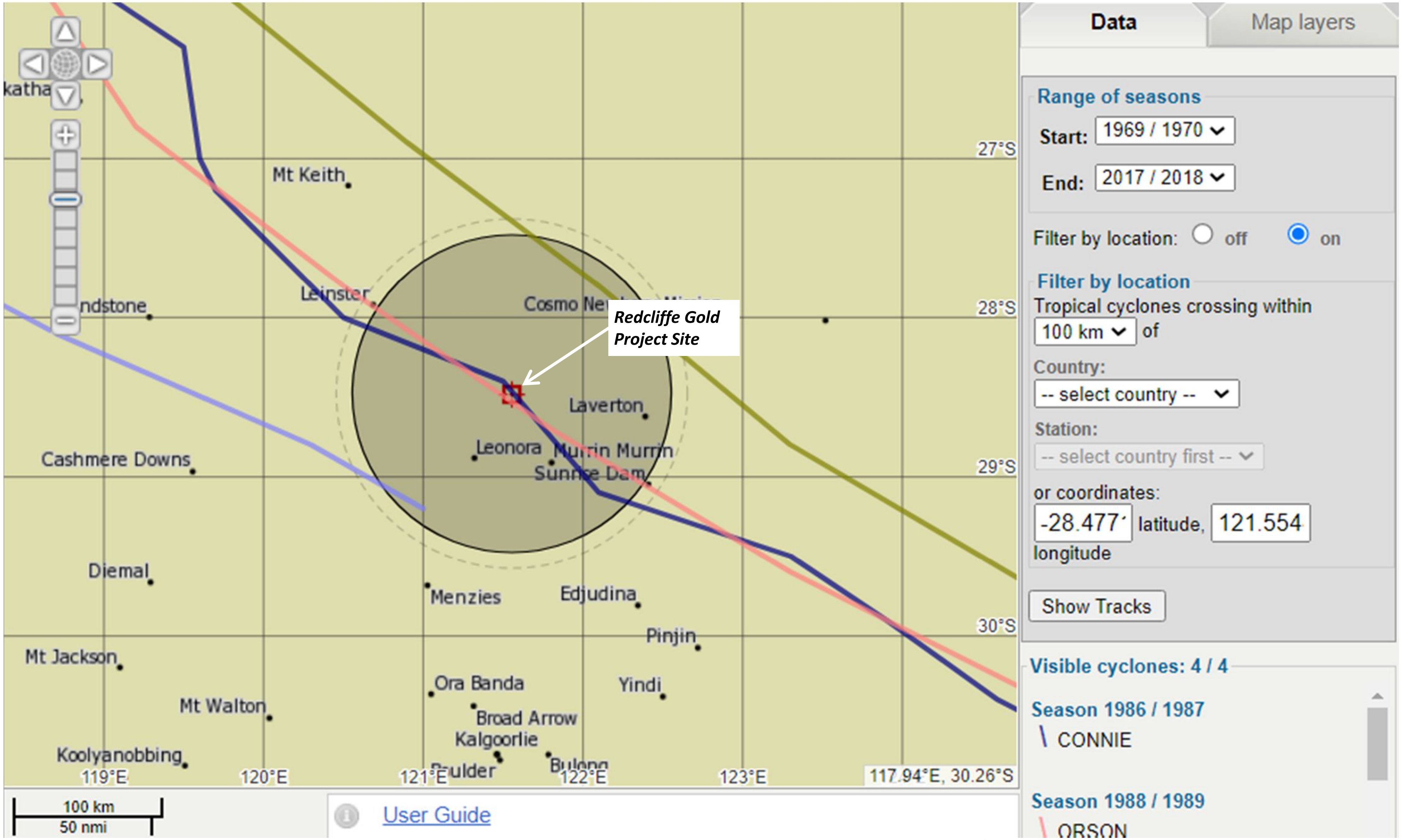


GROUNDWATER RESOURCE MANAGEMENT

APPENDIX D1
REDCLIFFE GOLD PROJECT
CYCLONE PATHS WITHIN
200 KM OF SITE

Date July 21
Client Dacian Gold Ltd
Project Redcliffe Gold Project
Document J2126R01

Notes
1. Cyclone paths from BoM data portal.

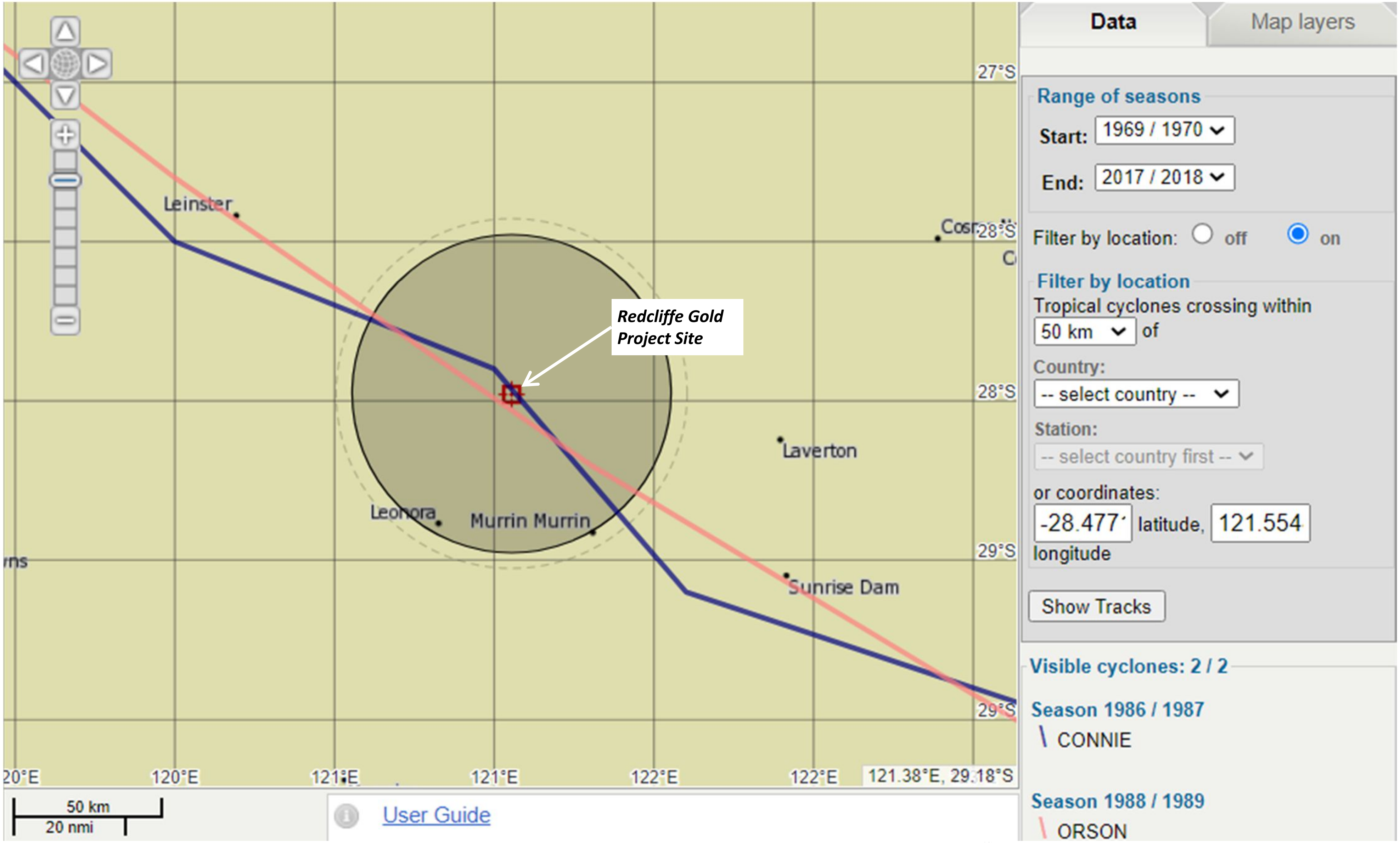


GROUNDWATER RESOURCE MANAGEMENT

APPENDIX D2
REDCLIFFE GOLD PROJECT
CYCLONE PATHS WITHIN 100 KM OF SITE

Date July 21
Client Dacian Gold Ltd
Project Redcliffe Gold Project
Document J2126R01

Notes
1. Cyclone paths from BoM dataset.



GROUNDWATER RESOURCE MANAGEMENT

APPENDIX D3
REDCLIFFE GOLD PROJECT
CYCLONE PATHS WITHIN 50 KM OF SITE

Date July 21
Client Dacian Gold Ltd
Project Redcliffe Gold Project
Document J2126R01

Notes
1. Cyclone paths from BoM dataset.

APPENDIX E

Selection of Photographs from Site Visit

01 Nambi - View North over existing Nambi Pit

02 Nambi - View South along Breakaway on western side of existing Nambi Pit

03 Nambi - View South along Breakaway on western side of existing Nambi Pit

04 Nambi - View east towards existing waste rock dump

05 Hub - Typical conditions along Proposed Northern Flood Bund alignment

06 Hub - Typical conditions along Proposed Southern Flood Bund alignment

07 Hub - View east along Dillon Creek channel

08 Hub - View west along Dillon Creek channel at Leonora-Nambi Road

09 GTS - View East along Unnamed Creek channel from Leonora-Nambi Road Floodway

10 GTS - View East along Unnamed Creek channel from Leonora-Nambi Road Floodway

11 GTS - View South along Leonora-Nambi Road Floodway

12 GTS - View North along Leonora-Nambi Road Floodway

13 GTS - Existing creekline near start of Proposed Diversion Channel

14 GTS - Existing creekline near start of Proposed Diversion Channel

15 GTS - Existing creekline near outlet of Proposed Diversion Channel

16 GTS - Existing creekline near outlet of Proposed Diversion Channel

APPENDIX F

Peak Flow Estimates & Calculation Worksheets

APPENDIX F

Dacian Gold Ltd - Redcliff Gold Project
Nambi North Upstream Catchment

Job No.: J2126R01			Sheet No.	1	of	6
Calc. By: Alistair Lowry			Chk'd By:			
Calc Date: 21 Oct 2021			Chk'd Date:			

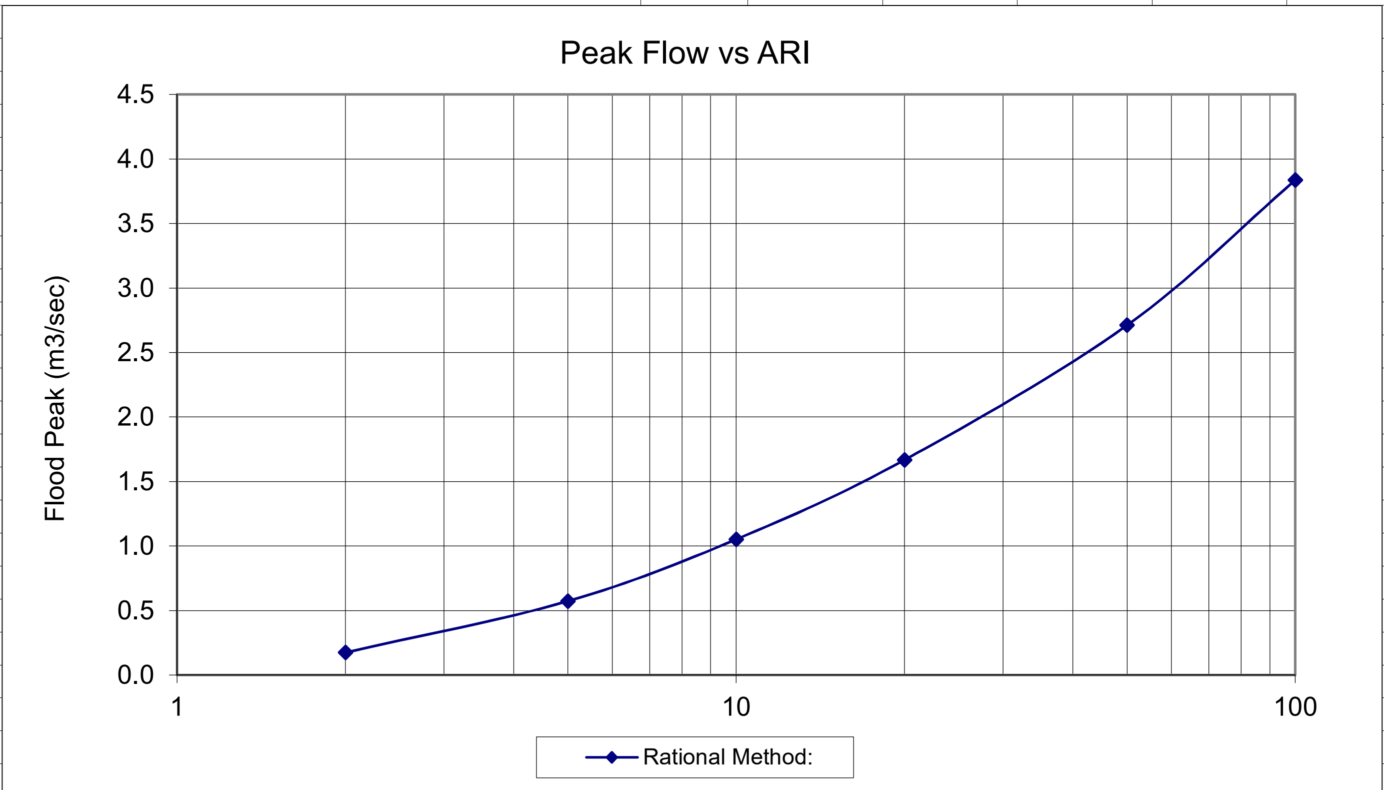
Sub-Catchment Peak Flow Estimation
(ref: AR&R 1987, Vol. 1, Book 4)

Assume Wheatbelt Loamy soil catchments 75-100% cleared
With Arid Interior Frequency Factors

Catchment Characteristics:

Catchment Area , A =	0.137	km2
Mainstream Length, L =	0.425	km
Equal Area Stream Slope, Se =	59.60	m/km
Cleared Area as percentage of catchment, CL =	75-100	%
Average Annual Rainfall, P =	239	mm

Rational Method:	**2**	**5**	**10**	**20**	**50**	**100**
tc=0.76A^0.38=	0.36	hours =	21	mins		
Rainfall Intensity for Time of Concentration => $I_{tc,Y}$=	27.3	43.4	55.8	69.0	88.7	105.3
C10=3.46*10^-1L^-0.42=	0.496	-				
	2	**5**	**10**	**20**	**50**	**100**
Frequency Factor (C_Y/C_{10})	0.34	0.7	1	1.28	1.62	1.93
Flood Peak Qy=0.278C_{10}(Cy/C10)IA (m3/sec)	0.2	0.6	1.1	1.7	2.7	3.8



APPENDIX F

Dacian Gold Ltd - Redcliff Gold Project
Nambi Central Upstream Catchment

Job No.: J2126R01			Sheet No.	2	of	6
Calc. By: Alistair Lowry			Chk'd By:			
Calc Date: 21 Oct 2021			Chk'd Date:			

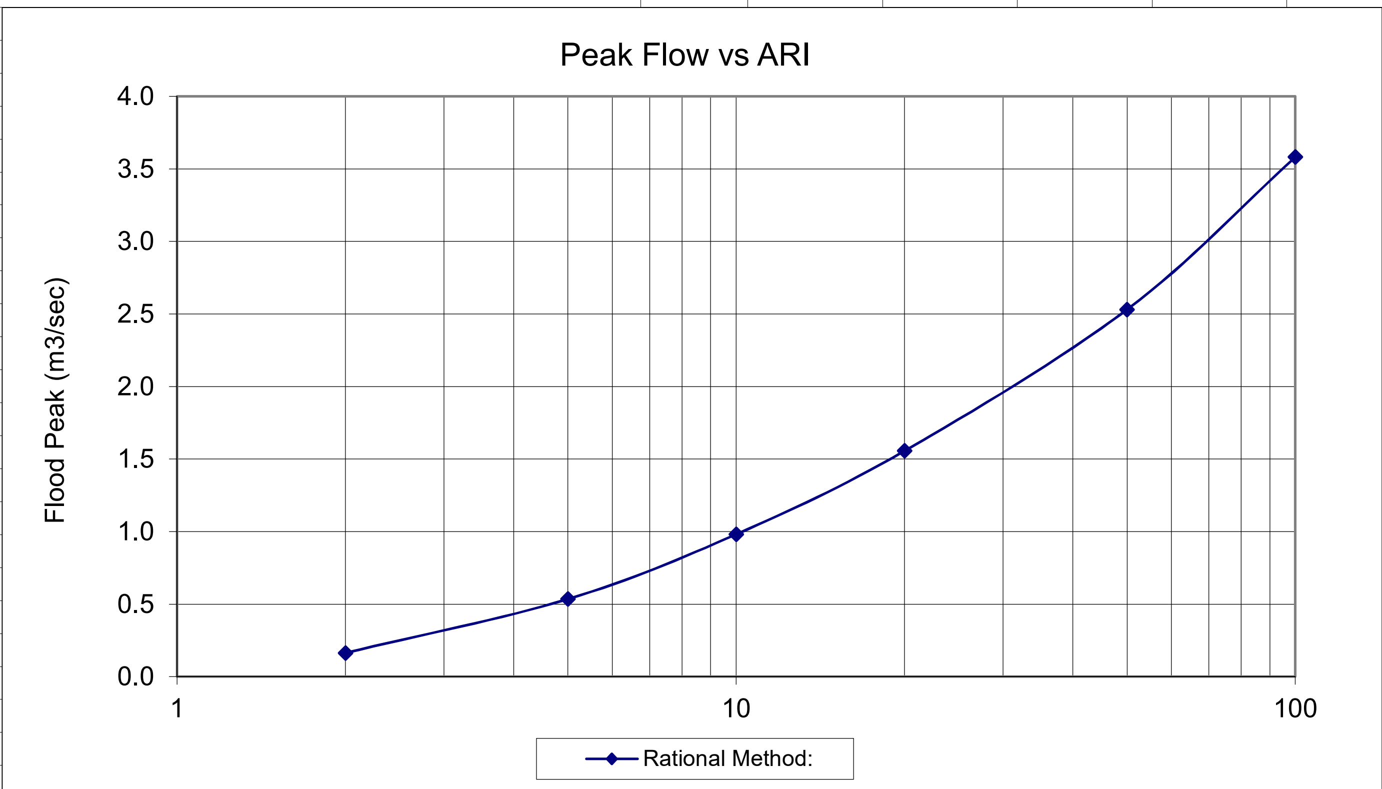
Sub-Catchment Peak Flow Estimation
(ref: AR&R 1987, Vol. 1, Book 4)

Assume Wheatbelt Loamy soil catchments 75-100% cleared
With Arid Interior Frequency Factors

Catchment Characteristics:

Catchment Area , A =	0.151	km2
Mainstream Length, L =	0.594	km
Equal Area Stream Slope, Se =	52.50	m/km
Cleared Area as percentage of catchment, CL =	75-100	%
Average Annual Rainfall, P =	239	mm

Rational Method:	**2**	**5**	**10**	**20**	**50**	**100**
tc=0.76A^0.38=	0.37	hours =	22	mins		
Rainfall Intensity for Time of Concentration => $I_{tc,Y}$=	26.6	42.3	54.3	67.3	86.4	102.7
C10=3.46*10^-1L^-0.42=	0.431	-				
	2	**5**	**10**	**20**	**50**	**100**
Frequency Factor (C_Y/C_{10})	0.34	0.7	1	1.28	1.62	1.93
Flood Peak Qy=0.278C_{10}(Cy/C10)IA (m3/sec)	0.2	0.5	1.0	1.6	2.5	3.6



APPENDIX F

Dacian Gold Ltd - Redcliff Gold Project
Nambi South Upstream Catchment

Job No.: J2126R01		Sheet No.	3	of	6
Calc. By: Alistair Lowry		Chk'd By:			
Calc Date: 21 Oct 2021		Chk'd Date:			

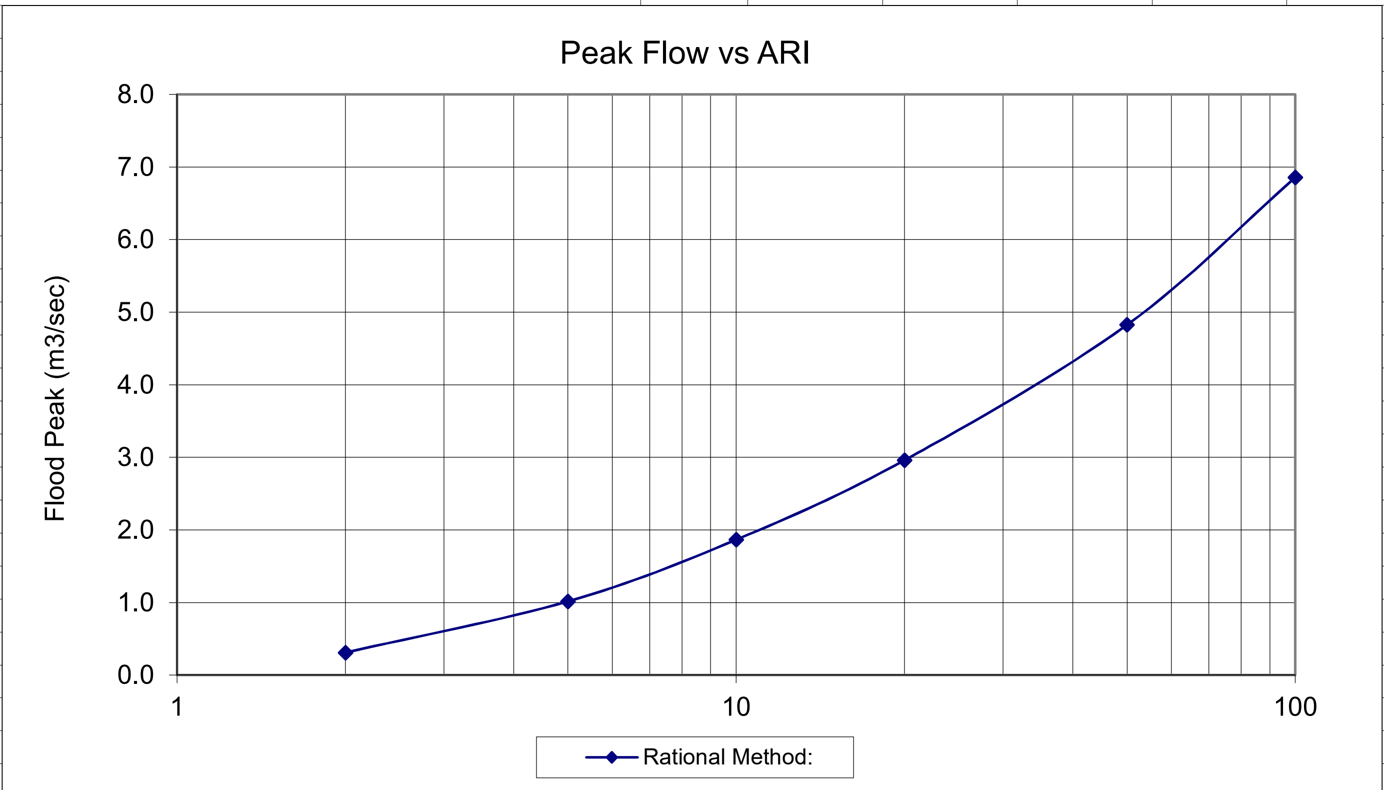
Sub-Catchment Peak Flow Estimation
(ref: AR&R 1987, Vol. 1, Book 4)

Assume Wheatbelt Loamy soil catchments 75-100% cleared
With Arid Interior Frequency Factors

Catchment Characteristics:

Catchment Area , A =	0.367	km2
Mainstream Length, L =	0.643	km
Equal Area Stream Slope, Se =	46.30	m/km
Cleared Area as percentage of catchment, CL =	75-100	%
Average Annual Rainfall, P =	239	mm

Rational Method:	**2**	**5**	**10**	**20**	**50**	**100**
tc=0.76A^0.38=	0.52	hours =	31	mins		
Rainfall Intensity for Time of Concentration => $I_{tc,Y}$=	21.5	34.2	43.9	54.4	70.1	83.6
C10=3.46*10^-1L^-0.42=	0.417	-				
	2	**5**	**10**	**20**	**50**	**100**
Frequency Factor (C_Y/C_{10})	0.34	0.7	1	1.28	1.62	1.93
Flood Peak Qy=0.278C_{10}(Cy/C10)IA (m3/sec)	0.3	1.0	1.9	3.0	4.8	6.9



