Native Vegetation Clearing Permit (Purpose): Supporting Documentation

Cardinia Project

Prepared for Kin Mining NL

6 June 2023

Project Number: TE22110

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Name	Position	File Reference
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APPENDIX C Stantec – Level 1 Flora, Vegetation and Fauna Assessment, Leonora Gold Project 2018c

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APPENDIX E Phoenix Environmental Services – Terrestrial Fauna Survey, Leonora Gold Project 2019

APPENDIX F Stantec – Subterranean Fauna Level 2 Assessment, Leonora Gold Project 2021

1 Introduction

1.1 Background

Talis Consultants was commissioned by Navigator Mining Pty Ltd (Navigator) to prepare a Native Vegetation Clearing Permit (NVCP) application for clearing associated with the next stage of mining at the Cardinia Gold Project (Cardinia) (the Site).

Navigator Mining Pty Ltd (Navigator) is a West Australian based gold development and exploration company, wholly owned by Kin Mining NL. Navigator's key focus is its 100% owned Cardinia Gold Project (CGP) located in the highly prospective North-Eastern Goldfields region of Western Australia, approximately 30 km north east of Leonora (Figure 1-1). The CGP comprises the Cardinia, Mertondale and Raeside Projects. This NVCP application is for the Cardinia Project (the Project).

Navigator is proposing to further develop the Project at Cardinia, which involves the development of a mine-truck-treat open pit mine and associated infrastructure. The Project is situated on a number of mining tenements as described in Table 1-1 and shown on Figure 1-2. Overlapping tenure includes other mining tenure, Pastoral Leases, a registered lodged Native Title Claim of the Nyalpa Pirniku People and registered Darlot Native Title Claim (Figure 1-2).

Mining has been undertaken by Navigator and others in the immediate vicinity over the last decade. Ore processing does not form part of this Project, as processing will be undertaken by a third party under a toll treatment or other contractual agreement. Mining will not proceed until a toll treatment agreement is in place with a nearby gold process plant.

Mining will be undertaken by conventional load and haul methods utilising excavators and dump trucks. A bulldozer will rip and clear the overburden and an excavator will load out mineralised ore and transport it to the run-of-mine pad (ROM), with drill and blast activities undertaken as required. Ore will be loaded onto road trains then hauled offsite. Waste rock from the mining activities will be deposited into the proposed waste rock landforms.

The Project proposes the creation of six open pit void complexes, six associated waste rock landforms (WRL's) and five Run-of-mine (ROM) pads, as well as associated supporting infrastructure such as laydown areas and transport and infrastructure corridors.

This NVCP application is to clear up to up to 994.42 hectares (ha) of native vegetation within the Development Envelope of approximately 4,322.2 ha (Figure 1-3).

Table 1-1: Cardinia Project Tenements

Tenement	Area (ha)	Holder	Expiry
M37/86	271.1	Navigator Mining Pty Ltd	21/12/2028
M37/88	17.805	Navigator Mining Pty Ltd	18/11/2028
M37/227	454.65	Navigator Mining Pty Ltd	10/04/2032
M37/277	454.65	Navigator Mining Pty Ltd	10/04/2032
M37/299	69.23	Navigator Mining Pty Ltd	21/10/2032
M37/300	60.025	Navigator Mining Pty Ltd	21/10/2032
M37/316	777.5	Navigator Mining Pty Ltd	27/12/2032
M37/317	659.8	Navigator Mining Pty Ltd	16/12/2032
M37/422	199.1	Navigator Mining Pty Ltd	03/02/2036
M37/428	31.805	Navigator Mining Pty Ltd	03/02/2036
M37/594	0.146	Navigator Mining Pty Ltd	08/08/2027
M37/646	122.85	Navigator Mining Pty Ltd	27/06/2027
M37/1303	180	Navigator Mining Pty Ltd	06/11/2037
M37/1304	97	Navigator Mining Pty Ltd	06/11/2037
M37/1318	363	Navigator Mining Pty Ltd	06/07/2038
M37/1319	160.35	Navigator Mining Pty Ltd	05/07/2038
M37/1328	316	Navigator Mining Pty Ltd	13/05/2039
M37/1331	50	Navigator Mining Pty Ltd	13/05/2039
M37/1332	167.402	Navigator Mining Pty Ltd	06/11/2039
L37/106	172	Navigator Mining Pty Ltd	16/08/2042
L37/127	12	Navigator Mining Pty Ltd	16/03/2024
L37/242	642	Navigator Mining Pty Ltd	16/06/2040
L37/243	90	Navigator Mining Pty Ltd	16/06/2040

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LEGEND

- Cardinia Project Site
- Town
- Village

Current Roads

- Freeway / Highway
- Main Road

Railway Lines

- Railway Lines

Hydrography

- Lake
- Water Courses

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0 200 400 600 800 1,000 km

LOCALITY

Cardinia Mining Proposal

Kin Mining

N

0 2 4 6 8 10 Km

Coordinate System: GDA2020 MGA Zone 51
Scale @ A3: 1:300,000

Prepared: T Baskerville	Date: 13/01/2023
Reviewed: J Mountford	Revision: A
Project: TE22110	

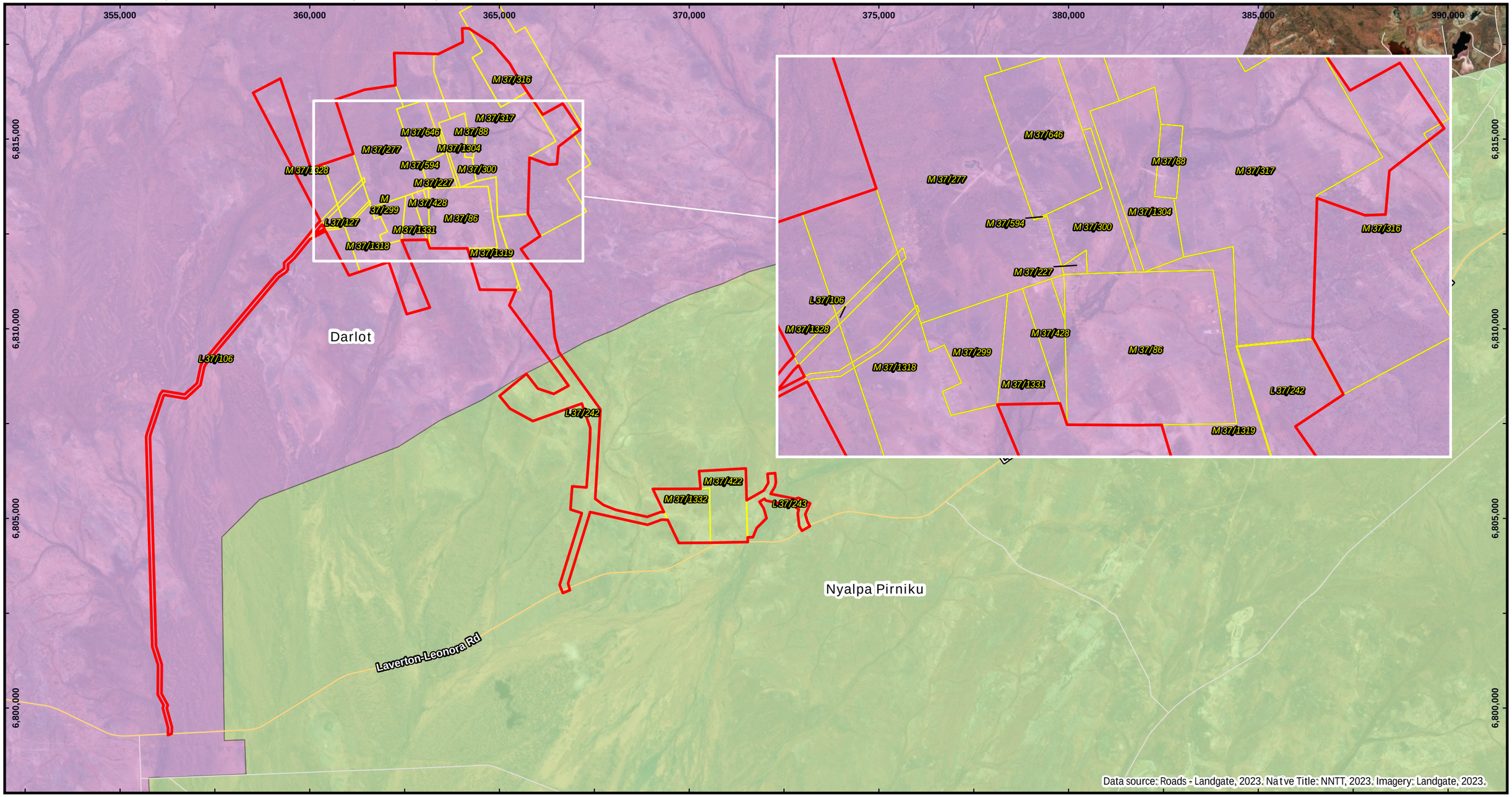
talis consultants

Figure 01

Data source: Lakes, Watercourses • GA, 2022. Roads • Landgate, 2022. Imagery: ESRI.

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LEGEND

- Cardinia Development Envelope
- Mining Tenements (DMIRS003)

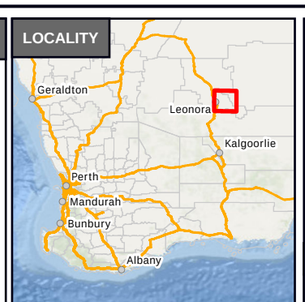
Native Title Claim Areas

- Darlot
- Nyalpa Pirniku

Current Roads (LGATE-012)

- Freeway / Highway
- Main Road
- Minor Road

LOCALITY



LAND TENURE

Cardinia Mining Proposal

Kin Mining
Cardinia Gold Project

0 1 2 3 4 5 km

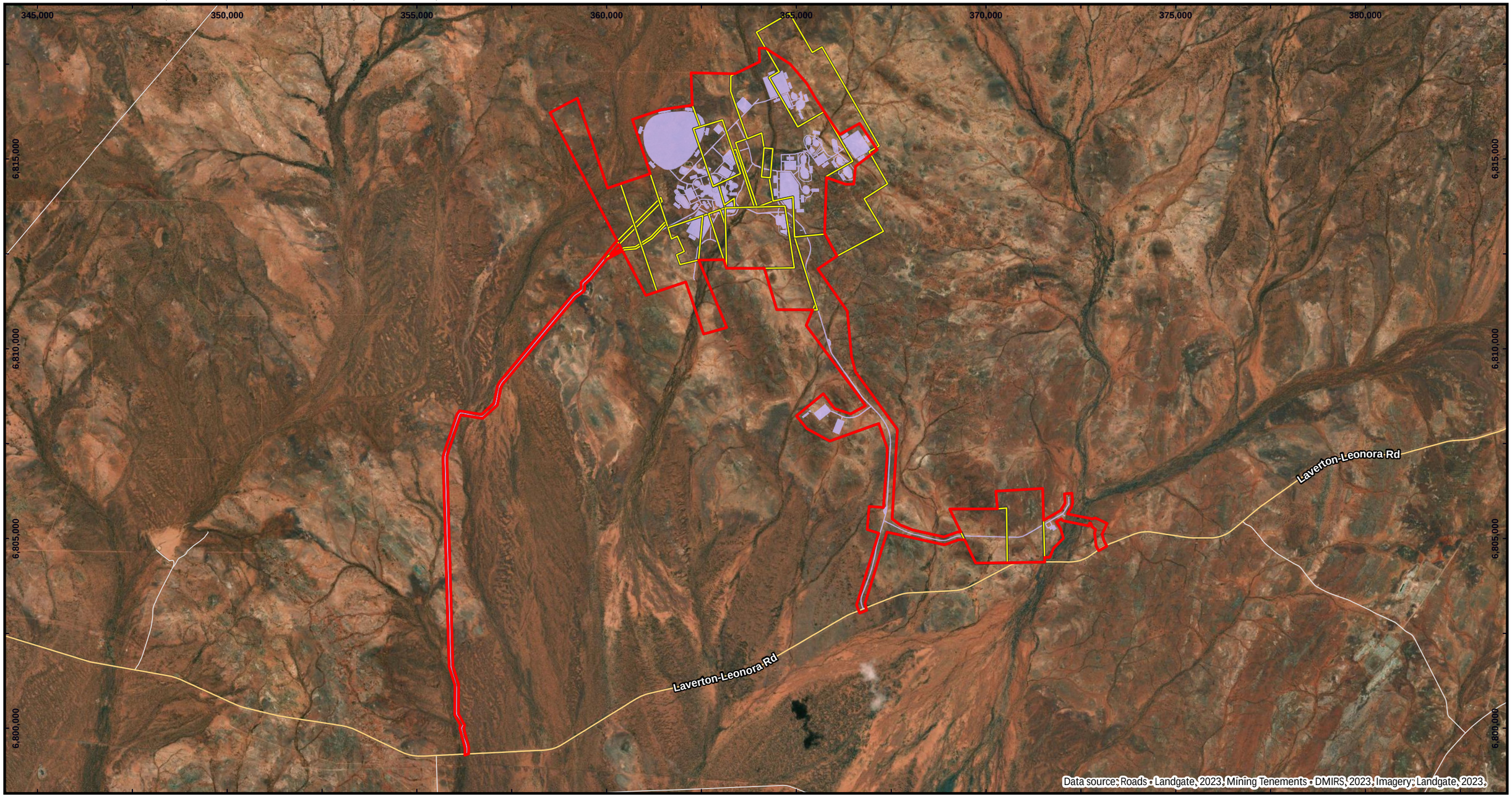
Scale @ A3: 1:100,000 Coordinate System: GDA2020 MGA Zone 51

Prepared:	E Jackson	Date:	16/05/2023
Reviewed:	A Jamieson		
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LEGEND

- Cardinia Development Envelope
- Mining Tenements (DMIRS003)

Cardinia Disturbance

- Cardinia Disturbance

Current Roads (LGATE-012)

- Freeway / Highway
- Main Road
- Minor Road

LOCALITY



DEVELOPMENT ENVELOPE

Cardinia Mining Proposal

0 1 2 3 4 5 km

Scale @ A3: 1:100,000 Coordinate System: GDA2020 MGA Zone 51

Kin Mining
Cardinia Gold Project

Prepared:	E Jackson	Date:	15/05/2023
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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 the (then) Departments of Environment Regulation (DER)'s *A guide to the assessment of applications to clear native vegetation* (2014) under Part V Division 2 of the *Environmental Protection Act 1986* (EP Act). This report identifies the potential environmental impacts associated with the proposal based on the best available data. This report and accompanying NVCP Purpose Permit application form will be submitted to DMIRS for assessment.

1.3 Proposed Timeframe

Clearing is proposed to commence in Q3 2023 with mining likely to be completed by 2030.

1.4 Responsible Applicant

Navigator are responsible for the implementation of the clearing described within this report. Correspondence relating to this NVCP application should be addressed to:

Chad Moloney
Mining Manager
Kin Mining
342 Scarborough Beach Road, Osborne Park, 6017
P: 0407 079 538
E: c.moloney@kinmining.com.au

2 Site Overview

2.1 Climate

The closest Bureau of Meteorology (BoM) weather station with a complete dataset is Leonora WA (012046), located approximately 31 km southwest of the Site (Department of the Environment and Energy, 1990) (Bureau of Meteorology, 2023). The region is arid to semi-arid and is within the bioclimatic category of 'desert; summer and winter rainfall,' where the months of the year are not reliably wet, zero rainfall can be recorded within any month and rainfall is typically erratic.

The long-term minimum temperature for Leonora ranges from 6.1˚C (July) to 21.8˚C (January) and the long-term mean maximum temperature ranges from 18.4˚C (July) to 37˚C (January) (1957-2014) (Plate 1) (Bureau of Meteorology, 2023). The long-term annual average rainfall is 236.4 mm (1898-2020) (Bureau of Meteorology, 2023).

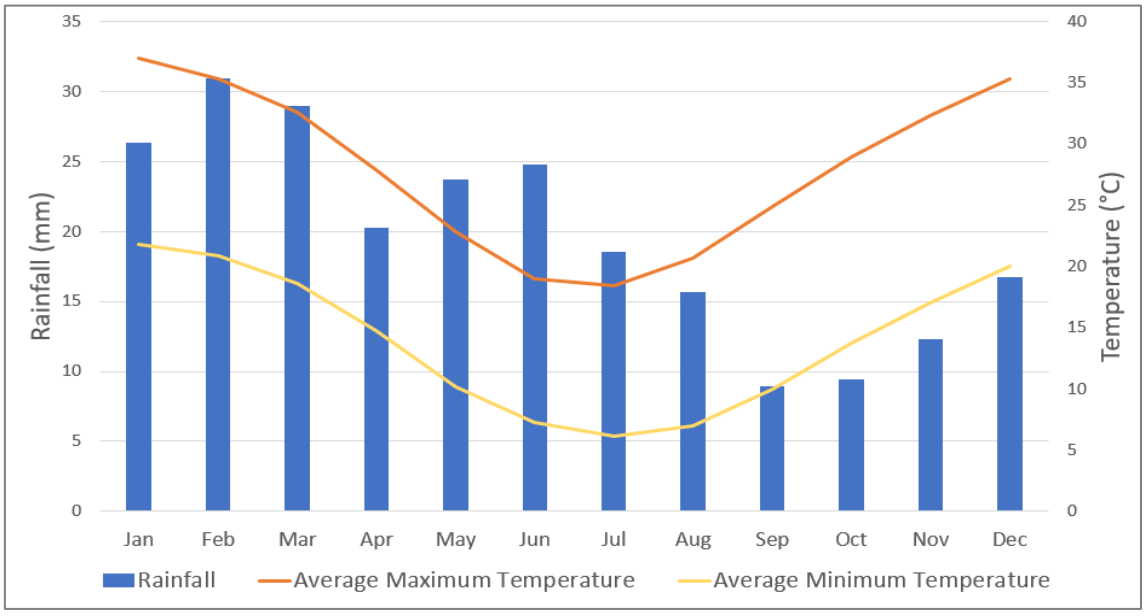


Figure 2-1 :Long-term Monthly total Rainfall, Maximum and Minimum Temperatures for Leonora (012046) (Bureau of Meteorology, 2023)

2.2 Topography

The topography of the site ranges from approximately 409 m Australian height Datum (AHD) to approximately 439 m AHD. The topographic lows (409 – 414 m AHD) are located on either side of Cardinia Creek, which runs through the Cardinia mining and exploration area.

2.3 Interim Biogeographic Regionalisation of Australia

Cardinia is located approximately 30 km northeast of Leonora and 700 km northeast of Perth in

Western Australia. The site is situated within the Shire of Leonora.

The Interim Biogeographic Regionalisation of Australia (IBRA) divides Australia into 89 bioregions based on major biological, geographical, and geological attributes. These bioregions are subdivided into 419 subregions as part of a refinement of the IBRA framework (Department of the Environment and Energy, 2016). The Site occurs within the Murchison bioregion and the Eastern Murchison subregion. The Eastern Murchison subregion is characterised by internal drainage, extensive areas of elevated red desert sandplains with minimal dune development (Department of Conservation and Land Management, 2002). The vegetation of the subregion is dominated by Mulga Woodlands which are often rich in ephemerals, hummock grasslands, saltbush shrublands and *Halosarcia* shrublands (Department of Conservation and Land Management, 2002).

2.4 Soil Landscape Systems

Cardinia is generally characterised by gently undulating stony plains and gravelly hardpan plains and contains a variety of vegetation communities including bluebush shrublands, mulga shrublands, mixed chenopod shrublands, halophytic shrublands and wanderrie grasses.

Soil landscapes and land system mapping of Western Australia describes broad soil and landscape characteristics from regional to local scales, and has been captured at scales ranging from 1:20,000 to 1:250,000. The Project is located across several Soil Landscape Systems listed below (Department of Primary Industries and Regional Development, 2019):

- Jundee System: hardpan plains with variable gravelly mantles and minor sandy banks supporting weakly groved mulga bushes;
- Nubev System: gently undulating stony plains, minor mylonitic low rises and drainage floors supporting mulga and halophytic shrublands;
- Gundockerta System: extensive, gently undulating calcareous stony plains supporting bluebush shrublands;
- Felix System: gently undulating plains with quartz mantles, supporting acacia-eremophila shrublands locally with wanderrie grasses;
- Tiger System: gravelly hardpan plains and sandy banks with mulga shrublands and wanderrie grasses;
- Mindura System: low hills, ridges and outcrops of granite, gneiss and quartz above convex, quartz-strewn interfluves and lower plains supporting sparse acacia shrublands becoming more dense in drainage floors;
- Laverton System: greenstone hills and ridges with acacia shrublands; and
- Leonora System: low greenstone hills and stony plains supporting mixed chenopod shrublands.

The majority of the Project key mine activities are located within the Nubev System with the miscellaneous activities spanning across the other land systems. The Project will not result in

significant changes to the local setting, given the small footprint in the context of the wider landscape and existing exploration, mining activities and historical activities in the area.

2.5 Hydrology and Wetlands

The Project is not located within any proclaimed Surface Water Areas (DWER, 2020). The Water Register (DWER, 2020) indicates that the Site is located within the Goldfields Groundwater Area and within the Raeside Sub area.

The wider proposed mine site lies across two main drainage lines flowing from the north to the south. Cardinia Creek and associated tributaries run through the middle of the site, while an unnamed creek lies to the west (Hydrologia, 2023). Flood protection infrastructure (drains and levees) will be required to ensure pit safety, as well as maintaining downstream water flow.

Raeside Lake is approximately 80 km downstream of the Project. Given the small contributing area of the Cardinia Creek to Raeside Lake and the wider Raeside-Ponton catchment, changes to the surface water flows associated with the Project are highly unlikely to have any impact on these downstream lakes.

Groundwater resources in the area comprise fractured bedrock, paleochannel sediments and alluvial sediments on the edge of the paleochannel system. Fractured rock aquifers dominate the area. The occurrence of groundwater is associated with isolated regional faults or shear zones which intersect surface water drainages (Groundwater Development Services, 2019).

2.6 Broad Vegetation Types

Mapping of pre-European broad vegetation within Western Australia was completed on a broad scale (1:1,000,000) by (Beard, 1976). These vegetation types were later re-assessed by Shepherd et. al (2002) with some larger vegetation units divided into smaller units. Together, this pre-European database contains a total of 819 vegetation types within Western Australia.

The Development Envelope is mapped within the Laverton 18.16 vegetation type which is described as low woodland, open low woodland, or sparse woodland (Figure 5). The flora description of Laverton 18.16 is *Mulga Acacia aneura* and associated species. (Department of Primary Industries and Regional Development, 2018). The representation at a state, regional and local level is shown in Table 2-1.

Table 2-1: Broad Vegetation Types within the State, Regional and Local Representation (Government of Western Australia, 2019)

Vegetation Type	Pre-European Extent (ha)	Current Extent (ha)	Remaining (%)	Current Extent Managed in DBCA Lands (%)
Representation across Western Australia				
Laverton 18.16	19,892,306.46	19,843,148.07	99.75	6.64
Representation across the Murchison Bioregion				
Laverton 18.16	12,403,172.2	12,363,252.4748565	99.86	4.97
Representation across the Eastern Murchison Subregion				
Laverton 18.16	10,269,896.44	10,234,838.22	99.66	5.14
Representation across the Shire of Leonora				
Laverton 18.16	2,010,057.24	2,002,508.00	99.62	1.70

2.7 Conservation Features

The Site is not located within any Environmentally Sensitive Areas (ESAs) and there are no ESAs located within a 90 km radius of the Site (Department of Water and Environmental Regulation, 2018a). The site is not located within any Department of Biodiversity, Conservation and Attractions (DBCA) Managed Lands (Department of Biodiversity Conservation and Attractions, 2019).

3 Flora and Vegetation Assessment

Flora and vegetation surveys have been undertaken by Kin Mining (owner of Navigator Mining) over the period 2017 to 2019. Prior to that, previous survey work had been completed by Mattiske (2002) and Outback Ecology (2009). The following summary and the assessment against the clearing principles is based on the most recent work completed by Western Botanical (Western Botanical, 2019) (Appendix A), supplemented by the 2017-2018 work by Stantec (Stantec 2018b, c, d) (Appendices B, C and D).

3.1 Desktop Assessment

Database searches were undertaken to generate a list of vascular flora and vertebrate fauna previously recorded within, and within the vicinity of the Study Area – with an emphasis on species of conservation significance and introduced species.

3.1.1 Flora Assessment

Twenty-three (23) flora taxa of conservation significance were identified from the database searches (Western Botanical, 2019). However, no flora of conservation significance had been identified during previous surveys undertaken in the Study Area (Stantec, 2018b, c, d). Of the 23 Priority listed flora species, four are listed as Priority 1, one is listed as Priority 2, 15 are listed as Priority 3 and three are listed as Priority 4. None of the conservation significant flora species are listed as Threatened under the *Biodiversity Conservation Act 2016* (BC Act) or listed under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). Table 3-1 summarises the likelihood of presence for each of the species (Western Botanical, 2019). The database results were used to generate a pre-survey assessment of the likelihood of presence of those species in the Survey Area.

Table 3-1 Significant Flora likely occur within the Study Area

Scientific Name	Conservation Status	Likelihood of occurrence within the Study Area
Acacia sp. Marshall Pool (G.Cockerton 3024)	P3	Known to be present
Gunniopsis propinqua	P3	Known to be Present
Angianthus prostratus	P3	Probable, (Very Likely)
Triglochin protuberans	P3	Probable (Likely)
Acacia websteri	P1	Possible, (Very Likely)
Calandrinia quartzitica	P1	Possible
Stenanthemum patens	P1	Possible (Likely)
Calytrix hislopii	P3	Possible
Calytrix praecipua	P3	Possible, (Very Likely)

Scientific Name	Conservation Status	Likelihood of occurrence within the Study Area
Cratystylis centralis	P3	Possible, (Very Likely), known outside the Study Area
Eremophila annoscaulis	P3	Possible (Likely)
Eremophila shonae subsp. *diffusa*	P3	Possible
Eremophila simulans subsp. *megacalyx*	P3	Possible
Eremophila veronica	P3	Possible
Goodenia lyrate	P3	Possible (Possible)
Hybanthus floribundus subsp. *chloroxanthus*	P3	Possible
Micromyrtus serrulate	P3	Possible
Phyllanthus baeckeoides	P3	Possible
Grevillea inconspicua	P4	Possible (Likely)
Hemigenia exilis	P4	Possible (Likely)
Eremophila mirabilis	P2	Possible (Likely)
Ptilotus tetrandrus	P1	Unlikely (Likely)
Conospermum todii	P4	Unlikely

3.1.2 Vegetation Assessment

No Threatened Ecological Communities (TECs) were identified from the State's Threatened and Priority Ecological Community database or the Department of Climate Change, Energy the Environment and Water (DCCEEW) Protected Matters Search Tool as occurring within or near to the Study Area.

3.2 Survey Timing

Western Botanical surveyed 13,924 ha which included the Cardinia area. The survey was undertaken over two seasons (October 2018 and February 2019) with 17 days of active surveying (excluding mobilisation time). The combined Stantec Mining Area surveys covered 2,287.6 ha and the survey was undertaken over two seasons. Stantec Survey 1 was completed between November and December 2016 and Survey 2 was completed in May 2017 (Stantec, 2018b; Stantec 2018c).

While both Western Botanical surveys were taken in periods of below average rainfall, when combined with the previous Stantec survey results (which returned a higher proportion of annual species), the overall dataset is considered to be robust (Western Botanical, 2019).

3.3 Flora and Vegetation Assessment

3.3.1 Vegetation

3.3.1.1 *Vegetation Condition*

Vegetation condition within the Study Area ranged from Excellent to Completely Degraded. The majority was assessed as Excellent or Very Good (87%), where only minor disturbances such as very occasional access tracks or weeds were observed. The other 13% was assessed as Completely Degraded (13%), where areas had been completely cleared and no longer supported any native vegetation. Little evidence of significant impact from grazing was observed on the bulk of native vegetation, except for cattle tracks nearby and within the major drainage lines where deeper soils and ephemeral surface water is present from time to time (Western Botanical, 2019).

3.3.1.2 *Vegetation Types*

Western Botanical recorded 51 Vegetation Associations at NVIS Level 5 within the Study Area, none of which were considered to be Priority or TECs. This relatively large number of community types is partially due to:

- The detail of mapping;
- The interplay between geological, topographic, hydrological and salinity factors within the study area; and
- The elongated linear nature of the study area stretching approximately 37 km north-south from the Leonora – Laverton Road to the Mertondale deposit area.

The vegetation communities identified have been grouped together into 11 logical vegetation complexes showing their relatedness to each other:

1. **Mulga Woodlands over Perennial Non-Halophytic Shrubs on hills and plains:** Seventeen vegetation associations with a diverse range of Mulga species (*Acacia aneura*, *A. aptaneura*, *A. caesaneura*, *A. fuscaneura*, *A. incurvaneura*, *A. macraneura*, *A. mulganeura* and *A. pteraneura*) form the dominant upper stratum as trees and shrubs 4 to 6 m in height. The understorey varies considerably with geological substrate type, soil depth and landscape position.
2. **Mulga Shrublands / Woodlands over Perennial Grasses on Plains:** Two vegetation associations, where silty-sandy soils over hardpan higher in the landscape are present. Here Mulga is associated with a grassy understorey of *Monachather paradoxus* and *Eragrostis eriopoda*, collectively known as Wanderrie grasses.
3. **Acacia Woodlands over Shrubs and Grasses in Major Drainage Lines and Groves:** Two major drainage tracts and several minor drainage lines occur within the Study Area,

draining from the north-east to the south-west. The vegetation of the major drainage line in the west of the Study Area, Cardinia Creek is dominated by Mulga species. Bummer Creek, with a small representation within the south-east of the Study Area is dominated by *Acacia burkittii*. The vegetation of the minor drainage lines within the Study Area reflect the vegetation on the adjacent hills and plains but are denser and with a greater species representation due to the accumulation of resources.

4. **Acacia (other than Mulga) Shrublands on Stony Hills:** Four vegetation associations on stony hills within a large proortion of the Study Area are dominated by Acacia trees and shrubs other than Mulga. Here *Acacia sp.* Marshall Pool (G. Cockerton 3024) is the dominant shrub to small tree on the stony gabbro and basalt hills of the Leonora Land System. It may also be co-dominant with *Acacia sibirica* in some locations. *Acacia doreta* short phyllode form (M. Stone & S. Colwill WB34381), being the typical form of the species, is also present in association with A. sp. Marshall Pool on one small hill in the central-west of the Study Area. *Acacia burkittii* was found to be dominant in small well defined areas of calcrete platform, higher in the landscape, presumably due to an elevated soil moisture availability in the calcrete.
5. ***Acacia papyrocarpa* Woodlands:** Four variants of the *Acacia papyrocarpa* woodland were observed. The dominant and defining understorey varies from *Tecticornia disarticulata* in more saline sites; to *Eremophila scoparia* where calcrete is present; to *Ptilotus obovatus* (Upright form), *Maireana triptera* and grasses where there is non-saline but mildly alkaline soil cover over underlying materials; to *Maireana pyramidata* in areas subject to some waterlogging and salinity. *Acacia papyrocarpa* is by far the largest and most prominent tall tree in the landscape within the Study Area and provides refuge and nesting opportunities for some larger birds of prey.
6. ***Acacia victoriae* Shrubland over Chenopods on Calcrete Plains:** The *Acacia victoriae* shrubland occurs on extensive alkaline calcrete plains in the southern part of the Study Area. It has a relatively diverse understorey dominated by chenopods (*Sclerolaena* and *Maireana* spp.) and may support patches of *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH26770).
7. **Perennial Grasslands:** Two perennial grasslands were mapped. These are small, discrete patches of *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH26770) on calcrete platforms (relatively low in the landscape); and similarly small, discrete patches of *Neurachne munroi* Hummock Grassland on Mudstone on low rises.
8. ***Hakea preissii* and/or Halophytic Chenopod Shrublands:** Thirteen topographically controlled variants of Chenopod Shrublands were recognised with a major distinction being those with *Hakea preissii* emergent above the lower shrubs in areas with a deeper soil profile vs. those lacking *H. preissii*, lower in the landscape and more frequently subject to inundation or waterlogging. These environments are all moderately to highly saline and support a largely well known group of Maireana, Atriplex (less tolerant of waterlogging) and Tecticornia (Samphire, more tolerant of waterlogging) species.

9. ***Casuarina pauper* Woodland on Calcrete Outcrops:** *Casuarina pauper* woodland is found in small, isolated and disjunct populations on calcrete platforms high in the landscape and a lower salinity with reliable soil moisture availability of the alkaline soils here is inferred.
10. **Claypans:** Two types of grassy claypans were recognised: one supporting almost exclusively *Eragrostis xerophila*; while another forms Gilgais (with heaving clay soils) supporting emergent *Pittosporum angustifolium*, *Acacia tetragonophylla* and *A. victoriae* Shrubland over *Eragrostis setifolia*, *Themeda australis* and other claypan grasses. These are both non-saline environments with heavy clay soils and are internally drained sumps in the landscape. By virtue of their clay soils, high moisture retention and internal drainage, they typically provide refuge for burrowing frogs and support some flora that are not generally found outside these environments. These are small in area, disjoint from each other and uncommon in the landscape within the Study Area.
11. **Breakaway Complex:** The breakaway complex is represented in the northern part of the Study Area south of Mertondale where *Eucalyptus striaticalyx* is present at the leading edge of the low (5 to 10 m high) lateritised breakaway and a range of species tolerant of kaolin clay soils and some salinity are present in a changing mosaic pattern on the mid to lower slopes of the landscape. Groups of species such as *Frankenia* spp., *Eremophila scoparia*, *Maireana* and *Tecticornia disarticulata* are dominant while Stantec reported *Gunniopsis propinqua* (P3) in this community type. The Breakaway Complex extends well outside the Study Area near the Mertondale deposit.

These vegetation types are similar to those mapped by Stantec; Figure 3-1 shows the combined mapping.

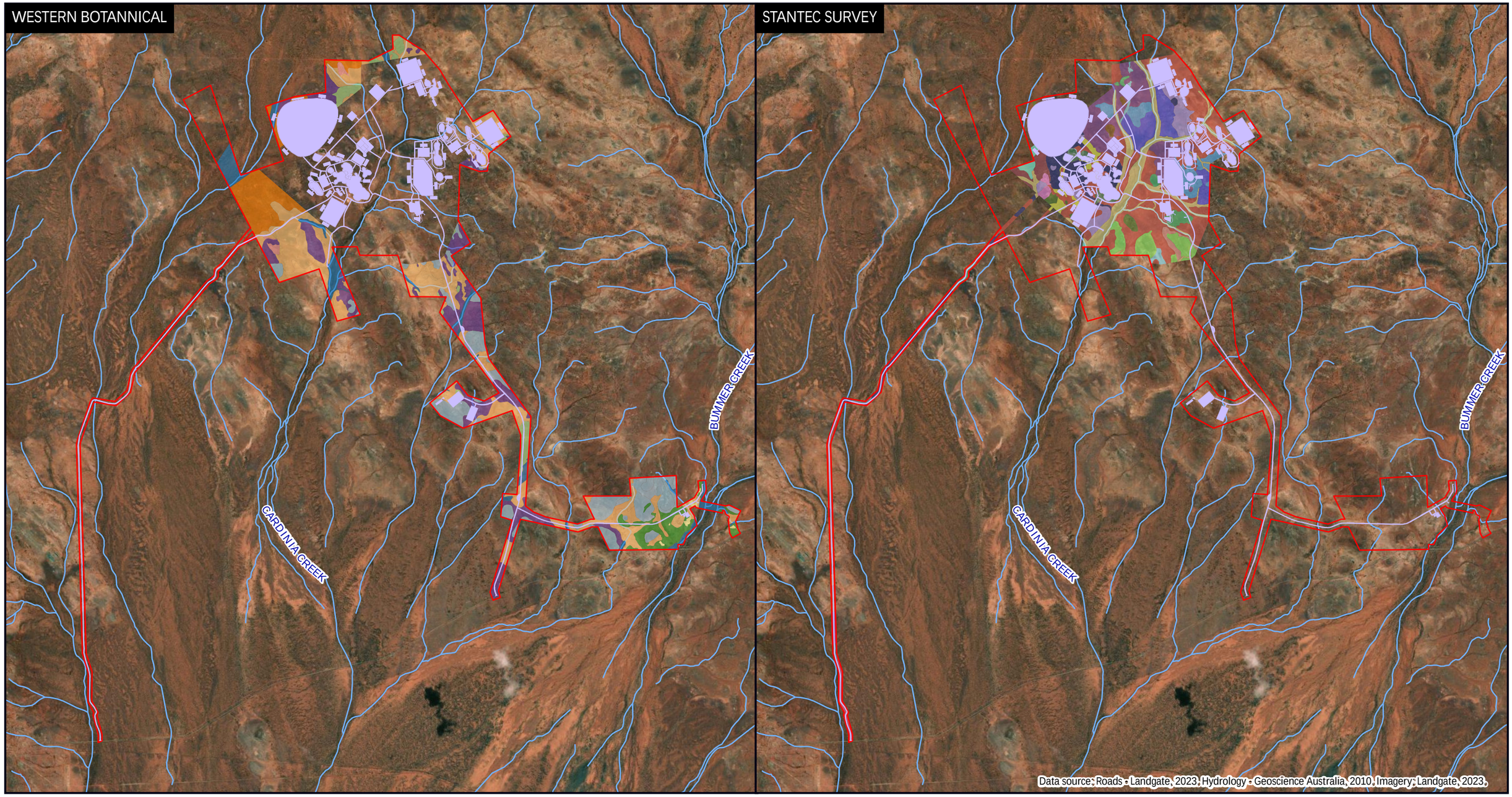
3.3.1.3 *Groundwater Dependent Vegetation*

Western Botanical (2019) determined the vegetation within their Study Area is dominated by Mulga, Acacia or Chenopods which are highly unlikely to be obligately accessing ground water. It is unlikely that any of the vegetation associations across the Project are Groundwater Dependent Ecosystems (GDE). Given that the proposed flood diversion bunds and drains will not prevent flow of water to downstream environments (only divert it around the pits, to continue its flow past the mining area) there is no risk to downstream environments associated with altered stream flows.

3.3.1.4 *Vegetation of Conservation Significance*

No State or Commonwealth Priority Ecological Communities (PECs) or TECs were recorded within the Study Area.

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LEGEND

- Cardinia Development Envelope
- Cardinia Disturbance
- Minor Sream

Vegetation Mapping

Western Botanical

- Acacia (other than Mulga) Shrublands on Stony Hills
- Acacia Woodlands over Shrubs and Grasses in Major Drainage Lines and Groves
- Acacia papyrocarpa Woodlands
- Acacia victoria Shrubland over Chenopods on Calcrete Plains
- Breakaway Complex
- Claypans
- Hakea preissii and/or Halophytic Chenopod Shrublands
- Mosaic
- Mulga Shrublands / Woodlands over Perennial Grasses on Plains
- Mulga Woodlands over Perennial Non-Halophytic Shrubs on hills and plains
- Perennial Grasslands

Stantec Survey

- A?dArrEspp.
- A?rSaMs
- AaAaEspp.
- AaAcEms
- AaArAq
- AaArEspp.
- AaAtEp
- AaAtEspp.
- AaSaMs
- AbAtTt
- AcAaSpp.M
- AcAtEo
- AcHpEp
- AiElEc
- AiMsTd
- AkAbMs
- AkHpEs
- Asp.MsEs
- CpArEo
- Disturbed
- HpCsMp
- MpTdSd
- PaAtEp

LOCALITY



VEGETATION MAPPING

Cardinia Mining Proposal

Kin Mining
Cardinia Gold Project

0 1 2 3 4 5 km

Scale @ A3: 1:100,000 Coordinate System: GDA2020 MGA Zone 51

Prepared:	E Jackson	Date:	16/05/2023
Reviewed:	A Jamieson		
Project:	TE22110		
Revision:	A		

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3.3.2 Flora

The combined information from the surveys conducted by Stantec (2018) and Western Botanical (2019) adds up to 321 from 132 genera and 44 families. The families include Poaceae, Fabaceae, Myoporaceae, Amaranthaceae, Malvaceae, and Frankeniaceae. The floral diversity and composition recorded from the Study Area is consistent with the Murchison bioregion, the landforms present, the season of the field survey, and the sampling intensity. The flora taxa recorded is consistent with Mulga shrublands of the bioregion.

3.3.2.1 *Threatened Flora*

No Threatened Flora were recorded during the surveys conducted by Stantec and Western Botanical. Further, no Threatened Flora are known in region nearby the Study Area and therefore no Threatened Species are considered likely to be present.

3.3.2.2 *Priority Flora*

Four Priority Flora were recorded by Western Botanical and/ or Stantec between 2017 and 2019, all are P3 (Figure 3-2):

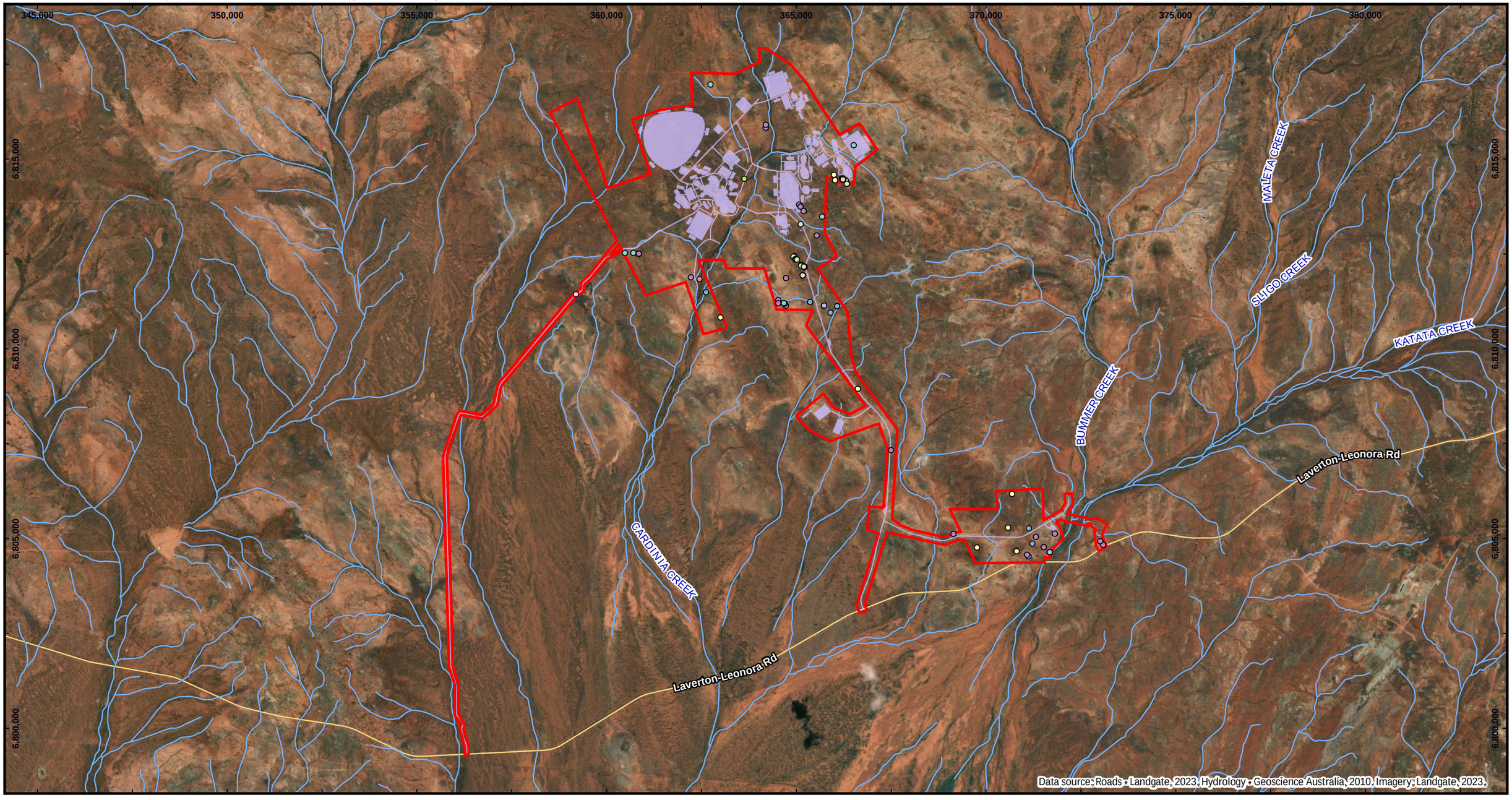
- *Acacia* sp. Marshall Pool (G. Cockerton 3024);
- *Eremophila annoscaulis* P3;
- *Cratystylis centralis* P3;
- *Gunniopsis propinqua* P3.

3.3.2.3 *Weeds*

Twenty weed species have been recorded during surveys for Kin (Stantec, 2018b, c, d; Western Botanical, 2019). Of these:

- Seventeen are regarded as introduced minor weed species and not of concern as they are not strongly competitive and are widely naturalised.
- Two species, (*Cenchrus ciliaris* and *Cenchrus setiger*) are widely promoted by the Pastoral industry, however, both are vigorous invasive weed species and their presence within the Study Area lowers the vegetation condition ranking in the habitat in which they occur.
- One species occurring just outside the Study Area, *Cylindropuntia fulgida* var. *mamillata*, Jumping Cholla or Coral Cactus, is listed as a Weed of National Significance (WoNS).
- One species, *Polycarpon tetraphyllum*, a small and non-competitive introduced species, represents the first collection of the species in the Murchison bioregion and a range extension of at least 500 km. It is a small plant and easily overlooked and may be more widespread than data currently indicates.

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LEGEND

- Cardinia Development Envelope
- Cardinia Disturbance
- Minor Sream

Priority Flora

- Acacia quadrimarginea narrow phyllode form (G. Cockerton WB38064)
- Acacia sp. Marshall Pool (G. Cockerton 3024)
- Alectryon oleifolius subsp. canescens
- Bidens bipinnata *
- Cenchrus ciliaris *
- Cenchrus setiger *
- Citrullus colocynthis *
- Cratystylis centralis
- Cucumis myriocarpus *
- Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)
- Hibiscus sp. Perrinvale Station (J. Warden & E. Ager WB 10581)
- Lepidium didymum *
- Neurachne munroi
- Polycarpon tetraphyllum *
- Rumex hypogaeus *

Current Roads (LGATE-012)

- Freeway / Highway
- Main Road



PRIORITY FLORA

Cardinia Mining Proposal

Kin Mining
Cardinia Gold Project

km
0 1 2 3 4 5

Scale @ A3: 1:100,000 Coordinate System: GDA2020 MGA Zone 51

Prepared:	E Jackson	Date:	15/05/2023
Reviewed:	A Jamieson		
Project:	TE22110		
Revision:	A		

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4 Terrestrial Fauna Assessment

The most recent fauna survey on the study area is work by Phoenix Environmental Sciences (2019) across the Mining Area and proposed mine access road. Stantec had previously surveyed the existing mine access road and mining area (Stantec, 2018c). The following assessment is based on Phoenix's (2019) which is the most recent work and additions from Stantec (2018c) are used for comparison and validating the species diversity.

4.1 Desktop Assessment

Database searches and a literature review were undertaken to identify the significant fauna values that may occur within the study area. Desktop review methods entailed (Phoenix, 2019; Appendix E):

- A review of existing environmental information relevant to the biological values of the study area including:
  - Base environmental datasets to define the physical characteristics of the study area.
  - Searches of relevant biological databases:
    - Protected Matters Search Tool
    - DBCA Threatened and Priority Fauna Database
    - DBCA/WAM NatureMap Database
    - Atlas of Living Australia
    - WA Museum Arachnid and Myriapod Database
    - WA Museum Mollusca Database.
- Review of the most recent vegetation mapping for the project (Western Botanical, 2019)
- Assessment of 'likelihood of occurrence' of Threatened and Priority species.

4.1.1 Vertebrate Fauna

Records for 274 terrestrial vertebrate fauna species were identified as potentially occurring within the study area in the desktop review. These comprised seven frogs, 55 reptiles, 174 birds (including two naturalised species) and 38 mammals (including 12 introduced).

A total of 30 species of conservation significant vertebrate taxa were identified in the desktop review (23 birds, seven mammals) as potentially occurring, including 13 species listed under the Commonwealth EPBC Act and/or Western Australian BC Act as Threatened or Specially Protected (Table 4-1). Seventeen species are listed as Migratory under the EPBC Act and BC Act (two also listed as Threatened). A further three are listed as Priority species by the DBCA. Two locally extinct species were also returned.

Table 4-1 Fauna Species of Conservation Significance Likely to Occur in the Study Area

Species	Common Name	Likelihood	Conservation Status*		
			EPBC Act	BC Act	DBCA List
Birds					
Leipoa ocellata	Malleefowl	Possible	VU	VU	-
Apus pacificus	Fork-tailed Swift	Possible	Mig	Mig	-
Plegadis falcinellus	Glossy Ibis	Unlikely	Mig	Mig	-
Falco hypoleucos	Grey Falcon	Likely	-	VU	-
Falco peregrinus	Peregrine Falcon	Likely	-	OS	-
Charadrius veredus	Oriental Plover	Possible	Mig	Mig	-
Thinornis rubricollis	Hooded Plover	Unlikely	-	-	P4
Pluvialis fulva	Pacific Golden Plover	Unlikely	Mig	Mig	-
Limosa lapponica	Bar-tailed Godwit	Unlikely	VU/Mig	VU/Mig	-
Actitis hypoleucos	Common Sandpiper	Unlikely	Mig	Mig	-
Tringa nebularia	Common Greenshank	Unlikely	Mig	Mig	-
Tringa glareola	Wood Sandpiper	Unlikely	Mig	Mig	-
Tringa stagnatilis	Marsh Sandpiper	Unlikely	Mig	Mig	-
Calidris canutus	Red Knot	Unlikely	EN/Mig	Mig	-
Calidris melanotos	Pectoral Sandpiper	Unlikely	Mig	Mig	-
Calidris ruficollis	Red-necked Stint	Unlikely	Mig	Mig	-
Calidris subminuta	Long-toed Stint	Unlikely	Mig	Mig	-

Species	Common Name	Likelihood	Conservation Status*		
			EPBC Act	BC Act	DBCA List
Calidris acuminata	Sharp-tailed Sandpiper	Possible	Mig	Mig	-
Gelochelidon nilotica	Gull-billed Tern	Unlikely	Mig	Mig	-
Polytelis alexandrae	Princess Parrot	Possible	VU	-	P4
Pezoporus occidentalis	Night Parrot	Unlikely	EN	CR	-
Motacilla cinereal	Grey Wagtail	Unlikely	Mig	Mig	-
Motacilla flava	Yellow Wagtail	Unlikely	Mig	Mig	-
Mammals					
Dasyurus geoffroii	Chuditch	Unlikely	VU	VU	-
Sminthopsis longicaudata	Long-tailed Dunnart	Likely	-	-	P4
Myrmecobius fasciatus	Numbat	Unlikely	VU	VU	-
Macrotis lagotis	Greater Bilby	Unlikely	VU	VU	-
Bettongia lesueur	Boodie	Recorded historical evidence/ Unlikely	VU/EX	VU/EX	-
Lagostrophus fasciatus	Banded Hare-wallaby	Unlikely	VU	VU	-
Leporillus conditor	Greater Stick-nest Rat	Recorded historical evidence/ Unlikely	VU	VU	-

4.1.2 Invertebrate Fauna

The WA Museum database searches returned 42 records of terrestrial invertebrate taxa, none were potential or confirmed Short-Range Endemics (SREs) (Table 4-2). The DBCA Threatened fauna database returned six records, representing two taxa of fairy shrimp. These are however not within 30 km of the study area.

Table 4-2 Invertebrate Fauna likely to occur within the study area.

Species	SRE Status	Likelihood of Presence
Anostraca (2)		
Thamnocephalidae (2)		
Branchinella apophysate	SRE	Unlikely
Branchinella simplex	SRE	Unlikely
Araneae (13)		
Araneomorphae (new world spiders) (12)		
Gnaphosidae (2)		
`Eilica?` `sp.`	No potential	-
Encoptarthria `Leonora sp. 1`	No potential	-
Miturgidae (2)		
Miturga `Leonora sp. 1`	No potential	-
Miturga `Leonora sp. 1`?	No potential	-
Sparassidae (1)		
Neosparassus `Leonora sp. 1`	No potential	-
Trochanteriidae (1)		
Longrita millewa	No potential	-
Zodariidae (6)		
*`Leonora* gen. 1` `Leonora sp. 1`	No potential	-
Habronestes `Leonora sp. 1`	No potential	-
Habronestes `Leonora sp. 2`	No potential	-
Neostorena `Leonora sp. 1`	No potential	-
Neostorena `Leonora sp. 2`	No potential	-
Storena `sp.`	No potential	-
Mygalomorphae (trap-door spiders) (1)		
Idiopidae (1)		
Eucyrtops eremaea	No potential	-
Scolopendrida (1)		
Scolopendridae (1)		
Cormocephalus `sp. (fragment)`	No potential	-

4.2 Terrestrial Fauna Field Assessment

Phoenix Environmental Sciences Pty Ltd (Phoenix Environmental) conducted a terrestrial fauna survey for the study area in April 2019. Survey methods for terrestrial vertebrate fauna included standardised Level 1 fauna survey sites. The methods used comprised of the following:

- Habitat assessment
- Active searches
- Avifauna surveys
- Bat echolocation recordings.

Searches were conducted across all habitat types to identify possible fauna taxa of conservation significance and to develop a fauna species list for the Study area. Potential wetlands or temporary water bodies with the capacity to support waterbirds or migratory waders were also targeted. Searching methods included:

- Hand-searching for cryptic species, for example by overturning logs and stones
- Searching beneath the bark of dead trees
- Investigating crevices
- Searching for burrows, tracks, diggings, scats, and other signs of fauna.

Aural surveys for avifauna were also carried out. All vertebrate fauna seen or heard, or whose presence was inferred from secondary evidence was documented. The nomenclature and taxonomy of mammals, birds, reptiles, and amphibians within this report follow the Checklist of the Vertebrates of Western Australia (WAM 2017).

4.2.1 Habitat Types

The study area forms part of an undulating plain sloping down from northeast to southwest, with low stony hills and plains dissected by shallow, seasonal, or ephemeral drainage lines. In terms of topography, hydrology, and vegetation it has relatively low diversity. Six broad fauna habitats were mapped within Phoenix's (2019) study area (Figure 4-1):

- Mulga woodland on plain: Open to sparse woodland or shrubland of Mulga (*Acacia aneura* group) or Bastard Mulga (*A. papyrocarpa*) over varying mid- and understorey of lower shrubs and/or grasses
- Acacia shrubland on stony hills: Rolling hills with gravel or cobble substrate, with shrubland vegetation dominated by Acacia other than Mulga
- Acacia woodland in drainage lines and groves: Drainage lines with associated riparian vegetation, usually Mulga or other Acacia over variable understory cover, often dominated by dense grass cover nearer to drainage line

- Cleared: Existing cleared and/or disturbed areas (i.e. existing tracks, roads and clearing for previous exploration or mining operations).