APPENDIX F

Dacian Gold Ltd - Redcliff Gold Project
Hub North Upstream Catchment

Job No.: J2126R01			Sheet No.	4	of	6
Calc. By: Alistair Lowry			Chk'd By:			
Calc Date: 21 Oct 2021			Chk'd Date:			

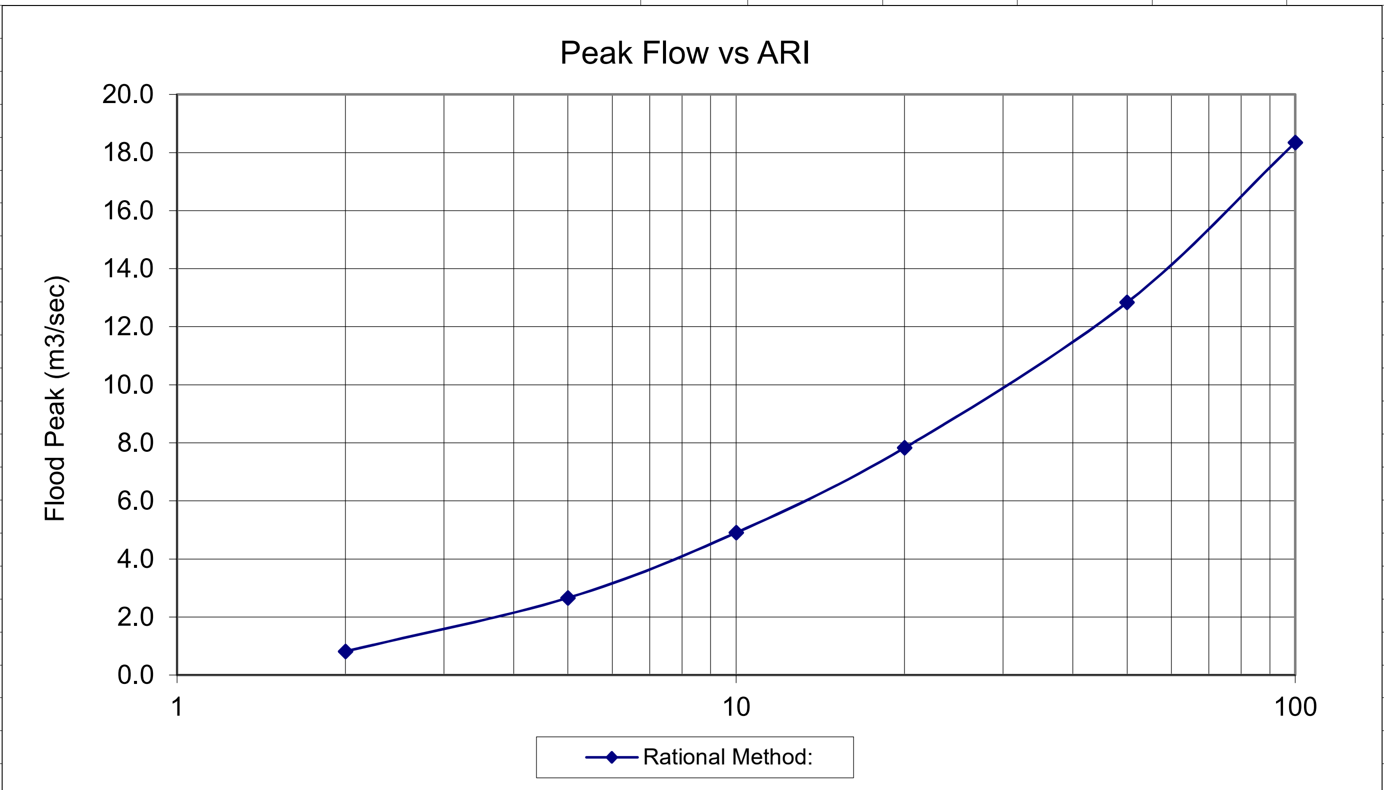
Sub-Catchment Peak Flow Estimation
(ref: AR&R 1987, Vol. 1, Book 4)

Assume Wheatbelt Loamy soil catchments 75-100% cleared
With Arid Interior Frequency Factors

Catchment Characteristics:

Catchment Area , A =	2.807	km2
Mainstream Length, L =	2.430	km
Equal Area Stream Slope, Se =	7.80	m/km
Cleared Area as percentage of catchment, CL =	75-100	%
Average Annual Rainfall, P =	239	mm

Rational Method:	**2**	**5**	**10**	**20**	**50**	**100**
tc=0.76A^0.38=	1.12	hours =	67	mins		
Rainfall Intensity for Time of Concentration => $I_{tc,Y}$=	12.9	20.4	26.4	32.9	42.6	51.1
C10=3.46*10^-1L^-0.42=	0.238	-				
	2	**5**	**10**	**20**	**50**	**100**
Frequency Factor (C_Y/C_{10})	0.34	0.7	1	1.28	1.62	1.93
Flood Peak Qy=0.278C_{10}(Cy/C10)IA (m3/sec)	0.8	2.7	4.9	7.8	12.8	18.3



APPENDIX F

Dacian Gold Ltd - Redcliff Gold Project
Hub South Upstream Catchment

Job No.: J2126R01		Sheet No.	5	of	6
Calc. By: Alistair Lowry		Chk'd By:			
Calc Date: 21 Oct 2021		Chk'd Date:			

Sub-Catchment Peak Flow Estimation
(ref: AR&R 1987, Vol. 1, Book 4)

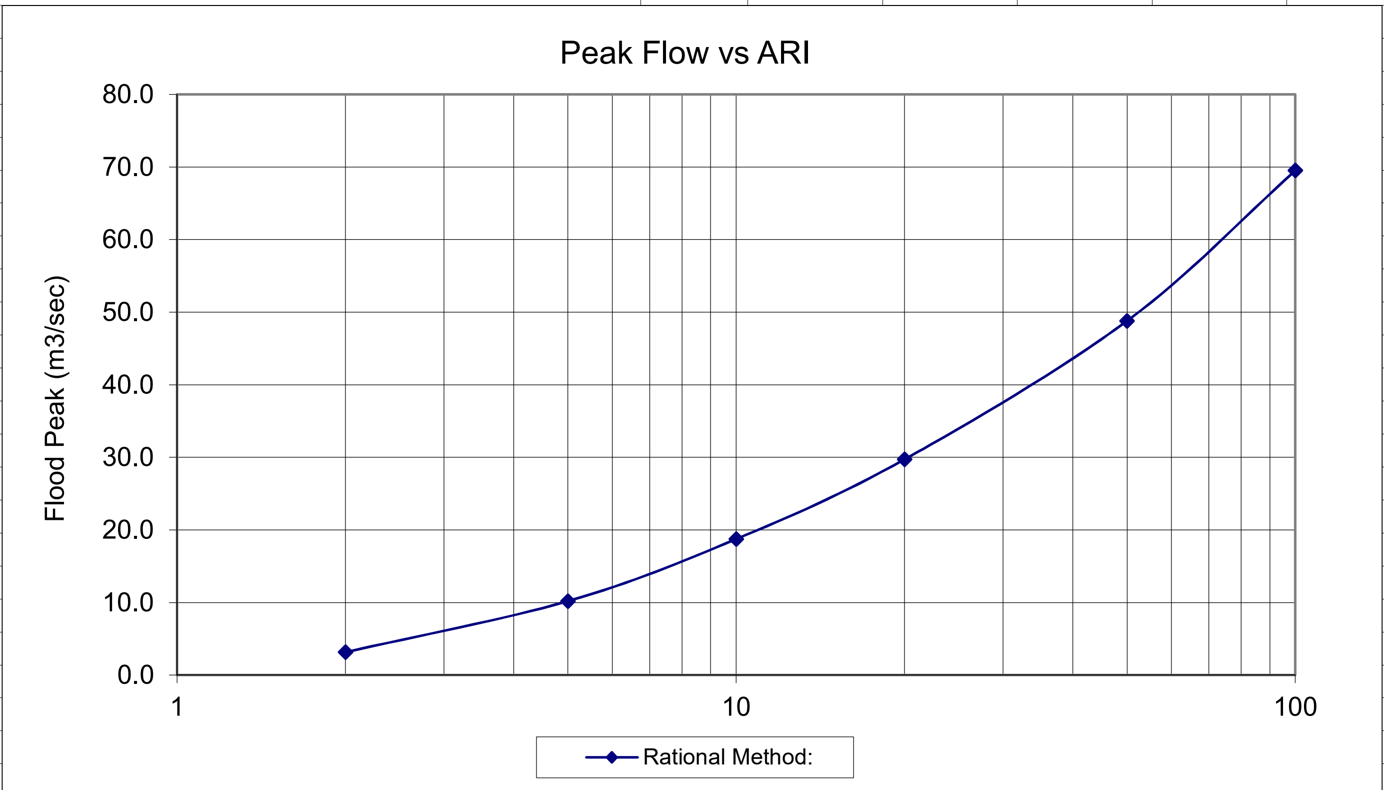
Assume Wheatbelt Loamy soil catchments 75-100% cleared
With Arid Interior Frequency Factors

Catchment Characteristics:

Catchment Area , A =	43.776	km2
Mainstream Length, L =	11.850	km
Equal Area Stream Slope, Se =	2.60	m/km
Cleared Area as percentage of catchment, CL =	75-100	%
Average Annual Rainfall, P =	239	mm

Rational Method:	**2**	**5**	**10**	**20**	**50**	**100**
tc=0.76A^0.38=	3.20	hours =	192	mins		
Rainfall Intensity for Time of Concentration => $I_{tc,Y}$=	6.2	9.8	12.6	15.6	20.2	24.2
C10=3.46*10^-1L^-0.42=	0.122	-				

	2	**5**	**10**	**20**	**50**	**100**
Frequency Factor (C_Y/C_{10})	0.34	0.7	1	1.28	1.62	1.93
Flood Peak Qy=0.278C_{10}(Cy/C10)IA (m3/sec)	3.1	10.2	18.7	29.7	48.8	69.5



APPENDIX F

Dacian Gold Ltd - Redcliff Gold Project
GTS Upstream Catchment

Job No.: J2126R01			Sheet No.	6	of	6
Calc. By: Alistair Lowry			Chk'd By:			
Calc Date: 21 Oct 2021			Chk'd Date:			

Sub-Catchment Peak Flow Estimation
(ref: AR&R 1987, Vol. 1, Book 4)

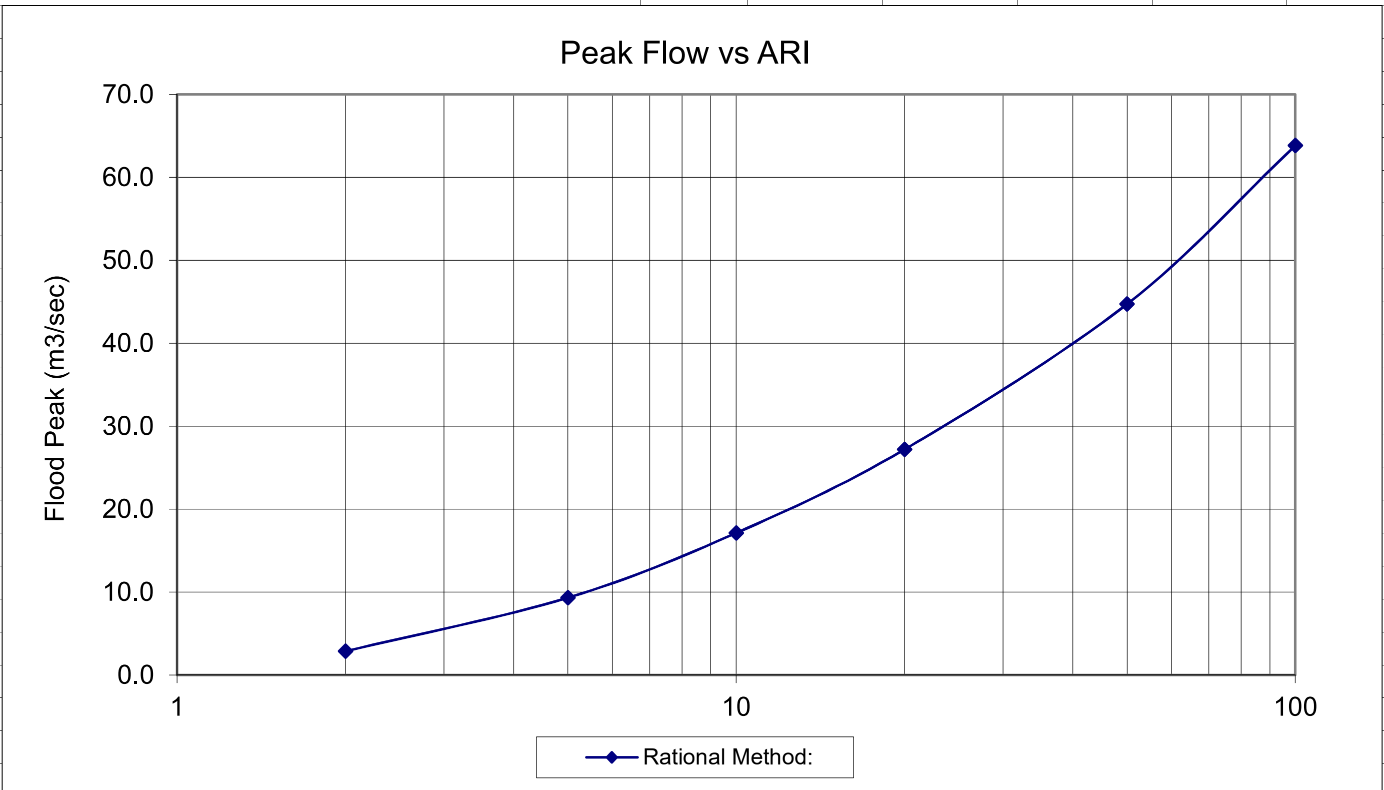
Assume Wheatbelt Loamy soil catchments 75-100% cleared
With Arid Interior Frequency Factors

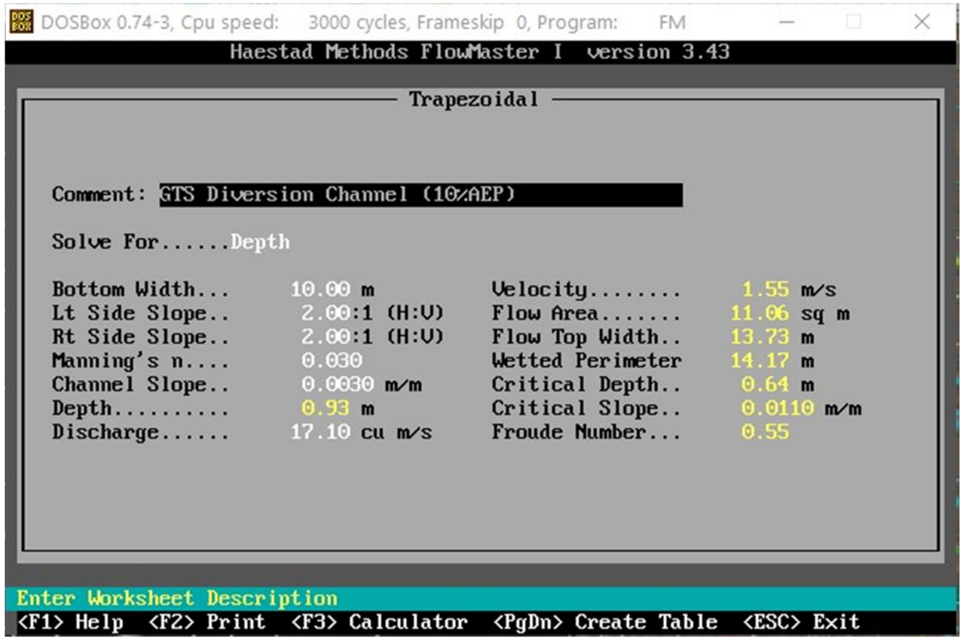
Catchment Characteristics:

Catchment Area , A =	28.330	km2
Mainstream Length, L =	7.020	km
Equal Area Stream Slope, Se =	10.68	m/km
Cleared Area as percentage of catchment, CL =	75-100	%
Average Annual Rainfall, P =	239	mm

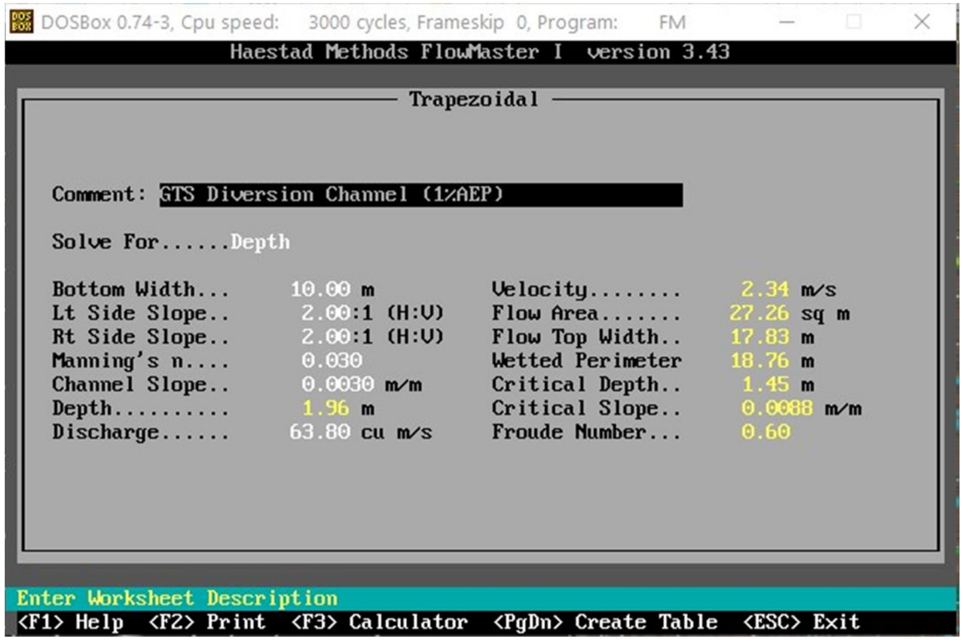
Rational Method:	**2**	**5**	**10**	**20**	**50**	**100**
tc=0.76A^0.38=	2.71	hours =	162	mins		
Rainfall Intensity for Time of Concentration => $I_{tc,Y}$=	7.0	11.1	14.3	17.7	23.0	27.5
C10=3.46*10^-1L^-0.42=	0.153	-				

	2	**5**	**10**	**20**	**50**	**100**
Frequency Factor (C_Y/C_{10})	0.34	0.7	1	1.28	1.62	1.93
Flood Peak Qy=0.278C_{10}(Cy/C10)IA (m3/sec)	2.9	9.3	17.1	27.2	44.7	63.8

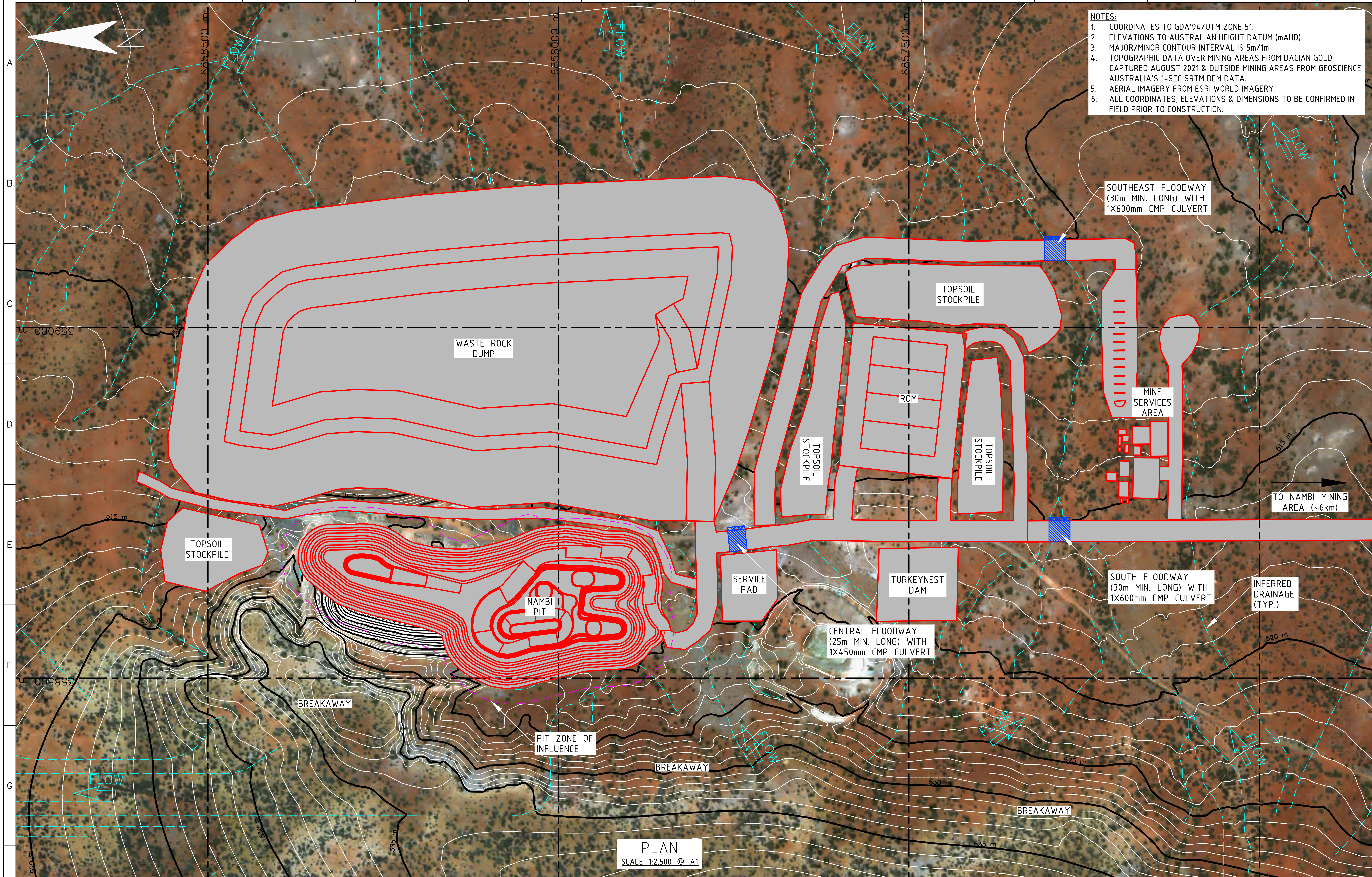




GTS Diversion Q10 Design



GTS Diversion Q100 Design



REVISION	DESCRIPTION	CHECKED INITS	CHECKED DATE	APPROVED INITS	APPROVED DATE
A	ISSUED FOR CLIENT REVIEW	AL	XX/10/21	_	_

PRELIMINARY NOT FOR CONSTRUCTION

GROUNDWATER RESOURCE MANAGEMENT

CLIENT	DACIAN GOLD LTD
DRAWN	AL — DATE 21-OCT-21
DRAWING CHECK	DATE
DESIGNED	AL — DATE 21-OCT-21
DESIGN CHECK	DATE
AUTHORISED	DATE
SCALE	AS SHOWN
PROJECT	REDCLIFFE GOLD PROJECT
DRAWING TITLE	NAMBI MINING AREA PRELIMINARY DESIGN OF SURFACE WATER MANAGEMENT MEASURES PLAN
DRAWING No.	J2126R01-D01
REVISION	A

A1

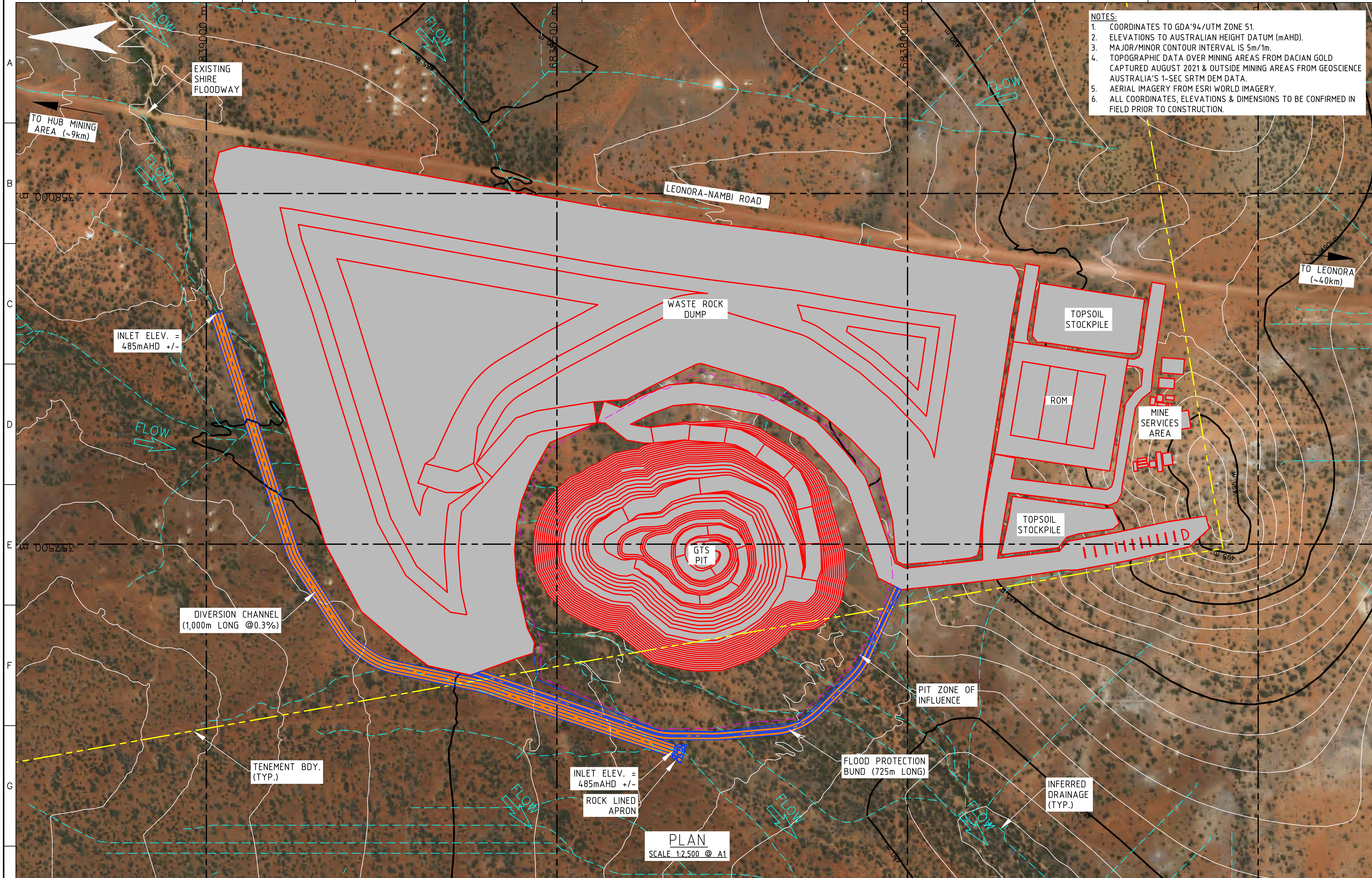
A	ISSUED FOR CLIENT REVIEW	AL	XX/10/21	–	–
REVISION	DESCRIPTION	INITS	DATE	INITS	DATE
		CHECKED		APPROVED	

PRELIMINARY NOT FOR CONSTRUCTION

GROUNDWATER RESOURCE MANAGEMENT

CLIENT	DACIAN GOLD LTD	PROJECT	REDCLIFFE GOLD PROJECT
DRAWN AL	DATE 21-OCT-21	DRAWING CHECK	DATE
DESIGNED AL	DATE 21-OCT-21	DESIGN CHECK	DATE
AUTHORISED	DATE	SCALE AS SHOWN	
DRAWING TITLE	HUB MINING AREA PRELIMINARY DESIGN OF SURFACE WATER MANAGEMENT MEASURES PLAN	DRAWING No. J2126R01-D02	A

A1



NOTES:

1. COORDINATES TO GDA'94/UTM ZONE 51.
2. ELEVATIONS TO AUSTRALIAN HEIGHT DATUM (mAHD).
3. MAJOR/MINOR CONTOUR INTERVAL IS 5m/1m.
4. TOPOGRAPHIC DATA OVER MINING AREAS FROM DACIAN GOLD CAPTURED AUGUST 2021 & OUTSIDE MINING AREAS FROM GEOSCIENCE AUSTRALIA'S 1-SEC SRTM DEM DATA.
5. AERIAL IMAGERY FROM ESRI WORLD IMAGERY.
6. ALL COORDINATES, ELEVATIONS & DIMENSIONS TO BE CONFIRMED IN FIELD PRIOR TO CONSTRUCTION.

PLAN

SCALE 1:2,500 @ A1

REVISION	DESCRIPTION	CHECKED INITS	CHECKED DATE	APPROVED INITS	APPROVED DATE
A	ISSUED FOR CLIENT REVIEW	AL	XX/10/21	–	–

PRELIMINARY NOT FOR CONSTRUCTION

GROUNDWATER RESOURCE MANAGEMENT

CLIENT	DACIAN GOLD LTD	PROJECT	REDCLIFFE GOLD PROJECT
DRAWN: AL, DATE: 21-OCT-21	DRAWING CHECK: DATE:	DRAWING TITLE	GTS MINING AREA PRELIMINARY DESIGN OF SURFACE WATER MANAGEMENT MEASURES PLAN
DESIGNED: AL, DATE: 21-OCT-21	DESIGN CHECK: DATE:		
AUTHORISED: DATE:	SCALE: AS SHOWN	DRAWING No. J2126R01-D03	A

A1

APPENDIX 7: REDCLIFFE GOLD PROJECT HYDROGEOLOGICAL INVESTIGATIONS REPORT (GRM 2021B)

REDCLIFFE GOLD PROJECT

HYDROGEOLOGICAL

INVESTIGATIONS REPORT

Prepared for:

Dacian Gold Limited

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J2126R02 December 2021

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Report Distribution

Revision	Date	Author	Reviewer	Issued to
V01	13 December 21	Peter Mayers	Karen Johnston	Peter Dunstan

GLOSSARY OF TERMS

Aquifer	A saturated geological unit that is permeable enough to yield economic quantities of water.
Aquitard	A geological unit that is permeable enough to transmit water but not sufficient to yield economic quantities.
Aquiclude	A geological unit that is impermeable, *i.e.* cannot transmit water.
Confined Aquifer	An aquifer bounded above and below by an aquiclude, where the water level in the aquifer extends above the aquifer top and is represented by a pressure head, *i.e.* the aquifer is completely saturated.
Drawdown	The change in hydraulic head observed at a well in an aquifer, typically due to pumping.
Leaky Aquifer or Semi-Confined Aquifer	An aquifer with upper and/or lower boundaries as an aquitard, where the water level in the aquifer extends above the aquifer top and is represented by a pressure head. Pumping from the aquifer induces leakage from the neighbouring aquitard units.
Unconfined or Water table Aquifer	An aquifer that is bounded below by an aquiclude, but is not restricted on its upper boundary, which is represented by the water table.
Hydraulic Conductivity (K) [Permeability]	The volume of water that will flow in a unit time under a unit hydraulic gradient through a unit area. Analogous to the permeability with respect to fresh water (units commonly m/d or m/s).
Transmissivity (T)	The product of the hydraulic conductivity and the saturated aquifer thickness (units commonly $m^3/d/m$ or m^2/d)
Specific Storage (S_s)	The volume of water released from a unit volume of aquifer under a unit decline in hydraulic head, assuming confined aquifer conditions. Water is released because of compaction of the aquifer under effective stress and expansion of the water due to decreasing pressure (units commonly m^{-1}).
Storativity (S)	The volume of water released from a unit area of aquifer, i.e. the aquifer column, per unit decline in hydraulic head (dimensionless parameter).
Specific Yield (S_y)	The volume of water released from an unconfined aquifer per unit decline in the water table. The release of water is mostly from aquifer draining. Contributions from aquifer compaction are generally small. Analogous with effective porosity (dimensionless parameter).

Terms referenced from Kruseman GP and deRidder NA (1994) 2nd edition, Analysis and Evaluation of Pumping Test Data. ILRI Publication 47 The Netherlands

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1.0 INTRODUCTION

Dacian Gold Limited (Dacian) owns the Redcliffe Gold Project (Redcliffe) which it acquired through a merger with NTM Gold Limited in March 2021. Dacian proposes to develop Redcliffe through its wholly owned subsidiary Redcliffe Operations Limited, with mining proposed to start around the middle of 2022.

Although a significant number of gold prospects and targets have been identified in the Mt Redcliffe area, the main focus of development currently involves three deposits; Golden Terrace South (GTS), Hub and Nambi. These deposits locate from south to north respectively, along an approximately 20 km zone of variably sheared and faulted Archean age greenstones which lie about 50 km north-northwest of Leonora in the Goldfields Region of Western Australia (Figure 1).

Mining of the three deposits is planned to occur over a 2-Year period, starting with the Hub, followed by GTS and finally Nambi deposits. The mined ore will be transported by road-train to Dacian's Mt Morgan's gold treatment plant near Laverton. The haul road alignment between Redcliffe and Mt Morgans is yet to be confirmed but will likely involve a combination of new road construction, as well as possible use of existing shire roads.

Dacian have engaged Groundwater Resource Management Pty Ltd (GRM) to undertake the relevant hydrogeological studies for the Redcliffe project, which focus on assessment of the likely mine dewatering requirements for the three proposed developments. GRM oversaw a 19-day groundwater drilling and testing programme during September 2021 at the Redcliffe project as part of this hydrogeological assessment. The programme comprised:

- airlift-recovery testing of 19 existing angled RC resource drill holes and a single water supply bore, and
- drilling, installation and airlift-recovery testing of 8 groundwater monitoring bores, and attempted installation and testing of … more monitoring bores, as well as
- collection of six groundwater samples for laboratory analysis.

This report summarises the results of the field investigation programme undertaken as well as analysis of the results, and compilation of laboratory water quality analyses. It also provides estimates of potential pit inflows which have been derived using a modified 2D analytical modelling solution for flow to a large diameter well.

2.0 BACKGROUND

2.1 Climate

The climate of the north-eastern Goldfields region is arid and can be characterised by its relatively low annual rainfall and large temperature range. During the warmer months between November and April the region is influenced by anti-cyclonic systems to the southeast and as a result the climate is typified by easterly winds and hot days with clear skies. The area is occasionally influenced by southern extensions of the Inter Tropic Convergence Zone (ITCZ) which may bring thunderstorm activity. Occasionally, remnant tropical cyclones, which have crossed the Pilbara coast, pass over the region during the summer months. These proceed in a south-easterly direction weakening as they progress to become rain-bearing troughs or depressions between the usual anti-cyclone patterns.

The mean annual rainfall is typically less than about 250 mm, but may vary annually from less than one third to almost three times that amount. The rainfall that occurs during the autumn and early winter months of May to July tends to be more reliable though generally of a lesser total amount than the less dependable, but more intense summer cyclonic rainfall from December to March. Temperature ranges of over 50°C have been recorded between summer maxima and winter minima. Annual pan evaporation rates typically exceed 2,500 mm/year and surpass rainfall by an order of magnitude.

Bureau of Meteorology (BoM) average monthly rainfall data for the two nearest recording stations to the project are summarised in Table 1. These BoM stations are Nambi (station No 12062), located 15 km northeast of the site, and Leonora (12046) which is around 50 km south-southwest of Mt Redcliffe.

Table 1:- Mean Annual Rainfall

Month	Nambi (1922-2020)	Leonora (1898-2014)
	Mean Monthly Rainfall (mm)	
January	31.7	26.3
February	29.8	30.9
March	30.7	29.0
April	22.7	20.3
May	24.3	23.7
June	24.1	24.8
July	16.6	18.5
August	12.7	15.7
September	8.3	8.9
October	8.7	9.4
November	11.4	12.3
December	16	16.7
Mean Annual	**228.1**	**236.4**

2.2 Other Groundwater Users

A search was undertaken of the Department of Water and Environmental Regulation (DWER) Water Information Reporting (WIR) database for other user bores within a 20 km radius of the Hub deposit area, and which also takes in the Nambi and GTS deposits. The search identified 28 registered bores or wells within the search radius, with the search results summarised in Table 2, and the bores plotted on the map in Figure 2.

Table 2:- WIR Registered Bores

Site Ref No	Site Name	Coordinates MGA94 (Zn51)		Owner Name	Depth Drilled (mbGL)
		Easting (m)	Northing (m)		
120412350	Old Homestead Well	351,580	6,832,943	Unknown	24.23
120412489	O'Keefe Well	345,366	6,864,350	Unknown	0
120412490	Stack Well	350,972	6,861,273	Unknown	0
120412494	Andy Macs	349,139	6,851,296	Unknown	44.2
120412495	Spinifex Well	346,197	6,847,836	Unknown	0
120413035	Stone	366,704	6,844,060	Unknown	32.61
120413036	Hugh	362,651	6,844,313	Unknown	25.6
120413037	Giant Well	361,800	6,838,580	Unknown	37.5
120413038	Lyons Well	361,960	6,834,261	Unknown	27.4
120413062	J.D. 7 Well	367,267	6,865,713	Nambi Station	5.49
120413065	Woolshed Well	366,130	6,868,764	Unknown	17.83
120413067	Winston Well	360,320	6,868,232	Unknown	21.79
120413069	Clifton Well	361,193	6,861,059	Unknown	19.81
120413070	Private	370,523	6,858,557	Unknown	6.1
120413071	Private	369,827	6,858,102	Unknown	8.53
120413072	Skies Well	376,585	6,858,797	Unknown	20.42
120413073	Charlie Well	365,815	6,854,570	Unknown	5.64
120413074	Elizabeth	370,171	6,855,226	Unknown	8.69
120413075	Redcliffe	360,716	6,853,818	Unknown	18.9
120413076	Henderson Well	356,770	6,851,196	Unknown	20.12
120413077	Wildcat Well	361,785	6,847,084	Unknown	16.31
120415359	Brakaway	351,172	6,837,600	Unknown	39.62
120415736	Steves	374,503	6,843,224	Unknown	21.7
120415741	Woolshed	364,838	6,868,396	Unknown	21.9
120415742	Woolie	364,832	6,868,396	Unknown	33.5
120415743	Barrett	373,384	6,850,620	Unknown	31.7
120415744	Homestead	370,496	6,858,557	Unknown	12.9
120415745	Homestead	370,496	6,858,557	Unknown	25.9

The 28 bores and wells found in the search were drilled (or dug) to depths of between 5.49 and 39.62 m. No information was available on depth to water table, bore construction or water quality for any of the bores and wells. Apart from the J.D.7 Well, all other bores have the owner listed as unknown, although based on the bore distribution it is likely that all 28 bores and wells are a combination of current or historic stock water bores used by the local pastoralists. The closest bore to the proposed GTS mine is Giant Well, located around 4km to the east. The two closest bores to the Hub development are Henderson Well, locates 2.6 km to the west and Redcliffe Well, located 3 km to the northeast. Redcliffe Well is also about 4.5 km to the southeast of Nambi. The only other bore close to the Nambi pit is Clifton Well, located 3.6 km to the northeast.

2.3 Regional Hydrogeology

The description of the regional hydrogeology in the Redcliffe area is derived from the hydrogeological assessment completed by Johnson (2004) for the Laverton 1:250,000 sheet, and Johnson and Commander's report on the groundwater resources of the Northern Goldfields (1999).

The region is characterised by low relief and a southerly draining palaeo-drainage systems, underlain by Archean sequences. Groundwater typically occurs in the following (from deepest to shallowest):

- Fresh and weathered Archean basement fractured rock aquifers.
- Tertiary palaeochannel sands.
- Surficial deposits including lacustrine sediments, alluvium / colluvium and calcrete.

Groundwater occurrences in the fresh bedrock are associated with discrete interconnected fractures. The fracturing is characterised by secondary permeability resulting from tectonic and decompression fracturing enhanced by chemical dissolution. Permeability of the fractures is often further enhanced by the deep weathering profile common in the region. Fractured bedrock aquifers occur more commonly in mafic, ultramafic and granitic rocks than in sedimentary, felsic volcanic and volcanoclastic units. In contrast the mafic and ultramafic dykes which are prevalent in the region can form hydraulic barriers to groundwater flow.

Fractured bedrock aquifers in the region can be high yielding. However, as a result of their discrete nature (i.e. having low storage characteristics and limited extents), they can dewater rapidly and consequently are not always reliable as a long term water supply, but are important to consider for mine dewatering. Permeability in the basement rocks away from these features is low, with low storage characteristics.

The Tertiary paleo-drainage systems are typically infilled with a basal palaeochannel sand (Wollubar Sandstone), which is overlain by low permeability clay. The palaeochannel sands form major aquifers in the region and will likely provide the largest reliable source of groundwater in the area. This resource is used extensively for ore processing across the Goldfields. The sands tend to have high permeability, but limited storage. Therefore, in the longer term most of the abstraction is supported by leakage from the overlying clays and surrounding basement rocks.

Shallow groundwater occurs in the surficial sediments, where they extend below the water table. Lacustrine sediments are generally fine grained and provide low yields. Alluvium/ colluvium tends to be more variable and can provide higher yields of up to 4 to 5 L/s in areas where deposits comprise predominantly sands and gravel. However, long-term abstraction is not always sustainable, because of the aquifer's limited extent.

Calcrete commonly occurs along drainage lines and at low points in the topography and can form important aquifers in the region. Calcrete aquifers are relatively thin (generally less than 10 to 15 m). However, because of their high permeabilities, relatively large areal extents and position low in the landscape, promoting rainfall recharge, these groundwater systems can sustain longer term abstractions of up to about 10 L/s.

Groundwater is recharged by direct rainfall infiltration or by stream flow during episodic rainfall events. Although difficult to quantify, recharge only constitutes a small proportion of rainfall. Most rainfall is lost to evaporation and evapo-transpiration. The rainfall recharge mainly occurs around outcropping basement, on sand-plains and sinkholes in the calcrete. Regional groundwater flows are generally towards the palaeo-drainages away from catchment divides. The palaeo-drainages discharge into salt lakes. In the salt lakes the groundwater is evaporated and concentrated to brine, which then descends and moves downstream eventually discharging into the Eucla Basin.

Groundwater salinities are extremely variable ranging from about 1,000 to 250,000 mg/L Total Dissolved Solids (TDS). Lower salinity groundwater, i.e. from 1,000 to 5,000 mg/L TDS occurs in areas most affected by direct rainfall recharge, e.g. near catchment divides and within shallow alluvium and calcrete units. The highest salinity groundwater occurs low down in the catchments within palaeochannel sands, salt lake sediments and in the deeper fractured rock aquifers.

2.4 Local Hydrogeology

The local hydrogeology in the Redcliffe project area, is dominated by fractured rock aquifers, hosted within a north trending sequence of mafic and ultramafic rocks. However, the basement rocks have undergone a significant degree of metamorphism, up to around greenschist facies.

In the Hub and GTS areas, deep weathering profiles have developed adjacent to ancient and modern drainages and overlie the fractured bedrock. The near surface is dominated by laterite and lateritic clays to a few meters below surface, with a thick sequence of saprolite clay extending below this horizon up to around 60 m below surface. The saprolite transitions to fresh, weakly jointed, low permeability bedrock through a saprock zone which has generally variable low- to moderate permeability. In the Nambi area the weathering profile is notably much shallower, and fractured rock aquifers poorly developed.

The thick clay sequences at Hub and GTS form a local confining layer with the piezometric surface around 8-10 mbgl at Hub and about 15 mbgl at GTS. The groundwater is deeper at Nambi, around 28-30 mbgl.

Groundwater quality is fresh to brackish at Hub and Nambi, less than 5,000 mg/L TDS. With a regional surface water divide striking northwest between the Hub and Nambi deposits. The regional groundwater flow direction north of this divide is towards a tributary paleochannel of the Carey Palaeovalley, which is located just south of the Hub deposit and runs in a northeasterly direction towards Nambi Homestead. A hydrogeological map of the project area is presented in Figure 2.

3.0 Field Investigations

Dacian commissioned a 19-day field investigation programme during September 2021 at the Redcliffe project as part of hydrogeological assessments for GTS, Hub and Nambi. The programme comprised airlift-recovery testing of 19 existing angled RC resource drill holes (and an existing water supply bore at GTS), as well as the drilling, attempted installation, and airlift-recovery testing of 8 groundwater monitoring bores, five of which were successful. The drilling and testing was undertaken by RC drilling contractors Strike Drilling based in Perth, with the drilling and hydraulic testing overseen by a GRM hydrogeologist. Summary details of the field work undertaken at each deposit area are provided below

3.1 Hydraulic Testing

Hydraulic testing was conducted on the RC resource holes, and successfully installed monitoring bores by airlift-recovery testing. This involves measuring the groundwater level recovery following controlled airlifting of groundwater from the drill hole using an RC drilling rig. Where possible airlifting was undertaken for approximately one hour followed by water level recovery measurement. The recovery monitoring was also undertaken for at least one hour, or until the water level has recovered to within 95% of the original groundwater level, where feasible. The water level data was collected by manual measurement, as well as using an automatic pressure transducer data logger lowered down the drill rod inner tubes immediately following the end of the airlift.

3.2 GTS

The hydrogeological assessment for the GTS area mostly involved review of a previous hydrogeological assessment overseen by Aquaterra (2010) for Pacrim Energy Ltd. However, a modest field investigation programme was also undertaken as part of the September 2021 investigations. The GTS deposit is located around 1.5 km north of the Mertondale open pit gold mine, which was mined during the 1980s.

The GTS field assessment involved:

- the drilling and attempted construction of one monitoring bore (GMB02) on the southeast side of the proposed GTS pit to a depth of 100m, and
- the re-entry, and airlift-recovery testing of an existing water supply bore M5WB8 (which was also airlift-recovery tested by Aquaterra in 2010), as well as
- the re-entry and airlift-recovery testing of one angled RC and diamond resource exploration hole (20RRC051).

3.3 Hub Area

The Hub area investigation comprised the re-entry, and airlift-recovery testing of 12 RC resource exploration drill holes, as well as the drilling and attempted construction of four groundwater monitoring bores each to 100 m depth, with airlift-recovery testing of the completed monitoring bores. Of the 12 resource exploration holes re-entered, only five holes (20RRC099, 20RRC100, 20RRC132, 20RRC134 and 20RRC136) were able to be airlifted due to thick sequence of swelling saprolite clay overlying the bedrock.

Of the four monitoring bores drilled, only two (HMB03 and HMB04) were successfully constructed as monitoring bores, with the casing installed to depths of 65 and 100 m respectively. Bore HMB01 could only have the casing installed to 29 m and bore HMB02 encountered fallback to within 18 m of surface, likely as a result of swelling in the pressurised clays.

3.4 Nambi

The field investigations for the Nambi pit area comprised the re-entry, and airlift-recovery testing of six RC resource exploration holes, as well as the drilling, construction and airlift testing of three groundwater monitoring bores each to 100 m depth. All six resource exploration holes (NBRC111, NBRC120, NBRC128, NBRC129, NBRC133, NBRC135) were successfully airlifted, as well as the three constructed monitoring bores NMB01, NMB02 and NMB03.

3.5 Water Quality Sampling

Groundwater samples for laboratory analysis were collected from the airlift discharge water at the end of drilling, for three of the monitoring bores at Hub (HMB01, HMB03, HMB04) and from three monitoring bores at Nambi (NMB01, NMB02, NMB03). The six samples were collected in plastic bottles with separate bottles for dissolved metals which were field filtered to pass 0.45 microns (µm). The water samples were kept cool and transported to ALS Environmental laboratories in Perth for analysis.

4.0 INVESTIGATION RESULTS

4.1 GTS

The drill hole GMB02 was successfully drilled to 100 m depth, however the hole collapsed due to overpressure in the saprolite clays, preventing the casing being installed and the monitoring bore completed. The water supply bore MSWB8 was airlift tested for 2-hours using a HDPE poly pipe placed down the bore. The average yields from MSWB8 were found to be 0.34 L/s, which was lower than the yield measured in 2010 by Aquaterra (1.37 L/s). The mis-match in yield is attributed to the different airlifting methodologies.