All habitat types are well represented within the local area and the proposed disturbance is unlikely to have a significant impact on fauna populations.

4.2.2 Recorded Species

A total of 65 terrestrial vertebrate fauna species were recorded during the field survey:

- Amphibians – Two species
- Reptiles - 12 species
- Native Birds - 38
- Introduced Birds - Zero
- Native Mammals - Seven
- Introduced Mammals – Seven.

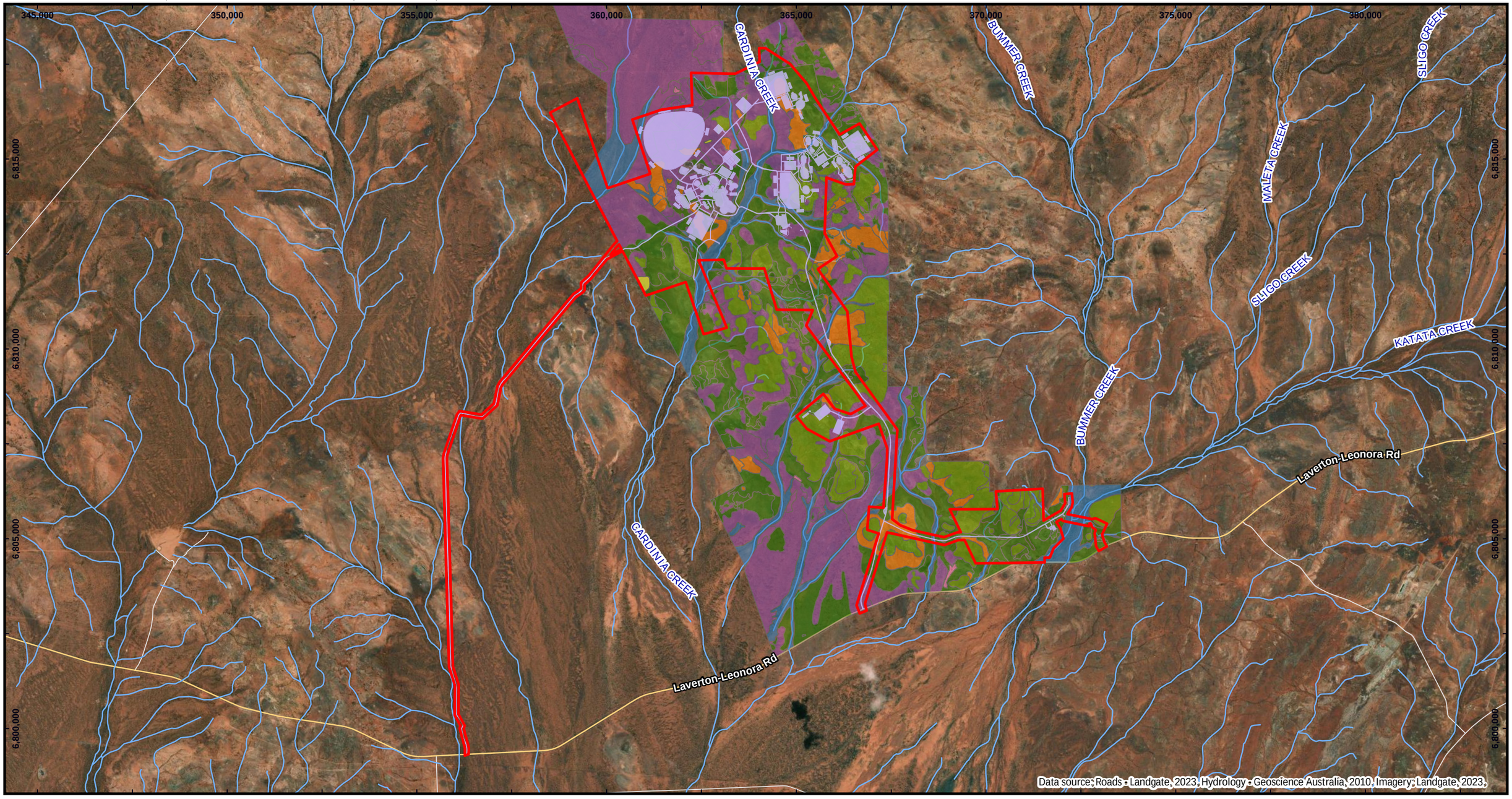
4.2.3 Conservation Significant Species

No conservation significant species were positively identified as currently occurring during the field survey, but three were recorded based on secondary evidence (Phoenix, 2019):

- Long-tailed Dunnart (P4): Long-tailed Dunnart is recorded provisionally based on small dasyurid scats associated with crevices on rocky hills and breakaways at three sites. Morphologically these could not be directly identified to the species and are also consistent with the other *Sminthopsis*, *Ningaui* or *Antechinomys* species that occur in the general area. Long-tailed Dunnart may also occur more broadly across habitats surrounding denning sites to forage or disperse when conditions and cover are suitable.
- Burrowing Bettong (EX): Burrowing Bettong (Boodie) was identified from historic secondary evidence within the study area. Evidence of past occurrence of Burrowing Bettong was recorded from six sites in the form of burrow complexes (warrens) extending under a layer of hardpan calcrete on plains or lower slopes of hills.
- Greater Stick-nest Rat (VU). Greater Stick- nest rat was recorded from secondary evidence within the study area. The Greater Stick-nest Rat from two old nests located in a breakaway. Its suitable habitat semi-arid to arid habitats where there is little or no fresh water. It inhabits perennial shrublands, particularly with succulent and semi-succulent plant species.

The potential for the study area to support SREs is constrained to significant outcrops, which are few and not proposed to be impacted (Phoenix, 2019).

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LEGEND

- Cardinia Development Envelope
- Cardinia Disturbance
- Minor Sream

2F Fauna Habitat

- Acacia shrubland on stony hills
- Acacia woodland in drainage lines and groves
- Cleared
- Mulga woodland on plain
- Mulga woodland on stony hills
- Outcropping and breakaway
- Shrubland on plain
- Vegetated gilgai/claypan

LOCALITY



FAUNA HABITAT MAPPING

Cardinia Mining Proposal

Kin Mining
Cardinia Gold Project

0 1 2 3 4 5 km

Scale @ A3: 1:100,000 Coordinate System: GDA2020 MGA Zone 51

Prepared:	E Jackson	Date:	15/05/2023
Reviewed:	A Jamieson		
Project:	TE22110		
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5 Subterranean Fauna Assessment

5.1 Desktop Assessment

Searches of both federal and state databases were undertaken as part of the desktop review to determine if any stygofauna or troglofauna taxa had been previously recorded from within or near the Project Area, and to identify if any TECs and PECs were in the vicinity (Stantec, 2021; Appendix F). The following data base tools were used:

- Western Australian Museum's (WAM) collection databases were searched for subterranean arachnids, crustaceans and myriapods within a 50 km radius
- Department of Biodiversity, Conservation and Attractions TEC/PEC database was searched for TECs and PECs occurring within a 30 km radius to obtain TEC and PEC buffer zones in the Project area.

The following Federal and State government lists were also checked against the database results, to identify any threatened or priority subterranean fauna that may occur within the search area:

- BC Act Schedule Species List
- EPBC Act TEC List
- EPBC Act Threatened Fauna List.

5.2 Subterranean Field Survey

A level 2 baseline stygofauna survey was conducted by Stantec from different surveys conducted between 2008 and 2019. The field survey methods and sampling effort employed for the Mertondale subterranean fauna survey followed the EPA technical guidance documents.

5.2.1 Stygofauna Survey

Stygofauna samples were taken from a mixture of wells, exploration drill holes and bores (collectively referred to hence forth as sites) using haul nets, which have been found to be the most efficient retrieval method (Allford et al. 2008).

A total of 18 stygofauna net haul samples were collected from 9 sites across the Mertondale study Area from four surveys: October 2008, December 2008, March 2009, and January–February 2017. The sampling method was as follows:

- Samples were collected using two weighted haul nets with mesh sizes of 150 µm and 50 µm. Each net was fitted with a collection vial with a base mesh of 50 µm.
- The 150 µm net was lowered first, to near the bottom of the site.
- Once at the bottom, the net was gently raised up and down to agitate the sediments.

- The net was then raised slowly, to minimize the 'bow wave' effect that may result in the loss of specimens, filtering the stygofauna from the water column on retrieval.
- Once retrieved, the collection vial was removed, the contents emptied into a 250 ml polycarbonate vial, and preserved with 100% undenatured ethanol.
- This process was repeated three times alternating with three samples with the 50 µm net.
- To prevent cross-contamination, all sampling equipment was washed thoroughly with decon 90 (2 to 5% concentration) and rinsed with potable water after each site.
- In the field, samples were placed into eskies with ice bricks prior to being transferred into a refrigerated environment on-site at the end of each survey day.
- Samples were couriered back to the Stantec laboratory in Perth, where they were stored in 100% ethanol and refrigerated at approximately minus 20°C.

5.2.2 Troglofauna Survey

Two net haul scrapes were completed at Mertondale, involving the following:

- Lowering of a stygofauna net to the bottom of a dry site or at least 1 m below the standing water level if groundwater is present
- Scraping the net up along the uncased wall surface of the site on retrieval with the aim of dislodging and collecting any invertebrates that may be present
- This process is repeated four times per site with each scrape sampling a different side of the wall surface of the site.

All haul samples were preserved in 100% ethanol prior to shipment back to the Stantec laboratory in Perth for processing. To enhance preservation of specimens and their DNA, samples were kept cool onsite in eskies with ice bricks then refrigerated at the end of each survey day. All samples were then shipped back to Perth in eskies with ice bricks then placed in freezers (at minus 20 Celsius) to further promote fixation of DNA.

5.2.3 Results

No troglofauna or stygofauna were recorded from the samples collected from the Mertondale area. The unsaturated subterranean habitat in the project area was found to not be prospective for troglofaunal and stygofauna as the overlying regolith was clay dominated and deep, extending to below the standing water level, offering limited to no habitat in the absence of sufficient interstitial pore space for colonisation and which would restrict the influx of resources (e.g. oxygen and nutrients). The non-prospective habitat in Mertondale was verified by scrape samples, collected over two sample rounds that failed to record any subterranean species. The development of Mertondale will not pose a conservation risk to any troglofauna and stygofauna species as these areas were found not to host any subterranean values.

The subterranean habitat within the Mertondale Study Area is considered less prospective for stygofauna and troglofauna with the absence of extensive groundwater associated calcrete systems. The most prospective habitat for stygofauna in the Mertondale Study Area occur in association with geological structures present within the fractured rock aquifer systems (e.g., primarily regional shear zones and faults, but also in more localised fractures, and unconformities), and in the coarse-grained alluvial sediments present along the main drainage lines and associated tributaries.

6 Environmental Management Measures

6.1 Avoid

The design of the mine and supporting infrastructure minimises clearing of vegetation. Navigator propose to mine, then truck ore for processing at a nearby existing plant. This will reduce the clearing footprint for the project by minimising the amount of infrastructure required on site.

6.2 Mitigation

Navigator have designed engineering controls to minimise clearing impact but still ensure safe operation on site.

Examples of environmental management measures which can be implemented to mitigate clearing impacts and management on site include but not limited to the following:

- Clearing area will be demarcated prior to the commencement of project activities and prior to the commencement of native vegetation clearing.
- Clearing will be undertaken in accordance with the site Ground Disturbance Permitting Procedure
- Induction of all contractors and/or internal personnel undertaking the clearing in accordance with Navigator's internal procedures. GPS coordinates of clearing permit area to be supplied to contractor.
- Prior to clearing activities, areas of native vegetation to be retained will be clearly demarcated by star pickets, coloured tape or bunting and all personnel should be made aware of the requirement to protect native vegetation in these areas.

Kin Mining NL (Navigator's parent) has an Environmental Management System for the Cardinia Project, as required by the current *Mining Proposal Statutory Guidelines* (DMIRS 2020).

7 Assessment Against the Ten Clearing Principles

The proposed clearing activities have been assessed against the ten clearing principles as defined in DER's Guide to Assessment: Clearing of Native Vegetation under the EP Act, considering the current extent and condition of the native vegetation on the site. This assessment is presented in Table 7-1.

Table 7-1: Assessment Against Clearing Principles

Principle	Assessment
Principle (a) – Native vegetation should not be cleared if it comprises a high level of biological diversity.	**Assessed Outcome:** Within the clearing area there are no threatened flora, threatened ecological communities and only a few Priority Flora populations. The proposed clearing area of up to 994.42 ha is not considered to comprise a high level of biological diversity according to field work conducted by Western Botanical (2019), Phoenix (2019) and Stantec (2018b, c, d). Therefore, the proposed clearing is unlikely to be at variance with this Principle. Refer to Section 3 and Section 4 for further detail.
Principle (b) – Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of a significant habitat for fauna indigenous to Western Australia.	**Assessed Outcome:** The Site is not considered necessary for the maintenance of a significant habitat for fauna indigenous to Western Australia and therefore the proposed clearing of up to 994.42 ha is unlikely to be at variance with this Principle. Based on the gathered information (Section 4), none of the identified species in the proposed clearing area are considered solely dependent on any of the terrestrial habitat types identified. Disturbance within the proposed clearing area is unlikely to significantly impact any of the species listed due to the presence of similar habitat within the vicinity of the area.
Principle (c) – Native vegetation should not be cleared if it includes, or is necessary for the continued existence of rare flora.	**Assessed Outcome:** No Threatened Flora were identified between Stantec or Western Botanical during surveys from 2017 to 2019 (Stantec, 2018b,c,d; Western Botanical, 2019). No rare or threatened flora were considered likely to be present, therefore the proposed clearing of up to 994.42 ha is unlikely to be at variance with this Principle.

Principle	Assessment
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 (TEC).	**Assessed Outcome:** No Threatened Ecological Communities were identified by Stantec or Western Botanical during the studies from 2017 to 2019. None of the vegetation associations correspond to any known Priority Ecological Communities (Stantec, 2018a, 2018b, 2018c; Western Botanical, 2019). Therefore, the proposed clearing of up to 994.42 ha is unlikely to be at variance with this principle.
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.	**Assessed Outcome:** The percentage of remaining vegetation association Laverton 18.16 is well above the threshold value of 30%, making the proposed clearing unlikely to be at variance with this Principal. The Mining Area is mapped within the Laverton 18 which is described as low woodland, open low woodland, or sparse woodland. The flora description of Laverton 18.16 is *Mulga Acacia aneura* and associated species. The EPA's Guidance Statement No. 33 has identified a minimum threshold of retention of 30% of pre-European extent of each community (Environmental Protection Authority, 2008). Laverton 18.16 is well above this threshold, representation of Laverton within shire of Leonora is 92.6%.
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.	**Assessed Outcome:** Due to the presence of several ephemeral watercourses within the Development Envelope, the clearing of up to 994.42ha may be at variance with this Principle. Regional hydrographic mapping identifies a number of minor ephemeral waterways in the Development Envelope, which has been confirmed in the vegetation mapping. The drainage lines within the Study Area are not considered regionally prominent and are not listed within the Directory of Important Wetlands in Australia (DoE 2015) or listed as an Environmentally Sensitive Area (ESA). Given the nature of ephemeral streams in the wider area, the large catchment, and Navigator's aim to mine from dry pits (i.e. surface water ingress will be managed with diversion drains and levees) the overall impact to local and regional hydrology is not considered to be significant.
Principle (g) – Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.	**Assessed Outcome:** The works associated with the clearing are unlikely to cause appreciable land degradation that is different or more significant than what has already occurred on site and the surrounding area to date. Therefore, the proposed clearing is unlikely to be at variance with this principle. The (then) DER has defined land degradation as including the following (Department of Environment Regulation, 2014): • The clearing of vegetation;

Principle	Assessment
	• Decline in vegetation condition; • Soil erosion and soil acidity (caused by wind and water erosion due to vegetation clearing); • Salinity; or • Waterlogging/flooding. The land use surrounding the site is mostly undisturbed, except for existing roads, mining landforms and access tracks. While clearing of vegetation for mine site development will directly impact native vegetation, development plans will include measures to minimise and mitigate interruptions to drainage, and the risk of sedimentation downstream.
Principle (h) – Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.	**Assessed Outcome:** There are no nearby or adjacent conservation areas or ESA's within the nearby vicinity of the proposed clearing, therefore it is unlikely the Proposal is at variance with this Principle. The Site is not located within any Environmentally Sensitive Areas (ESA) and there are no ESAs located within a 90 km radius of the Site (Department of Water and Environmental Regulation, 2018a). The site is not located within any DBCA Managed Lands (Department of Biodiversity Conservation and Attractions, 2019). The proposed clearing is not likely to have an impact on the environmental values of any adjacent or nearby conservation areas considering where it is located and the proximity of conservation areas.
Principle (i) – Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.	**Assessed Outcome:** The proposed clearing is not within a Proclaimed Surface Water Area (PSWA), nor is it likely to affect the quality of surface or groundwater, making it unlikely to be at variance with this Principle. No permanent surface water features were observed in the Study Area however drainage lines are present. Clearing and/or construction should not impact on drainage or surface water quality, provided sediments are controlled during construction and operation by implementing standard management procedures. Surface water management infrastructure will be constructed of competent, non-polluting materials. Pathways for contamination of groundwater include usage of unused pits for water storage, however materials characterisation of the waste rock from the Cardinia area show that the rock is non-acid forming, and unlikely to be dispersive. Groundwater drawdown impacts are unlikely to be problematic as no vegetation complexes in the clearing area are considered to be groundwater dependant (Section 3.3.1.3).

Principle	Assessment
Principle (j) – Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding.	**Assessed Outcome:** The proposed clearing is unlikely to cause, or exacerbate, the incidence of flooding therefore it is unlikely to be at variance with this principle. The 1% AEP Floodway and Fringe Areas mapping did not identify the Site or the surrounding as being within a flood risk area (Department of Water and Environmental Regulation, 2018b). Diversion drains and levees are proposed to divert surface water from the pits and maintain downstream creek flow. The incidence of flooding in the Study Area is not anticipated to be exacerbated by clearing of the vegetation due to the fact that the Study Area occurs on free draining soils and is relatively flat in terrain. The minor drainage lines that flow through the Study Area would not carry a high volume of surface water during annual rainfall events.

8 Summary of Assessment

The assessment concludes that the clearing of up to 994.42 ha of native vegetation for the further development of the Cardinia Project is not at variance with nine of the Clearing Principles. Where the Development Envelope intersects with minor, ephemeral drainage lines the clearing may be at variance with Principal. However, this is not considered to be a significant impact as the creeks are ephemeral and only run after heavy rainfall, and the local and wider area contains many similar ephemeral drainage lines and minor creeks. As such, any temporary changes to downstream volumes will not be significant.

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10 Appendices

APPENDIX A

Western Botanical – Flora and Vegetation Assessment, Leonora Gold Project 2019

Western Botanical

Flora and Vegetation Assessment, Leonora Gold Project

JUNE 2019

Prepared for: Kin Mining Pty Ltd

Report Ref: WB903



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Executive Summary

Kin Mining Pty Ltd (Kin) is in the process of seeking approval to develop the Leonora Gold Project (LGP) comprised of a series of adjoining tenements some 31 km east and north-east of Leonora (the Study Area), Figure 1. Western Botanical (WB) was commissioned to undertake an assessment of the flora and vegetation associations of the 139 sq. km Study Area in support of a Mining Proposal.

A desktop assessment of (i) any listed Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs); and (ii) likely conservation significant flora in the region was undertaken prior to the field works by Kin and the results supplied to WB. These were then assessed for likelihood of occurrence within the Study Area based on distribution, habitat preference and land systems of the Study Area.

Field surveys were undertaken over two events, 10th to 19th October 2018 and 5th to 17th February 2019 inclusive of travel, a period of 21 days with 17 days spent actively spent conducting assessments in the field. Vegetation was described using 74 advanced Relevés (projected foliar cover estimated for each species present), extensive in-vehicle and on-foot traverses and mapped at NVIS Level 5 *Association.* The majority of flora was collected for reference material and all species were identified using the resources of the WA Herbarium with reference to Western Botanical's reference herbarium. Species with conservation significance were mapped and species profiles generated for each vegetation association.

The Study Area intersects nine Land Systems – which are generally well represented in both the local and broader region, though often demonstrating disjunct occurrences. It includes extensive areas of (i) saline flats supporting chenopod shrublands in its central region; (ii) extensive non-saline washplains in the north and south; and (iii) substantial areas of gabbro and basalt hills in the south-east. Flora associated with the (i) saline flats and (ii) gabbro or basalt hills respectively have a high degree of correlation with their respective habitat types and can be predicted reasonably consistently in the local region. Flora of non-saline colluvial plains can be quite variable, dependent upon depth of soil over hardpan, underlying geology and soil moisture availability, inferred soil chemistry, and the frequency and duration of sheet flow or inundation.

Fifty one vegetation associations at were recognised within the LGP Study Area. This relatively large number of community types is partially due to (i) the detail of mapping, (ii) the interplay between complex geological, topographic, hydrological and salinity factors within the Study Area and (iii) the elongated linear nature of the northern part of the Study Area extending some 36.8 km north-south from the Leonora – Laverton road to the Mertondale deposit area.

Table 1. Vegetation Groups of the Study Area

Vegetation Group	Number of Vegetation Associations at NVIS 5
1. Mulga Woodlands over Perennial Non-Halophytic Shrubs on hills and plains	17
2. Mulga Shrublands / Woodlands over Perennial Grasses on Plains	2
3. Acacia Woodlands over Shrubs and Grasses in Major Drainage Lines and Groves	3
4. Acacia (other than Mulga) Shrublands on Stony Hills	4
5. Acacia papyrocarpa Woodlands	4
6. Acacia victoriae Shrubland over Chenopods on Calcrete Plains	1
7. Perennial Grasslands	2
8. Hakea preissii and/or Halophytic Chenopod Shrublands	13 including 1 devoid of perennial vegetation
9. Casuarina pauper Woodland on Calcrete Outcrops	1
10. Claypans	2
11. Breakaway Complex	1 Vegetation Complex

Two hundred and thirty six species (including subspecies and varieties) from 102 genera and 42 families, inclusive of 224 native endemic species and species 12 weed species. Annuals and geophytes were largely absent due to the dry seasonal conditions prevailing at the time of both surveys. Combining the species lists from the Stantec 2017, 2018a and 2018b studies and the current works, the total flora statistics stands at around 321 species from 132 genera and 44 families, inclusive of 18 weed species, with doubtful species omitted and misidentified species corrected as best as possible.

No Threatened Flora species listed under the Biodiversity Conservation Act 2016 (WA) and no species listed under the EPBC Act 1999 (C'wlth) were encountered and none are expected in the immediate vicinity of the Study Area. Of the 224 native flora species encountered, three species (*Acacia* sp. Marshall Pool (G Cockerton 3024), *Cratystylis centralis* and *Eremophila annoscaulis*) are listed at Priority 3 Flora by the Department of Biodiversity, Conservation and

Attractions. The record of *Cratystylis centralis* lies outside the Study Area but is adjacent to the existing Cardinia access road. A fourth species, *Gunniopsis propinqua* P3, was recorded by Stantec (2017, 2018a), however, the seasonal conditions prevailing at the time of this study precluded this species from being observable.

Two collections appear to represent species new to science and are recognised here for the first time. The first is here labelled *Hibiscus* sp. Perrinvale Station (J. Warden & E. Ager WB10581), a shrub to 1m, and was confirmed at five points within the Study Area with a further four points possibly representing this species. All sites are on stony ground or hills with either chert, ironstone or basalt rocks prevalent at the surface. Seven of the nine sites occur near the proposed mine infrastructure in north-east of the existing Cardinia development envelope while two sites occur on stony chert hills in the south of the Cardinia development envelope. *Hibiscus* sp. Perrinvale Station (J. Warden & E. Ager WB10581) has been previously collected by Western Botanical on a low banded ironstone range on Perrinvale Station, on the eastern shore of Lake Barlee, some 170 km west-south-west of the LGP and 132 km north-west of Menzies. The second species is here labelled *Centrolepis* sp. Leonora (G. Cockerton & G. Grigg WB40071) and is a small herb to 5 cm high. It was recorded in association with Mulga and *Ptilotus obovatus* upright form in the region north of the Cardinia development envelope.

Of the 12 weed species encountered, the majority are small, non-invasive, widely naturalised and not of concern. One is a Weed of National Significance (*Cylindropuntia fulgida* var. *mamillata*), occurring just outside the Study Area; and one is a recognised invasive species, *Cenchrus ciliaris* (Buffel Grass) found within the southern portion of the Study Area, an artefact of historical and current Pastoral land use in the region.

Recommendations

In order to address some of the listed priority flora, poorly collected or suspected novel species within the Study Area, the following recommendations are made:

1. Undertake an assessment of the population numbers and distribution of *Eremophila annoscaulis* Priority 3 within the Study Area and known locations nearby the Study Area to determine the local population and potential proportional impacts to this species in development of the LGP. Strategies of either avoiding disturbance, or allowable proportional impact to this species in development of the LGP, can therefore be appraised.

2. Undertake a recollection and assessment of *Centrolepis* sp. Leonora (G. Cockerton & G. Grigg WB40071) to (i) confirm its taxonomic status and (ii) determine its distribution, population numbers and potential impacts to the species within the Study Area in development of the LGP.

3. Undertake a recollection and assessment of *Hibiscus* sp. Perrinvale Station (J. Warden & E. Ager WB10581) within the Study Area and in areas of similar geology and landform outside the Study Area to (i) confirm its taxonomic status; and (ii) determine its distribution, population numbers and potential impacts to the species within the Study Area in the Cardinia development envelope.

4. During appropriate seasonal conditions, undertake an assessment of annual species throughout the current Study Area. Particular focus should be given to the areas on the fringes of the saline damp lands which may support conservation significant flora known in the region but not yet recorded within the Study Area due to prevailing seasonal conditions during the current study.

1. Introduction

Kin Mining Pty Ltd (Kin) is in the process of seeking approval to develop the Leonora Gold Project (LGP) comprised of a series of adjoining tenements some 31 km east and north-east of Leonora (the Study Area), Figure 1. Western Botanical (WB) was commissioned in mid 2018 to undertake an assessment of the flora and vegetation associations of the 139 sq. km Study Area in support of a Mining Proposal.

1.1. Previous Surveys

Flora and vegetation of portions of the Study Area have been assessed in the recent past by Stantec Pty Ltd, Table 2.

Table 2. Previous Assessments

Author, Date	Title	Summary Findings
Stantec 2017	Leonora Gold Project: Level 1 Flora, Vegetation and Fauna Assessment	Survey of two areas in two events: eight days field assessment in Nov-Dec 2016 and three days in May 2017 at a total of 66 releve sites. Two hundred and fifty seven flora species including one Priority 3 taxon *Gunniopsis propinqua,* a putative hybrid *Acacia* sp. nov. aff. *resinimarginea*[1] and eight weeds including one weed of National Significance (WoNS), *Cylindropuntia fulgida* var. *mamillata*, were recorded. Four broad habitat types were recognised.
Stantec 2018a	Leonora Gold Project Proposed Mertondale Haul Road and Pipeline Deviation and Cardinia Access Road Flora, vegetation and Fauna Report	Assessment of flora, vegetation and fauna of relatively narrow linear alignments for proposed haul road and pipeline from Myrtondale prospect to the LGP proposed processing facility and the Cardinia Access Road. Field study over 5 days at 14 releve sites. Findings included 14 vegetation types and 120 flora species with no conservation-significant flora noted.
Stantec 2018b	Leonora Gold Project Flora and Fauna Extrapolation Exercise Report	Desktop and short reconnaissance survey in March 2018 expanding the vegetation mapped around the Cardinia site from previously ground truthed surveys.
Western Botanical 2018	Regional survey for *Acacia* sp. Marshall Pool (G. Cockerton 3024)	Regional survey for *Acacia* sp. Marshall Pool (G. Cockerton 3024) incorporating the results of a targeted assessment of *Acacia* sp. Marshall Pool within a portion of the Leonora Gold Project tenements.