Resource drill hole 20RRC051D was re-entered, but the drillers struggled to get the rods to the full depth in the swelling clay sequence, taking three hours to work the drill rods to 114m. Air-circulation could not be confidently gained in the hole, so the test was abandoned. Summary results of the bore drilling and airlift testing at GTS are provided below in Table 3, with a map showing the bore and test hole locations (including the current and previous Aquaterra (2010) testing) provided in Figure 3. A graphic bore log for GMB02 is provided in Appendix A.

The investigation results indicate the presence of a thick clay saprolite sequence in the GTS pit area, similar to that around Hub, with the clay extending to 70 m depth, at least around bore GMB02. The clay sequence overlies the main mineralised zone which forms a fractured rock aquifer with variable, potentially low to moderate permeability. The airlift testing undertaken for GMB02 and 20RRC051D did not produce any measurable results due to the clay swelling and resultant loss of circulation.

4.2 Hub Area

For the 12 resource exploration holes re-entered for testing , only five holes were able to be airlifted (20RRC099, 20RRC100, 20RRC132, 20RRC134 and 20RRC136) due to the deep weathering profile and thick sequence of saprolite clays overlying the bedrock. Of the four attempted monitoring bores, only two (HMB03 and HMB04) were successful with the casing installed to depths of 65 and 100 m respectively. Bore HMB01 could only have the casing installed to 29 m and bore HMB02 encountered fallback to within 18 m of surface, following removal of the drill rods and hammer after drilling. Summary results of the bore drilling and airlift testing are provided below in Table 3, with a map showing the bore locations shown in Figure 4. Graphic bore logs for the monitoring bore drilling are provided in Appendix A.

The results found that airlift yields ranged between 0.22 and 4.4 L/s, indicating variable but generally low fracture permeability in the basement rocks, apart from monitoring bore HMB04. However, it should be noted that air circulation could not be established for seven of the RC holes and two of the monitoring bores, reducing the number of test data points significantly. Bore HMB04 to the west of Hub encountered elevated permeability in a fractures within the saprock zone, with a yield of 4.4 L/s. This site should be further investigated with installation and testing of a production bore, which could assist with mine dewatering and provide a local water supply.

The investigation results also indicate that the overlying saprolite sequence has low to very low permeability, and is prone to swelling when drilled with air-hammer techniques. The low permeability of the clays may lead to problems with pit-slope stability as the clays will remain pressurised after lowering of the water table.

4.3 Nambi

All six resource exploration holes (NBRC111, NBRC120, NBRC128, NBRC129, NBRC133, NBRC135) at Nambi were successfully airlifted, as well as the three constructed monitoring bores NMB01, NMB02 and NMB03. Although airlift yield data was measured for the two monitoring bores, NMB01 and NMB02, as well as with the two RC resource holes, NBRC120, NBRC129, the data logger was unable to record the recovering water levels. This was due to either;

- The groundwater level recovering too slowly for the logger to capture within a reasonable time, or
- The logger failing to deploy far enough down the drill rods due to the shallow inclination of the RC holes (55 degrees)

Summary results of the monitoring bore drilling and airlift testing results are compiled below in Table 3, with a map showing the monitoring bore and RC test hole locations (with RC drillhole traces) provided in the attached Figure 5.

The results indicate that the Nambi pit is located within an area of fractured and weathered schists with only minor saprolite development in the weathering zone. Airlift yields are generally low, varying between trace and 1.5 L/s indicative of generally low permeability conditions.

Table 3: Redcliffe Drilling and Hydraulic Testing Results

Bore ID	Deposit/ Pit Area	Bore Type	Coordinates (MGA94Zn51)		Azimuth	Dip	Drilled Depth	Test Interval	Airlift Yield	Comment
			Easting (m)	Northing (m)	(deg mag)	(deg)	(m)	(m)	(L/s)	
GMB02	GTS	Monitoring	357,686	6,838,256	0	90	100	–	–	Drilled to 100m; unable to be cased and tested no outside return
M5WB8	GTS	Production	357,575	6,838,265	0	90	86.5	16 – 86.5	0.34	2-hour airlift with HDPE poly pipe
20RRC051D	GTS	RC -Resource	357,673	6,838,007	65	270	120?	–	–	Rods reamed to 114m unable to gain circulation
20RRC067	Hub	RC -Resource	359,416	6,850,949	270	55	70	–	–	Hole blocked from clay swelling
20RRC087	Hub	RC -Resource	359,354	6,851,026	90	60	84	–	–	Abandoned - blow out to adjacent RC hole
20RRC088	Hub	RC -Resource	359,335	6,851,025	90	60	120	–	–	Hole blocked from clay swelling
20RRC093	Hub	RC -Resource	359,334	6,851,125	90	60	78	–	–	Hole blocked from clay swelling
20RRC095	Hub	RC -Resource	359,332	6,851,000	90	60	108	–	–	Hole blocked from clay swelling
20RRC099	Hub	RC -Resource	359,319	6,851,174	90	60	100	8.7 – 120	0.45	Only top part of hole tested
20RRC100	Hub	RC -Resource	359,307	6,851,174	90	62	130	9.4 – 44	0.32	Successful test
20RRC101	Hub	RC -Resource	359,390	6,851,152	270	60	82	–	–	Hole blocked from swelling clays
20RRC122	Hub	RC -Resource	359,298	6,851,473	270	60	64	–	–	Hole blocked from swelling clays
20RRC132	Hub	RC -Resource	359,265	6,851,377	90	60	100	9.8 – 66	1.5	Lower part of hole blocked by clays
20RRC134	Hub	RC -Resource	359,256	6,851,351	90	60	124	9.2 – 120	1.2 – 1.8	High to very high clay content in airlift water
20RRC136	Hub	RC -Resource	359,292	6,851,326	90	60	70	8.4 – 70	0.22	Successful test
HMB01	Hub	Monitoring	359,323	6,850,503	0	90	29	–	–	Drilled to 100m blocked at 29m when running casing

Investigation Results

Bore ID	Deposit/ Pit Area	Bore Type	Coordinates (MGA94Zn51)		Azimuth	Dip	Drilled Depth	Test Interval	Airlift Yield	Comment
			Easting (m)	Northing (m)	(deg mag)	(deg)	(m)	(m)	(L/s)	
HMB02	Hub	Monitoring	359,257	6,851,568	0	90	18	–	–	Drilled to 100m fallback to 18m
HMB03	Hub	Monitoring	359,570	6,851,141	0	90	66	8.3 – 66	0.6	Drilled to 100m; 80mm ND PVC casing to 66m
HMB04	Hub	Monitoring	359,116	6,851,112	0	90	108	10 – 104	4.4	Drilled to 100m; 80mm ND PVC casing to 100m
NBRC111	Nambi	RC-Resource	358,736	6,858,141	270	70	133	27 – 120	0.8	Clean hole to 120m; 100 minute airlift test
NBRC120	Nambi	RC-Resource	358,680	6,858,050	270	55	202	28 – 120	1.3	Unable seat logger deeper than 39m down rods
NBRC128	Nambi	RC-Resource	358,695	6,858,231	270	55	178	36 – 150	0.8	Rapid early time recovery
NBRC129	Nambi	RC-Resource	358,727	6,858,050	272	55	280	32 – 180	1.5	Foamy, logger could not be seated deeper than 37m down rods
NBRC133	Nambi	RC-Resource	358,734	6,858,007	270	55	220	27 – 102	0.6	Unable to get outside return water airlifted through cyclone
NBRC135	Nambi	RC-Resource	358,658	6,857,968	270	55	166	27 – 132	0.8	Logger installed to 95m depth, left in hole overnight
NMB01	Nambi	Monitoring	358,603	6,857,799	0	90	100	30 – 100	trace	80mm PVC casing to 100m; Recovery too slow for logger to capture data
NMB02	Nambi	Monitoring	358,700	6,858,449	0	90	100	26 – 100	0.4	80mm PVC casing to 100m; Successful data capture with logger
NMB03	Nambi	Monitoring	358,723	6,858,038	0	90	100	30 – 100	0.2	80mm PVC casing to 100m; Recovery too slow for logger capture

5.0 Data Analysis and Modelling

5.1 GTS

The successful airlift-recovery test result (water bore MSWB8) was reviewed and analysed using *Aqtesolv* (version 4.50) software. The analysis used the Theis (1935) recovery solution, with a plot of the analysis result presented in Appendix B . The solution calculated a transmissivity of 1 m^2/d, which was comparable with the result derived by Aquaterra in 2010 (0.9 m^2/d).

5.1.1 Pit Inflow Estimate

Estimates of potential pit inflows to the GTS pit during mining were re-calculated using the Aquaterra (2010) test data, in combination with an updated pit shell and mining schedule provided by Dacian. The inflow estimate used a simplified *Excel* spreadsheet-based analytical model that calculates staged pit inflows to the mine once the development advances below the water table. The solution is based on the DuPuit-Forchheimer and Thiem equations for flow to a large diameter well. This appears to be similar to the methodology used in the Aquaterra 2010 assessment. The aquifer permeability is assumed to be uniform throughout the simulation and uses the geometric mean value of the hydraulic conductivity measurements (0.29m/d), rather than the averaged values, which were adopted by Aquaterra. A specific yield (Sy) of 3% was adopted, the same as that used by Aquaterra, which was deemed reasonable. The inflow modelling uses the 15-month mining schedule for GTS supplied by Dacian. An averaged pit radius of 100 m was used as an approximation of the large diameter well. A plot of the model output for the GTS dewatering estimate is provided in the attached Appendix C.

The model results indicate that potential pit inflow rates may get up to around 5-10 L/s during mining, similar to the rates predicted by Aquaterra. However, it should be noted that the inflow estimates do not take into account the low permeability saprolite horizon, which may restrict groundwater flow to the pit until the saprock rock horizon is mined into. Short term inflows could therefore potentially be higher (when mining advances below the saprolite) than those indicated without advanced lowering of the water table in the pit area.

5.2 Hub

The airlift-recovery test data was reviewed and data from the four deepest bore sites across the deposit area were selected for analysis using *Aqtesolv* (version 4.50) software. The data was analysed using the Theis (1935) recovery solution, with plots of the four analyses shown in Appendix B and results summarised in Table 4.

Table 4:- Hub Recovery Analysis Results

Bore ID	Airlift Yield	Theis -Recovery	Adopted Aquifer Thickness	Hydraulic Conductivity (K)
	(L/s)	Transmissivity -T (m^2/d)	(m)	(m/d)
20RRC100	0.3	1.7	67	0.025
20RRC134	1.5	10.9	46	0.24
HMB03	0.6	2.4	13	0.18
HMB04	4.4	20.9	12	1.74

The results in Table 4 show that transmissivity ranged between 1.7 and 20.9 m^2/d. Using the best estimates of aquifer thickness from the available data, the hydraulic conductivity values could range between 0.025 and 1.74 m/d. The high value from HMB04 (K= 1.74m/d) possibly relates to the fracture zone coincident with the fault structure shown on the map in Figure 4. The geometric mean permeability value from the four analyses was calculated to be 0.21 m/d.

5.2.1 Pit Inflow Estimate

Estimates of groundwater inflows to the pit during mining at Hub were calculated using the same *Excel* spreadsheet-based analytical modelling as was used for the GTS assessment. The model adopted the geometric mean hydraulic conductivity from the data analysis and assumed an overall specific yield (Sy) of 1%. The modelling assumes a uniform mining rate with a pit developed over a 12 month period. The pit radius was averaged at 100 m for the simulation, which was based on the pit shell provided by Dacian. A copy of the model output results for the Hub pit are provided in the attached Appendix C. The model results indicate that potential pit inflow rates may range between 15 and 25 L/s during mining. It should be noted that the analytical model is a 'bulked parameter' model based on fairly limited data.

It should also be noted that the relatively wide range for the inflow estimate (15-25 L/s) is related to uncertainty around the high permeability found in monitoring bore HMB04 (1.74 m/d), which will need to be better assessed by installation and test pumping of a production bore adjacent to HMB04.

The inflow estimates also do not take into account the low permeability saprolite horizon which may restrict groundwater flow to the pit until the saprock rock horizon is mined into. This adds a further uncertainty in estimating the potential inflows at Hub. Therefore short term inflows could potentially be higher than those indicated when mining advances below the saprolite, without advanced lowering of the water table in the pit area.

5.3 Nambi

The Nambi airlift recovery data was reviewed and analysis for all nine combined RC holes and monitoring bores. The four bores with valid recovery data (NBRC111, NBRC128, NBRC135 and NMB02) were analysed using *Aqtesolv* (version 4.50) software utilising the Theis (1935) recovery solution, with individual plots of each of the analyses compiled in Appendix B, and the results summarised in Table 5. For the other five bores (NMB01, NMB03, NBRC120, NBRC129, NBRC133) which lacked recovery data, the airlift rate information was analysed using a steady state Thiem (1906) equation for flow to a well. The steady state analytical solution is also setup in an *Excel* based spreadsheet. A copy of the spreadsheet analyses results along with the assumptions underlying the analyses are provided in Appendix C, with the analysis results compiled in Table 5.

The analyses found that transmissivity ranged between 0.16 and 1.48 m^2/d, equating to a hydraulic conductivity range of between 0.002 and 0.051 m/d using the adopted saturated thicknesses shown. The geometric mean permeability value from the 9 test bores was calculated to be 0.012 m/d.

Table 5: - Airlift Recovery Analysis Results

Bore ID	Airlift Yield	Theis -Recovery (1935)	Thiem (1906)	Saturated Thickness	Hydraulic Conductivity (K)
	(L/s)	Transmissivity -T (m^2/d)		(m)	(m/d)
NMB02	0.4	3.8	–	74	0.051
NBRC111	0.5	1.16	–	85	0.014
NBRC128	0.8	1.48	–	93	0.016
NMB01	0.1	–	0.16	69.5	0.002
NMB03	0.2	–	0.36	70	0.005
NBRC120	1.4	–	2.3	70	0.027
NBRC129	1.5	–	1.44	120	0.01
NBRC133	0.6	–	1.16	60	0.016

5.3.1 Pit Inflow Estimate

Estimates of the potential pit inflows were calculated using the same simplified *Excel* spreadsheet based analytical modelling as used for GTS and Hub. The model adopted the geometric mean hydraulic conductivity from the data analysis (0.12 m/d) and assumed an overall specific yield (Sy) of 1%. The mining schedule supplied by Dacian with the pit developed over a 6 month period was applied to the model. A plot of the model output for the Nambi dewatering estimate is provided in Appendix C.

Inflows are predicted to be modest, around 5 L/s or less due to the massive nature of the bedrock and poorly developed bedrock aquifers in the area. These inflows include the contribution from the historical pit void once the existing pit lake is dewatered.

5.4 Saprolite Depressurisation

Although only limited drilling data was available for GTS, the investigation results indicate that a thick clay saprolite sequence is present in the GTS as well as Hub pit areas. The challenges found when undertaking hydraulic testing indicate these clays have low permeability and are likely to be slow draining, maintaining positive hydrostatic pressures close to pit-walls. These elevated pit wall pressures increase the risks of geotechnical instability.

GRM were commissioned by Dacian to further assess the extent of pit wall pressurisation for the GTS and Hub pits using groundwater modelling. The results of this study are reported in a separate technical memorandum to Dacian (GRM, 2021).

6.0 IMPACT ASSESSMENT

Dewatering of the three Redcliffe pits will induce a cone of depression in the local groundwater systems which will extend radially out from the pits over time. The analytical modelling estimates the extent of the cone of depression as a radius from the assumed pit (r_o) with time using Cooper-Jacob (1946), as well as an estimate of steady state inflow using an assigned r_o (Thiem, 1906). The two methods were used iteratively to estimate the likely maximum radius of the drawdown impacts for each of the pits. The modelled predictions for each pit drawdown impact are also compiled in Appendix C.

The results indicate that:

- The maximum drawdown extents from dewatering at GTS, Hub and Nambi pit are likely to be 400, 1,200 and 200 m respectively at the end of mining. Which when taking into account the varying pit plan geometries, the estimated impact zone limits are then estimated to extend radially to 600, 1,300 and 400 m respectively, for simplicity.
- No WIR registered bore falls within the modelled impact zone of mine dewatering at any of the pit locations.

Maps showing the impact extents as radii from the centre of each pit are plotted for the GPS pit in Figure 6 and Hub and Nambi pits in Figure 7. It should be noted that the model results are conservative as they do not include the effects or recharge.

A search was undertaken of the online Groundwater Dependent Ecosystem (GDE) Atlas managed by the Bureau of Meteorology (BoM), to determine if any aquatic or terrestrial ecosystems were likely to be impacted from the Redcliffe dewatering. No GDE's are identified within the immediate project area.

7.0 WATER QUALITY RESULTS

The six groundwater samples collected were submitted to ALS Environmental laboratories in Perth. The samples were analysed for a range of standard parameters including pH, electrical conductivity (EC), total dissolved solids (TDS) and alkalinity, as well as dissolved major cations and anions and a suite of dissolved metals comprising Al, As, Cd, Cr, Pb, Mn, Ni, Se, Zn and Fe as well as mercury and nitrates.

The laboratory results are collated in Table 6 and are compared against the Australian Drinking Water Guidelines[1] results for potable water quality. Copies of the laboratory certificates of analyses are compiled in Appendix D.

The results indicate that the groundwater quality at Hub is fresh to brackish and neutral to slightly alkaline and of the sodium chloride type with elevated sulfate. The water quality at Nambi is fresh, neutral to slightly alkaline and also of the sodium chloride type. The groundwater at both Hub and Nambi are within the potable limits for dissolved metals and most other parameters, although the elevated TDS may affect taste and require pretreatment before drinking.

No groundwater samples were taken at GTS, although the previous Aquaterra (2010) study found the groundwater to be brackish to saline, neutral to slightly alkaline, and of the sodium chloride type.

[1] ADWG, 2011: Australian Drinking Water Guidelines 6; National Health and Medical Research Council, Canberra.

Table 6:- Water Quality Results

Analyte	Detection Limit	Unit	HUBM01	HUBM03	HUBM04	NMB01	NMB02	NMB03	Potable Limit
			25-9-21	24-9-21	26-9-21	21-9-21	19-9-21	21-9-21	
pH Value	0.01	pH Unit	8.12	8.29	8.12	7.76	8.09	7.94	6.5-8.5#
Electrical Conductivity @ 25°C	1	µS/cm	1920	5000	3750	876	839	707	NA
Total Dissolved Solids @180°C	10	mg/L	**1160**	**3200**	**2350**	**673**	**648**	**561**	500 ^
Hydroxide Alkalinity as CaCO3	1	mg/L	<1	<1	<1	<1	<1	<1	NA
Carbonate Alkalinity as CaCO3	1	mg/L	<1	<1	<1	<1	<1	<1	NA
Bicarbonate Alkalinity as CaCO3	1	mg/L	205	436	396	62	111	84	NA
Total Alkalinity as CaCO3	1	mg/L	205	436	396	62	111	84	NA
Silicon as SiO2	0.1	mg/L	52.4	22.8	66.9	71.8	88.1	86.8	NA
Sulfate as SO4 - Turbidimetric	1	mg/L	158	**613**	**436**	60	50	53	250 ^
Chloride	1	mg/L	**411**	**1040**	**786**	183	160	126	250 ^
Calcium	1	mg/L	79	54	66	44	53	44	NA
Magnesium	1	mg/L	49	75	66	31	33	27	NA
Sodium	1	mg/L	**268**	**1030**	**702**	90	75	66	180 ^
Potassium	1	mg/L	19	30	23	10	7	7	NA
Dissolved metals									
Aluminium	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.1
Arsenic	0.001	mg/L	0.002	<0.001	0.005	<0.001	0.002	<0.001	0.01
Cadmium	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.002
Chromium	0.001	mg/L	0.003	0.018	0.001	<0.001	<0.001	<0.001	0.05
Lead	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01
Manganese	0.001	mg/L	<0.001	0.169	0.023	0.067	0.007	0.012	0.5
Nickel	0.001	mg/L	<0.001	<0.001	0.001	0.002	<0.001	0.001	0.02
Selenium	0.01	mg/L	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.01
Zinc	0.005	mg/L	<0.005	<0.005	<0.005	0.023	0.019	0.02	3^
Iron	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.3^
Mercury	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.001
Nitrate and Nitrite									
Nitrite as N	0.01	mg/L	<0.01	0.08	0.01	0.01	<0.01	0.01	3
Nitrate as N	0.01	mg/L	17.2	19.3	13.5	21	17.3	13.1	100 adults/ 50 infants
Nitrite + Nitrate as N	0.01	mg/L	17.2	19.4	13.5	21	17.3	13.1	See above
Ion balance									
Total Anions	0.01	meq/L	19	50.8	39.2	7.65	7.77	6.34	NA
Total Cations	0.01	meq/L	20.1	54.4	39.8	8.92	8.8	7.47	NA
Ionic Balance	0.01	%	2.91	3.44	0.87	7.65	6.21	8.2	NA

= Recreational guideline no limit set for potable use; ^= No potable limit set, based on aesthetics teste/smell etc

8.0 SUMMARY AND RECOMMENDATIONS

Dacian engaged GRM to undertake the relevant hydrogeological studies for the Redcliffe project which have focus on assessment of the likely mine dewatering requirements for the proposed developments at GST, Hub and Nambi. These studies involved a 19-day field investigation programme which was undertaken during September 2021. The programme comprised airlift-recovery testing of a total of 19 existing angled RC resource drill holes (and an existing water supply bore at GTS), as well as the drilling, attempted installation, and airlift-recovery testing of eight groundwater monitoring bores. The drilling and testing was undertaken by RC drilling contractors Strike Drilling based in Perth, with the drilling and hydraulic testing overseen by a GRM hydrogeologist.

The results of the airlift-recovery testing were modelled using two dimensional (2D) analytical solutions for simulation of flow to a large diameter well. The results of the modelling indicate that potential pit inflow rates:

- May get up to around 5-10 L/s during mining at GTS, similar to the rates predicted by Aquaterra (2010), although there is some uncertainty to the timing of the peak inflows due to the thick saprolite horizon.
- Are estimated to have a maximum range between 15 and 25 L/s during mining at Hub, although these is some uncertainty around these estimates due to the thick clay saprolite horizon overlying the deposit.
- Are predicted to be quite modest at Nambi, around 5 L/s or less due to the massive nature of the bedrock and poorly developed bedrock aquifers in the area.

The challenges found while undertaking hydraulic testing indicate the overlying clays at GTS and Hub will have low permeability and are likely to be slow draining, which will maintain positive hydrostatic pressures close to pit-walls.

The maximum drawdown extents from dewatering at GTS, Hub and Nambi pit are estimated to be 600, 1,300 and 400 m respectively at the end of mining. These estimates are considered conservative as they do not include recharge.

Laboratory analysis indicate that the groundwater quality at Hub is fresh to brackish, neutral to slightly alkaline and of the sodium chloride type with elevated sulfate. The water quality at Nambi is fresh, neutral to slightly alkaline and also of the sodium chloride type. The groundwater at both Hub and Nambi are within the potable limits for dissolved metals and most other parameters, although the elevated TDS may affect taste and require pretreatment before drinking.

It is recommended that a groundwater production bore be installed adjacent to monitoring bore HMB04 at Hub. The production bore should target the same structural feature intersected in HMB04 and be tested with multi-rate (step) and constant rate pumping tests to better assess aquifer parameters. The abstraction from this production bore could also prove both:

- a local site water supply for dust suppression, and
- help depressurise the overlying saprolite at Hub. .

Signatures

Groundwater Resource Management Pty Ltd

Karen Johnston

Peter Mayers

PRINCIPAL HYDROGEOLOGIST

Karen Johnston

PRINCIPAL HYDROGEOLOGIST

Doc Ref: J2126R02_Draft

REFERENCES

Aquaterra, 2010.; Golden Terrace South Hydrogeological Assessment. Unpublished hydrogeological report for Pacmin Energy.

GRM, 2021; Pit Wall Pressures: Hub and GTS. Unpublished technical memorandum (J2126TM02) for Dacian Limited.

Johnson, S.L, Commander, D.P, and O'Boy C,A., 1999; Groundwater Resources of Northern Goldfields , Western Australia. Water and Rivers Commission Hydrogeological Report Series.