[1] *Acacia* sp. nov. aff. *resinimarginea* was later verified as a new species, *Acacia* sp. Marshall Pool (G. Cockerton 3024) and subsequently listed as Priority 3 by DBCA.

Figure 1. Study Area

330000 340000 350000 360000 370000 380000 390000

6860000 6850000 6840000 6830000 6820000 6810000 6800000 6790000 6780000

Legend
Baseline Survey Limits

Mertondale 5

Mertondale

Baseline Survey Limits

Cardinia

Bummer Creek

LOCALITY

WESTERN AUSTRALIA

PROJECT AREA

Kalgoorlie

Perth

NUMEROUS CLEARED LINES MAY POSE A NAVIGATION HAZARD

Source: Topography: GSA

Consultant
Western Botanical

Layout

N

0 2,800 5,600 m
Scale: 1:250,000
MGA94 (Zone 51)

CAD Ref: a2553_Veg_WB_01_01
Date: May 2019 | Rev: A | A3

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Leonora Gold Project
Locality

1.2. Current Survey

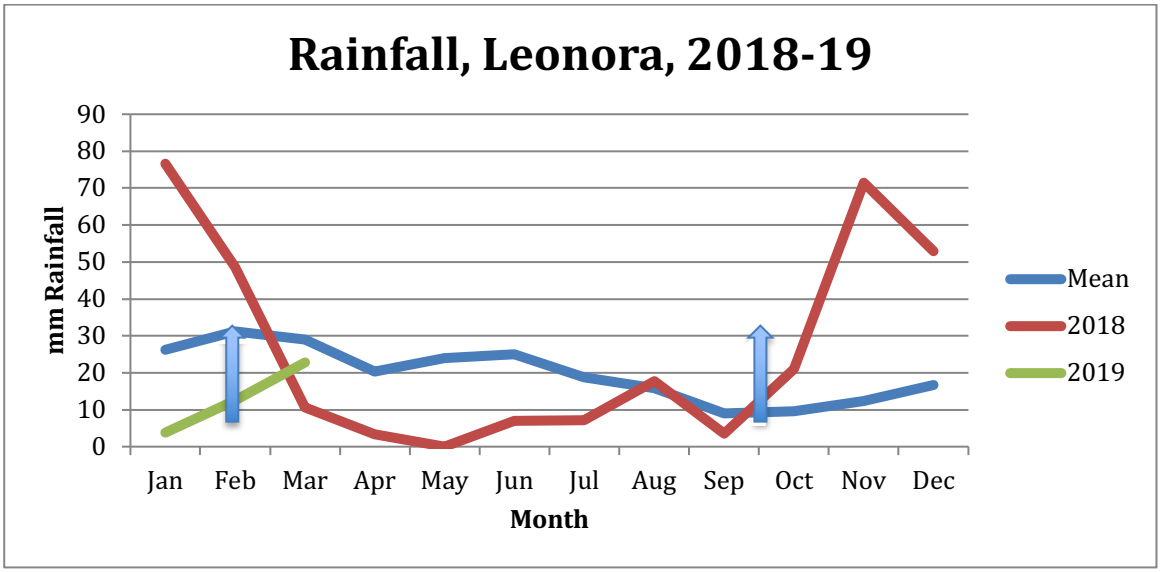
The Study Area consists of a 139 sq. km (13945.84 ha) polygon extending northwards from the Leonora – Laverton road to the mining prospects north of the proposed Leonora Gold Project (LGP) Cardinia Processing Facility and included a narrow linear alignment extending northwards to the old Mertondale minesite. The area formally assessed in this survey excludes most areas previously mapped by Stantec (2017, 2018a, 2018b) at the Cardinia site and around three prospects to the north, though observations of flora and vegetation were conducted within these areas as necessary. Given the narrow proposed haul road and pipeline alignment from Cardinia northwards to Mertondale, this area was included in the current works program and therefore vegetation mapping here supersedes that prepared by Stantec.

1.3. Physical Environment

1.3.1. Climate

The mean rainfall recorded at Leonora over the period 1989 – 2019 is 238.1 mm with a distinct summer maximum experienced from November to February associated with summer thunderstorm and cyclonic events. The period April to October tends to be dry with less than 20mm recorded monthly.

Figure 2. Rainfall Leonora



Arrows indicate Survey timing: October 2018 and February 2019.

1.4. Biological Environment

1.5. Interim Biogeographic Regionalisation of Australia

The Study Area lies within the MUR 1 eastern Murchison biogeographic sub region which includes broad vegetation assemblages characterised by (i) Mulga (*Acacia aneura* and its allies) woodlands on hardpan plains; (ii) Mulga over perennial Wanderrie Grasses on shallow sandy soils, (iii) Spinifex hummocked grasslands on deeper sandplains, (iv) *Acacia* shrublands on stony hills, (v) minor breakaways with associated kaolinised slopes, (vi) Drainage tracts with Mulga and other *Acacia* species and (vii) Saline plains supporting Samphire and other chenopods. These broad vegetation formations are widespread within the Murchison biogeographic region.

1.6. Land Systems

Land Systems are broad areas of similar geology, landscape and vegetation mapped by the Department of Agriculture (DoA 1994). Nine Land Systems are present within the Study Area, Table 3, Figure 3. These are also grouped with underlying geology and soils noted in Table 4.

Rocky hills in the Study area are represented by the Laverton, Leonora and Wyarri Land Systems. The Laverton Land system with its greenstone metagabbro and basalt geology is prevalent in the south and south-east of the Study Area and support the well known *Acacia* sp. Marshall Pool (Priority 3) on non-saline soils. This is also present south and west of the Study area and supports a similar suite of species including *Acacia* sp. Marshall Pool. The Leonora Land System also has the underlying greenstone geology but has saline soils supporting halophytic shrublands. The Wyarri Land System with its granitic geology is only present in a small part of the northern extent of the transport corridor near the Mertondale prospect.

Irregular plains with low rises are comprised of the Nubev Land System with limonitic (iron rich) geology and saline soils while the Violet Land System also has a predominantly limonitic geology but generally has non-saline soils. These may support populations of *Eremophila annoscaulis* (Priority 3).

Washplains with underlying hardpan are represented by the Monk Land System as well as the Jundee (gravely hardpans) and Rainbow (hardpan) Land Systems. These support varying communities with a Mulga overstorey.

Stony Plains and lower alluvial plains with saline soils and halophytic shrublands are represented by the Gundockerta land system with extensive calcrete and associated alkaline soils.

Broad drainage tracts, and associated outwash hardpan plains supporting Mulga or *Acacia* are represented by the Monk Land System with sandy soils supporting Mulga (Cardinia Creek) and the Monitor Land System with sandy soil supporting Mulga (and/or *Acacia burkittii*) (Bummer Creek and associated outwash plain).

Table 3. Land Systems of the Study Area

Land Type	Land System	Description	Area (ha) within Study Area	Percentage of the Study Area	Total Area (ha) within the North-Eastern Goldfields	Percentage of the area of the NE Goldfields
Hills with *Acacia* shrublands	Laverton	Ridges and hills on greenstone and basalt with *Acacia, Ptilotus obovatus, Maireana sedifolia* shrublands	803.58	5.76%	10,590,000	0.0143%
	Wyarri	Granite domes, hills and tor fields with gritty surfaced fringing plains supporting Mulga and Granite Wattle (*Acacia quadrimarginea*)	85.03	0.61%	8,710,000	0.0010%
Irregular plains and low rises supporting Mulga, Bowgada and halophytic shrublands	Nubev	Gently undulating plains and low rises with limonite above alluvial plains with saline soils supporting Mulga and halophytic *Maireana pyramidata, M. sedifolia* shrublands	2,501.08	17.93%	14,050,000	0.0178%
	Violet	Undulating plains with stony and gravely mantles and low rises with limonite supporting Mulga (SIMS) shrublands	1,295.09	9.29%	16,110,000	0.0080%
Low hills with eucalypt or *Acacia* – halophyte shrublands	Leonora	Low hills and plains on greenstone with ironstone ridges supporting mixed stony chenopod (*Maireana pyramidata, M. sedifolia*) shrublands on plains	2,229.73	15.99%	10,740,000	0.0208%
Stony Plains and lower alluvial plains with saline soils and halophytic shrublands	Gundockerta	Extensive gently undulating calcareous plains with stony mantles and lower alluvial tracts on weathered greenstone supporting Bluebush shrublands	3,003.40	21.54%	21,050,000	0.0143%

Land Type	Land System	Description	Area (ha) within Study Area	Percentage of the Study Area	Total Area (ha) within the North-Eastern Goldfields	Percentage of the area of the NE Goldfields
Washplains and sandy tracts on hardpan, with Mulga and Wanderrie grasses	Monk	Hardpan plains with occasional sandy banks supporting Mulga Shrublands (HPMS, GRMU) and Wanderrie grasses (MUWA)	363.23	2.60%	81,620,000	0.0004%
	Monitor	Alluvial fans and wash plains receiving distributary flow from adjacent greenstone systems	1,171.08	8.40%	5,630,000	0.0208%
Washplains on hardpan with Mulga Shrublands	Jundee	Level to very gently inclined hardpan wash plains with mantles of fine ironstone gravel supporting Mulga shrublands	2,493.40	17.88%	26,560,000	0.0094%
Total			13,945.84	100%		

Table 4. Land Types and Land Systems with Underlying Geology and Soils.

Land Type	Land System (underlying Geology or soil type)
Hills with *Acacia* shrublands	Laverton (Greenstone), Wyarri (Granite)
Low hills with eucalypt or *Acacia* – halophyte shrublands	Leonora (Greenstone, Ironstone)
Irregular plains and low rises supporting Mulga, Bowgada and halophytic shrublands	Nubev (Limonite, saline), Violet (Limonite, non-saline)
Stony Plains and lower alluvial plains with saline soils and halophytic shrublands	Gundockerta (Calcrete)
Washplains and sandy tracts on hardpan, with Mulga and Wanderrie grasses	Monk (hardpan)
Washplains on hardpan with Mulga Shrublands	Jundee (gravely soils), Rainbow (hardpan)
Broad drainage tracts, hardpan plains supporting Mulga or *Acacia*	Monk (sandy soils supporting Mulga), Monitor (sandy soil supporting *Acacia burkittii* and/or Mulga)

The representation of each land system within the Study Area represents very small proportions of the overall area of each Land System within the north-eastern Goldfields: between 0.0208% (Leonora and Monitor Land Systems) to 0.004% (Monk Land System). At this broad scale, the Study Area incorporates very minor proportions of each of the Land Systems mapped in the entire north-eastern Goldfields in a regional sense.

Figure 3. Land Systems of the Study Area

360000
370000
6830000
6820000
6810000
Leonora–Nambi Road

Legend
Baseline Survey Limits
Road
Track
Mapping Unit, MU Name
Bev, Bevon Land System
Blm, Bullimore Land System
Brk, Brooking Land System
Des, Desdemona Land System
Fel, Felix Land System
Grs, Gransal Land System
Gun, Gundockerta Land System
Hoo, Hootanui Land System
Jun, Jundee Land System
Lav, Laverton Land System
Leo, Leonora Land System
Mok, Monk Land System
Mot, Monitor Land System
Nub, Nubev Land System
Rai, Rainbow Land System
Ran, Ranch Land System
She, Sherwood Land System
Ste, Steer Land System
Tig, Tiger Land System
Vio, Violet Land System
Win, Windarra Land System
Wya, Wyarri Land System

Source: Land Systems: DPIRD, Tenements: DMIRS, Topography: Landgate

Consultant
Western Botanical

Layout
Leonora

N

0 1,250 2,500 m
Scale: 1:110,000
MGA94 (Zone 51)
CAD Ref: a2553_Veg_WB_02_01
Date: Jun 2019 | Rev: B | A3

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Leonora Gold Project
Rangelands Soil Landscape

1.7. Beard Pre-European Vegetation

The Beard (1976) Pre-European vegetation mapped at a scale of 1:1 million is useful in defining only the broadest vegetation units within the Study Area and across the region, Table 5 . Unit 18.16 Low Woodlands, low open woodland or sparse woodland representing the areas dominated by Mulga and other *Acacia* species; and unit 39.3 Scrub, open scrub or sparse scrub represent the low halophytic chenopod shrublands (*Tecticornia, Maireana* shrublands) prevalent in the south-central portion of the Study Area and common to salt lake margins in the region.

Table 5. Representation of Beard Pre-European Vegetation within the Study Area

Beard (1976) Unit	Area Within the Study Area (ha)	% of the Study Area
Unit 18.16 Low Woodlands, low open woodland or sparse woodland representing the areas dominated by Mulga and other *Acacia* species	6,181.84	44.3%
Unit 39.3 Scrub, open scrub or sparse scrub represent the low halophytic chenopod shrublands (*Tecticornia, Maireana* shrublands)	7,764 .00	55.7%

These broad scale units are very generalised and are not particularly useful for analysis of vegetation associations within the Study Area at the level of detail required for environmental impact assessment.

Figure 4. Pre-European Vegetation of the Study Area

360000
370000
6830000
6820000
6810000

Legend
Baseline Survey Limits
Road
Track
SA_Code - , Structural Description
18.16 - Low woodland, open low woodland or sparse woodland
28 - Low woodland, open low woodland or sparse woodland
39.3 - Scrub, open scrub or sparse scrub
109.1 - Shrub-steppe

109.1
18.16
39.3
28
Leonora_Nambi_Road

Source: Pre European Vegetation: DPIRD, Tenements: DMIRS, Topography: Landgate

Consultant
Western Botanical

Layout
Leonora

N

0 1,250 2,500 m
Scale: 1:110,000
MGA94 (Zone 51)
CAD Ref: a2553_Veg_WB_03_01
Date: May 2019 | Rev: A | A3

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Leonora Gold Project
Pre European Vegetation

2. Methods

2.1. Desktop Survey

The Desktop Assessment conducted prior to the field survey included a review of results of a recent interrogation of the Department of Biodiversity, Conservation and Attractions (DBCA) WA Herbarium (WAHERB) Threatened and Priority Flora (TPFL) databases conducted by Stantec in August 2018 and provided to WB by Kin. The database search was regarded as current, having been implemented two months prior to the first round of field assessment. Reports prepared by Stantec for Kin (Stantec 2017, 2018a, 2018b) were also reviewed and names of flora were checked against those known in the region by the author and against a NatureMap database search centred on the Study Area.

2.2. Field Survey

The field survey consisted of the Study Area being traversed in-vehicle and on-foot by Senior Botanist Geoff Cockerton and Senior Field Technician Ms. Gemma Grigg supplied by Kin. Surveys were conducted over two periods: 10th to 19th October 2018 and 5th to 17th February 2019 inclusive of travel, a period of 21 days with 17 days spent actively spent conducting assessments in the field. Field assessment consisted of mapping vegetation associations at the NVIS Level 5 '*Association'* level of detail where the three dominant flora species in each stratum observed was used to define vegetation units.

Field maps consisted of (i) 1:7,500 scale laminated A2 aerial photographs for the majority of the southern portion of the Study Area and (ii) 1:12,500 A4 non-laminated aerial photographs for additions to the Study Area in the second round of field works, inclusive of the alignment from Cardinia to Mertondale. CAD Resources provided an electronic tablet with high resolution recent aerial photography of the entire Study Area which was extremely useful in interrogating areas at higher resolution that the hard copy maps allowed.

Vegetation units were described at 74 Relevé sites where representative photographs were taken, comprehensive species profiles were assembled and assessment sites recorded using hand held GPS (typically +/- 5m accuracy) with all data entered directly into a laptop and coded polygons drawn onto field maps. In all cases, community boundaries are presented at +/- 50 to 100m accuracy.

The majority of flora was collected for reference, with each specimen being allocated a unique field collection number and any specimens not readily identified in the field were then assessed using the resources of the Western Botanical reference herbarium, the Western Australian Herbarium (WAHERB), appropriate on-line resources and published texts. Specimens of challenging taxa were reviewed by Dr. David Leach (WB). Some flora were also photographed in the field for future reference. Populations of flora with known Conservation listing were recorded using GPS.

Given large amount of historical mining, exploration and Pastoral activity in the large Study Area, numerous tracks were present for vehicular access. However, large areas of the region south of Cardinia lacked trafficable access routes and some off-track driving and walking was required to access areas for mapping and investigation of flora and vegetation.

2.3. Statistical Analysis

Statistical analysis of the advanced Relevé data was conducted by entering into proprietary Microsoft Access database (developed by Griffin 2012). Statistical analysis of these sites was conducted to investigate floristic similarity amongst sites, groupings of sites, and the relationships amongst groupings. Projected foliage cover (PFC) for each species was used to incorporate dominance of key species within vegetation association groupings.

All annual species, weed species, and singleton species (those occurring at only one site) were excluded from the dataset to minimize noise within analysis and interpretation of results. A small number of taxa were merged for the purposes of analysis:

- Taxa with uncertain determination (e.g. *Acacia ?aneura*) were assumed correct and merged with records of certain determination (*Acacia aneura*).
- Hybrid taxa (typically mulga and *Senna* identities) were merged with their first/dominant component of their hybridity.
- Taxa of the same species but different form/forma were merged where no difference in habitat was found during field survey.

The option to remove non-discriminatory (less important) species from the analysis in order to reduce ordination stress was discounted in favour of retaining such species that may be important for determining finer-scale vegetation associations.

Analysis of flora data was conducted using PATN v3.12 statistical package software (Blatant Fabrications 2004). Association (Bray and Curtis), Classification (Flexible UPGMA Agglomerative Hierarchical Fusion), and Ordination (Semi-Strong Hybrid) components of PATN were utilised in the analysis. The primary output produced was a dendrogram of site (quadrat) similarity/dissimilarity with suggested broad vegetation association groupings provided by PATN

3. Results and Discussion

3.1. Desktop Survey

Results of the desktop assessment are presented in Table 7, Table 7 and Figure 5. Information known to the author on the presence of *Acacia* sp. Marshall Pool (G. Cockerton 3024) P3 and preferred habitats of species, combined with their known distributions both nearby the Study Area and within the region, have been used to develop a Likelihood of Occurrence ranking.

Table 6. Likelihood of Occurrence

WB Assessment	Description	Stantec (2018) Assessment
Known to be present	Species is **Known to be Present**, has been verified within the Study Area though it's entire distribution may not be mapped and population numbers may be tentative at present.	
Probable	Based on habitat preference of the species, similar habitats within or adjoining and contiguous with the Study Area, and geographical distribution of the species in close proximity to the Study Area, it is Probable that the species may occur within the Study Area.	Very Likely
Possible	Based on habitat preference of the species, similar habitats present within the Study Area and proximal geographical distribution of the species, it is Possible that the species may occur within the Study Area.	Likely
Unlikely	Based on habitat preference of the species, suitable habitats absent within the Study Area and distant geographical distribution of the species, it is Unlikely that the species may occur within the Study Area.	

Table 7. Desktop Assessment of Likelihood of Conservation Significant Flora being present within the Study Area.

Species	Cons_Status	Source	Preferred Habitat	Likelihood of Occurrence within Kin Tenements (Stantec 2017 Assessment)
Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	WAHERB, Stantec, Western Botanical	Upper slopes of gabbro and basalt hills	Known to be present
Gunniopsis propinqua	P3	WAHERB, Stantec	Samphire and Frankenia Shrublands, Saline Claypans	Known to be Present
Angianthus prostratus	P3	TPFL, WAHERB	Samphire Shrublands, Saline Claypans	Probable, (Very Likely)
Triglochin protuberans	P3	WAHERB	Drainage lines, margins of claypans	Probable (Likely)
Acacia websteri	P1	WAHERB	Drainage areas	Possible, (Very Likely)
Calandrinia quartzitica	P1	WAHERB	Samphire and Frankenia Shrublands, Saline Claypans	Possible
Stenanthemum patens	P1	TPFL, WAHERB	Stony chert, quartz and lateritic hills, granite breakaways	Possible (Likely)
Calytrix hislopii	P3	WAHERB	Lateritic and BIF hills, scree slopes	Possible
Calytrix praecipua	P3	WAHERB	Weathered granite and ironstone breakaways	Possible, (Very Likely)
Cratystylis centralis	P3	WAHERB	Calcrete expressions, non-saline	Possible, (Very Likely), known outside the Study Area
Eremophila annoscaulis	P3	WAHERB	Stony hills and associated plains	Possible (Likely)
Eremophila shonae subsp. diffusa	P3	WAHERB	Stony ironstone hill tops	Possible
Eremophila simulans subsp. megacalyx	P3	WAHERB	Stony ironstone hill tops	Possible
Eremophila veronica	P3	WAHERB	Hills, plains, drainage areas	Possible
Goodenia lyrata	P3	TPFL, WAHERB	Drainage areas, claypans	Possible (Possible)

Species	Cons_Status	Source	Preferred Habitat	Likelihood of Occurrence within Kin Tenements (Stantec 2017 Assessment)
Hybanthus floribundus subsp. chloroxanthus	P3	WAHERB	Creeklines associated with gabbro and basalt outcrops	Possible
Micromyrtus serrulata	P3	WAHERB	Stony lateritic, granitic, BIF hills	Possible
Phyllanthus baeckeoides	P3	TPFL	Creeklines associated with lateritic hills	Possible
Grevillea inconspicua	P4	TPFL, WAHERB	Gabbro and basalt outcrops	Possible (Likely)
Hemigenia exilis	P4	TPFL, WAHERB	Gabbro and basalt outcrops	Possible (Likely)
Eremophila mirabilis	P2	TPFL, WAHERB	Weathered granite breakaways	Possible (Likely)
Ptilotus tetrandrus	P1	TPFL, WAHERB	Sandplains, dunes	Unlikely (Likely)
Conospermum todii	P4	WAHERB	Sand Dunes	Unlikely

Note, the unconfirmed *Grevillea* ?*inconspicua* P4 reported in Stantec 2018a had been omitted from this assessment pending review of the identity of the taxon.

The Study Area is known to have extensive areas of (i) saline flats supporting chenopod shrublands in its central region; (ii) extensive non-saline washplains in the north and south; and (iii) substantial areas of gabbro and basalt hills in the south-east. Flora associated with the first and third areas are highly specialised and can be predicted reasonably consistently in the local region. Flora of non-saline wash plains can be variable.

Two species with Conservation listing (*Acacia* sp. Marshall Pool (G. Cockerton 3024) P3, and *Gunniopsis propinqua* P3) were known to be present within the Study Area.

> *Acacia* sp. Marshall Pool has been recently found to be abundant within the south-eastern portion of the Study Area, specifically associated with low to moderate rounded weathered basalt hills of the Gundockerta Land System on Minara Station and adjacent areas towards Kookynie and on Weebo Station north of Leonora. It was briefly assessed both within parts of the current Study Area (Stantec 2018c) recording around 10,000 plants (an incomplete assessment of the Study Area); and in the region between Laverton, Leonora and Wiluna (Western Botanical 2018) where over 37,000 individuals were estimated. This is not considered an exhaustive assessment of the species in the region.
>
> *Gunniopsis propinqua* P3 is a small ephemeral halophytic herb growing to 5 cm in height. It is widespread in the Murchison and Gascoyne regions, always associated with

saline environments (fringes of claypans, Samphire flats, breakaway footslopes). Stantec recorded four sites supporting *Gunniopsis propinqua* within the current Study Area. It is considered highly likely that this species is both more prevalent within the Study Area and in the broader region, however, it is cryptic and can only reliably be assessed in favourable seasonal conditions.

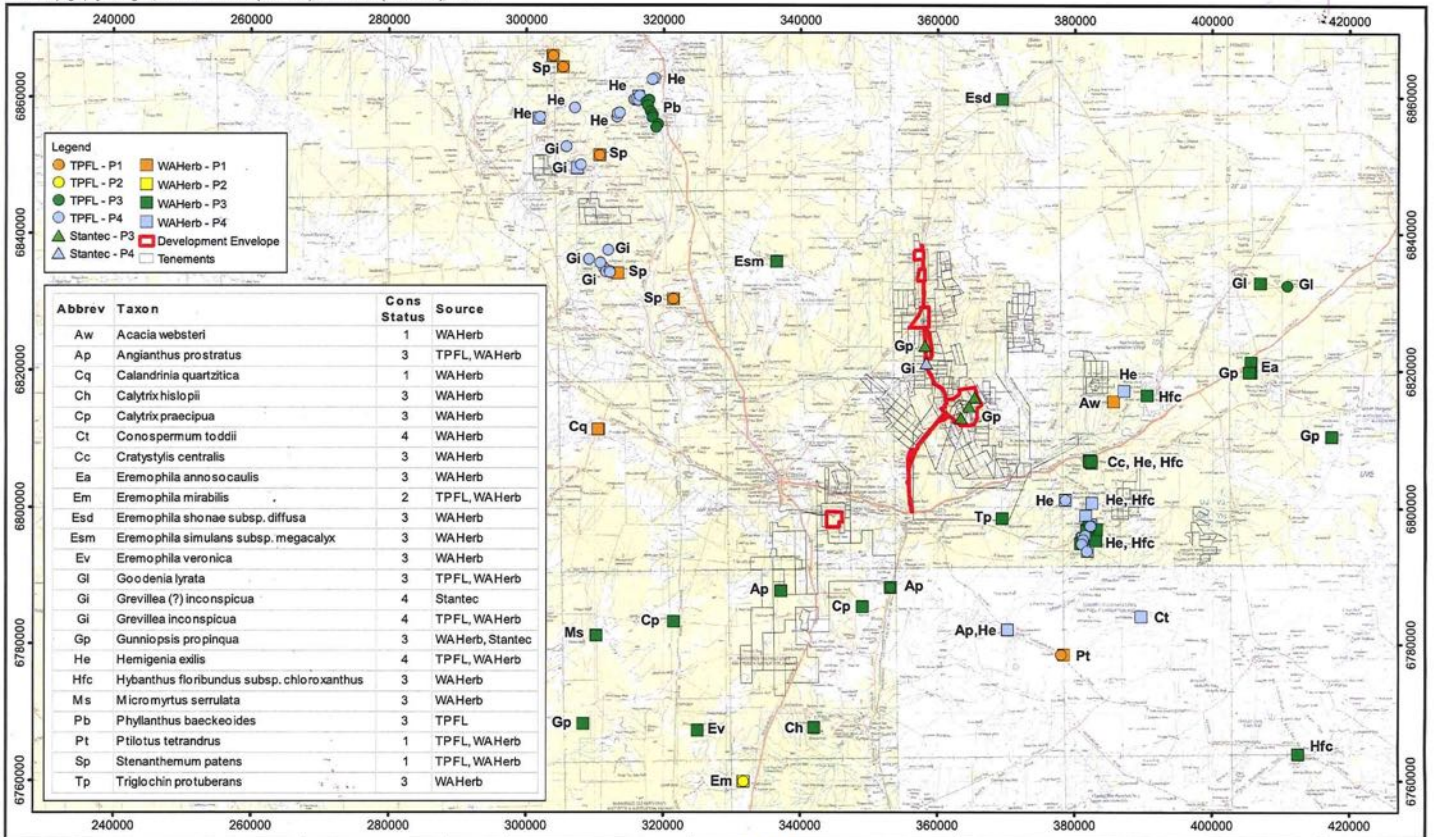
Two species with conservation listing (*Angianthus prostratus* P3 and *Triglochin protuberans* P3), are associated with the saline margins of salt lakes and Samphire Shrublands or drainage channels and are therefore considered to have a Probable likelihood occurrence within the Study Area. *Angianthus prostratus* is an annual herb to 30 cm diameter and is known from five loci in the eastern Murchison biogeographic region, all in association with paleochannels or salt lakes. *Triglochin protuberans* is a tiny, cryptic ephemeral herb to 5 cm high and is known from six loci, five of which occur up to 250 km east of Geraldton while one lies just south-east of the Study Area within the Bummer Creek distributary fan, in the Monitor Land System. These would both need to be assessed at an appropriate time of year following sufficient rainfall.