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FIGURES

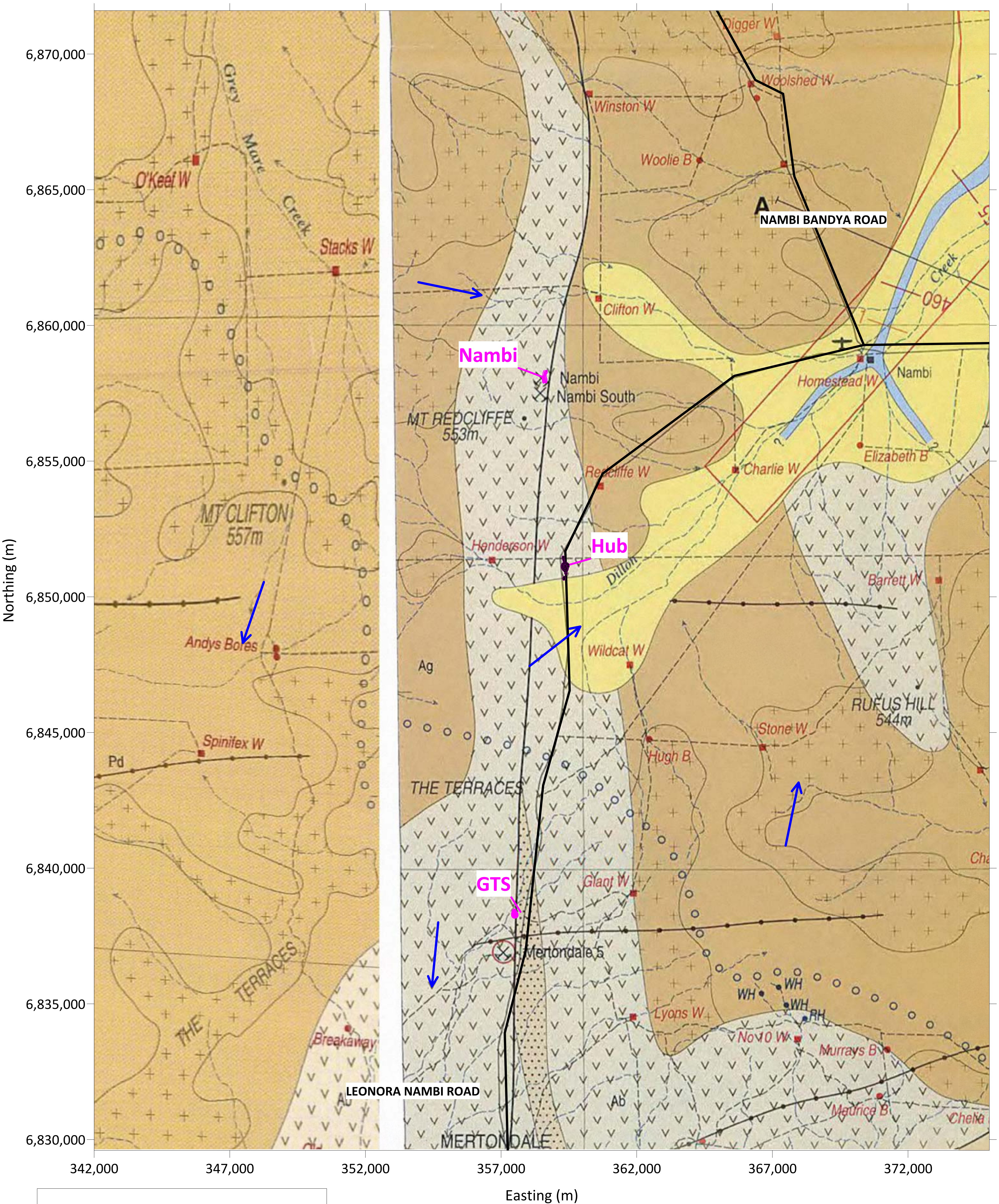
GROUNDWATER RESOURCE MANAGEMENT

FIGURE 1
PROJECT LOCATION

Date Dec 21
Client Dacian Gold
Project Redcliffe Development
Document J2126R01

Notes
Not to scale
Base Map Geoscience Australia

File: J2126/Deliverables/Figures/Powerpoint /J2126R01_location plan.ppx



LEGEND

Hugh B ▪ Bore or well

Grondwarer flow direction

Regional road

Surface water divide

Geology Legend

- Cz Alluvium and colluvium - clay, sand gravel
- Tw Wollubar Sandstone - sandstone, siltstone, gravel
- Mafic and ultramafic dykes
- q Quartz veins
- Ac Chert and banded iron formations
- Ab Mafic and ultramafic rocks
- Ag Granitoid rocks, includes porphyry

GROUNDWATER RESOURCE MANAGEMENT

FIGURE 2
REGIONAL HYDROGEOLOGY AND WIR BORES

Date Dec 21
Client Dacian Gold
Project Redcliffe Development
Document J2126R02

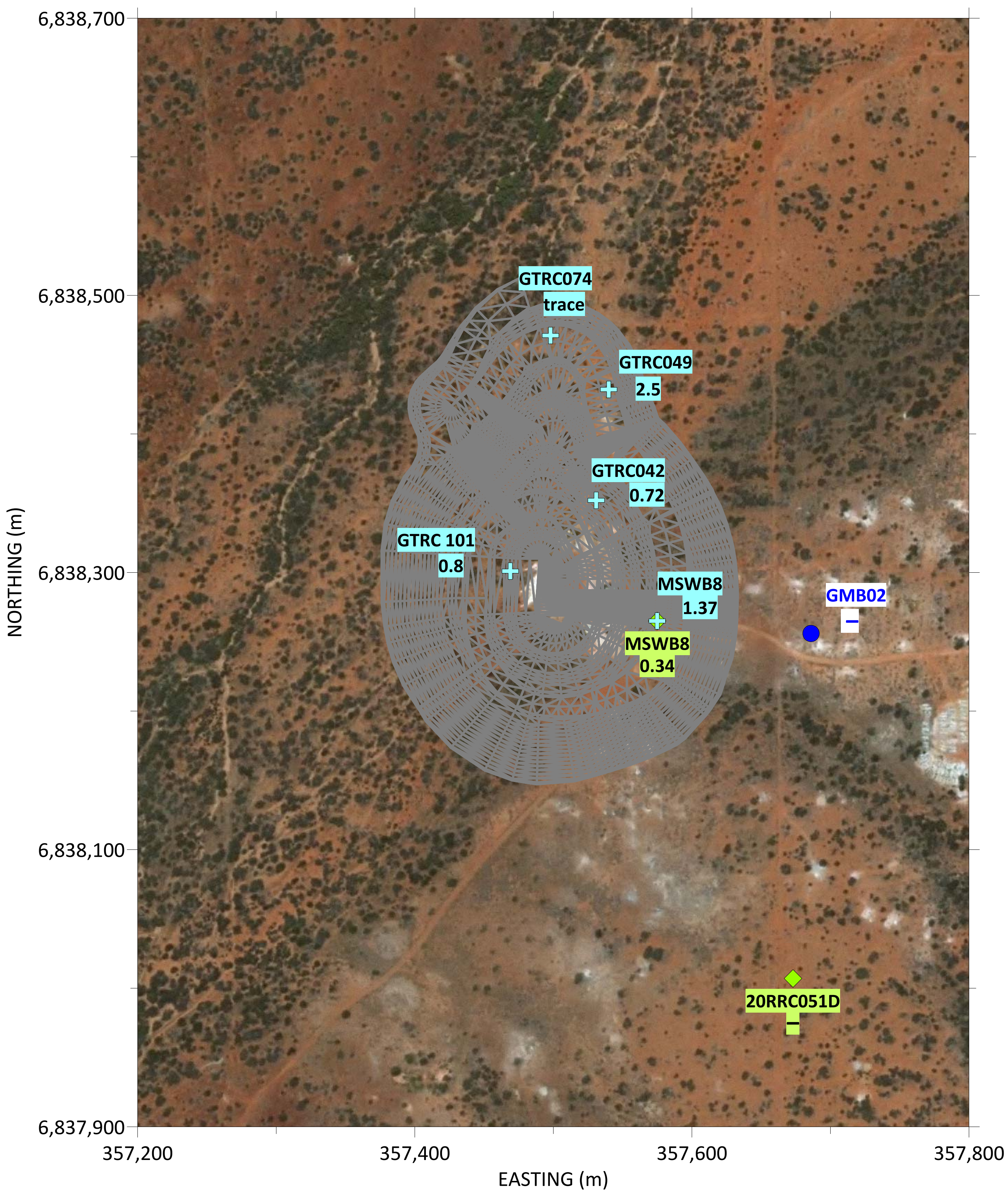
Coordinate System
GDA94 Zone 51

Data Sources
LEONORA 1:250,000 HYDROGEOLOGY Map
LAVERTON 1:250,000 HYDROGEOLOGY Map

SCALE 1:140,000

0m 5,000m 10,000m

FILE:/J2126/Deliverables/Figures/Surfer/Fig2 Hydrogeology &WIR bores



LEGEND

MSWB8 1.37	Airlift test hole (Aquaterra 2010) with yield L/s	GMB02 –	Attempted monitoring bore with airlift yield L/s
MSWB8 0.34	Airlift test hole (GRM 2021) with airlift yield L/s		

GROUNDWATER RESOURCE MANAGEMENT

FIGURE 3
GTS BORES AND AIRLIFT YIELDS

Date Dec 21
Client Dacian Gold
Project Redcliffe Development
Document J2126R01

Coordinate System
GDA94 Zone 51

Data Sources
World Imagery

SCALE 1:4,000
0m 100m 200m

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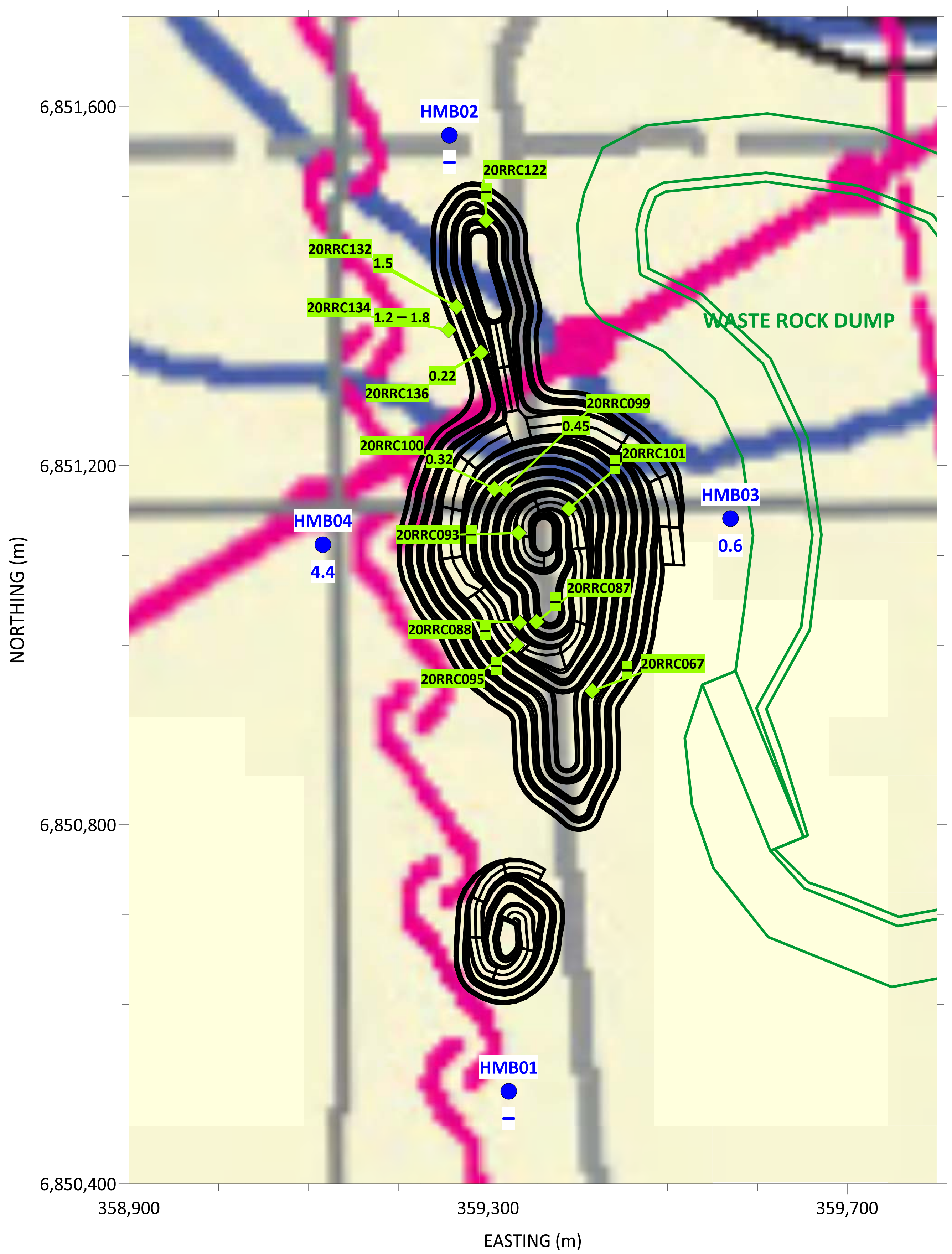

LEGEND

HMB04 4.4 — Monitoring bore with airlift yield (L/s)

20RRC132 1.5 — RC resource drill hole with airlift yield (L/s)

Fault

Dyke or vein

GROUNDWATER RESOURCE MANAGEMENT

FIGURE 4
HUB AREA BORES AND AIRLIFT YIELDS

Date Dec 21
Client Dacian Gold
Project Redcliffe Development
Document J2126R01

Coordinate System GDA94 Zone 51

Data Sources MAMBI_3241 1:100,000 GEOLOGY

SCALE 1:6,000

0m 200m

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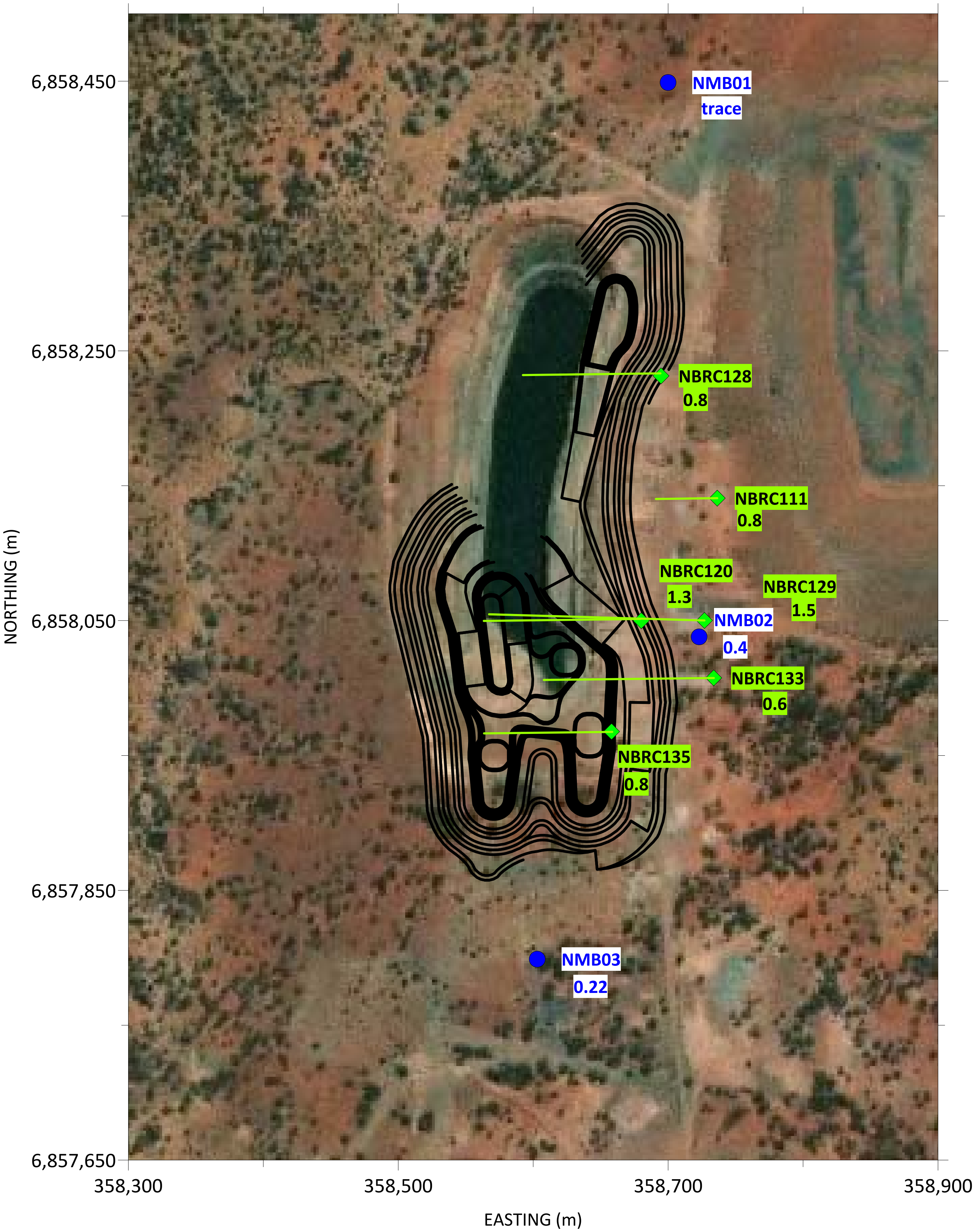


LEGEND

NMB03 0.22 — New monitoring bore with airfit yield (L/s)

NBRC133 0.6 — RC test drill hole with airfit yield (L/s)

RC drillhole trace

GROUNDWATER RESOURCE MANAGEMENT

FIGURE 5
NAMBI PIT
BORES AND AIRLIFT YIELDS

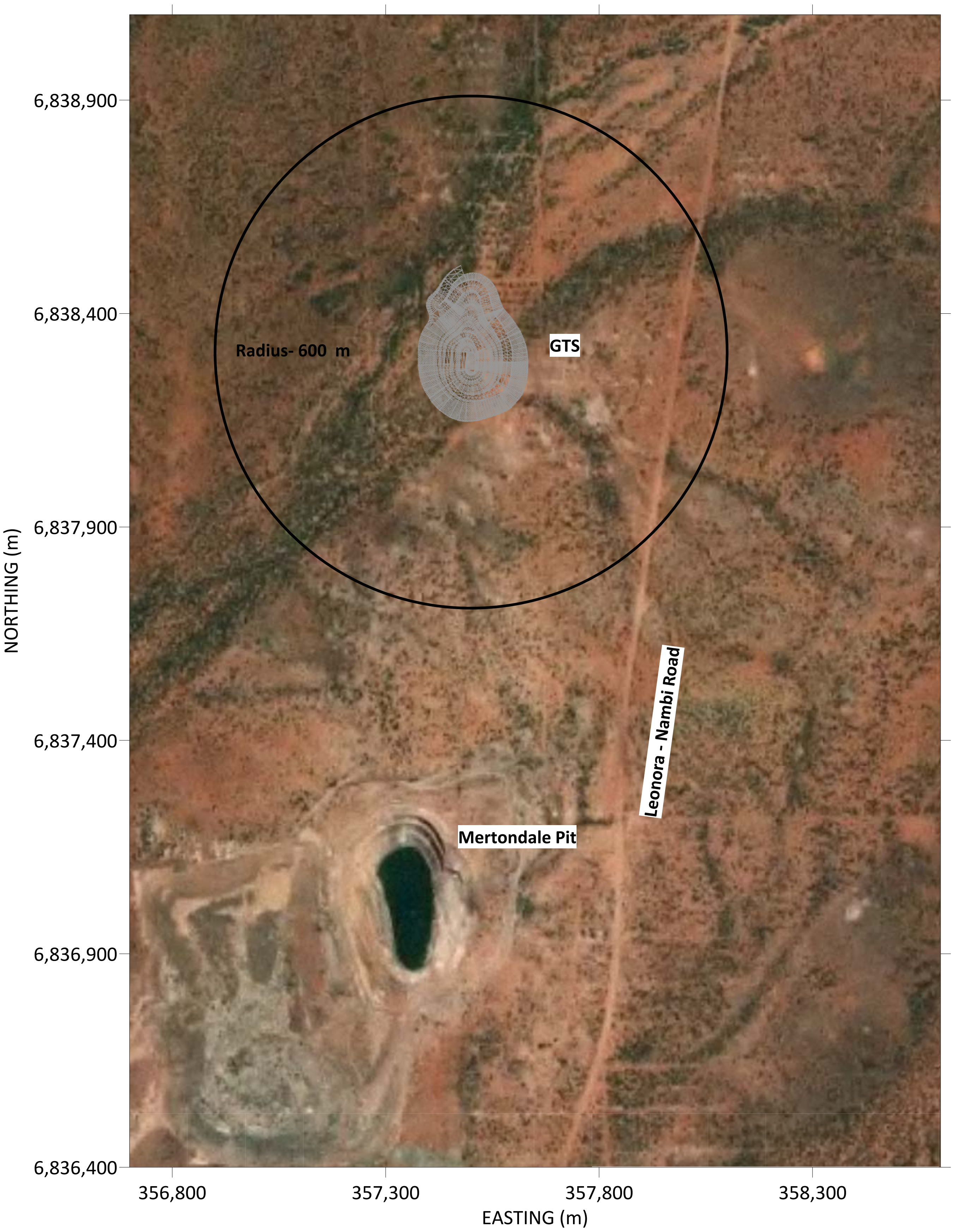
Date Dec 21
Client Dacian Gold
Project Redcliffe Development
Document J2126R01

Coordinate System
GDA94 Zone 51

Data Sources
World Imagery

SCALE 1:4,000
0m 200m

FILE:/Jobs 2021/Deliverables/Nambi /Fig5 Nambie bores and test hole locations.srf



GROUNDWATER
RESOURCE MANAGEMENT

FIGURE 6
DRAWDOWN EXTENT GTS PIT

Date Dec 21
Client Dacian Gold
Project Redcliffe Development
Document J2126R01

Coordinate System
GDA94 Zone 51

Data Sources
World Imagery

SCALE 1:12,500
0 500

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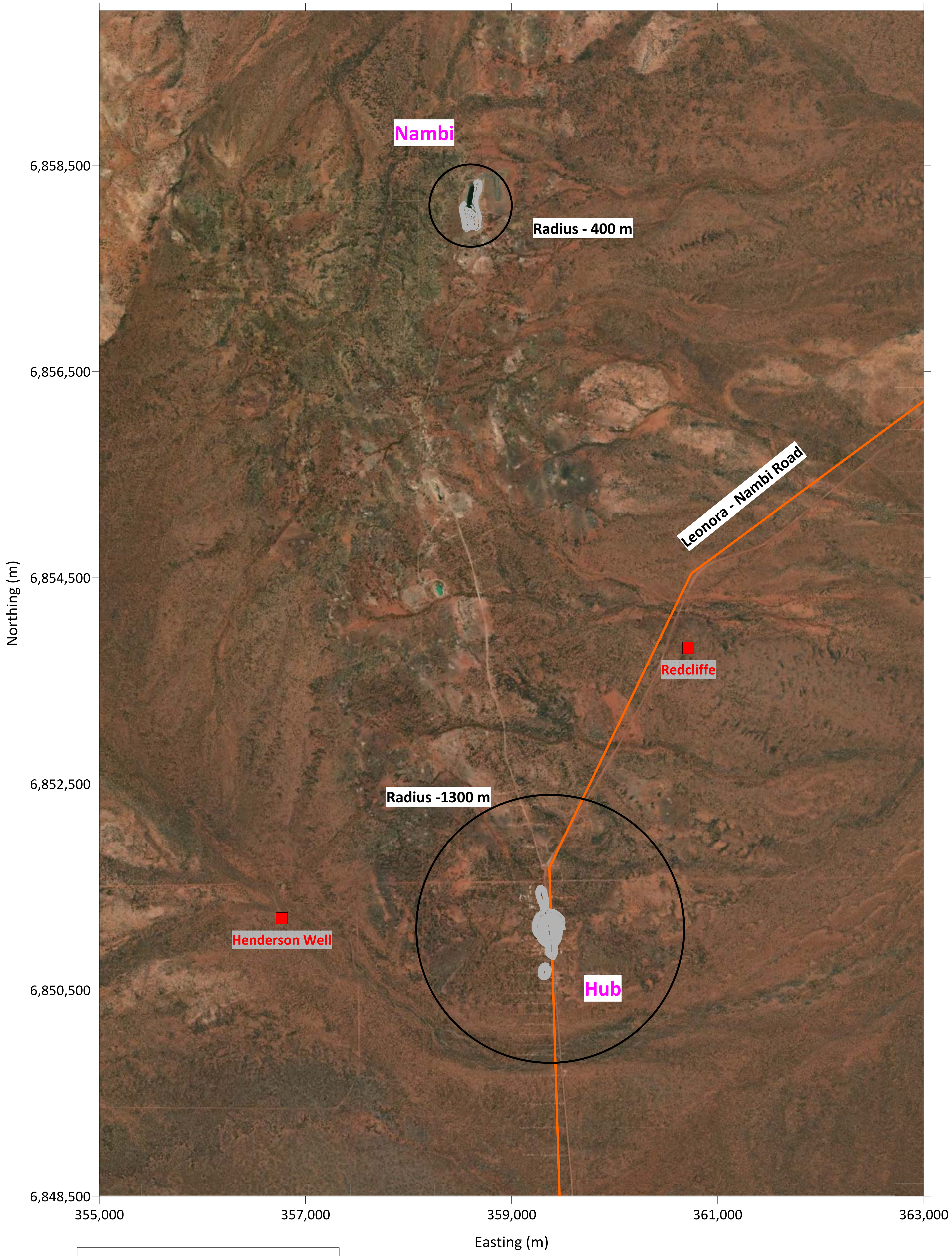


LEGEND

- WIR Registered bore
- Regional road

GROUNDWATER RESOURCE MANAGEMENT

FIGURE 7
DRAWDOWN EXTENTS
HUB & NAMBI

Date Dec 21
Client Dacian Gold
Project Redcliffe Development
Document J2126R02

Coordinate System
GDA94 Zone 51

SCALE 1:37,500
0m 2,000m

FILE:/J2126/Deliverables/Figures/Surfer/Fig7 Drawdown extents Hub and Nandi

Appendix A: Graphic Bore Logs

GROUNDWATER RESOURCE MANAGEMENT

PO Box 442 Bayswater WA 6933
15 Harborne Street
Wembley WA 6014
Ph: +61 8 9433 2222 Fx: +61 8 9433 2322
Email: water@g-r-m.com.au

ID: **GMB02**		JOB NUMBER: J2126	
CLIENT: Dacian Gold Redcliffe		PROJECT: Redcliffe Development	
COMMENCED: 26-Sep-21	EASTING: 357686	INCLINATION: 90 degrees	
COMPLETED: 27-Sep-21	NORTHING: 6838256	AZIMUTH: 0 degrees	
DRILLED BY: Strike	ELEVATION: 485	SWL (date): - mbtoc (-)	
LOGGED BY: SLA	GRID SYSTEM: J51		

Depth (m bgl)	Lithological Description	Field Notes	Bore Construction
0	GRAVELS: ferruginous - ferricrete and qtz detritus		+0.1-3m: 6" ND PVC casing
5	SAPROCK: fawn bleached after v.fine gr. metasediment. Abundant grit minor clay		
15	SAPROCK: fawn bleached after v.fine gr. felsic metasediment. Moderate clay and grit		
20			2-100m: 146mm ND air-hammer drill hole
25	CLAY: cream minor indurated cemented saprock? Bands	Cut Water	
45	CLAY: grey-cream clays Fe stone grit 43m, plastic buff clay at 54-55m		
50			24-100m Fallback
55	CLAY: dark brown Fe stone bands in clay host. Qtz vein 56-57m. Pisolitic unit at 60-61m		
60	CLAY: red-brown minor Fe stone grit/ pisolites.		
65	CLAY: pale brown minor felsic? Primary lithology and Fe stone grits		
75	BASALT: grey-fawn weathered mafic, minor clays.		
90	BASALT: grey black, fine grained, fresh, massive		
100			

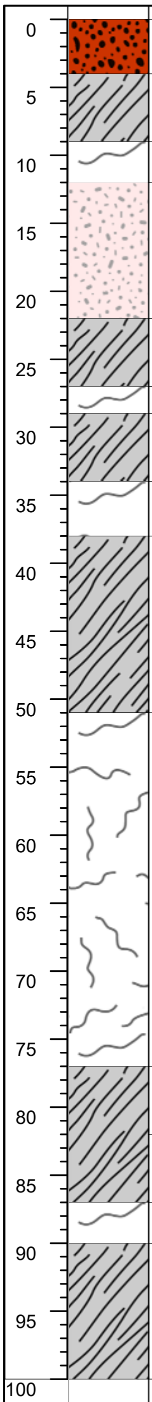
GROUNDWATER RESOURCE MANAGEMENT

PO Box 442 Bayswater WA 6933
15 Harborne Street
Wembley WA 6014
Ph: +61 8 9433 2222 Fx: +61 8 9433 2322
Email: water@g-r-m.com.au

ID:	**HMB01**	JOB NUMBER:	J2126
CLIENT:	Dacian Gold Redcliffe	PROJECT:	Redcliffe Development

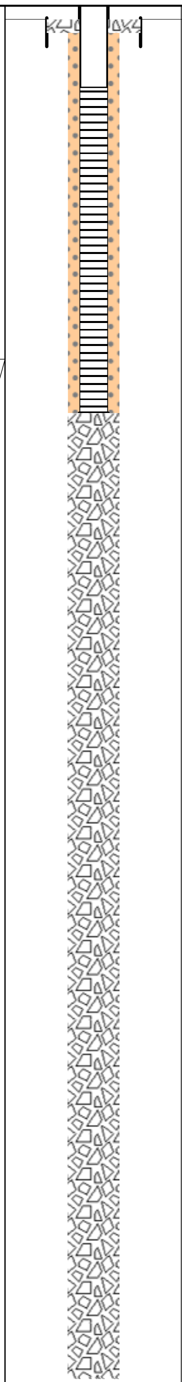
COMMENCED:	24-Sep-21	EASTING:	359323	INCLINATION:	90 degrees
COMPLETED:	25-Sep-21	NORTHING:	6850503	AZIMUTH:	0 degrees
DRILLED BY:	Strike	ELEVATION:	497	SWL (date):	10.54 mbtoc (29-Sep-21)
LOGGED BY:	SLA	GRID SYSTEM:	J51		

Depth (m bgl)	Graphic + Stratigraphy	Lithological Description	Field Notes	Bore Construction



Lithological Description
FERRICRETE: Red brown cemented flaggy ironstone
SCHIST: pale brown-green highly weathered, mafic foliated fine grained metasiltstone?
QUARTZ: veins ~80% of cuttings minor weathered mafic schist
CLAY: yellow clays - saprock?
SCHIST: yellow-brown mottled highly weathered,moderate clay content
QUARTZ: vein qtz. 90% O
SCHIST: limonitic yellow-brown mottled, foliated fine grained metasiltstone
QUARTZ: vein qtz. 70% in weathered foliated clayey metasilstone
SCHIST: limonitic yellow-brown mottled, foliated fine grained metasiltstone
QUARTZ: vein minor yelloow-brown clayey mafic schist?
SCHIST: grey weathered foliated mafic schist abundant qtz veins
SCHIST: grey-black mafic unweathered foliated fine grained metasiltstone
QUARTZ: vein qtz, unweathered minor clayey mafic schist
SCHIST: grey-black mafic unweathered foliated v.fg metasiltstone, 20% qtz veins and clay

Field Notes: 25m: Flow 0.014L/s, EC 1.7 mS/cm, pH 7.4, temp 22°C



Bore Construction:

+0.1-2m: 6" ND PVC casing

0-1m: cuttings backfill

+1.2-10m: 80mm ND CL12 uPVC blank casing

29m: 50mm ND CL 12 uPVC end cap

5-29m: 50mm ND CL12uPVC machine slotted casing (1mm aperture)

2-100m: 146mm ND air-hammer drill hole

1-66m: +1.6-3.2mm graded gravel pack

29-100m Fallback

GROUNDWATER RESOURCE MANAGEMENT

PO Box 442 Bayswater WA 6933
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Wembley WA 6014
Ph: +61 8 9433 2222 Fx: +61 8 9433 2322
Email: water@g-r-m.com.au

ID:	HMB02	JOB NUMBER:	J2126
CLIENT:	Dacian Gold Redcliffe	PROJECT:	Redcliffe Development
COMMENCED: 22-Sep-21	EASTING: 359257	INCLINATION: 90 degrees	
COMPLETED: 23-Sep-21	NORTHING: 6851568	AZIMUTH: 0 degrees	
DRILLED BY: Strike	ELEVATION: 498	SWL (date): - mbtoc (29-Sep-21)	
LOGGED BY: SLA	GRID SYSTEM: J51		

Depth (m bgl)	Lithological Description	Field Notes	Bore Construction
0	FERRICRETE: Red brown cemented flaggy ironstone		+0.1-2m: 6" ND PVC casing
0–8	SCHIST: pale grey to pink weathered, foliated fine grained felsic metasiltone		
8–14	SCHIST: grey to orange weathered felsic fine grained		
14–17	SCHIST: red orange wferruginous felsic v.fine grained		
17–20	SCHIST: pale grey high silica weathered, 50% qtz veins, caving ground		2-100m: 146mm ND air-hammer drill hole
20–36	CLAY: pale grey to pink clays, swelling?		
36–46	CLAY: grey - white - yellow. Minor to trace chips of schist, ironstone and vein qtz		
46–55	CLAY: pale grey, minor vein qtz - possible shear?		18-100m Fallback
55–70	SCHIST: pale broen weakly weathered felsic v.fine grained. 25% qtz veins		
70–87	SCHIST: dark grey trace weathering to 79m, foliated f.gr mafic metasiltstone, qtz veins 80-81m. Minor clays 80-88m		66-100m Fallback
87–100	SCHIST: unweathered dark grey mafic, siliceous foliated fine grained metasiltstone, minor qtz veins 90-92m		

GROUNDWATER RESOURCE MANAGEMENT

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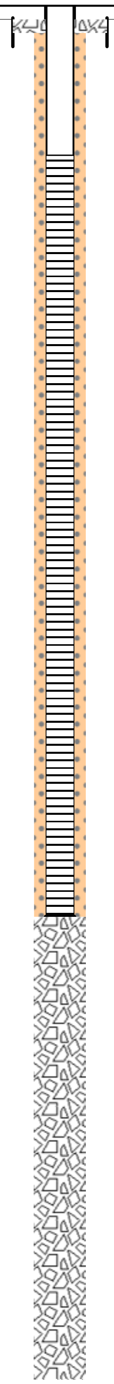
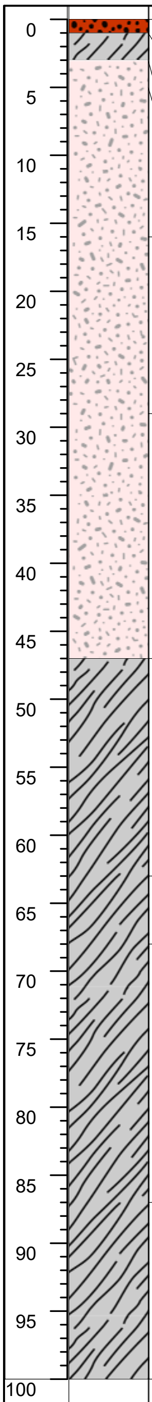
Email: water@g-r-m.com.au

ID:	HMB03			JOB NUMBER:	J2126
CLIENT:	Dacian Gold Redcliffe			PROJECT:	Redcliffe Development
COMMENCED:	23-Sep-21	EASTING:	359570	INCLINATION:	90 degrees
COMPLETED:	23-Sep-21	NORTHING:	6851141	AZIMUTH:	0 degrees
DRILLED BY:	Strike	ELEVATION:	496	SWL (date):	8.23 mbtoc (29-Sep-21)
LOGGED BY:	SLA	GRID SYSTEM:	J51		

Depth (m bgl)	Graphic + Stratigraphy	Lithological Description	Field Notes	Bore Construction
0		FERRICRETE: Red brown cemented flaggy ironstone		+0.1-2m: 6" ND PVC casing
		SCHIST: highly weathered feksic schiat ~10% qtz.brown red weathered chloritic, foliated fine grained metasiltstone		
5		CLAY: pale grey, 10% vein qtz		+1.2-10m: 80mm ND CL12 uPVC blank casing
10		CLAY: mauve clays minor Fe-stone lenses		1-66m: +1.6-3.2mm graded gravel pack
20		CLAY: dark brown clay		2-100m: 146mm ND air-hammer drill hole
35		CLAY: dark brown with fe pisolitic grits. Cut water @ 34m		10-66m: 50mm ND CL12uPVC machine slotted casing (1mm aperture)
55		SCHIST: weathered mafic? Metasediment foliated moderate clay content ? Saprock	53m: Flow 0.6L/s, EC 4.9 mS/cm, pH 7.5, temp 23°C	
65		SCHIST: felsic weathered f.gr schist. Moderate clay content. Vein Qtz 65-67m		66m: 50mm ND CL 12 uPVC end cap
75		SCHIST: grey-green felsic foliated f.gr. Metasiltstone. Moderate clay to 74m		66-100m Fallback
90		SCHIST: fresh mafic foliated massive metatbasalt?		
100				





GROUNDWATER RESOURCE MANAGEMENT	ID: **HMB04**		JOB NUMBER: J2126	
	CLIENT: Dacian Gold Redcliffe		PROJECT: Redcliffe Development	
PO Box 442 Bayswater WA 6933 15 Harborne Street Wembley WA 6014 Ph: +61 8 9433 2222 Fx: +61 8 9433 2322 Email: water@g-r-m.com.au	COMMENCED: 25-Sep-21	EASTING: 359116	INCLINATION: 90 degrees	
	COMPLETED: 26-Sep-21	NORTHING: 6851112	AZIMUTH: 0 degrees	
	DRILLED BY: Strike	ELEVATION: 498	SWL (date): 9.8 mbtoc (29-Sep-21)	
	LOGGED BY: SLA	GRID SYSTEM: J51		

Depth (m bgl)	Graphic + Stratigraphy	Lithological Description	Field Notes	Bore Construction
0		FERRICRETE: Red brown cemented flaggy ironstone		+0.1-2m: 6" ND PVC casing
		GRAVELS: Fe stone		
5		PORPHYRY: weathered mottled yellow-buff felsic. Mafic band 8m. Cut water @7m		+1.2-10m: 80mm ND CL12 uPVC blank casing
10		SCHIST: grey yellow weathered, limonite on fractures - v.fg mafic		
20				1-66m: +1.6-3.2mm graded gravel pack
25		SCHIST: mafic massive laminated siliceous mylonite? limonite on fractures. Hiugh water flows at 32m ~4L/S visual est.		
35		BASALT: grey black, fine grained, fresh, massive, generally fractured limonite partings		
40		SCHIST: mafic massive laminated siliceous mylonite? limonite on fractures trace py		10-66m: 50mm ND CL12uPVC machine slotted casing (1mm aperture)
50		SCHIST: fresh mafic massive laminated siliceous mylonite? trace py		
65				66m: 50mm ND CL 12 uPVC end cap
90				2-100m: 146mm ND air-hammer drill hole
102			102m: Flow 4L/s, EC 7.7 mS/cm, pH 7.1, temp 24°C	
107.7			107.7m: Flow 4L/s, EC 7.6 mS/cm, pH 7.2, temp 24°C	
110				

GROUNDWATER
RESOURCE MANAGEMENT

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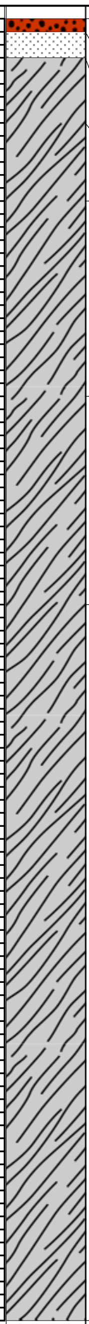
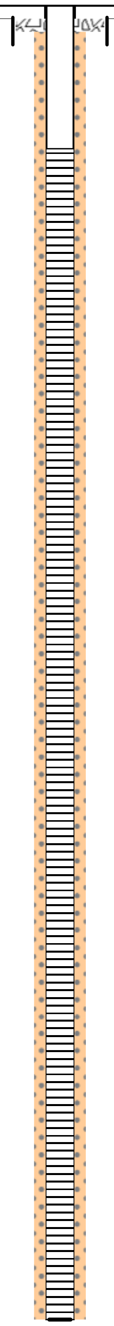
Email: water@g-r-m.com.au

ID:	**NMB01**			JOB NUMBER:	J2126
CLIENT:	Dacian Gold Redcliffe			PROJECT:	Redcliffe Development
COMMENCED:	20-Sep-21	EASTING:	358700	INCLINATION:	90 degrees
COMPLETED:	20-Sep-21	NORTHING:	6858449	AZIMUTH:	0 degrees
DRILLED BY:	Strike	ELEVATION:	524	SWL (date):	30.5 mbtoc (29-Sep-21)
LOGGED BY:	SLA	GRID SYSTEM:	J51		

Depth (m bgl)	Graphic + Stratigraphy	Lithological Description	Field Notes	Bore Construction
0		FERRICRETE: Red brown cemented flaggy ironstone		+0.1-2m: 6" ND PVC casing
		SAPROCK: pale yellow, strongly weathered schist, very soft		+1.2-10m: 80mm ND CL12 uPVC blank casing
5		SCHIST: dark grey weathered, foliated fine grained metasiltsone		
10		SCHIST: yellow ochre weathered, foliated fine grained siliceous		
15–30		SCHIST: pale grey/yellow mottled limonitic, moderatly weathered, foliated fine grained metasiltstone, minor qtz veins?		2-100m: 146mm ND air-hammer drill hole
30–45		SCHIST: pale grey weakly weathered foliated fine grained metasiltstone, minor qtz veins?		10-100m: 50mm ND CL12uPVC machine slotted casing (1mm aperture)
45–100		SCHIST: unweathered dark grey mafic, siliceous foliated fine grained metasiltstone, minor qtz veins 87-91m	0m: Flow 0.01L/s, EC 0.92 mS/cm, pH 7.5, temp 22°C	1-100m: +1.6-3.2mm graded gravel pack; 100m: 50mm ND CL 12 uPVC end cap

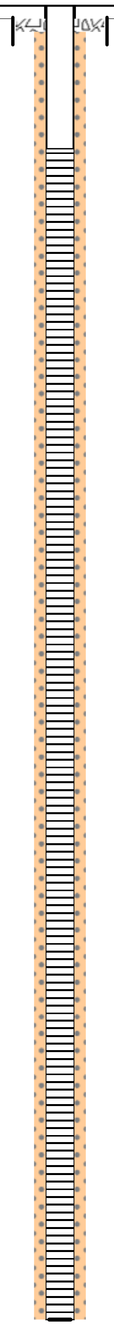
Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100





GROUNDWATER RESOURCE MANAGEMENT	ID: **NMB02**		JOB NUMBER: J2126
	CLIENT: Dacian Gold Redcliffe		PROJECT: Redcliffe Development
PO Box 442 Bayswater WA 6933 15 Harborne Street Wembley WA 6014 Ph: +61 8 9433 2222 Fx: +61 8 9433 2322 Email: water@g-r-m.com.au	COMMENCED: 18-Sep-21	EASTING: 358723	INCLINATION: 90 degrees
	COMPLETED: 20-Sep-21	NORTHING: 6858038	AZIMUTH: 0 degrees
	DRILLED BY: Strike	ELEVATION: 517	SWL (date): 25.86 mbtoc (29-Sep-21)
	LOGGED BY: SLA	GRID SYSTEM: J51	

Depth (m bgl)	Graphic + Stratigraphy	Lithological Description	Field Notes	Bore Construction
0		COLLUVIUM: Red brown cemented ironstone nodules and sand		+0.1-2m: 6" ND PVC casing
5		SCHIST: buff to orange weathered felsic fine grained - leached appearance		+1.2-10m: 80mm ND CL12 uPVC blank casing
		SCHIST: pale yellow to grey weathered, foliated fine grained metasiltstone		
10				
15		SCHIST: dark grey weakly weathered foliated fine grained metasiltstone, limonite on fractures		
20				2-100m: 146mm ND air-hammer drill hole
25				
30		SCHIST: dark grey minor weathering, foliated fine grained mafic metasiltstone		
35				
40				10-100m: 50mm ND CL12uPVC machine slotted casing (1mm aperture)
45		SCHIST: grey-black, trace limonite of fractures, hard - siliceous foliated metasandstone		
50				
55				
60				
65				
70				
75		SCHIST: grey-black, hard - siliceous foliated metasandstone		
80				1-100m: +1.6-3.2mm graded gravel pack
85				
90				100m: 50mm ND CL 12 uPVC end cap
95				
100			99m: Flow 0.4L/s, EC 0.89 mS/cm, pH 7.3, temp 21.6°C	



GROUNDWATER RESOURCE MANAGEMENT

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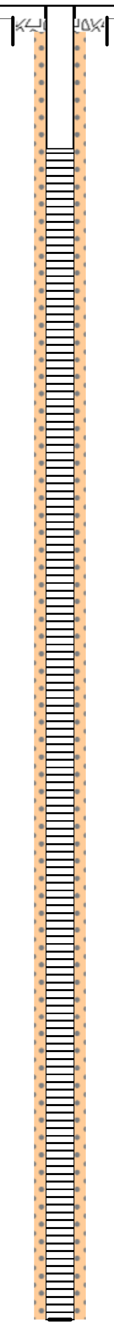
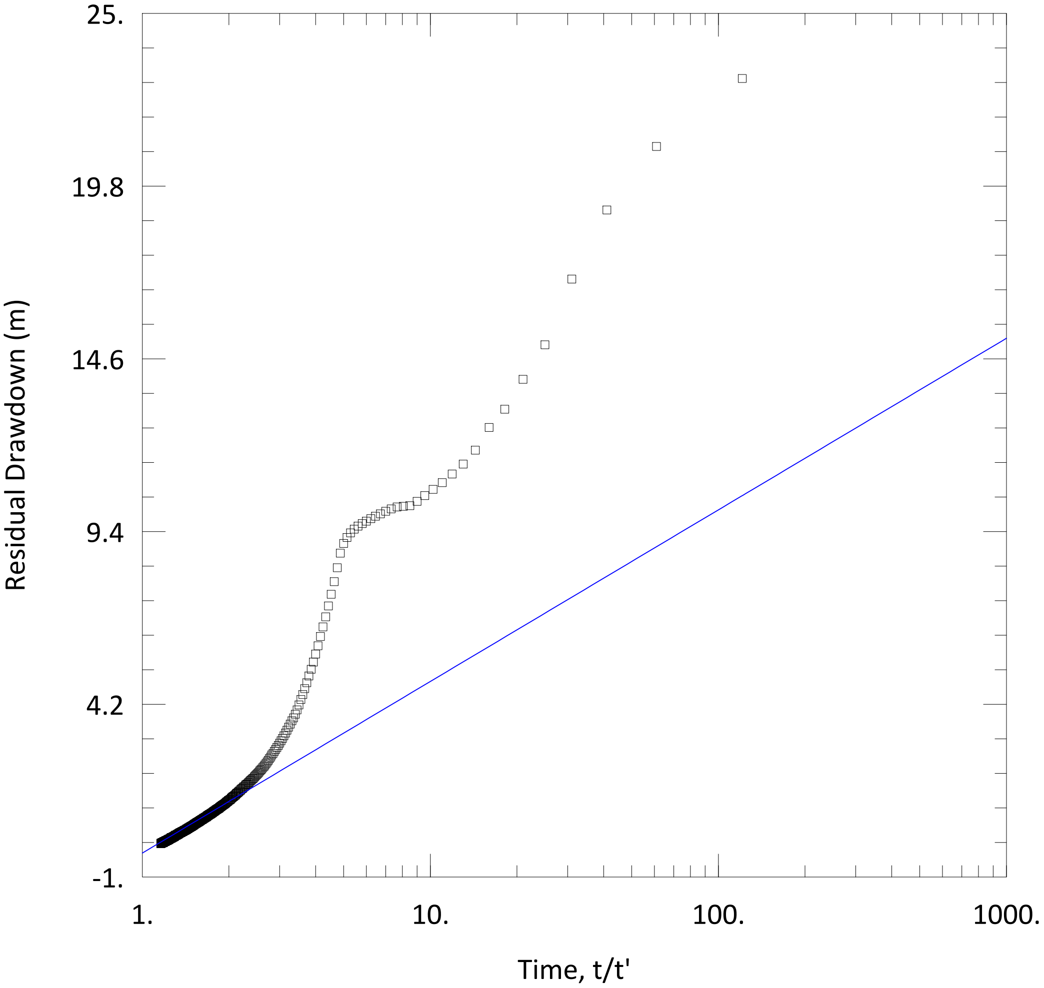
ID:	NMB03	JOB NUMBER:	J2126
CLIENT:	Dacian Gold Redcliffe	PROJECT:	Redcliffe Development