Sixteen of the 23 species with conservation significance known in the vicinity of the Study Area are considered to have a Possible likelihood occurrence within the Study Area, Table 7. Populations of these species are known within 10 to 20 km of the Study Area, though their presence will be dependent upon on suitable geology, soils and landscapes being present. The majority are perennial shrubs that are readily recognised in the field whether plants are in flower or in a vegetative state, so timing of field survey is not critical for identification (eg: *Acacia, Calytrix, Cratystylis, Eremophila, Hybanthus, Phyllanthus* species). In one case, being assessed in the appropriate seasonal conditions following adequate rainfall, is critical (eg: annual species *Goodenia lyrata* P3).

Two species (*Ptilotus tetrandrus* P1 and *Conospermum todii* P4) are considered Unlikely to occur within the Study Area as they are known from Aeolian sandplains and dunes, which do not occur in the Study Area. These can therefore be discounted from further consideration.

Figure 5. Desktop Assessment of DBCA's WA Herbarium, Threatened and Priority Flora Database Search (Stantec 2018 via Kin Mining)

Source: Topography: Landgate, Tenements: DMIRS (18/5/2018), Flora: DBCA (24/08/2018), Stantec



Abbrev	Taxon	Cons Status	Source
Aw	Acacia websteri	1	WAHerb
Ap	Angianthus prostratus	3	TPFL, WAHerb
Cq	Calandrinia quartzitica	1	WAHerb
Ch	Calytrix hislopii	3	WAHerb
Cp	Calytrix praecipua	3	WAHerb
Ct	Conospermum toddii	4	WAHerb
Cc	Cratystylis centralis	3	WAHerb
Ea	Eremophila annosocaulis	3	WAHerb
Em	Eremophila mirabilis	2	TPFL, WAHerb
Esd	Eremophila shonae subsp. diffusa	3	WAHerb
Esm	Eremophila simulans subsp. megacalyx	3	WAHerb
Ev	Eremophila veronica	3	WAHerb
Gl	Goodenia lyrata	3	TPFL, WAHerb
Gi	Grevillea (?) inconspicua	4	Stantec
Gi	Grevillea inconspicua	4	TPFL, WAHerb
Gp	Gunniopsis propinqua	3	WAHerb, Stantec
He	Hemigenia exilis	4	TPFL, WAHerb
Hfc	Hybanthus floribundus subsp. chloroxanthus	3	WAHerb
Ms	Micromyrtus serrulata	3	WAHerb
Pb	Phyllanthus baeckeoides	3	TPFL
Pt	Ptilotus tetrandrus	1	TPFL, WAHerb
Sp	Stenanthemum patens	1	TPFL, WAHerb
Tp	Triglochin protuberans	3	WAHerb

Locality

N

0 15km
Scale: 1:750,000
MGA94 (Zone 51)

CAD Ref: a2553_Flora_F002_02
Date: August 2018 | Rev: A | A4

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Leonora Gold Project
Threatened & Priority Species

Figure: 2

3.2. Field Survey

3.2.1. Recent Climate

Total rainfall at Leonora in 2018 was 320.2 mm with 20 to 30 mm per month recorded January to June and below 20 mm per month recorded thereafter, Figure 2. January and February 2019 were also relatively dry with no summer cyclonic events experienced. Therefore both field surveys were conducted in relatively dry seasonal conditions and few annuals were recorded except in low lying moisture gaining sites.

3.2.2. Landforms

The following major landforms were noted within the Study Area:

- Low rounded gabbro or basalt hills and minor drainage lines associated with the Hootanui, Laverton and Leonora Land Systems
- Low ironstone or chert hills and minor drainage lines associated with the Bevon, Violet and Laverton Land Systems
- Low breakaways of weathered granite and associated saline kaolinised slopes of the Sherwood Land System
- Extensive non-saline hardpan wash plains associated with the Monitor and Jundee Land Systems
- Extensive saline plains and low rises associated with the Nubev Land Systems
- Small, discrete areas of paleo groundwater calcrete

3.3. Vegetation

3.3.1. Vegetation Associations

Fifty one vegetation associations at NVIS Level 5 *Association* were recognised within the LGP Study Area, Table 8. This relatively large number of community types is partially due to (i) the detail of mapping, (ii) the interplay between geological, topographic, hydrological and salinity factors within the Study Area and (iii) the elongated linear nature of the Study Area stretching some 36.8 km north-south from the Leonora – Laverton road to the Mertondale deposit area. This complexity builds on that observed in the Land System mapping of the region (DoA 1994), Table 3, Table 4.

It also and demonstrates the greater level of differentiation in vegetation associations compared to the relatively broad view taken by DoA in their treatment of Land Systems.

Table 8. Vegetation Associations of the Study Area

Vegetation Group	Final Mapping Numeric Code	Vegetation Association Name	Veg Association Code
1. Mulga Woodlands over Perennial Non-Halophytic Shrubs on hills and plains	1.01	Acacia aneura, A. ramulosa, Eremophila platycalyx subsp. Leonora (Morrisey J. 252), Ptilotus obovatus (Upright form) Shrubland and grasses	AaArEpLPoU, Grasses
	1.02	Acacia aneura (forms), Ptilotus obovatus (Upright form), Maireana triptera Shrubland	AaPoUMt
	1.02 D	Dead vegetation, formerly Acacia aneura (forms), Ptilotus obovatus (Upright form), Maireana triptera Shrubland	Dead AaPoUMt
	1.03	Acacia aneura, Maireana sedifolia, Scaevola spinescens Narrow leaf spiny form Ptilotus obovatus (typical Goldfields form) Shrubland	AaMsSsNPoG
	1.04	Acacia burkittii, Senna artemisioides subsp. filifolia, Maireana spp. Shrubland	AbSafAmpMt
	1.05	Acacia aneura (forms) over Eremophila platycalyx subsp. Leonora (Morrisey J. 252) over Senna spp. over Ptilotus obovatus (Upright form) and Maireana triptera Shrubland	AaEpLSsppPoUMt
	1.06	Acacia aneura (forms) over Eremophila spp. (E. margarethae, E. compacta subsp. compacta, E. simulans subsp. simulans or E. annoscaulis P3) over Ptilotus schwartzii Shrubland	AaEmP
	1.07	Stony Ironstone Mulga Shrubland Acacia aneura, Eremophila latrobei, Sida ectogamma Shrubland on summits of chert, quartz hills and slopes	SIMS AaElSe
	1.08	Stony Ironstone Mulga Shrubland Acacia aneura, Ptilotus obovatus (Upright form), Ptilotus schwartzii Shrubland on midslopes of chert, quartz hills and slopes	SIMS AaPoUSe
	1.09	Stony Ironstone Mulga Shrubland Acacia aneura (forms) over Eremophila clarkei, Eremophila forrestii Shrubland on summit of low ferricrete hills	SIMS AaEcEf

Vegetation Group	Final Mapping Numeric Code	Vegetation Association Name	Veg Association Code
	1.10	Acacia aneura over Maireana sedifolia over Ptilotus obovatus (Upright form) Shrubland over Maireana triptera Shrubland and grasses	AaMsPoUMt
	1.11	Maireana pyramidata, Maireana sedifolia, Frankenia spp. Open Low Shrubland and grasses	MpMsFspp
	1.12	Acacia aneura (sens. lat.), Eremophila platycalyx subsp. Leonora (Morrisey J. 252) over Eremophila compacta and Ptilotus obovatus (Upright form) Shrubland	AaEpLEm
	1.13	Acacia aneura (sens. lat.), Acacia ramulosa, Acacia quadrimarginea, Eremophila platycalyx subsp. Leonora (Morrisey J. 252) Shrubland	AaArAqEp
	1.14	Stony Acacia - Eremophila Shrubland	SAES
	1.15	Hardpan Plain, deflation zone	HPDS
	1.16	Hardpan Mulga Shrubland	HPMS
	1.17	Acacia aneura, Maireana triptera, Ptilotus obovatus Goldfields Form Shrubland over Aristida contorta	AaPoGMt
2. Mulga Shrublands / Woodlands over Perennial Grasses on Plains	2.01	Mulga-Wanderrie (Acacia aneura, Eragrostis eriopoda) Grassland	MUWA
	2.02	Wanderrie Bank Grassy Shrublands (Eragrostis eriopoda) Grassland	WABS
3. *Acacia* Woodlands over Shrubs and Grasses in Major Drainage Lines and Groves	3.01	Drainage Line Mulga (Acacia aneura sens. lat.) Woodland	DRMS
	3.02	Drainage line Acacia burkittii Woodland	DRAbS
	3.03	Groved Mulga Woodland	GRMU
4. *Acacia* (other than Mulga) Shrublands on Stony Hills	4.01	Acacia sp. Marshall Pool (G. Cockerton 3024) Shrubland	Amp

Vegetation Group	Final Mapping Numeric Code	Vegetation Association Name	Veg Association Code
	4.02	Acacia sp. Marshall Pool (G. Cockerton 3024), A. sibirica, Acacia aneura, A. burkittii Shrubland	AmpAsAa
	4.03	Acacia doreta short phyllode form (M. Stone & S. Colwill WB34381), Acacia sp. Marshall Pool (G. Cockerton 3024) Open Woodland Ptilotus obovatus (Goldfields form) Shrubland	AdAspMPPoG
	4.04	Acacia burkittii, Ptilotus obovatus (Goldfields form) Shrubland	AbPoG
5. *Acacia papyrocarpa* Woodlands	5.01	Acacia papyrocarpa Open Low Woodland, Tecticornia disarticulata Shrubland	ApTdS
	5.02	Acacia papyrocarpa Open Low Woodland, Eremophila scoparia and Maireana spp. Shrubland	ApEsMspp
	5.03	Acacia papyrocarpa Open Low Woodland, Ptilotus obovatus (Upright form), Maireana triptera Shrubland and grasses	ApPoUMt
	5.04	Acacia papyrocarpa Open Low Woodland, Maireana pyramidata Shrubland	ApMt
6. *Acacia victoriae* Shrubland over Chenopods on Calcrete Plains	6.01	Acacia victoriae Shrubland	AvS
7. Perennial Grasslands	7.01	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH 26770) Hummock Grassland on Calcrete	EyC
	7.02	Neurachne munroi Hummock Grassland on Mudstone	NmHG
8. *Hakea preissii* and/or Halophytic Chenopod Shrublands	8.01	Hakea preissii, Maireana pyramidata, Tecticornia disarticulata Shrubland	HpTdMpS
	8.02	Hakea preissii, Maireana pyramidata, Cratystylis subspinescens Shrubland	HpMpCs
	8.03	Hakea preissii, Maireana pyramidata, Eremophila scoparia Shrubland	HpMpEs

Vegetation Group	Final Mapping Numeric Code	Vegetation Association Name	Veg Association Code
	8.04	Hakea preissii, Ptilotus obovatus (Goldfields form), Maireana triptera Shrubland	HpPoGMt
	8.05	Hakea preissii, Maireana pyramidata, Maireana tomentosa (type 1 WB38650) complex Shrubland and grasses	HpMpMsp59
	8.06	Hakea preissii, Eremophila scoparia, Maireana triptera Shrubland	HpEsMt
	8.07	Maireana triptera, Frankenia spp. Low Open Shrubland	MtFsp
	8.08	Maireana pyramidata, M. georgei Shrubland	MpMg
	8.09	Tecticornia disarticulata, Surreya diandra, Frankenia setosa, Maireana tomentosa (type 1 WB38650) complex Shrubland	TdFsppMt
	8.10	Maireana tomentosa (type 1 WB38650) Tecticornia disarticulata Shrubland	Mt, Td
	8.11	Frankenia spp. Shrubland	Fspp
	8.12	Acacia masliniana, Cratystylis subspinescens Shrubland	AmCs
	8.13	Bare claypan, no vegetation	Cpn-B
9. *Casuarina pauper* Woodland on Calcrete Outcrops	9.01	Casuarina pauper Woodland over Chenopods on Calcrete outcrops	CpW
10. Claypans	10.01	Grassy Claypan (Eragrostis xerophila Grassland)	CPN-G
	10.02	Gilgai: Pittosporum angustifolium, Acacia tetragonophylla and A. victoriae Shrubland over Claypan Grasses	Gilgai
11. Breakaway Complex	11.01	Eremophila scoparia, Frankenia spp. Shrubland with Sclerolaena diacantha	EsFsppSspp

In order to discuss the Vegetation Associations, they have been grouped together in 11 logical Vegetation Complexes showing their relatedness to each other. These are:

1. **Mulga Woodlands over Perennial Non-Halophytic Shrubs on hills and plains**

   Seventeen vegetation associations with a diverse range of Mulga species (*Acacia aneura, A. aptaneura, A. caesaneura, A. fuscaneura, A. incurvaneura, A. macraneura, A. mulganeura* and *A. pteraneura*) form the dominant upper stratum as trees and shrubs 4 to 6 m in height. The understorey varies considerably with geological substrate type, soil depth and landscape position, from *Eremophila clarkei, E. forrestii, E. platycalyx* subsp. Leonora (J. Morrisey 252), *E. simulans* subsp. *simulans*, *E. latrobei* or *E. annoscaulis* P3 on stony hill tops and slopes; to *Eremophila compacta* subsp. *compacta* on loamy wash plains; to *Eremophila galeata* scattered shrublands on skeletal soils on hardpan plains and granite platforms. Some areas of Mulga woodlands have an understorey dominated by two informally recognised species; either *Ptilotus obovatus Upright form (G Cockerton et al 15206)* or *Ptilotus obovatus Typical Goldfields form (G Cockerton et al 15213)* which reflect differing soil types with the former associated with calcareous soils and the latter with non-calcareous soils. Both species are common and widespread in the eastern Goldfields of W.A. and occasionally occur together within a Vegetation Association.

2. **Mulga Shrublands / Woodlands over Perennial Grasses on Plains**

   Two vegetation associations, where silty-sandy soils over hardpan higher in the landscape are present. Here Mulga is associated with a grassy understorey of *Monachather paradoxus* and *Eragrostis eriopoda*, collectively known as Wanderrie grasses.

3. ***Acacia* Woodlands over Shrubs and Grasses in Major Drainage Lines and Groves**

   Two major drainage tracts and several minor drainage lines occur within the Study Area, draining from the north-east to the south-west. The vegetation of the major drainage line in the west of the Study Area, Cardinia Creek, with it's upper reaches draining from the Cardinia deposit areas in the Leonora and Gundockerta Land Systems, is dominated by Mulga species. Bummer Creek, with a small representation within the south-east of the Study Area, drains from the Violet Land System (the site of the Murrin Murrin minesite, east of the Study Area), and is dominated by *Acacia burkittii*. The vegetation of the minor drainage lines within the Study Area reflect on the vegetation adjacent hills and plains, but are denser and with a greater species representation due to the accumulation of resources.

4. *Acacia* (other than Mulga) Shrublands on Stony Hills

Four vegetation associations on stony hills within a large proportion of the Study Area are dominated by *Acacia* trees and shrubs other than Mulga. Here *Acacia* sp. Marshall Pool (G. Cockerton 3024) is the dominant shrub to small tree on the stony gabbro and basalt hills of the Leonora Land System. It may also be co-dominant with *Acacia sibirica* in some locations. *Acacia doreta* short phyllode form (M. Stone & S. Colwill WB34381), being the typical form of the species, is also present in association with *A*. sp. Marshall Pool on one small hill in the central-west of the Study Area. *Acacia burkittii* was found to be dominant in small well defined areas of calcrete platform, higher in the landscape, presumably due to an elevated soil moisture availability in the calcrete.

5. *Acacia papyrocarpa* Woodlands

Four variants of the *Acacia papyrocarpa* woodland were observed. The dominant and defining understorey varies from *Tecticornia disarticulata* in more saline sites; to *Eremophila scoparia* where calcrete is present; to *Ptilotus obovatus* (Upright form), *Maireana triptera* and grasses where there is non-saline but mildly alkaline soil cover over underlying materials; to *Maireana pyramidata* in areas subject to some waterlogging and salinity. *Acacia papyrocarpa* is by far the largest and most prominent tall tree in the landscape within the Study Area and provides refuge and nesting opportunities for some larger birds of prey (Hobbys actively nesting were observed in *Acacia papyrocarpa* woodlands during 2018 and 2019 surveys). Hobbys are not listed as having conservation significance (Stantec, 2017).

6. *Acacia victoriae* Shrubland over Chenopods on Calcrete Plains

The *Acacia victoriae* shrubland occurs on extensive alkaline calcrete plains in the southern part of the Study Area. It has a relatively diverse understorey dominated by chenopods (*Sclerolaena* and *Maireana* spp.) and may support patches of *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH26770).

7. Perennial Grasslands

Two perennial grasslands were mapped. These are small, discrete patches of *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH26770) on calcrete platforms (relatively low in the landscape); and similarly small, discrete patches of *Neurachne munroi* Hummock Grassland on Mudstone on low rises.

8. *Hakea preissii* and/or Halophytic Chenopod Shrublands

Thirteen topographically controlled variants of Chenopod Shrublands were recognised with a major distinction being those with *Hakea preissii* emergent above the lower shrubs in areas with a deeper soil profile vs. those lacking *H. preissii*, lower in the landscape and more frequently subject to inundation or waterlogging. These environments are all moderately to highly saline and support a largely well known group of *Maireana*, *Atriplex* (less tolerant of waterlogging) and *Tecticornia* (Samphire, more tolerant of waterlogging) species. They may also support species with conservation significance as identified in the Desktop Study, Table 7.

9. *Casuarina pauper* Woodland on Calcrete Outcrops

Casuarina pauper woodland is found in small, isolated and disjunct populations on calcrete platforms high in the landscape and a lower salinity with reliable soil moisture availability of the alkaline soils here is inferred.

10. Claypans

Two types of grassy claypans were recognised: one supporting almost exclusively *Eragrostis xerophila*; while another forms Gilgais (with heaving clay soils) supporting emergent *Pittosporum angustifolium, Acacia tetragonophylla* and *A. victoriae* Shrubland over *Eragrostis setifolia, Themeda australis* and other claypan grasses. These are both non-saline environments with heavy clay soils and are internally drained sumps in the landscape. By virtue of their clay soils, high moisture retention and internal drainage, they typically provide refuge for burrowing frogs and support some flora that are not generally found outside these environments. These are small in area, disjunct from each other and uncommon in the landscape within the Study Area.

11. Breakaway Complex

The breakaway complex is represented in the northern part of the Study Area south of Mertondale where *Eucalyptus striaticalyx* is present at the leading edge of the low (5 to 10 m high) lateritised breakaway and a range of species tolerant of kaolin clay soils and some salinity are present in a changing mosaic pattern on the mid to lower slopes of the landscape. Groups of species such as *Frankenia* spp., *Eremophila scoparia*, *Maireana* and *Tecticornia disarticulata* are dominant while Stantec reported *Gunniopsis propinqua* P3 in this community type. The Breakaway Complex extends well outside the Study Area near the Mertondale deposit.

3.3.2. Groundwater Dependent Vegetation

Vegetation containing species that are known to be relatively high water users and with low xylem potentials can be used as a guide for determining whether such vegetation associations should be considered Groundwater Dependent Vegetation. Within the north-eastern Goldfields, three vegetation types could be considered as falling into this category: (i) eucalypt dominated vegetation within major drainage lines indicating highly fractured geology and fresh water aquifers; (ii) eucalypt woodlands and mallee shrublands on sandplains accessing perched fresh water aquifers; and (iii) *Melaleuca* shrublands on calcrete accessing perched fresh water aquifers. Conversely, more water efficient and more drought tolerant species with higher xylem potentials are less likely to rely on perched fresh aquifers and are more likely to be accessing non-saturated soil moisture within the upper soil profiles which is readily replenished in rainfall events. This latter group includes Mulga shrublands on hills and hardpan plains, *Acacia* shrublands on stony hills and chenopod shrublands in broad saline valleys.

The vast majority of vegetation within the LGP Study Area is dominated by Mulga, *Acacia* or Chenopods and is considered highly unlikely to be obligately accessing ground water and is therefore unlikely to be Groundwater Dependent. A few *Eucalyptus striaticalyx* are present on the rim of the low breakaway system in the transport corridor from Cardinia to Mertondale, however, these appear to be growing on kaolinitic clay soil (vegetation complex unit 11.1). It is unknown whether there is a suitable perched water table in this area, however, being eucalypts, these trees would have a relatively high transpirational load. These occupy a negligible area within the Study Area and direct impacts can readily be avoided.

Two communities within the Study Area are associated with calcrete platforms with relatively high hydrological transmissivities and suggested elevated infiltration rates. These are: (i) *Acacia victoriae* shrublands on calcrete platforms (vegetation association 6.01); and (ii) *Casuarina pauper* woodlands on calcrete (vegetation association 9.01). Within the Study Area, the *Acacia victoriae* shrublands are associated broadly with the Gundockerta land system in the southern part of the Study Area while the *Casuarina pauper* woodlands are associated with small, isolated and disjunct calcrete outcrops amongst the gabbro hills of the Leonora land system. It is considered unlikely that either of these communities represent Groundwater Dependent Vegetation.

The vegetation of Bummer Creek in the south-east of the Study Area is unusual in that is dominated by *Acacia burkittii*. Most creeklines of this nature and magnitude in the north-eastern Goldfields are dominated by varieties of Mulga. *Acacia burkittii* is most often found in either (i) small internally drained low lying areas with medium clay soils, fed by rainfall; or on calcrete rises with shallow surficial fresh water lenses. The surface soils of Bummer Creek are deep alluvial gravely silty sand or clayey sand soils that have originated from the Leonora land system to the north and east. It is suggested that the depth of this alluvium, the relatively high inferred infiltration rates, the large catchment up-stream and inferred high amounts of plant available non-saturated soil moisture within this alluvium support this vegetation unit.

It is considered unlikely therefore that any of the vegetation associations within the Study Area would be considered Groundwater Dependent Vegetation.

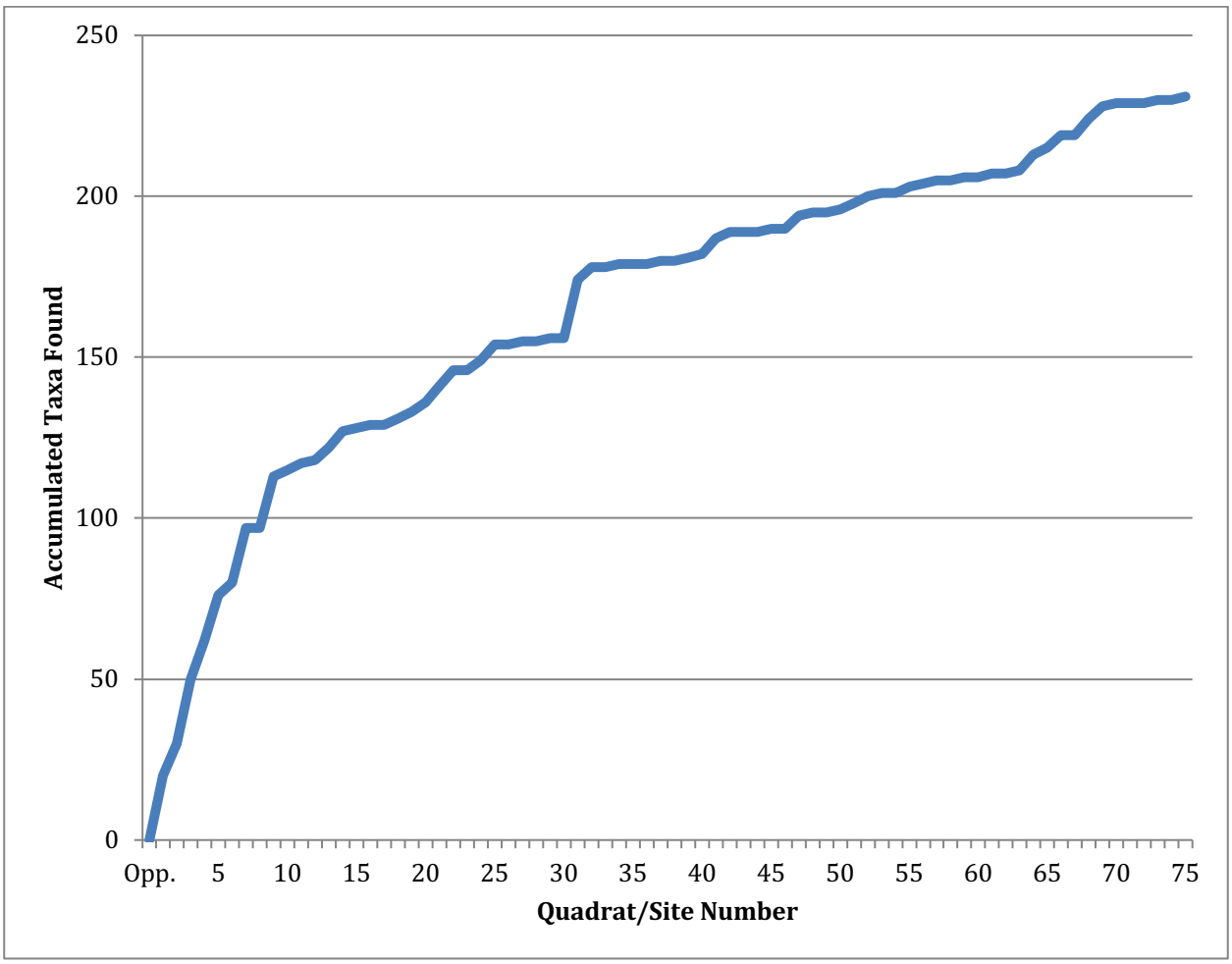
3.4. Flora

Two hundred and thirty six species (including subspecies and varieties) from 45 families and 103 genera, inclusive of 224 native endemic species and species 12 weed species were encountered during the 2018-19 studies. The most prevalent family was Poaceae (42 species of grasses) and the most well represented genera were *Acacia* (29 species), *Eremophila* (21 species), *Maireana* (12 species), *Sida* (8 species), *Eragrostis* (8 species) and *Frankenia* (5 species). These statistics are reasonably representative of the flora of similar landforms of the north-eastern Goldfields. With surveys having been conducted in relatively dry seasonal conditions (Oct 2018, Feb 2019), few annuals were present except those in moisture gaining sites. It is likely that a full inventory of flora would include in the order of 50 annual herbs and grasses including the genera *Brachyscome, Cyperus, Goodenia, Gunniopsis*, and various grasses including *Eragrostis* and *Eriachne*. This compares reasonably favourably with the flora statistics reported in Stantec (2017) of 257 species from 37 families and 103 genera in a significantly smaller area but conducted in better seasonal conditions.

Combining the species lists from the Stantec 2017, 2018a and 2018b studies and the current works, the total flora statistics stands at 321 species from 132 genera and 44 families, inclusive of 18 weed species.

Utilising the species list generated in this assessment alone, a Species Accumulation Curve has been generated, Figure 6. This shows an asymptotic approach to the maximum of 236 species (including weeds) and a plateauing within the last ten Releve sites, indicating few new species being added to the species list. Given that both phases of these surveys were conducted in dry seasonal conditions it is anticipated that in the order of 30 to 50 annual species (grasses and herbs) would be expected in addition to this number.