COMMENCED:	21-Sep-21	EASTING:	358603	INCLINATION:	90 degrees
COMPLETED:	21-Sep-21	NORTHING:	6857799	AZIMUTH:	0 degrees
DRILLED BY:	Strike	ELEVATION:	524	SWL (date):	30 mbtoc (29-Sep-21)
LOGGED BY:	SLA	GRID SYSTEM:	J51		

Depth (m bgl)	Graphic + Stratigraphy	Lithological Description	Field Notes	Bore Construction
0		SCHIST: orange fe weathered felsic v.fine grained - leached appearance		+0.1-2m: 6" ND PVC casing
5		SCHIST: red orange weathered felsic v.fine grained		+1.2-10m: 80mm ND CL12 uPVC blank casing
10		SCHIST: pale brown weathered, foliated fine grained metasiltone		
15–30		SCHIST: yellow ochre weathered, foliated fine grained		2-100m: 146mm ND air-hammer drill hole
35		SCHIST: grey-black mafic weakly weathered foliated fine grained metasiltstone		10-100m: 50mm ND CL12uPVC machine slotted casing (1mm aperture)
45–95		SCHIST: grey-black mafic unweathered foliated fine grained metasiltstone, qtz veins 52-60m, Trace Py		1-100m: +1.6-3.2mm graded gravel pack
				100m: 50mm ND CL 12 uPVC end cap
100			99m: Flow 0.22L/s, EC 0.75 mS/cm, pH 7.3, temp 24.5°C	



Appendix B: Airlift-Recovery Analysis Plots



GTS PIT AIRLIFT-RECOVERY TEST MSWB8

Data Set: E:\...\MSWB8.aqt
Date: 11/18/21 Time: 15:22:51

PROJECT INFORMATION

Company: GRM
Client: Dacian Gold
Project: J2126
Location: Redcliffe_GTS
Test Well: MSWB8
Test Date: 1/10/21

AQUIFER DATA

Saturated Thickness: 70.5 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
MSWB8	357575	6838265

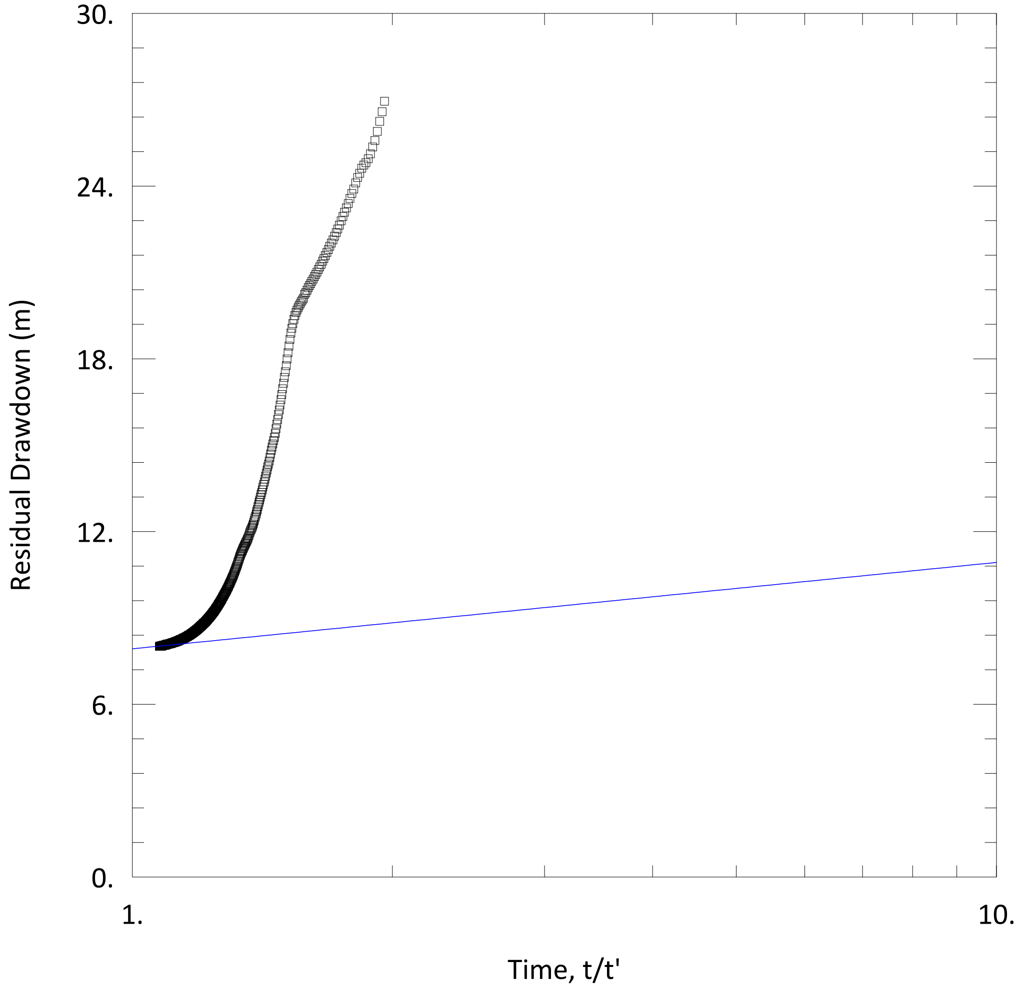
Observation Wells

Well Name	X (m)	Y (m)
□ MSWB8	357575	6838265

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 1.042 m^2/day S/S' = 1.134



HUB PIT AIRLIFT -RECOVERY 20RRC100

Data Set: E:\...\20RRC100.aqt
Date: 11/13/21 Time: 10:29:22

PROJECT INFORMATION

Company: GRM
Client: Dacian Gold
Project: J2126
Location: Redcliffe_Hub
Test Well: 20RRC100
Test Date: 30/9/21

AQUIFER DATA

Saturated Thickness: 98. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
20RRC100	359307	6851174

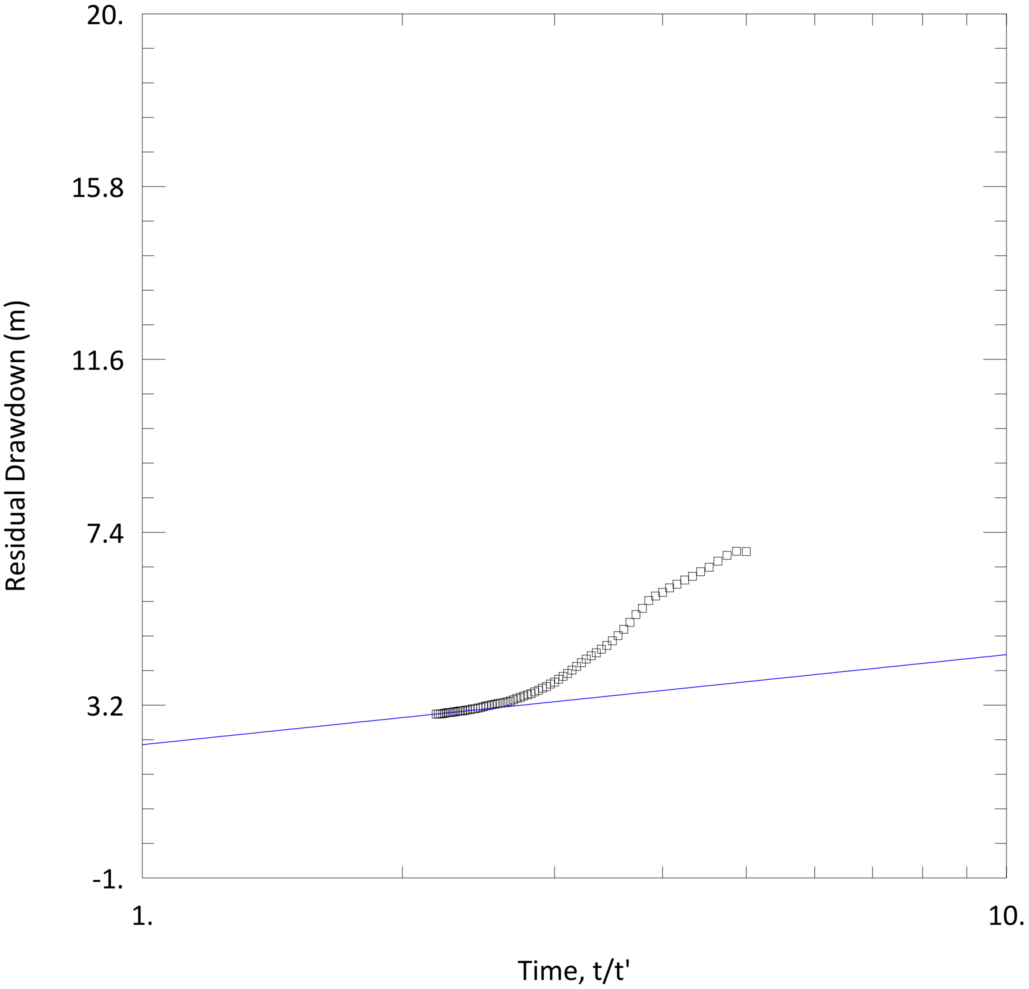
Observation Wells

Well Name	X (m)	Y (m)
□ 20RRC100	359307	6851174

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 1.689 m^2/day S/S' = 0.002282



HUB PIT AIRLIFT -RECOVERY 20RRC134

Data Set: E:\...\20RRC134.aqt
Date: 11/13/21 Time: 10:30:48

PROJECT INFORMATION

Company: GRM
Client: Dacian Gold
Project: J2126
Location: Redcliffe_Hub
Test Well: 20RRC134
Test Date: 13/9/21

AQUIFER DATA

Saturated Thickness: 98. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
20RRC134	359256	6851351

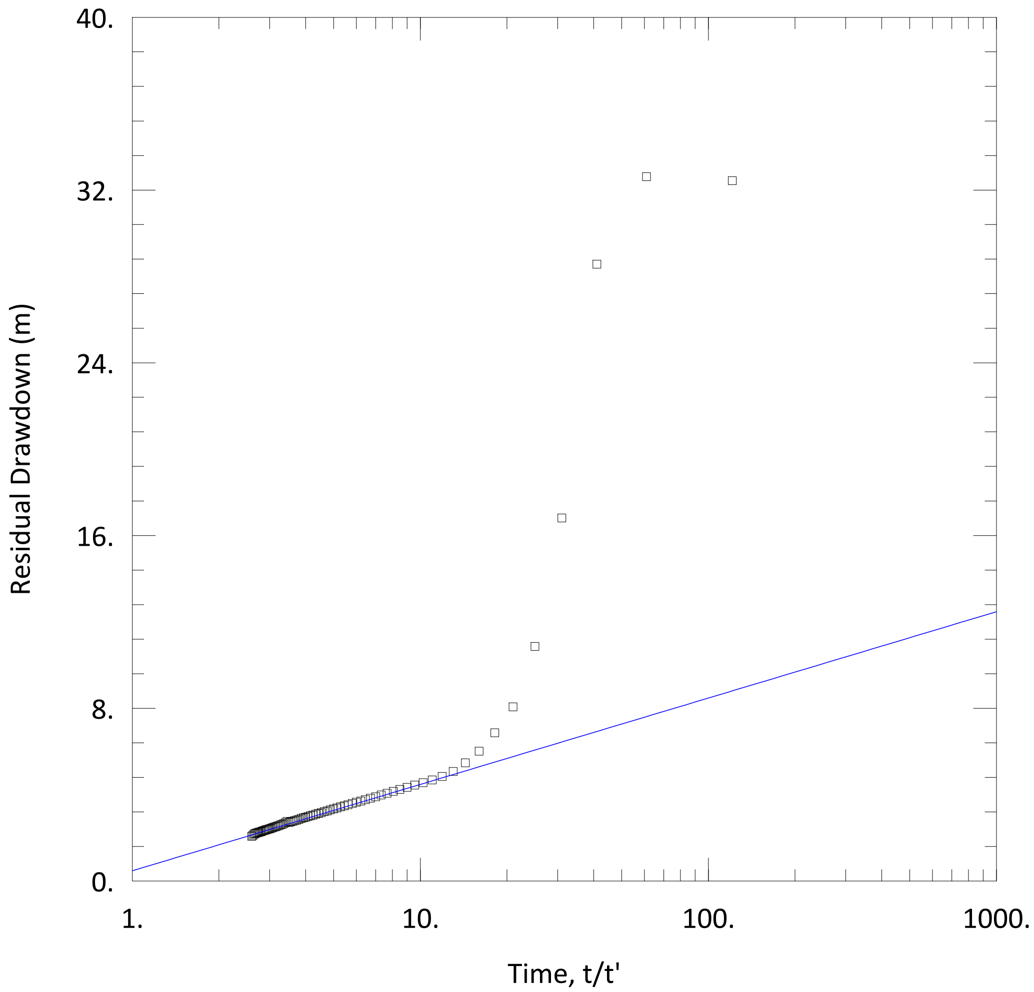
Observation Wells

Well Name	X (m)	Y (m)
□ 20RRC134	359256	6851351

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 10.86 m^2/day S/S' = 0.09486



HUB PIT AIRLIFT -RECOVERY MONITORING BORE HMB03

Data Set: E:\...\HMB03.aqt
Date: 11/13/21 Time: 17:15:30

PROJECT INFORMATION

Company: GRM
Client: Dacian Gold
Project: J2126
Location: Redcliffe_Hub
Test Well: HMB03
Test Date: 24/9/21

AQUIFER DATA

Saturated Thickness: 19. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
HMB03	358700	6851141

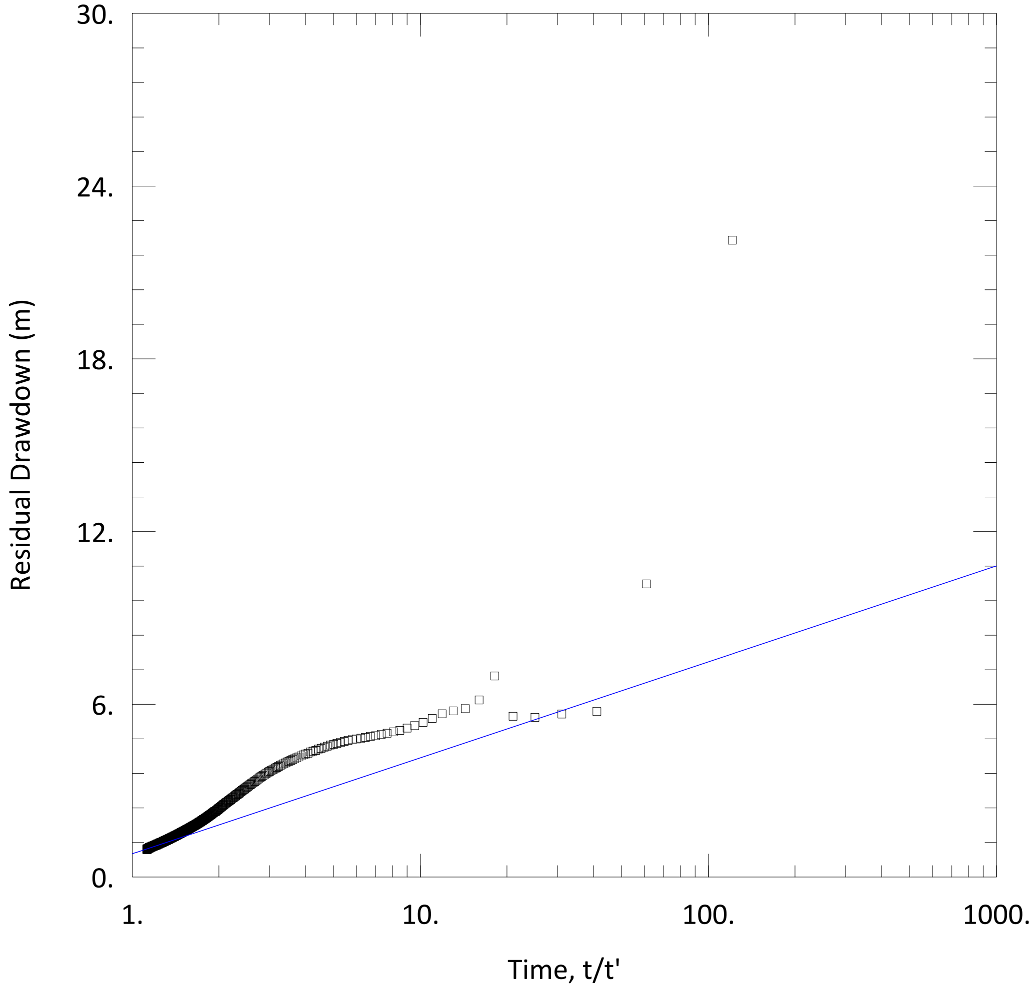
Observation Wells

Well Name	X (m)	Y (m)
□ HMB03	358700	6851141

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 2.375 m^2/day S/S' = 0.7628



HUB PIT AIRLIFT -RECOVERY BORE HMB04

Data Set: E:\...\HMB04.aqt
Date: 11/13/21 Time: 16:40:39

PROJECT INFORMATION

Company: GRM
Client: Dacian Gold
Project: J2126
Location: Redcliffe_Hub
Test Well: HMB04
Test Date: 30/9/21

AQUIFER DATA

Saturated Thickness: 22. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
HMB04	359116	6851112

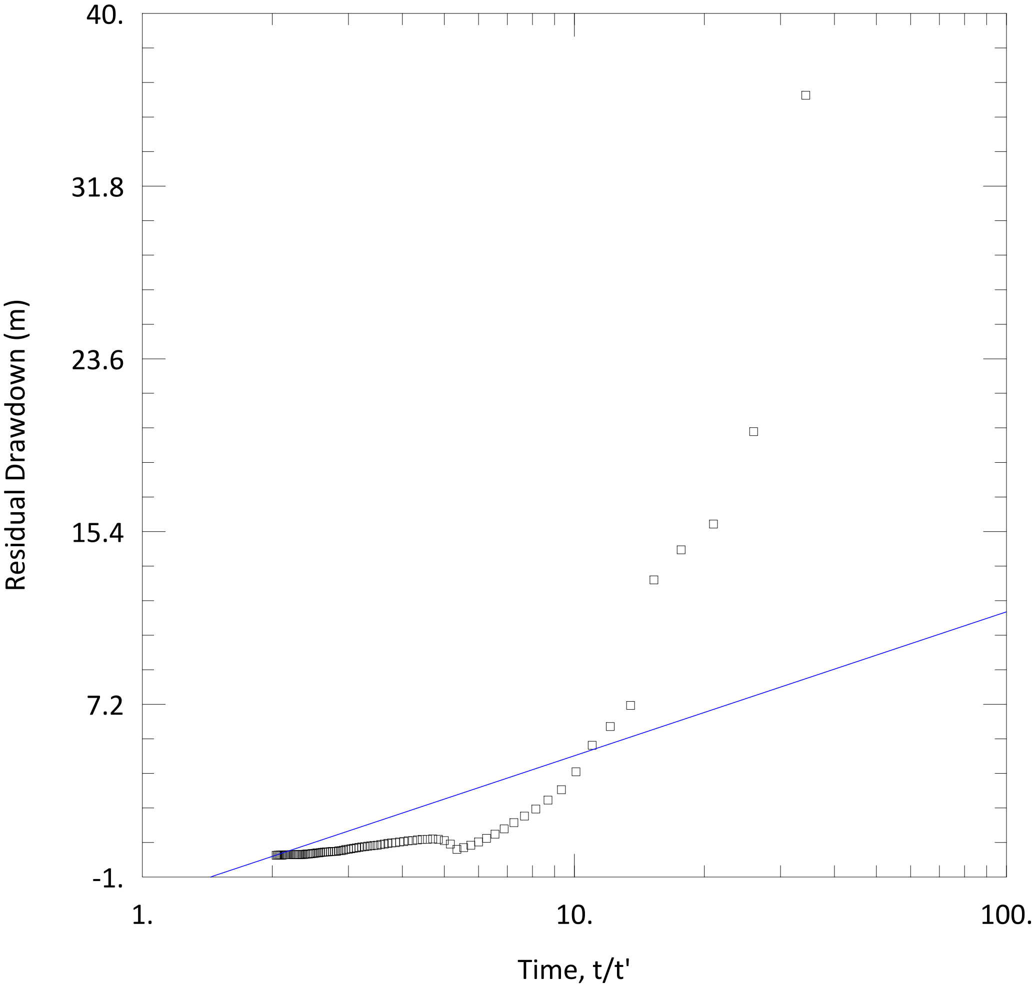
Observation Wells

Well Name	X (m)	Y (m)
□ HMB04	359116	6851112

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 20.9 m^2/day S/S' = 0.5732



NAMBI PIT AIRLIFT-RECOVERY NBRC111

Data Set: E:\...\NBRC111.aqt
Date: 11/16/21 Time: 15:35:12

PROJECT INFORMATION

Company: GRM
Client: Dacian Gold
Project: J2126
Location: Redcliffe_Nambi
Test Well: NBRC111
Test Date: 16/9/21

AQUIFER DATA

Saturated Thickness: 85. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
NBRC111	358736	6858141

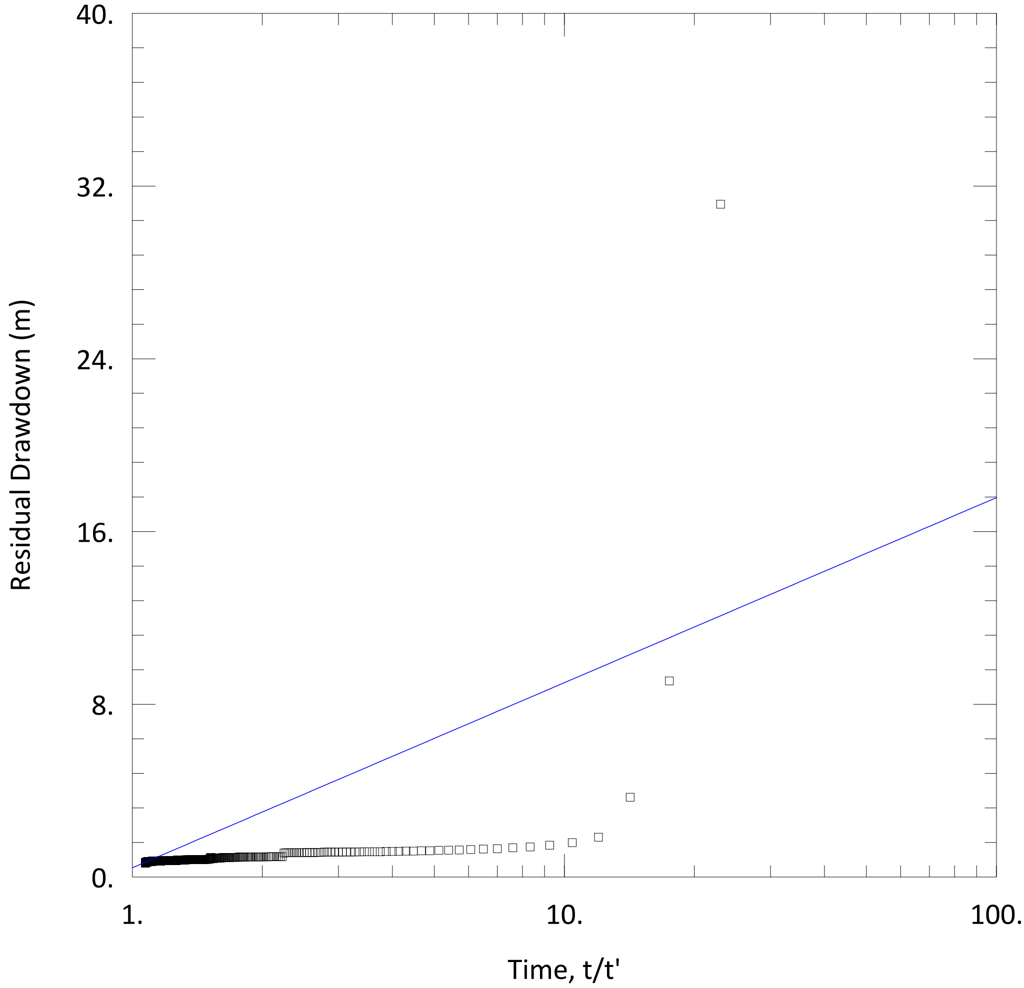
Observation Wells

Well Name	X (m)	Y (m)
□ NBRC111	358736	6858141

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 1.159 m^2/day S/S' = 2.018



NAMBI PIT AIRLIFT-RECOVERY NBRC128

Data Set: E:\...\NBRC128.aqt
Date: 11/16/21 Time: 15:25:32

PROJECT INFORMATION

Company: GRM
Client: Dacian Gold
Project: J2126
Location: Redcliffe_Nambi
Test Well: NBRC128
Test Date: 15/9/21

AQUIFER DATA

Saturated Thickness: 93.27 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
NBRC128	358695	6858231

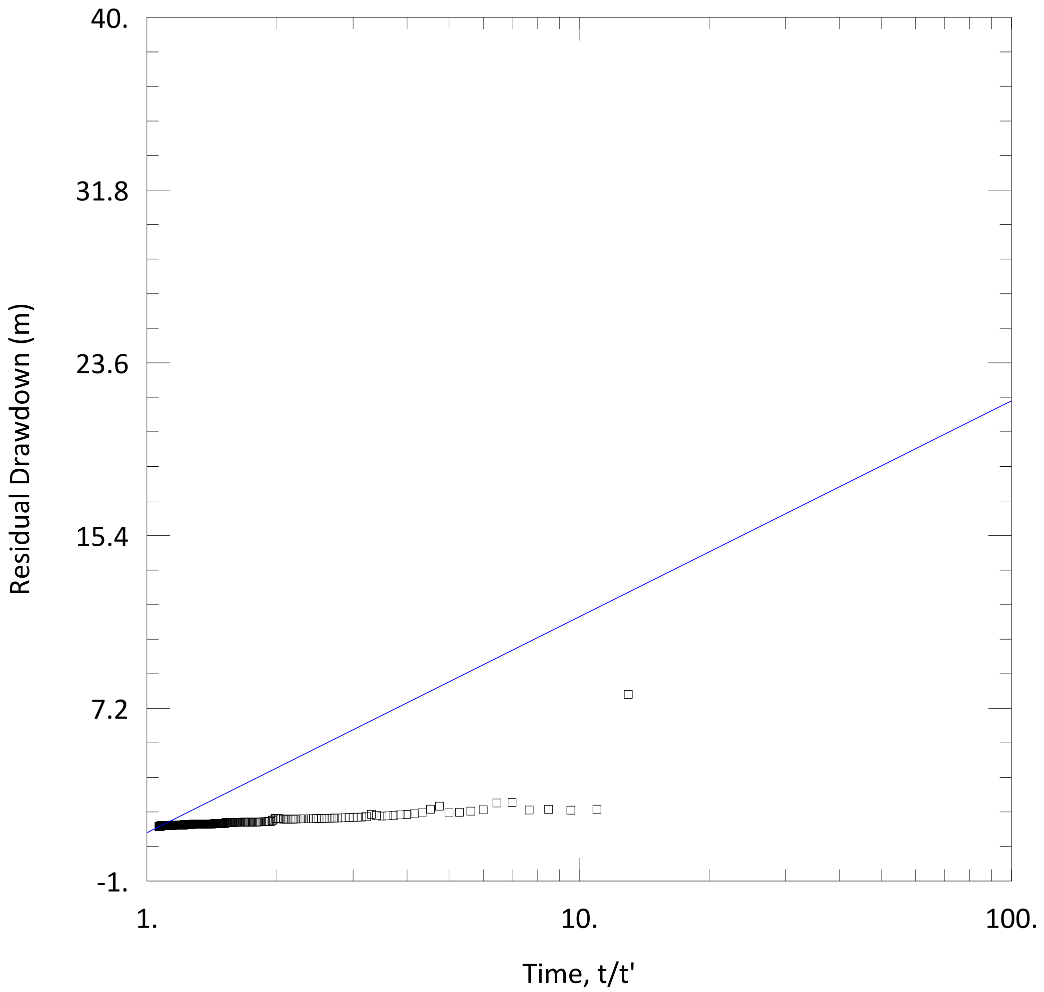
Observation Wells

Well Name	X (m)	Y (m)
□ NBRC128	358695	6858231

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 1.478 m^2/day S/S' = 0.8921



NAMBI PIT AIRLIFT-RECOVERY NBRC135

Data Set: E:\...\NBRC135.aqt
Date: 11/16/21 Time: 15:38:01

PROJECT INFORMATION

Company: GRM
Client: Dacian Gold
Project: J2126
Location: Redcliffe_Nambi
Test Well: NBRC135
Test Date: 16/9/21

AQUIFER DATA

Saturated Thickness: 108.1 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
NBRC135	358658	6858968

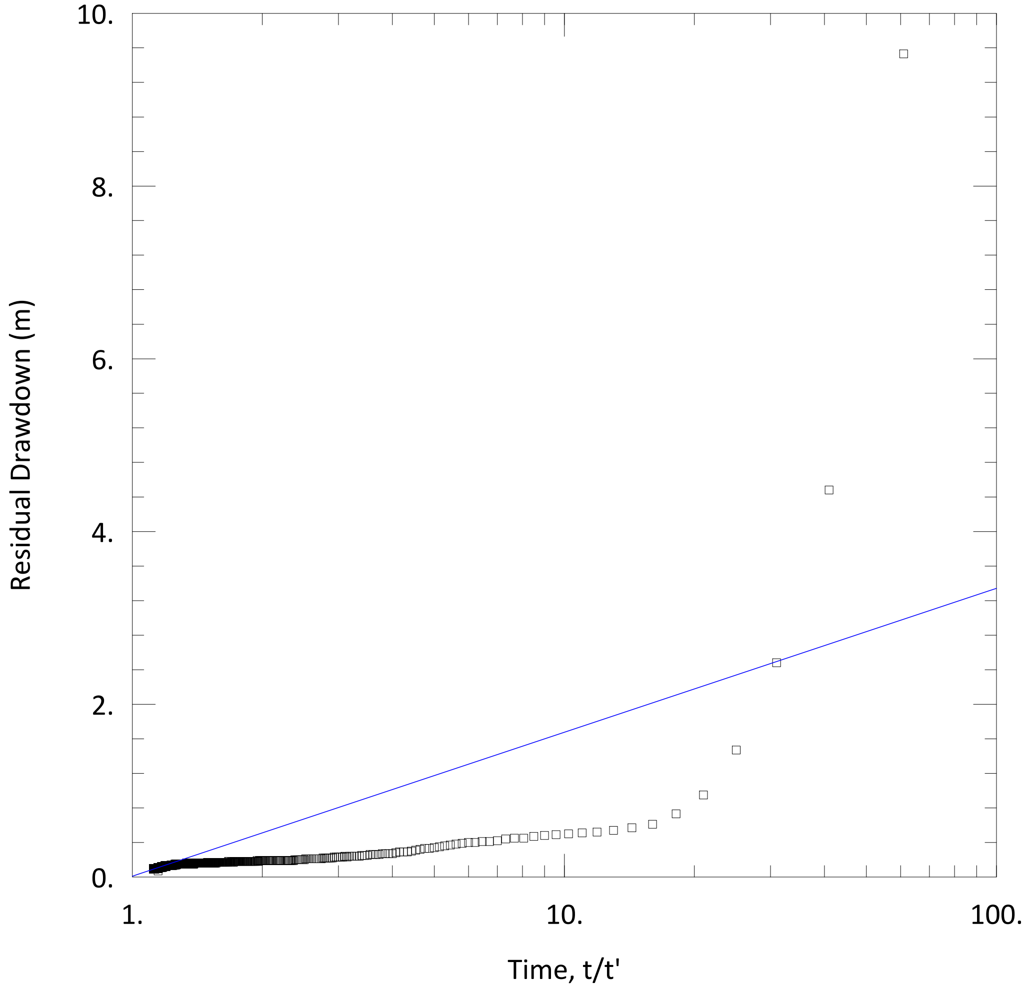
Observation Wells

Well Name	X (m)	Y (m)
□ NBRC135	358658	6858968

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 1.236 m^2/day S/S' = 0.7483



NAMBI PIT AIRLIFT-RECOVERY MONITORING BORE NMB02

Data Set: E:\...\NMB02.aqt
Date: 11/16/21 Time: 11:01:30

PROJECT INFORMATION

Company: GRM
Client: Dacian Gold
Project: J2126
Location: Redcliffe_Nambi
Test Well: NMB02
Test Date: 18/9/21

AQUIFER DATA

Saturated Thickness: 74. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
NMB02	358700	6858449

Observation Wells

Well Name	X (m)	Y (m)
□ NMB02	358700	6858449

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 3.8 m^2/day S/S' = 0.9887

Date	Bore/ Hole ID	SWL (mdh)	Hole Dip (degr)	Hole Depth (m)	Depth of Rods (mdh)	Vert Drawdown (m)	Sat Thick (m)	rw (m)	rmax (m)	Q (m3/d)	T (m2/d)	K (m/d)	Assumptions
20/09/2021	NMB01	30.5	90	100	100	69.5	69.5	0.071	20	8.64	0.163506	0.002353	Equation after Thiem (1906) based on steady state flow to a well. ***rmax*** is the
21/09/2021	NMB03	30	90	100	100	70	70	0.071	20	19	0.356993	0.0051	distance to the limit of the drawdown cone (i.e. fixed head boundary), ***rw*** is the
17/09/2021	NBRC120	34.3	55	120	120	70.2013302	85.7	0.066	20	121	2.296309	0.026795	radius of the well, ***Q*** is the steady state flow. The assumptions include the
19/09/2021	NBRC129	32.8	55	180	180	120.5791809	147.2	0.066	20	130	1.436353	0.009758	following: the depth of the rods is equivalent to the drawdown in the bore, there
18/09/2021	NBRC133	28.8	55	102	102	59.96192964	73.2	0.066	20	52	1.155362	0.015784	is no well loss, the flow is in steady state, the extent of drawdown is known.
						0	0				#DIV/0!	#DIV/0!	The results are indicative and other methods should be used if possible.
						0	0				#DIV/0!	#DIV/0!	However, the estimate of T is insensitive to ***rmax.***

Appendix C: Analytical Modelling Results

Client:	**Dacian Gold**
Project:	**Redcliffe - GTS**

MINE INFLOW OR OUTFLOW ESTIMATE USING DUPUIT-THIEM EQUATION APPLIED FOR AN EQUILIVENT LARGE DIAMETER WELL

UNCONFINED AQUIFER CONDITIONS

Q=pi.k.(ho^2-hw^2)/ln(ro/rw)

where:-

Q =inflow or outflow from large diameter well or pit (kL/d)

k =hydraulic conductivity (m/d)

ho =height of SWL above base of aquifer (m)

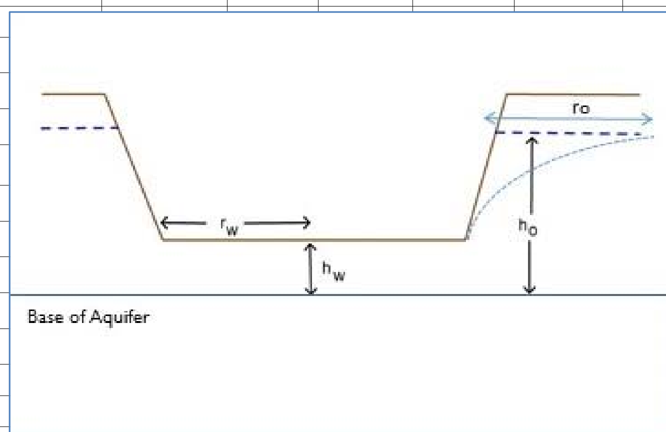
hw =height of depressed water level in bore or pit (m)

rw =radius of well or equivalent radius of pit (m)

ro =radius of max extent of cone of drawdown (m)=SQRT(2.25.k.ho.t/Sy)

t =time since pumping or inflow started (days)

Sy =specific yield



1. Transient Inflows:- to final pit void

(variable t with calculated ro using Cooper-Jacob)

k (m/d) =	0.03		
ho (m) =	97		
hw (m) =	0		
rw (m) =	100		
t (days) =	730		
Sy=	0.03		
ro (m) =	399		
Q (kL/d) =	641	7	**(L/s)**

2. Steady State Inflows:- to final pit void

(assumed ro) ***note:- ro must be > rw***

ro (m) =	400		
Q (kL/d) =	640	7	**(L/s)**

3. Progressive Pit Development Inflows

Mine rate per time step(m)= 10

	Step	Time	hw - end of step	ro-end of step	Inflow-end of step	Inflow-end of step
	(days)	**(days)**	**(m)**	**(m)**	**(kL/d)**	**(L/s)**
Time Step 1	45	45	97	99	0	0
Time Step 2	45	90	97	140	0	0
Time Step 3	45	135	97	172	0	0
Time Step 4	45	180	95	198	53	1
Time Step 5	45	225	85	222	259	3
Time Step 6	45	270	80	243	320	4
Time Step 7	45	315	60	262	568	7
Time Step 8	45	360	50	280	632	7
Time Step 9	45	405	15	297	795	9
Time Step 10	45	450	0	313	776	9

APPENDIX C:- GTS PIT INFLOW ESTIMATE

GROUNDWATER RESOURCE MANAGEMENT

Client:	**Dacian Gold**
Project:	**Redcliffe - Hub Pit**

MINE INFLOW OR OUTFLOW ESTIMATE USING DUPUIT-THIEM EQUATION APPLIED FOR AN EQUILIVENT LARGE DIAMETER WELL

UNCONFINED AQUIFER CONDITIONS

Q=pi.k.(ho^2-hw^2)/ln(ro/rw)

where:-

Q =inflow or outflow from large diameter well or pit (kL/d)

k =hydraulic conductivity (m/d)

ho =height of SWL above base of aquifer (m)

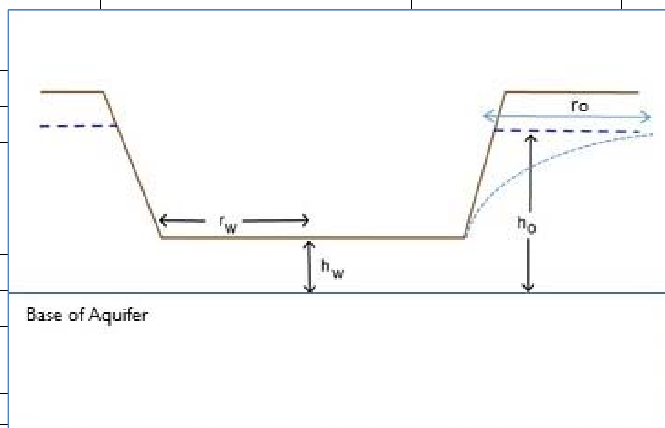
hw =height of depressed water level in bore or pit (m)

rw =radius of well or equivalent radius of pit (m)

ro =radius of max extent of cone of drawdown (m)=SQRT(2.25.k.ho.t/Sy)

t =time since pumping or inflow started (days)

Sy =specific yield



1. Transient Inflows:- to final pit void

(variable t with calculated ro using Cooper-Jacob)

k (m/d) =	0.21		
ho (m) =	92		
hw (m) =	0		
rw (m) =	100		
t (days) =	365		
Sy=	0.01		
ro (m) =	1260		
Q (kL/d) =	2204	26	**(L/s)**

2. Steady State Inflows:- to final pit void

(assumed ro) ***note:- ro must be > rw***

ro (m) =	1200		
Q (kL/d) =	2247	26	**(L/s)**

3. Progressive Pit Development Inflows

Mine rate per time step(m)= 10

	Step	Time	hw - end of step	ro-end of step	Inflow-end of step	Inflow-end of step
	(days)	**(days)**	**(m)**	**(m)**	**(kL/d)**	**(L/s)**
Time Step 1	36.5	36.5	90	398	174	2
Time Step 2	36.5	73	75	563	1084	13
Time Step 3	36.5	109.5	60	690	1662	19
Time Step 4	36.5	146	45	797	2047	24
Time Step 5	36.5	182.5	45	891	1943	22
Time Step 6	36.5	219	45	976	1865	22
Time Step 7	36.5	255.5	45	1054	1804	21
Time Step 8	36.5	292	40	1127	1870	22
Time Step 9	36.5	328.5	25	1195	2085	24
Time Step 10	36.5	365	0	1260	2204	26

APPENDIX C :- HUB PIT INFLOW ESTIMATE

GROUNDWATER RESOURCE MANAGEMENT

Client:	**Dacian Gold**
Project:	**Redcliffe - Nambi**

MINE INFLOW OR OUTFLOW ESTIMATE USING DUPUIT-THIEM EQUATION APPLIED FOR AN EQUILIVENT LARGE DIAMETER WELL

UNCONFINED AQUIFER CONDITIONS

Q=pi.k.(ho^2-hw^2)/ln(ro/rw)

where:-

Q =inflow or outflow from large diameter well or pit (kL/d)

k =hydraulic conductivity (m/d)

ho =height of SWL above base of aquifer (m)

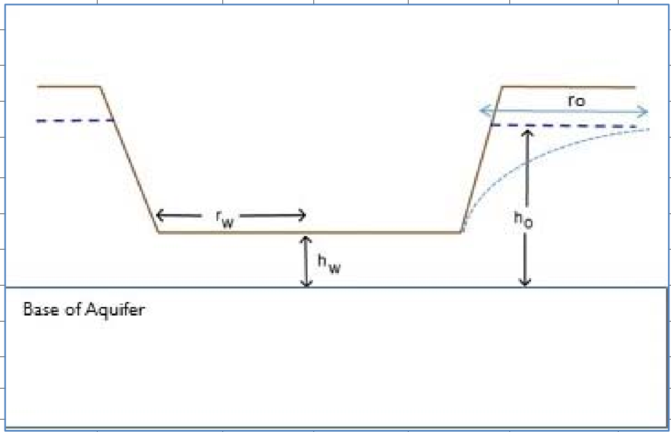
hw =height of depressed water level in bore or pit (m)

rw =radius of well or equivalent radius of pit (m)

ro =radius of max extent of cone of drawdown (m)=SQRT(2.25.k.ho.t/Sy)

t =time since pumping or inflow started (days)

Sy =specific yield



1. Transient Inflows:- to final pit void

(variable t with calculated ro using Cooper-Jacob)

k (m/d) =	0.012		
ho (m) =	49		
hw (m) =	10		
rw (m) =	100		
t (days) =	270		
Sy=	0.01		
ro (m) =	189		
Q (kL/d) =	136	2	**(L/s)**

2. Steady State Inflows:- to final pit void

(assumed ro) ***note:- ro must be > rw***

ro (m) =	200		
Q (kL/d) =	125	1	**(L/s)**

3. Progressive Pit Development Inflows

Mine rate per time step(m)= 10

	Step	**Time**	**hw - end of step**	**ro-end of step**	**Inflow-end of step**	**Inflow-end of step**
	(days)	**(days)**	**(m)**	**(m)**	**(kL/d)**	**(L/s)**
Time Step 1	18	18	49	49	0	0
Time Step 2	18	36	49	69	0	0
Time Step 3	18	54	49	85	0	0
Time Step 4	18	72	49	98	0	0
Time Step 5	18	90	49	109	0	0
Time Step 6	18	108	42	120	135	2
Time Step 7	18	126	35	129	174	2
Time Step 8	18	144	25	138	208	2
Time Step 9	18	162	20	146	198	2
Time Step 10	18	180	10	154	200	2

APPENDIX C :- NAMBI PIT INFLOW ESTIMATE

GROUNDWATER RESOURCE MANAGEMENT

Appendix D: Certificates of Laboratory Analysis

CERTIFICATE OF ANALYSIS

Work Order	: **EP2111491**	Page	: 1 of 6
Client	: **Groundwater Resource Management**	Laboratory	: Environmental Division Perth
Contact	: Jan Vermaak	Contact	: Customer Services EP
Address	: PO BOX 442 BAYSWATER 6933	Address	: 26 Rigali Way Wangara WA Australia 6065
Telephone	: ----	Telephone	: +61-8-9406 1301
Project	: J2126	Date Samples Received	: 28-Sep-2021 13:20
Order number	: ----	Date Analysis Commenced	: 28-Sep-2021
C-O-C number	: ----	Issue Date	: 05-Oct-2021 22:14
Sampler	: ----		
Site	: ----		
Quote number	: ----		
No. of samples received	: 6		
No. of samples analysed	: 6		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Canhuang Ke	Inorganics Supervisor	Perth Inorganics, Wangara, WA
Chris Lemaitre	Laboratory Manager (Perth)	Perth Inorganics, Wangara, WA

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	HUBM01	HUBM03	HUBM04	NMB01	NMB02
			Sampling date / time	25-Sep-2021 00:00	24-Sep-2021 00:00	26-Sep-2021 00:00	21-Sep-2021 00:00	19-Sep-2021 00:00
Compound	CAS Number	LOR	Unit	EP2111491-001	EP2111491-002	EP2111491-003	EP2111491-004	EP2111491-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.12**	**8.29**	**8.12**	**7.76**	**8.09**
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1920**	**5000**	**3750**	**876**	**839**
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**1160**	**3200**	**2350**	**673**	**648**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**205**	**436**	**396**	**62**	**111**
Total Alkalinity as CaCO3	----	1	mg/L	**205**	**436**	**396**	**62**	**111**
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	**52.4**	**22.8**	**66.9**	**71.8**	**88.1**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**158**	**613**	**436**	**60**	**50**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**411**	**1040**	**786**	**183**	**160**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**79**	**54**	**66**	**44**	**53**
Magnesium	7439-95-4	1	mg/L	**49**	**75**	**66**	**31**	**33**
Sodium	7440-23-5	1	mg/L	**268**	**1030**	**702**	**90**	**75**
Potassium	7440-09-7	1	mg/L	**19**	**30**	**23**	**10**	**7**
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	**0.01**
Arsenic	7440-38-2	0.001	mg/L	**0.002**	<0.001	**0.005**	<0.001	**0.002**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	**0.003**	**0.018**	**0.001**	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	7439-96-5	0.001	mg/L	<0.001	**0.169**	**0.023**	**0.067**	**0.007**
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	**0.001**	**0.002**	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	**0.01**	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	**0.023**	**0.019**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	HUBM01	HUBM03	HUBM04	NMB01	NMB02
			Sampling date / time	25-Sep-2021 00:00	24-Sep-2021 00:00	26-Sep-2021 00:00	21-Sep-2021 00:00	19-Sep-2021 00:00
Compound	CAS Number	LOR	Unit	EP2111491-001	EP2111491-002	EP2111491-003	EP2111491-004	EP2111491-005
				Result	Result	Result	Result	Result
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	**0.08**	**0.01**	**0.01**	<0.01
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**17.2**	**19.3**	**13.5**	**21.0**	**17.3**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**17.2**	**19.4**	**13.5**	**21.0**	**17.3**
EN055: Ionic Balance								
ø **Total Anions**	----	0.01	meq/L	**19.0**	**50.8**	**39.2**	**7.65**	**7.77**
ø **Total Cations**	----	0.01	meq/L	**20.1**	**54.4**	**39.8**	**8.92**	**8.80**
ø **Ionic Balance**	----	0.01	%	**2.91**	**3.44**	**0.87**	**7.65**	**6.21**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	NMB03	----	----	----	----
			Sampling date / time	21-Sep-2021 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2111491-006	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.94**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**707**	----	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**561**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**84**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**84**	----	----	----	----
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	**86.8**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**53**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**126**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**44**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**27**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**66**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**7**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.012**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.001**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.020**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	NMB03	----	----	----	----
			Sampling date / time	21-Sep-2021 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EP2111491-006	--------	--------	--------	--------
				Result	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	**0.01**	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**13.1**	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**13.1**	----	----	----	----
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**6.34**	----	----	----	----
ø Total Cations	----	0.01	meq/L	**7.47**	----	----	----	----
ø Ionic Balance	----	0.01	%	**8.20**	----	----	----	----