Figure 6. Species Accumulation Curve



3.5. Significant Flora

Significant Flora have been dealt with in the following categories:

- Conservation Significant Flora
    - Threatened Flora
    - Priority Flora
- Species with Taxonomic Interest
- Species at Limit of Range or representing Range Extensions
- Species uncommon in the landscape within the Study Area and the broader NE Goldfields

Locations of these significant flora and also of recorded weed species within the LGP Study Area are presented in the relevant maps (Figure 12, Figure 16, Figure 19, Figure 21, Figure 22 and in Appendix 6.

3.5.1. Conservation Significant (Threatened and Priority) Flora

Threatened Flora

No Threatened Flora were recorded during the cumulative surveys inclusive of Stantec 2017, 2018a, 2018b, Western Botanical 2018 and the current program. Further, no Threatened Flora are known in region nearby the Study Area and therefore no Threatened Species likely to be present.

Priority Flora

Cumulatively, four species with Priority listing were recorded: *Acacia* sp. Marshall Pool (G. Cockerton 3024) P3, *Eremophila annoscaulis* P3, *Cratystylis centralis* P3 (outside the Study Area) and *Gunniopsis propinqua* P3 (Stantec 2017, 2018a). Stantec (2017, 2018a) also reported *Acacia* sp. nov. aff. *resinimarginea*, which was subsequently recognised as *Acacia* sp. Marshall Pool P3. See Figure 12. These species are discussed below.

3.5.2. Acacia sp. Marshall Pool (G. Cockerton 3024)

Acacia sp. Marshall Pool (G. Cockerton 3024) is a single trunked small tree 2.5 to 4m high x 2 to 6 m wide, killed by fire and regenerating from soil stored seed. It has rough dark grey bark and long thin dark green glossy phyllodes, 1 mm wide x 15 to 80 mm long which are square in cross section. Flowers are dark yellow, rod shaped and to 15 mm long and fruits are flattened, sickle shaped, raised over seeds with a slightly thickened margin, dark green to brownish-green and with a sticky resinous coating when fresh. Seeds are oval shaped, 5 x 4 mm and black with a thick seed coat. See Plate 1 and Plate 2.

Plate 1. *Acacia* sp. Marshall Pool tree and habitat



Within the Study Area, *Acacia* sp. Marshall Pool is confined to low to high rounded hills of weathered gabbro and basalt with infiltrated paleo groundwater calcrete. This landform in found in the south-eastern part of the Study Area, Figure 12, and has been mapped regionally by DoA as the Leonora Land System.

Plate 2. *Acacia* sp. Marshall Pool flower, foliage and fruit



Flower, about actual size



Fruit, about actual size

During regional surveys for this and related species in May 2017, Western Botanical and Stantec recorded the following summary statistics for the species:

> "The Regional Survey Area was defined to capture a significant region inclusive of the known range of *Acacia* sp. Marshall Pool and a range of geologies from Laverton to Menzies and Wiluna, approximately 374 km north-south and 270 km east-west at the widest points and has an area of 69,734 sq. km.
>
> Western Botanical, 2018 estimated 37,266 plants of *Acacia* sp. Marshall Pool at three population centres:

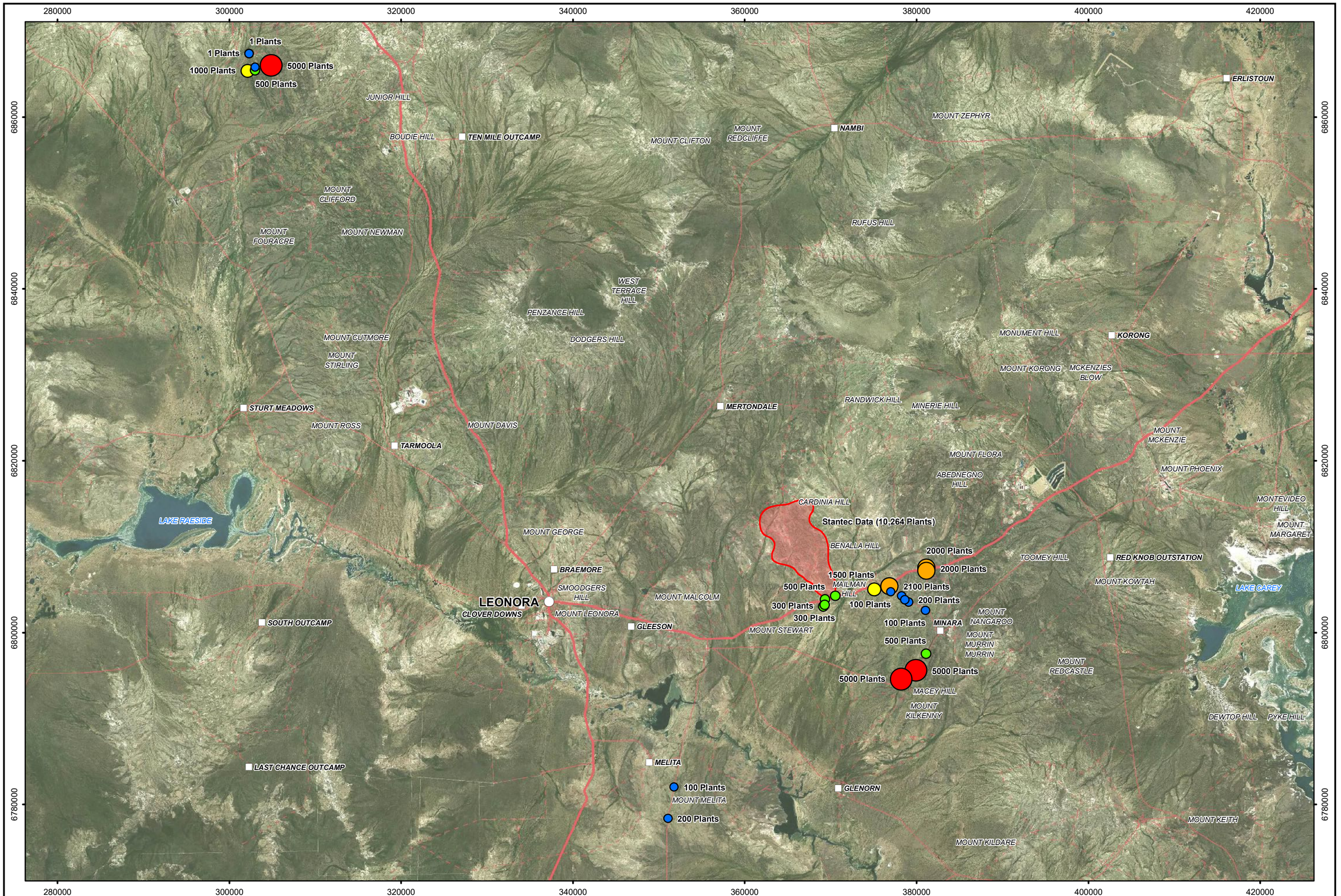
(i) Major populations on the low basalt ranges both north and south of the Leonora – Laverton road on Minara (26,364+ plants, 70.7% of the overall population) and Glenorn Stations (5,000+ plants, 13.4%);

(ii) Small occurrences on low basalt hills on Melita Station (300+ plants, 0.8%), some 26 km SE of Leonora, 26 km north of Kookynie; and

(iii) A major population at the original 1997 collection site, on low basalt hills on Weebo Station (5,602 plants, 15.0%), the former Anaconda Nickel's "Marshall Pool" tenement."

Population (i) above lies within and adjacent to the Study Area while the others are respectively north-west and south of the Study Area, Figure 7.

Figure 7. Regional occurrences of *Acacia* sp. Marshall Pool (G. Cockerton 3024)



Legend

Minimum Plants

- 1 - 200
- 201 - 500
- 501 - 1500
- 1501 - 2100
- 2101 - 5000
- Stantec Data (10,264 Plants)

Client: KIN MINING NL

0 5 10 km

Scale: 1:400,000
MGA94 (Zone 51)

CAD Ref: g2533_F002

Date: May 2018 | Rev: A | A3

Western Botanical

Author: G. Cockerton | WB Ref:

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

Kin Mining NL

Acacia sp. Marshall Pool (G. Cockerton 3024)

Satellite Imagery

Figure: **2**

3.5.3. *Eremophila annoscaulis* P3

Eremophila annoscaulis P3 is a low densely branching shrub to 0.8m high x 1 m wide with small purple flowers, Plate 3. Regionally, it is known from four populations,

(i) Two populations, respectively 22 km and 35 km east of the Study Area, adjacent to the Murrin Murrin minesite; and

(ii) Two populations approximately 280 km north and north-north-east of the Study Area, respectively some 150 km to 250 km east of Wiluna.

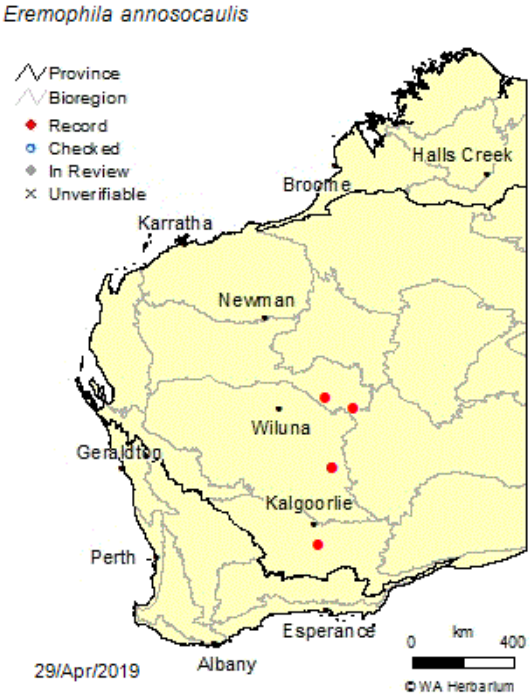
A fifth point shown on the WA Herbarium's Florabase website is erroneously plotted near Widgiemooltha, south of Coolgardie, a geocode error that will be addressed in due course.

Within the Study Area, *E. annoscaulis* was found at 4 loci (9 sites in total), extending from near the Mertondale minesite to the southern-central part of the Study Area, Figure 12. *Eremophila annoscaulis* was not identified until specimens were sorted following the field program, so no estimate of population size or detailed mapping of populations was undertaken at that time. It was found associated with stony hill tops and mid to lower slopes associated with these, growing in association with Mulga.

Plate 3. *Eremophila annoscaulis* images (Florabase)



Figure 8. Distribution of *Eremophila annoscaulis* in W.A.

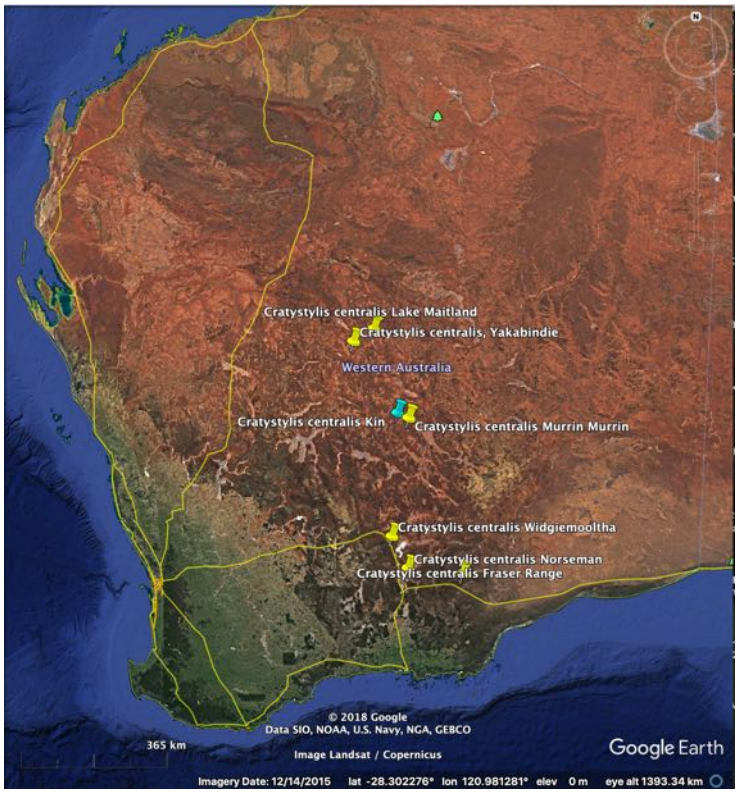


(Note erroneous point south of Kalgoorlie)

3.5.4. *Cratystylis centralis* P3

A population of *Cratystylis centralis* P3 was noted en-route to the Study Area, adjacent to the existing Cardinia access road, within an area previously reported by Stantec, Figure 12. During this survey, the population of 268 plants adjacent to the existing Cardinia access road was mapped and data supplied to Kin. This population represents the seventh population of the species known in W.A, Figure 9.

Figure 9. Regional distribution of *Cratystylis centralis* in W.A. (WA Herbarium and Western Botanical data)



Other than the population reported within the Study Area, six populations of *Cratystylis centralis* are known in W.A.:

(i) The closest population known to the Study Area lies some 9.6 km east of the Study Area, south of the Leonora – Laverton Rd, adjacent to the Murrin Murrin minesite, associated with Mulga (PERTH 08800936 *et. al.);*

(ii) A second population (PERTH 08974462) is known near Lake Maitland, some 105 km south-east of Wiluna;

(iii) A third population of around 500 plants is known by WB to occur on Yakabindie Station, at the abandoned McFarlane's Find prospect, some 180 km north-north-west of the Study Area, associated with *Eucalyptus striaticalyx* and *Eremophila pantonii* (not yet vouchered at WA Herbarium); and

(iv) A single plant was recorded by WB in late 2018 on Fraser Range Station some 125 km east of Norseman, north of the Eyre Highway, some 390 km south-east of the Study Area (not yet vouchered at WA Herbarium).

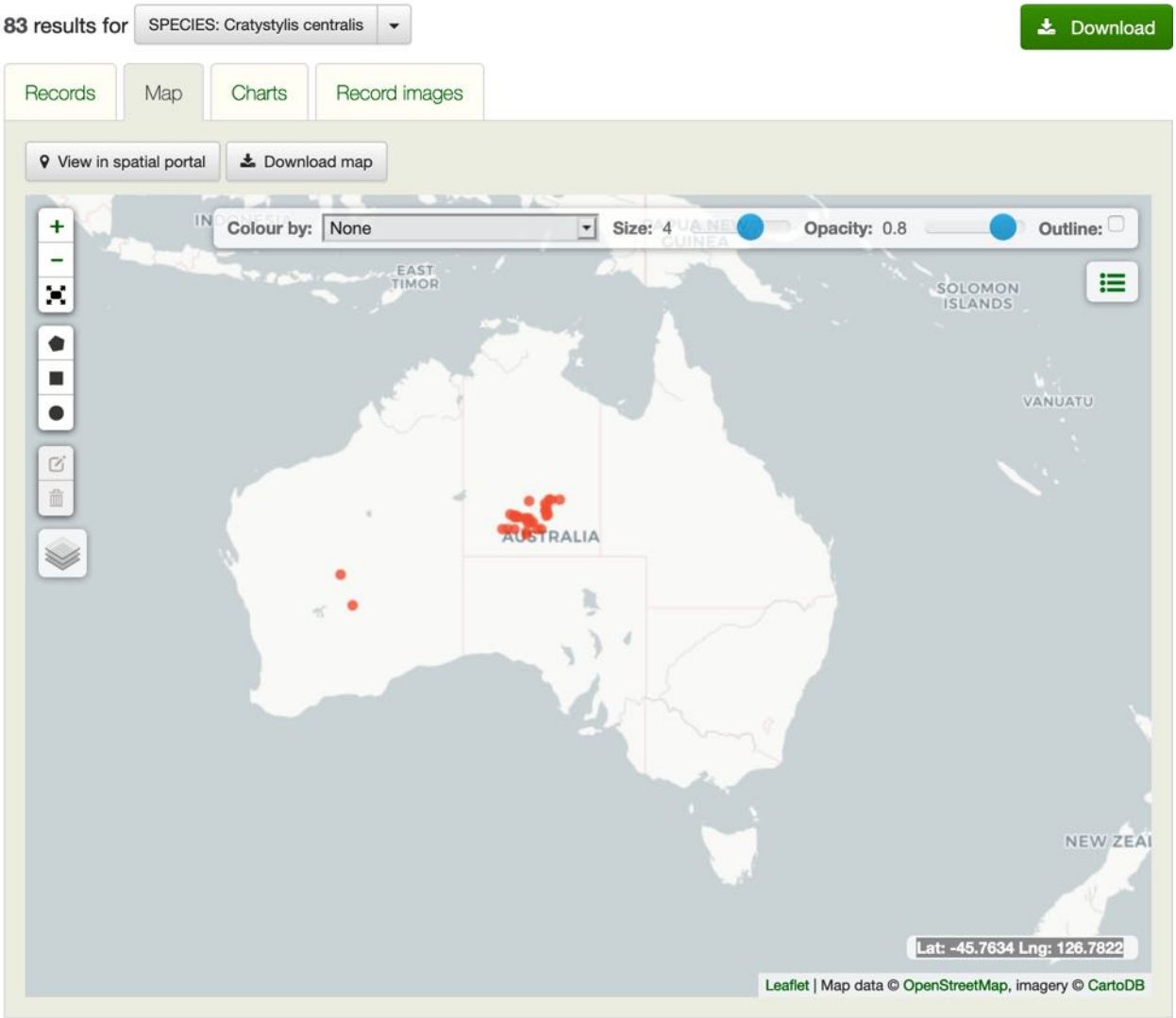
(v) Five plants are known near Widgiemooltha, on a low breakaway.

(vi) A single record from near Norseman on the margin of Lake Cowan is also known.

Only two of these have been vouchered at the WA Herbarium, Figure 12 . In W.A. populations of *Cratystylis centralis* known to the author are found in association with calcareous soils with a shallow mantle of red silty sandy soil and ironstone pizolites.

Cratystylis centralis has an enigmatic distribution with the majority of records in the southern Northern Territory and a few scattered populations in the north-eastern Goldfields and one in the eastern Coolgardie bioregion, Figure 10.

Figure 10. Distribution of *Cratystylis centralis* in Australia (AVH) (vouchered specimens)



Western Botanical

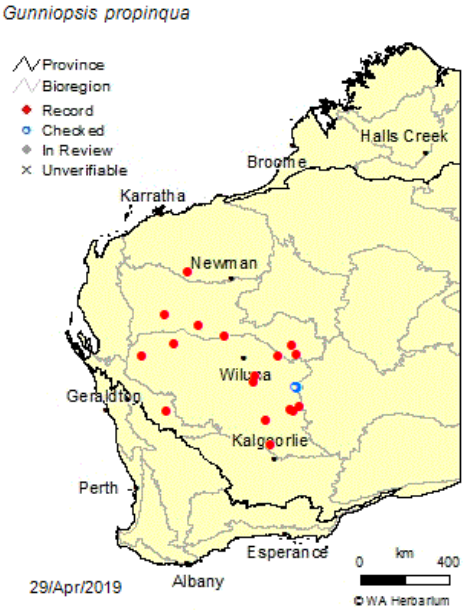
Western Botanical (2017) reported "Wilson & Albrecht (2002) note that the Western Australian specimens differ in the number of florets in the flowering head (capitula) from those in the Northern Territory. However, the lack of good flowering material made it difficult to separate the two groups adequately. They record the species as a putative hybrid between *C. conocephala* and *C. microphylla* with a Western Australian distribution. The species, while currently considered within *C. centralis sens. lat.* and with a P3 conservation listing in W.A. due to the distribution in W.A. and N.T., remains of taxonomic and conservation interest (Mike Hislop, pers. comm.). It is more likely that the Western Australian species is a new taxon and worthy of a revised conservation ranking.

Preliminary investigations undertaken by WB in August 2016 on specimens housed at the WA Herbarium have shown the WA species (Armstrong, P.G. (07/970)) has two flowers per capitula (flower head) while those from the Northern Territory (specimen on loan from NT Herbarium, collected by P.K. Latz) have four. This is considered a significant difference (Paul Wilson pers. comm.) and indicates that the WA taxon requires further taxonomic investigation."

3.5.5. *Gunniopsis propinqua* P3

Gunniopsis propinqua P3 is a small cryptic succulent annual herb to 5 cm high found growing in association with Samphire species on the margins of saline chenopod dominated plains. It is widespread in W.A. with records in the eastern Gascoyne, throughout the Murchison and one point in the Yalgoo bioregions, Figure 11, Figure 12 . Assuming identifications of all specimens plotted is correct, this distribution suggests a downwards revision of Priority Status is likely warranted. Stantec (2017) reported four sites supporting *Gunniopsis propinqua* within the current Study Area numbers of plants were not provided.

Figure 11. Distribution of *Gunniopsis propinqua* in W.A.



A map showing the distribution of all four Priority 3 species cumulatively reported within the Study Area is presented in Figure 12.

Figure 12. Cumulative Records of Priority Flora within the Study Area

360000

370000

6830000

6820000

6810000

Legend

Western Botanical Flora

Acacia sp. Marshall Pool (G. Cockerton 3024)

Cratystylis centralis

Eremophila annoscaulis

Stantec Flora

Acacia ? resinimargine

Gunniopsis propinqua

DBCA TPFL

DBCA WA Herberium

Baseline Survey Limits

Stantec Clip Bdry

Mining Area Bdry

Road

Track

WB Vegitation Association

Acacia sp. Marshall Pool (G. Cockerton 3024) Shrubland

Acacia sp. Marshall Pool (G. Cockerton 3024), *A. sibirica, Acacia aneura, A. burkittii* Shrubland

Source: Land Systems: DPIRD, Tenements: DMIRS, Topography: Landgate

Consultant

Western Botanical

Layout

Leonora

N

0 1,250 2,500 m

Scale: 1:110,000
MGA94 (Zone 51)

CAD Ref: a2553_Veg_WB_05_01

Date: May 2019 | Rev: A | A3

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Leonora Gold Project

Priority Species

Western Botanical, Stantec and DBCA

***Grevillea inconspicua* P4 and *Hemigenia exilis* P4**. Stantec (2017) reported *Grevillea ?inconspicua* occurring north of the Cardinia development envelope, within the proposed haul road alignment to Mertondale. This site was specifically reviewed in February 2019 and the more common and widespread *Grevillea acuaria* was located at the reported site. The author is very familiar with the distribution and habitat preference of both *Grevillea inconspicua* P4 and *Hemigenia exilis* P4, which are known from the Murrin Murrin, Leinster, Yakabindie and Mt Keith nickeliferous minesites. *G. inconspicua* is associated with basalt and gabbro outcrops and subcrops and *H. exilis* has an obligate association with volcaniclastic sediments associated with nickel bearing basalts and volcanics. It is suggested therefore that *Grevillea inconspicua* and *Hemigenia exilis* do not occur within the Study Area and can safely be discounted.

3.6. Species with Taxonomic Interest

Eight species were considered to have taxonomic interest, Figure 16. These are:

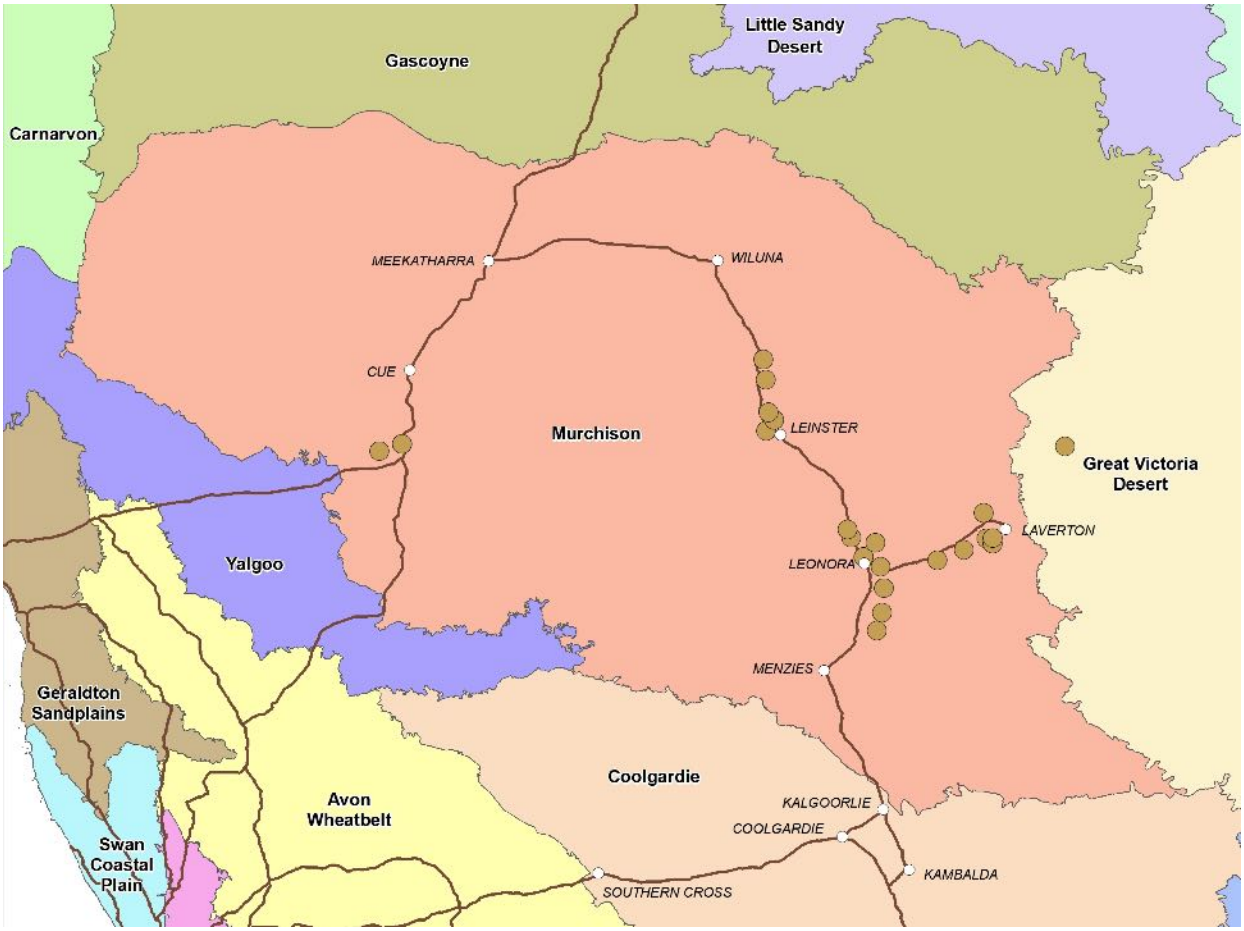
- *Acacia quadrimarginea* narrow phyllode form (G. Cockerton WB38064)
- *Centrolepis* sp. Leonora (G. Cockerton & G. Grigg WB40071)
- *Eremophila platycalyx* subsp. Leonora (J. Morrisey 252)
- *Eriachne mucronata* desert form glabrous (G. Cockerton & S. Cockerton WB40048)
- *Frankenia setosa* type 1
- *Frankenia setosa* type 2
- *Hibiscus* sp. Perrinvale (J. Warden & E. Ager WB10581)
- *Maireana tomentosa* complex (type 1 WB38650)

These are briefly discussed below.

- Two of the seven; *Centrolepis* sp. Leonora (G. Cockerton & G. Grigg WB40071) and *Hibiscus* sp. Perrinvale (J. Warden & E. Ager WB10581), may also have conservation significance and should be flagged for re-collection with flowers and/or fruits and their taxonomy carefully reviewed to confirm whether they represent new species. The other six species are well known and do not require any further investigation. *Acacia quadrimarginea* narrow phyllode form is mapped for reference (Figure 16), however, the other five species are not specifically mapped within the Study Area.

***Acacia quadrimarginea* narrow phyllode form (G. Cockerton WB38064)** is a single stemmed shrub to small tree to 4 m in height with narrow glossy phyllodes held upright and resinous flattened pods. It is always associated with basalt, gabbro or phyllite shale and is widespread in the north-eastern Goldfields between Laverton and Yakabindie Stations with some records near Mt Magnet, Figure 13. It has recently been differentiated from typical *Acacia quadrimarginea* sens. str. It is not considered to warrant conservation ranking. *Acacia quadrimarginea* narrow phyllode form (G. Cockerton WB38064) was reported as *Acacia* sp. East Murchison Basalt in Western Botanical (2018b).

Figure 13. Regional Distribution of *Acacia quadrimarginea* Narrow phyllode form (G. Cockerton WB38064) (Western Botanical 2018b)



***Centrolepis* sp. Leonora (G. Cockerton & G. Grigg WB40071)** is a small herb to 5 cm in height, Plate 4, that was recorded at one point in the Study Area, associated with Mulga, *Ptilotus obovatus* upright form and *Maireana triptera* on a hill slope, Figure 16.

Centrolepis sp. Leonora does not match any known *Centrolepis* species, however, only a tiny specimen was collected and a review of further material is suggested before any determination of taxonomic status can be made. The site at which this species was collected lies just within the north-eastern boundary of the Study Area, north of the Cardinia development area. It requires a review of its taxonomy prior assessing the need for any targeted surveys for the species.

Plate 4. *Centrolepis* sp. Leonora (G. Cockerton & Grigg WB40071) (actual size)



***Eremophila platycalyx* subsp. Leonora (J. Morrisey 252),** Plate 5**,** is the only form of the complex *E. platycalyx* group known in the Leonora – Laverton area. It is widespread in this region, often associated with granitoid or gabbro geologies, and in currently undergoing taxonomic description by Dr. Bevan Buirchell. It is commonly encountered within the Study Area and not considered to warrant conservation ranking.

Plate 5. *Eremophila platycalyx* subsp. Leonora (J. Morrisey 252), Leinster, July 2016.



A perennial grass, here termed ***Eriachne mucronata*** **desert form glabrous (G. Cockerton & S. Cockerton WB40048),** is common and widespread in Western Australia, though often found in small, disjunct occurrences on stony environments. Western Botanical has recorded the species from Warburton in the Gt. Victoria Desert and Central Ranges bioregions to the eastern Murchison bioregion, from Leonora to Wiluna. It was found at seven sites within the Study Area, both on rocky hill tops (either chert or gabbro). It currently is held within the variable *Eriachne mucronata* group, though clearly represents a separate species. It is not considered to have a limited distribution and would not attract conservation listing.

Plate 6. Images of *Eriachne mucronata* desert form glabrous (G. Cockerton & S. Cockerton WB40048), Wanjarri Nature Reserve, 2018



Two ***Frankenia*** species, both falling within *Frankenia setosa* but having differing flora structures, are uncertain and require review of flowering and fruiting material. The taxonomy of the genus *Frankenia* is well known as being out of date and requiring major revision and it is not surprising there are taxonomic anomalies within this group. The two taxa, *Frankenia setosa* type 1 and *F. setosa* type 2, do not resemble any species with known conservation significance. These are not discussed further.

***Hibiscus* sp. Gardneri (A.L. Payne PRP 1435),** Plate 7**,** was recorded at five locations in the Study Area, associated with stony gabbro and basalt hills. It has also been seen more broadly in the NE Goldfields by the author between Leinster and Wiluna, including during surveys in 2018 and is well collected within W.A. from the Pilbara, Carnarvon, Gascoyne and Murchison biogeographic regions, Figure 14. It does not warrant conservation ranking.

Plate 7. *Hibiscus* sp. Gardneri (A.L. Payne PRP 1435), Wanjarri Nature Reserve, 2018.



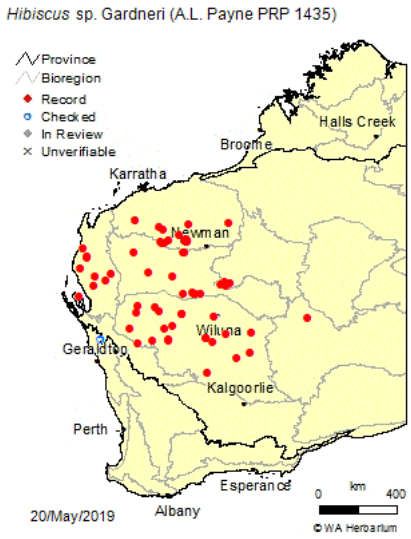
Foliage



Flower

The material of *Hibiscus* sp. Gardneri (A.L. Payne PRP 1435) housed at the WA Herbarium has been reviewed by the author and the species is reasonably uniform throughout its range.

Figure 14. Distribution of *Hibiscus* sp. Gardneri (A.L. Payne PRP 14325) in W.A.



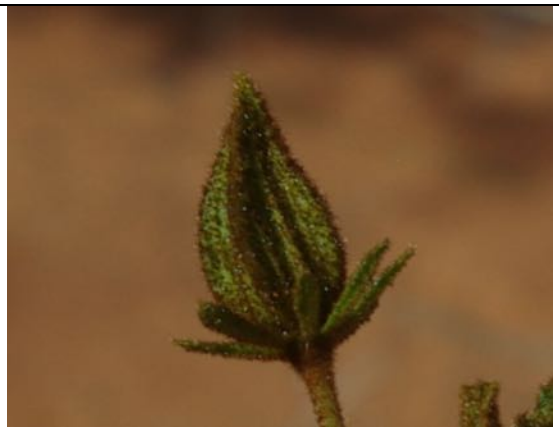
***Hibiscus* sp. Perrinvale (J. Warden & E. Ager WB10581),** Table 9 and Plate 8**,** represents a new species that is not as yet represented within the collection at the WA Herbarium. It was confirmed at five sites within the LGP with a further four sites being possible locations for the species. All sites are on stony ground or hills with either ironstone or basalt rocks prevalent at the surface. Four of these sites occur near the proposed mine infrastructure in north-east of the existing Cardinia development envelope, two in association with Mulga and two in association with *Acacia* sp. Marshall Pool. The remining five sites, where only vegetative material was observed, occur either on stony chert hills in the south-western part of the Study Area associated with Mulga or on metagabbro hills in association with *Acacia* sp. Marshall in the eastern and central parts of the southern Study Area. The latter group have been fagged as ?*Hibiscus* sp. Perrinvale , Figure 16.

Hibiscus sp. Perrinvale Station has been previously collected once by Western Botanical on a low banded ironstone range on Perrinvale Station, on the eastern shore of Lake Barlee, some 170 km west-south-west of the LGP and 132 km north-west of Menzies. At that time, it was regarded as *Hibiscus* sp. Gardneri and the review of taxonomy has only occurred following this field survey and review of specimens held by Western Botanical.

Hibiscus sp. Perrinvale Station has some superficial similarities to *Hibiscus* sp. Gardneri (A.L. Payne PRP 1435), however, it differs in several characteristics, Table 9. It does not key to any named or as yet un-named species within the Florabase online interactive Malvaceae key (Hollister & Thiele) and does not match any un-named species already held at the WA Herbarium.

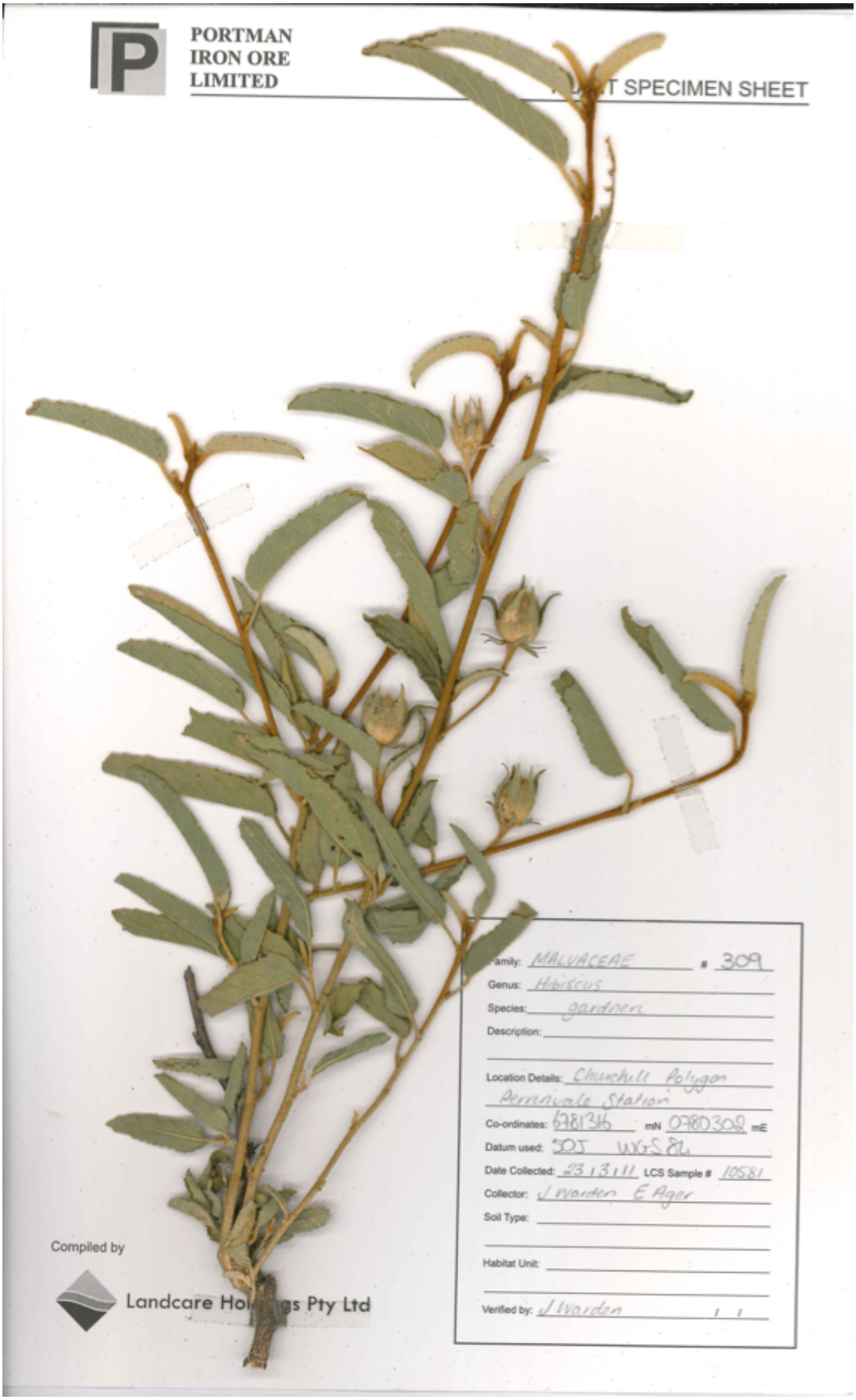
Table 9. Features differentiating the two *Hibiscus* species

Feature	***Hibiscus* sp. Gardneri (A.L. Payne PRP 1435),**	***Hibiscus* sp. Perrinvale (J. Warden & E. Ager WB10581)**
Hairs on entire plant	Golden stellate hairs covering the entire plant	White stellate hairs covering the entire plant
Leaves	Broadly ovate, acute, dark green colouration, with prominent raised veination on ventral surface, dentate.	Broadly lanceolate, broadly acute, grey-blue colouration, dentate, less prominent raised veination on ventral surface.
Epicalyx	Slender flat oblanceolate epicalyx 10 to 15mm long x 2mm wide, covered in golden stellate hairs.	Slender flat, lanceolate epicalyx 10 mm long x 1.5 mm wide, covered in white stellate hairs.

Feature	***Hibiscus* sp. Gardneri (A.L. Payne PRP 1435),**	***Hibiscus* sp. Perrinvale (J. Warden & E. Ager WB10581)**
Inner Calyx	Broadly triangular, 20 to 40 mm long x 5 to 8 mm wide, with elongated acuminate distal end, dark green, free to base, lobes slightly overlapping at base, prominently ridged, covered in golden stellate hairs.	Broadly triangular, acute, 12 to 15 mm long, co-joined for approximately half the length, lobes not overlapping, surface smooth, covered in white stellate hairs.
Bud and Fruit images		

Hibiscus sp. Perrinvale Station (J. Warden & E. Ager WB10581) was not recognised as requiring specific survey whilst in the field and therefore numbers or distribution at each site have not been recorded. Further, the material collected in October 2018 was less than optimal as a reference specimen. It is considered as warranting further collection of flowering and fruiting material and targeted survey within and adjacent to the LGP Study Area .

Plate 8. Specimen of *Hibiscus* sp. Perrinvale Station (J. Warden & E. Ager WB10581), Perrinvale Station, 23rd March 2011.



Western Botanical

***Maireana tomentosa* complex (type 1 WB38650)** is part of the polymorphic *Maireana tomentosa* complex, widespread and common in arid parts of Australia, Figure 15. The species encountered within the Study Area is widely distributed between Laverton and Wiluna and is not considered to warrant conservation interest.

Figure 15. Distribution of *Maireana tomentosa* within Australia

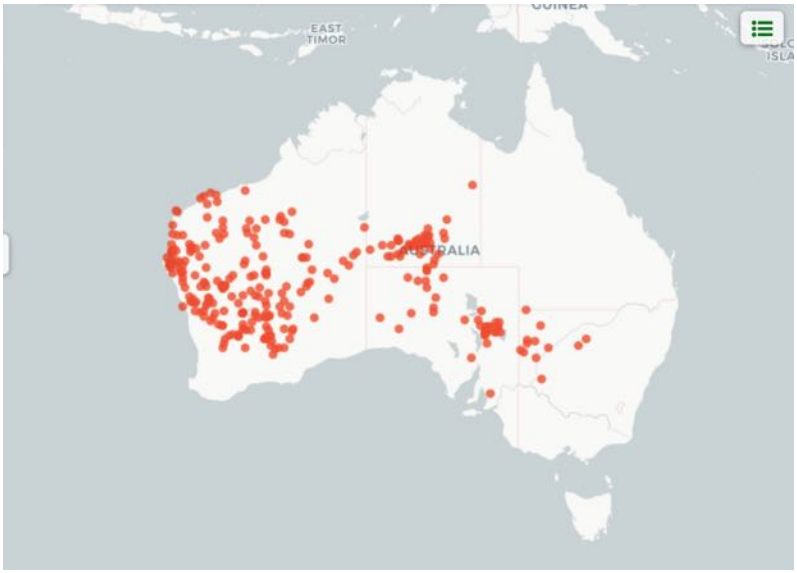


Figure 16. Noteworthy Species with Taxonomic Interest within the Study Area.

Map Legend:

Code	Species Informal Phrase Name
CspL	Centrolepis sp. Leonora (G. Cockerton & G. Grigg WB40071)
HspP	Hibiscus sp. Perrinvale (J. Warden & E. Ager WB10581)
AqNP	Acacia quadrimarginea narrow phyllode form (G. Cockerton WB38064)

360000 370000

6830000 6820000 6810000

Legend

TAXON

- *Acacia quadrimarginea* narrow phyllode form (G. Cockerton WB38064)
- *Centrolepis* sp. Leonora (G. Cockerton and G. Grigg WB40071)
- *Hibiscus* sp. Perrinvale Station (J. Warden and E. Ager WB10581)
- ? *Hibiscus* sp. Perrinvale Station (J. Warden and E. Ager WB10581)
- Baseline Survey Limits
- Stantec Clip Bdry
- Mining Area Bdry
- Road
- Track

CspL
HspP2
HspP1
HspP3
HspP4
AqNP1
?HspP7
?HspP6
?HspP5
?HspP8
?HspP9
AqNP2

360000 370000

Source: Land Systems: DPIRD, Tenements: DMIRS, Topography: Landgate

Consultant: Western Botanical

Layout: Leonora

N

0 1,250 2,500 m

Scale: 1:110,000
MGA94 (Zone 51)

CAD Ref: a2553_Veg_WB_05_03

Date: May 2019 | Rev: A | A3

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Leonora Gold Project
Species of Taxonomic Interest

3.7. Species at Limit of Range or Representing Range Extensions

Four endemic species and one weed species are represented at the Limit of their known range or represent range extensions in W.A.:

1. *Alectryon oleifolius* subsp. *canescens*
2. *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH 26770)
3. *Sarcozona praecox*; and
4. *Sporobolus actinocladus*
5. *Polycarpon tetraphyllum* * (Weed)

Alectryon oleifolius* subsp. *canescens is a tree to 6m x 8m with foliage that resembles that of an Olive, Plate 9. Its occurrence within and adjacent to the Study Area represents a slight north-westerly range extension of around 100 km from the nearest known occurrence south of Murrin Murrin. It is uncommon in the landscape, and while not considered rare or a Priority species, should be avoided whenever possible when developing infrastructure as the population here represents the northern limit of the range of the species in W.A. Within W.A. it is more widely recorded in the southern Goldfields and Nullarbor regions and is widely distributed in the eastern states.

Plate 9. *Alectryon oleifolius* subsp. *canescens* within the Study Area



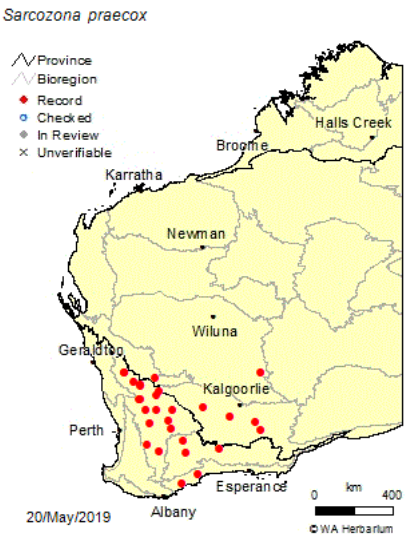
Sarcozona praecox is a succulent prostrate plant with trailing stems and thick, fleshy dark green triangular leaves, Plate 10. Its occurrence in the Study Area represents a minor range extension as the species is more widely known from the Coolgardie and Avon-Wheatbelt bioregions in W.A., Figure 17

The closest record of the species, PERTH 3183149, is on the south-western shore of Lake Carey, some 80 km south-east of the Study Area. Given that the species was not identified until after field works were completed, its distribution within the Study Area was not mapped. It does not warrant conservation focus.

Plate 10. Image of *Sarcozona praecox* (Florabase)



Figure 17. Distribution of *Sarcozona praecox* in W.A.



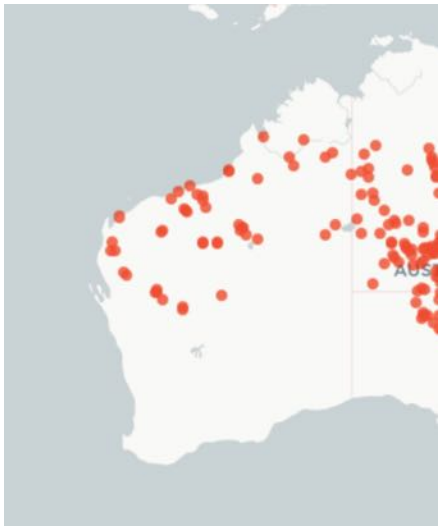
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Sporobolus actinocladus is an annual or perennial grass associated with saline margins of Samphire and *Maireana* dominated chenopod shrublands in low lying seasonally inundated areas. It was commonly recorded within this range of community types in the Study Area. It is widely distributed in northern Australia and its occurrence in the saline Chenopod Plains of the Study Area represent a 292 km southerly range extension for the species from its closest known location north-east of Wiluna (AVH dataset). Given that the species was not identified until after field works were completed, its distribution within the Study Area was not mapped though it is considered to be abundant and widespread in suitable habitats.

Plate 11. Drawing of *Sporobolus actinocladus* (Ausgrass)



Figure 18. Distribution of *Sporobolus actinocladus* within W.A. (AVH)



The weed *Polycarpon tetraphyllum*, a small and non-competitive introduced species, represents the first collection of the species in the Murchison bioregion and a range extension of at least 500 km.

Figure 19. Species within the Study Area being at Limit of Range or Representing Range Extensions in W.A.

Map Legend

Code	Species
Aoc	Alectryon oleifolius subsp. canescens
Sp	Sarcozona praecox
PtW	Polycarpon tetraphyllum * (Weed)

360000

370000

6830000

6820000

6810000

Legend

TAXON

Alectryon oleifolius subsp. *canescens*

Polycarpon tetraphyllum *

Sarcozona praecox

Baseline Survey Limits

Stantec Clip Bdry

Mining Area Bdry

Road

Track

Aoc11

Aoc10

Aoc9

Aoc8

Sp1

Sp2

Aoc7

Aoc6

Aoc5

Aoc3

Aoc2

PtW1

Source: Land Systems: DPIRD, Tenements: DMIRS, Topography: Landgate

Consultant

Western Botanical

Layout

Leonora

N

0 1,250 2,500 m

Scale: 1:110,000
MGA94 (Zone 51)

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Leonora Gold Project

Species at Limit of Range or Range Extent

3.8. Species uncommon in the landscape within the Study Area and the broader North-Eastern Goldfields

Santalum acuminatum (Quandong) (2 trees noted); and ***Alectryon oleifolius*** **subsp.** ***canescens***

Two tree species were markedly uncommon in the landscape within the Study Area: *Santalum acuminatum* (Quandong) (2 trees noted); and *Alectryon oleifolius* subsp. *canescens* (discussed under Range Extensions) with 16 plants at 11 sites (9 x 1 plant, 1 x 2 plants, 1 x 5 plants) observed. Four of these sites, representing eight plants, occur outside the Study Area. Both are medium sized trees and are readily recognised in the field. Only the positions of *Alectryon oleifolius* subsp. *canescens* were recorded using GPS, Figure 19. During development of the LGP, avoidance of impact to these species is recommended due to their scarcity in the landscape as removal of individuals may influence the survival of the local populations.

Acacia doreta Short phyllode form (M. Stone & S. Colwill WB34381) is the typical form of this species and has a widespread distribution in the eastern and northern parts of its range from the southern Pilbara to the eastern Murchison biogeographic regions. It is uncommon in the immediate vicinity of the LGP and this also represents the south-eastern extent of its known distribution, making any occurrences in this area significant. *Acacia doreta* Short phyllode form was found on one gabbro hill on the western margin of the Study Area in association with Acacia sp. Marshall Pool, Figure 21. *Acacia doreta* Long phyllode form (G. & S. Cockerton 38632) is prevalent between Leinster and Wiluna.

Eragrostis **sp. Yeelirrie Calcrete (S. Regan LCH 26770)** is a perennial colonial grass forming a dense colony of small individuals to 10 cm high x up to 40 cm across, always associated with calcrete expressions,

Plate 12, Plate 13. It is often heavily grazed by kangaroos and rabbits and is readily overlooked in the field.

Eragrostis sp. Yeelirrie Calcrete was found at 48 sites throughout the south-eastern portion of the Study Area and its distribution was recorded when observed. It is also known from many paleochannels in the Murchison bioregion including the Lake Way, Yeelirrie, Lake Mason and Lake Miranda systems and is not considered as warranting conservation ranking.

Plate 12. *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH 26770) habitat.



Plate 13. *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH 26770) form of plant.

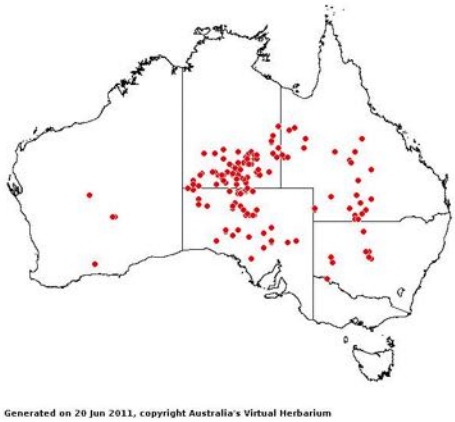


Neurachne munroi is a perennial grass to 0.4m in height which has an enigmatic distribution across central Australia, Plate 14. In WA it is particularly poorly collected, with few specimens vouchered at the WA Herbarium. *Neurachne munroi* was recorded at eight locations within the Study Area, Figure 21, and was always found in association with stony hill slopes on uplifted and weathered mudstone, usually on north and east facing slopes. It has been occasionally recorded by Western Botanical in the Central Ranges, Great Victoria Desert and Murchison bioregions, however, populations area always on similar geology and landscapes, are small in size and highly disjunct. Dr. Terry McFarlane, WA Herbarium, is currently reviewing the taxonomy of this species.

Plate 14. *Neurachne munroi* Within the Study Area



Figure 20. Distribution of *Neurachne munroi* in Australia (AVH)



While *Neurachne munroi* is not a listed Priority species, it is uncommon in the landscape and impacts should be avoided during project development where possible.

Figure 21. Poorly Collected Species

Code	Species
EspYC	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)
Ad	Acacia doreta Short phyllode form (M. Stone & S. Colwill WB34381
Nm	Neurachne munroi

360000

370000

6830000

6820000

6810000

Legend

TAXON

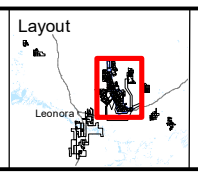
- *Acacia doreta* short phyllode form (M. Stone and S. Colwill WB34381)
- *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH26770)
- *Neurachne munroi*
- Baseline Survey Limits
- Stantec Clip Bdry
- Mining Area Bdry
- Road
- Track

Source: Land Systems: DPIRD, Tenements: DMIRS, Topography: Landgate

Consultant

Western Botanical

Layout



N

0 1,250 2,500 m

Scale: 1:110,000
MGA94 (Zone 51)

CAD Ref: a2553_Veg_WB_05_06

Date: May 2019 | Rev: A | A3

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Leonora Gold Project

Poorly Collected Species uncommon in area

3.9. Weeds

A cumulative 20 weed species have been recorded during surveys for Kin Mining (Stantec 2017, this survey), Table 10, Figure 22. Of these:

- Seventeen are regarded as introduced minor weed species and not of concern as they are not strongly competitive and are widely naturalised.
- Two species, (*Cenchrus ciliaris* and *Cenchrus setiger*) are widely promoted by the Pastoral industry, however, both are vigorous invasive weed species and their presence within the Study Area lowers the vegetation condition ranking in the habitat in which they occur.
- One species occurring just outside the Study Area, *Cylindropuntia fulgida* var. *mamillata*, Jumping Cholla or Coral Cactus, is listed as a Weed of National Significance (WoNS).
- One species, *Polycarpon tetraphyllum*, a small and non-competitive introduced species, represents the first collection of the species in the Murchison bioregion and a range extension of at least 500 km. It is a small plant and easily overlooked and may be more widespread than data currently indicates.

Cylindropuntia fulgida var. *mamillata* is known at the northern end of the Study Area, around the Mertondale prospect, and is the subject of largely very effective active control measures (G. Grigg pers. comm.). Individual locations of this species were not mapped during field surveys and the location provided is indicative only.

One non-endemic species reported by Stantec (2017), *Carpobrotus aequilaterus,* may have been confused with the native *Sarcozona praecox*. Both species are recorded in the area (Florabase), however, only one record of *C. aequilaterus* is noted in the Murchison bioregion, east of the Study Area, with the bulk of collections being peri-coastal in south-west W.A., indicating there may be confusion in the identification of the species. *Sarcozona praecox* was noted at two sites during the 2018-19 surveys associated with Chenopod Shrublands in saline claypan areas and has a similar leaf morphology to *C. aequilaterus*, affording the chance of confusion. It is suggested that this reported weed be disregarded unless verified in subsequent field survey.

Buffel Grass (*Cenchrus ciliaris*) and Birdwood Grass (*Cenchrus setiger*) are species introduced to WA and often encouraged by Pastoralists for forage value. Both are recognised as environmental risks in that they are vigorous and highly competitive, readily outcompeting native species and pose an elevated fire risk. However, in the north-eastern Goldfields, both species are naturalised and tend to occur in non-saline moisture gaining sites and are therefore restricted in their distribution to roadsides and non-saline creeklines. Neither Buffel Grass nor

Birdwood Grass are listed as Declared Plants in Rangelands in Western Australia and neither require active management. While these species were recorded when observed, locations provided for Buffel Grass and Birdwood Grass are only indicative within the Study Area as no systematic survey for these was conducted during field surveys.

Table 10. Weeds of the Study Area (cumulative list)

Family	Taxon	Common Name	Status	Comment	Source
Aizoaceae	Carpobrotus aequilaterus *	Angular Pigface	Introduced	May have been confused with native species Sarcozona praecox	Stantec 2017
Anacardiaceae	Schinus terebinthifolia *	Brazilian Pepper Tree	Introduced		WB 2019
Asteraceae	Bidens bipinnata *	Beggars Tick	Introduced		WB 2019
Asteraceae	Sonchus oleraceus *	Common Sowthistle	Introduced		WB 2019
Brassicaceae	Lepidium didymum *	Lesser Swine-Cress	Introduced		WB 2019
Brassicaceae	Sisymbrium erysimoides	Smooth Mustard	Introduced		Stantec 2017
Brassicaceae	Sisymbrium irio	London Rocket	Introduced		Stantec 2017
Convolvulaceae	Cuscuta planiflora	Small Seeded Dodder	Introduced		Stantec 2017
Cucurbitaceae	Citrullus colocynthis *	Bitter Apple	Introduced		WB 2019
Cucurbitaceae	Citrullus myriocarpus *	Prickly Paddy Melon	Introduced		WB 2019
Fabaceae	Medicago sp. Indet. *	A Medic	Introduced		WB 2019
Malvaceae	Malvastrum americanum *	Spiked Malvastrum	Introduced	WB record just outside Study Area but may be present within	WB 2019, Stantec 2017
Poaceae	Cenchrus ciliaris *	Buffel Grass	Environmental risk, naturalised		WB 2019
Poaceae	Cenchrus setiger *	Birdwood Grass	Environmental risk, naturalised		WB 2019
Polygoniaceae	Rumex hypogaeus*	Doublegee			WB 2019, Stantec 2017
Polygalaceae	Rumex vesicarius *	Ruby Dock			WB 2019, Stantec 2017
Primulaceae	Lysimachia arvensis *	Pimpernel			WB 2019, omitted from Stantec 2017
Verbenaceae	Salvia verbenacea *				WB 2019
Caryophyllaceae	Polycarpon tetraphyllum *	Four-leaf Allseed		500 km Range Extension in WA	WB 2019
Cactaceae	Cylindropuntia fulgida var. mamillata *	Jumping Cholla or Coral Cactus	Weed of National Significance (WoNS)	Abundant outside the Study Area near Mertondale prospect	WB 2019, Stantec 2017

Figure 22. Weeds within the Study Area.

Map Legend:

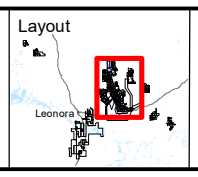
Code	Weed Species
BpW	Bidens bipinnata *
CcilW	Cenchrus ciliaris *
CsetW	Cenchrus setiger *
CitColW	Citrullus colocynthis *
CucMyrW	Cucumis myriocarpus *
CylFulMamWoNS	Cylindropuntia fulgida var. mamillata * (WoNS)
EmeuW	Rumex hypogaeus *
LdW	Lepidium didymum *
MaW	Malvastrum americanum *
PtW	Polycarpon tetraphyllum *
StW	Schinus terebinthifolia

360000
370000
6830000
6820000
6810000

Legend
TAXON
- *Bidens bipinnata* *
- *Cenchrus ciliaris* *
- *Cenchrus setiger* *
- *Citrullus colocynthis* *
- *Cucumis myriocarpus* *
- *Cylindropuntia fulgida* var. *mamillata* *
- *Lepidium didymum* *
- *Malvastrum americanum* *
- *Polycarpon tetraphyllum* *
- *Rumex hypogaeus* *
- Baseline Survey Limits
- Stantec Clip Bdry
- Mining Area Bdry
- Road
- Track

Source: Land Systems: DPIRD, Tenements: DMIRS, Topography: Landgate

Consultant
Western Botanical

Layout


N

0 1,250 2,500 m
Scale: 1:110,000
MGA94 (Zone 51)
CAD Ref: a2553_Veg_WB_05_05
Date: May 2019 | Rev: A | A3

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Leonora Gold Project
Weeds

3.10. Amendments to Previous Flora Records

The following flora previously reported by Stantec were found likely to have been misidentified and corrections are offered. This is undertaken based on field observations of species and not on a review of specimens collected by Stantec. Not all species with uncertain identification reported by Stantec could be addressed in this fashion.

Stantec 2017, 2018a, b Identification	Suggested correct identification	Reason
Acacia assimilis subsp. assimilis	Acacia papyrocarpa	Mis-identification confirmed.
Carpobrotus aequilaterus *	Sarcozona praecox	Likely mis-identification.
Ptilotus sp. Goldfields (R. Davis 10769)	Ptilotus exaltatus	Taxonomic update.
Cynanchum floribundum	Marsdenia australis	Likely mis-identification, Cynanchum floribundum would represent a 400 km range extension.
Vittadinia sp.	Vittadinia eremaea	V. eremaea is prevalent throughout the Study Area.
Enchylaena ?tomentosa	Enchylaena tomentosa	Enchylaena tomentosa confirmed in 2018-19.
Maireana ? platycarpa	Maireana sp. decussate leaves (G. Cockerton & G. Grigg WB 40064)	Specimens reviewed following 2018-19 also keyed to Maireana aff. platycarpa but its taxonomy is uncertain.
Maireana ? tomentosa	Maireana tomentosa (type 1 WB38650) complex	Specimens reviewed following 2018-19 match Maireana tomentosa (type 1 WB38650) complex.
Rhagodia? drummondii	Rhagodia drummondii	Rhagodia drummondii is prevalent in the Study Area.
Duperreya? commixta	Duperreya commixta	Duperreya commixta is prevalent in the Study Area.
Acacia? oswaldii	Acacia oswaldii typical form	Acacia oswaldii typical form is prevalent in the Study Area, as distinct from Acacia oswaldii Calcrete form (BR Maslin 7757) which retains juvenile foliage in adult phase and which is not present in the Study Area.
Baeckea sp. Melita Station (H. Pringle 2738)	Baeckea occlusa	Taxonomic update.
Digitaria ?brownii	Digitaria brownii	Digitaria brownii is prevalent in the Study Area.
Lysimachia arvensis	Lysimachia arvensis *	Lysimachia arvensis is a non-endemic weed species.

Stantec 2017, 2018a, b Identification	Suggested correct identification	Reason
Triodia basedowii	Eriachne mucronata Desert form glabrous	Photographs of habitats containing the species suggest this change

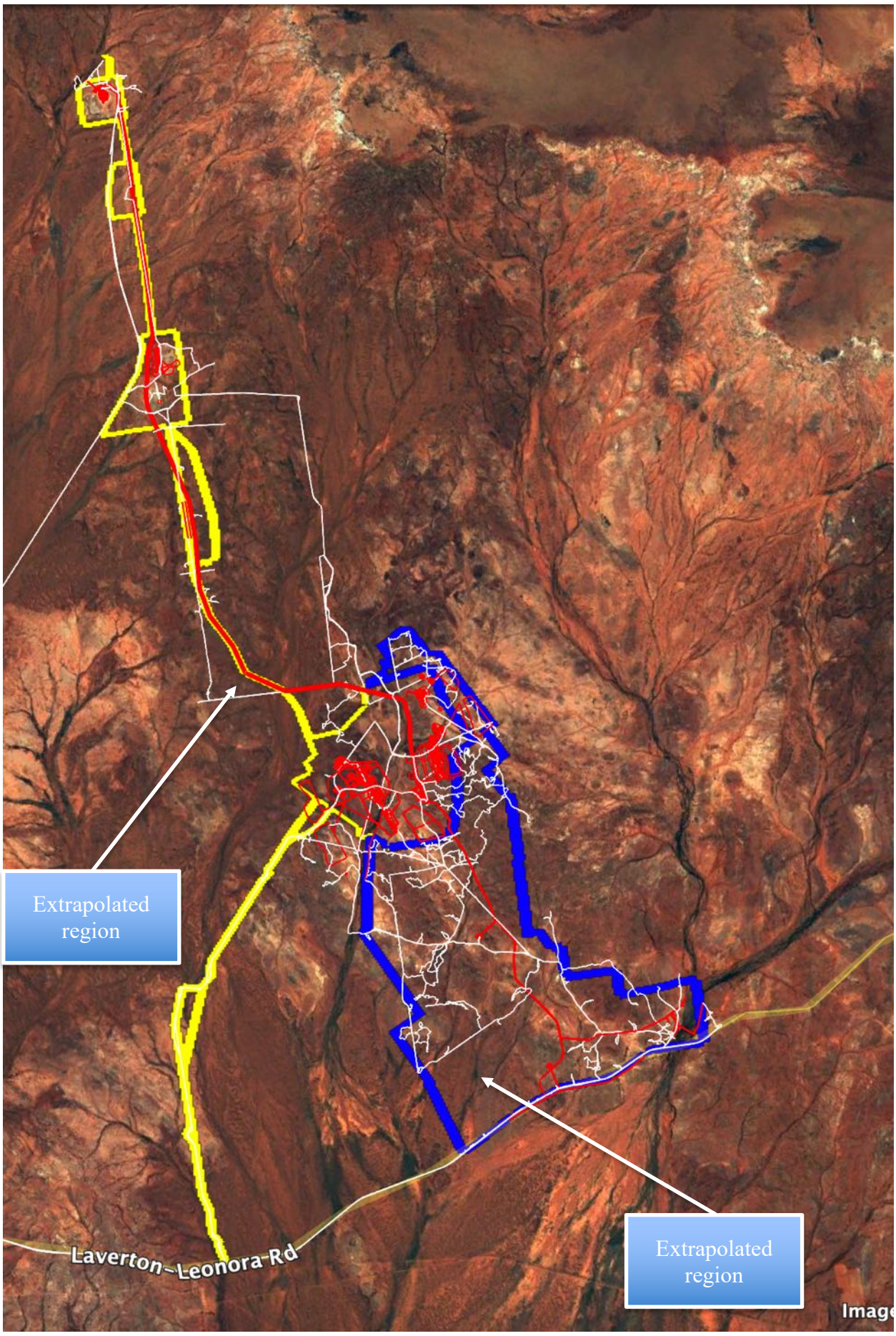
3.11. Survey Effort and Coverage with the Study Area

As access was excellent throughout much of the Study Area, survey coverage was facilitated by numerous existing tracks or fence lines, Figure 23. Where access was limited, but where aerial photography indicated anomalous landscapes, these were accessed on foot where necessary to map the vegetation and develop flora inventories. However, two regions within the Study Area appeared as relatively homogeneous landscapes, were readily access on their perimeters but posed challenges to off-track access within them within the time frame available for survey. The vegetation of these three regions were mapped by extrapolating from the margins at accessible points. These areas were:

- South-western portion of the Study Area north of the Leonora – Laverton Rd – a region of broad drainage lines and broad gently sloping distributary fans.
- Central portion of the Study Area representing the southern 5 km of the proposed haul road from Mertondale to Cardinia, a region with a complex of Hardpan Mulga Shrublands (HPMS), Mulga-Wanderrie Grassy Woodlands (MUWA) and Stony *Acacia* – *Eremophila* Shrublands (SAES) vegetation associations.

The community types in both the extrapolated areas are not particularly complex and all are widely distributed within both the Study Area and the eastern Murchison bioregion. Despite the issue with limited access in the two extrapolated areas, Western Botanical is confident that the vegetation mapping has been conducted effectively and sufficiently accurately given the size of the Study Area and the observed complexity of both flora and vegetation.

Figure 23. GPS Track Logs and Survey Intensity Within the Study Area


Extrapolated region
Laverton-Leonora Rd
Extrapolated region

3.12. Vegetation Condition

The bulk of vegetation was observed within the Study Area as being of either Pristine (1) ("Pristine or nearly so, no obvious signs of disturbance"); or Excellent (2) ("Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species") Condition, utilising the Keighery (1994) scale, Appendix 3.

Exceptions to this were in areas either recently or historically disturbed in exploration, mining or pastoralism (fence lines). The areas of stony hill tops supporting *Acacia* and Mulga were generally Pristine while major drainage lines (Cardinia Creek and Bummer Creek) supported patches of aggressive weed species such as Buffel and Birdwood Grasses that reduced the condition score to Very Good (3) ranking ("Vegetation structure altered, obvious signs of disturbance … such as the presence of some more aggressive weeds..").

Little evidence of significant impact from grazing was observed on the bulk of native vegetation, with the exception of cattle tracks nearby and within the major drainage lines where deeper soils and ephemeral surface water is present from time to time.

Figure 24. Vegetation Condition Map

360000 370000

6830000 6820000 6810000

Legend
- Baseline Survey Limits
- Stantec Clip Bdry
- Road
- Track

Vegetation Condition
- Excellent
- Very Good
- Good
- Degraded
- Completely Degraded

Leonora Nambi Road

Source: Vegetation: Western Botanical, Stantec; Tenements: DMIRS, Topography: Landgate, Image: Outline Imagery (09/07/2018

Consultant: Western Botanical

Coverage: Western Botanical, Stantec

Layout: Leonora

N

0 1,250 2,500 m

Scale: 1:110,000
MGA94 (Zone 51)

CAD Ref: a2553_Veg_WB_06_01

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Leonora Gold Project
Vegetation Condition
Western Botanical & Stantec Mapping

3.13. Statistical Analysis of Vegetation Associations

The statistical analysis of vegetation associations provided insights into the inter-relatedness of vegetation associations, Figure 25. Those communities demonstrating halophytic vegetation components, whether the full suite of *Hakea preissii, Maireana* and / or *Tecticornia* species (8.x vegetation unit series) representing the saline chenopod plains prevalent in the central region of the Study Area surrounding the Cardinia development site, or those of the often adjacent *Acacia papyrocarpa* woodlands (5.x vegetation unit series) grouping together due to the influence of the understorey species prevalent in both community groups. While these two differ markedly in vegetation structure, the *A. papyrocarpa* woodlands representing the tallest woodlands in the region, the understorey clearly shows they are closely related in species composition. Interestingly, the Breakaway complex (11.01 vegetation unit) also nests with this group, sharing much of the understorey components of *Maireana* species and *Eremophila scoparia*.

The Mulga woodlands on non-saline soils (1.x vegetation unit series) nest with the *Acacia* spp. (other than Mulga) on stony (gabbro and basalt) hills (4.x vegetation unit series), indicating a shared suite of understorey species among both groups of vegetation associations. The dominant and defining overstorey varies markedly between the two with the suite of Mulga species generally found on neutral or acidic soils (*Acacia aneura, A. aptaneura, A. caesaneura, A. fuscaneura, A. incurvaneura, A. macraneura* and *A. mulganeura*) not showing habitat specificity in the data set available, but strongly contrasting with the *Acacia* sp. Marshall Pool and/or *A. sibirica* dominated communities, the *Acacia doreta* short phyllode form and the *Acacia burkittii* shrublands on basalt or meta-gabbro geologies which have all been infiltrated with groundwater calcretes, producing alkaline soils. The non-Mulga *Acacia* species prevalent on the greenstone hills are very habitat specific while Mulga seems far more relaxed in its habitat preference.

The calcrete influenced soils of the Gundockerta Land System support the *Acacia victoriae* shrublands (6.01 vegetation unit) along with large patches of *Hakea preissii* over *Eremophila scoparia* (8.06 vegetation unit) and small, isolated, disjunct patches of *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH26770) (7.01 vegetation unit). The occurrence of the latter represents a slight range extension for this species which is often encountered on calcrete platforms on the margins of salt lakes and paleochannels in the eastern Murchison biogeographic region.

Low lying non-saline sites subject to waterlogging following heavy rainfall may support either (i) small gilgai with species tolerant of heavy clay soils such as Claypan Grass *Eragrostis setifolia* and tall shrubs such as *Pittosporum angustifolium* (10.02 vegetation unit) or (ii) in the a few cases, support dense *Eragrostis xerophila* (Neverfail) grasslands (10.01 vegetation unit). These are both infrequent in the landscape though the component species of the vegetation associations are very widespread in WA and more broadly in inland Australia.

While the data set available is relatively small (74 Relevés) in relation to the number of community types described (51 vegetation associations) and has little replication is small vegetation units, the PATN analysis has lumped a disparate group of Gilgai (*Pittosporum*

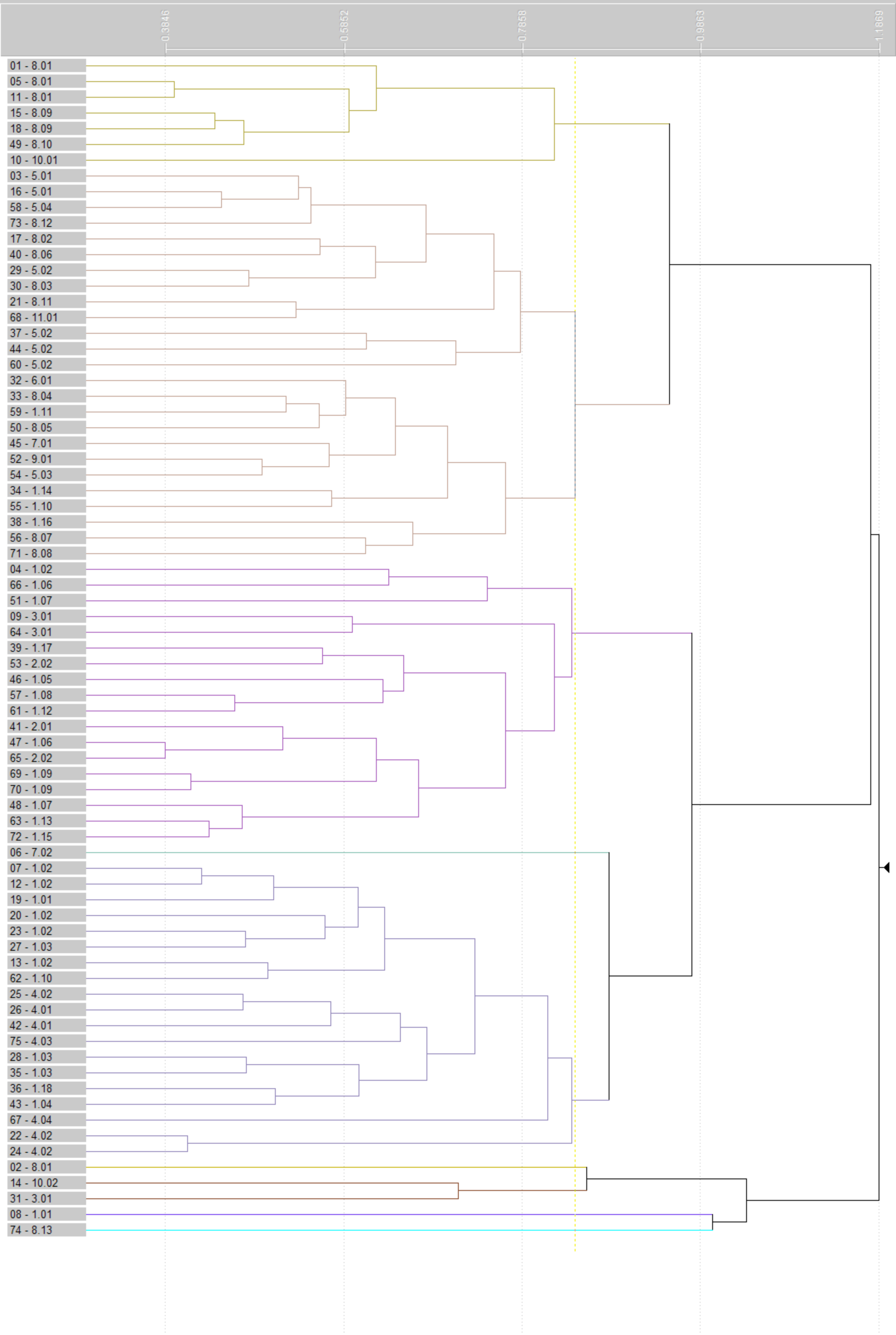
angustifolium, *Acacia tetragonophylla* and *A. victoriae* Shrubland over Claypan Grasses, 10.02), a *Hakea preissii – Tecticornia disarticulata* Shrubland (8.01), Mulga Woodland over *Eremophila platycalyx* subsp. Leonora (1.01), drainage line with Mulga (3.01) and a bare claypan (8.13) together. This could be an artefact of one or two species being relatively dominant within these communities or in having a generally low projected foliar cover.

Major drainage lines dominated by Mulga (vegetation unit 3.01 representing Cardinia Creek and similar communities) do not nest together, and are scatted within the dendrogram, likely due to the varying understorey composition at each site, strongly influenced by adjacent community types.

The dendrogram produced on this data set indicates insufficient replication of Relevés to show a strong grouping of community types. However, descriptions of community types were made over relatively large areas within each community and species profiles at each Relevé site were comprehensive, capturing a high proportion of the biodiversity present at the time of survey.

Figure 25. Vegetation Association Row Fusion Dendrogram

Row Fusion Dendrogram



3.14. Regional Context of Vegetation

The vegetation of the Study Area has been mapped at a high level of detail, NVIS Level 5 *Association.* Regional context (outside the Study Area) of vegetation associations is only available at a coarser level of detail, Land Systems as mapped by DoA (1994). However, it is the authors professional judgement that the majority of vegetation associations of the Study Area are broadly representative of those in the immediate region between Leonora and Laverton.

- The vegetation associated with stony hills with limonite, weathered granite Breakaways and the broad colluvial and alluvial plains are well represented;
- The saline lake systems are similarly widely distributed in the numerous paleochannels of the Murchison biogeographic region.

Those vegetation associations that are observed within the Study Area to be small in area, associated with specific geology and disjunct from similar associations include:

- *Eragrostis* sp. Yeelirrie Calcrete grasslands on calcrete. This appears to be associated with occurrences of the Gundockerta Land System within the Study Area. This species is associated with the Cosmo and Melaleuca Land Systems in other paleochannels north of the Study Area.
- *Neurachne munroi* grasslands on mudstone shale on stony hill slopes. It is difficult to draw any meaningful relationship between this species and the relatively broad Land System scale regional mapping available.
- *Acacia doreta* Short phyllode form (M. Stone & S. Colwill WB34381) – *Acacia* sp. Marshall Pool woodland on gabbro and basalt hill. *Acacia doreta* Short phyllode form (M. Stone & S. Colwill WB34381) has a widespread distribution in the eastern and northern parts of its range while *Acacia doreta* Long phyllode form (G. & S. Cockerton 38632) is prevalent between Leinster and Wiluna.

While *Acacia* sp. Marshall Pool Shrublands and *Acacia* sp. Marshall Pool – *Acacia sibirica* Shrublands are common and extensive within the southern part of the Study Area, and they are also common in the region immediately east and south of the Study Area on adjacent occurrences of the Leonora Land System on Minara and Glenorn Stations. They are not known to be widely distributed in the region other than an occurrence at Weebo Station some 70 km NNW of the Study Area (Western Botanical 2018b).

4. Assessment Against the 10 Clearing Principles

Principle (a) – Native vegetation should not be cleared if it comprises a high level of biological diversity.

While the Study Area has a significant diversity of Land Systems and Vegetation Associations (at NVIS 5 *Association*), the diversity of flora within each community type is consistent with that expected respective community types throughout the north-eastern Goldfields.

A total species richness of 236 species is considered typical of a large Study Area though few annuals were observed in the 2018 and 2019 surveys. It is estimated that in the order of 50 annual species could be encountered in more favourable seasons.

The Project is not at variance with this principle.

Principle (b) – Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.

While flora and vegetation are utilised by fauna and for food and habitat, there are no known obligate fauna-flora correlations within the Study Area. Stantec (2017) recorded a range of vertebrate fauna but none that indicated a specific requirement for flora or vegetation within the Study Area. The *Acacia papyrocarpa* woodlands offer nesting sites for birds of prey (active nesting of Australian Hobbys was observed) and areas with active nests should be identified and avoided with significant buffers where possible. Australian Hobbys are not listed as having conservation concern (Stantec, 2017).

Parts of the Study Area may be at variance with this principle with regard to *Acacia papyrocarpa* woodlands and nesting opportunities for some birds of prey.

Principle (c) – Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.

No Threatened (Rare) Flora were recorded in any of the studies conducted within the Study Area and none are known in the immediate area adjacent to the Study Area. Further, while several undescribed species are known within the Study Area, none of these are considered likely to acquire Threatened Flora conservation listing based upon current understanding.

The Project is not at variance with this principle.

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 are no vegetation related no PECs or TECS within the Study Area and the habitats of the Study Area do not reflect any vegetation related PECs or TECs in the region.

The Project is not at variance with this principle.

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.

The region encompassing the Study Area has been subject to significant historical Pastoralism, exploration and mining, however, the bulk of vegetation in the region has not been cleared and is in Excellent to Good condition with many of the hill tops being in a near-Pristine condition.

The Project is not at variance with this principle.

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.

Two major and several minor ephemeral Mulga (*Acacia aneura* and its allies) or *Acacia burkittii* dominated creeklines drain from north-east to south-west within the Study Area. Some of the deposit areas lie at or near the heads of these ephemeral creek systems and the proposed borefield lies within a section of Bummer Creek in the south-eastern part of the Study Area. While surface water may pond for periods of time in parts of the major creeklines, these are not permanent water holes. While these are ephemeral water courses, they are not considered wetlands.

The Project may be at variance with this principle.

Principle (g) – Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.

While direct clearing of vegetation for minesite development will directly impact native vegetation, development plans will include measures to minimise and mitigate interruptions to drainage, and the risk of sedimentation down stream.

The Project is not at variance with this principle.

Principle (h) – Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.

No conservation areas lie in close proximity to the Study Area.

The Project is not at variance with this principle.

Principle (i) – Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.

Mine development planning will include measures to minimise and mitigate the risk of increased sedimentation downstream of development envelopes while maintaining surface runoff patterns around infrastructure.

The Project is not at variance with this principle.

Principle (j) – Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding.

The proposed developments within the Study Area are relatively small and will have measures implemented to maintain surface drainage around infrastructure, maintaining surface flows downstream.

The Project is not at variance with this principle.

5. Limitations

Limitation	Discussion
Available sources of contextual information	Previous reports on the flora and vegetation of areas immediately adjacent to the Study Area were useful references while the regional scale work on Land Systems by DoA provide a broad-scale view of vegetation – landscape – geology patterns in the region. Geoff Cockerton, senior botanist, has had over 30 years' experience working on the flora and vegetation of the north-eastern Goldfields and is familiar with much of the flora of the region. This is not considered a limitation.
The Scope of the survey	The scope of the survey was adequate to gain a good and comprehensive assessment of the perennial flora and vegetation associations of the Study Area. While not incorporating quadrats, the study relied on the implementation of 74 Relevés and development of comprehensive species lists within vegetation associations mapped at NVIS 5 Association level. This is not considered a limitation.
Proportion of flora collected and identified	The perennial flora of the Study Area is considered well assessed. However, the annual and geophytic species were largely not assessed during the 2018-19 surveys due to dry seasonal conditions. Fifteen of the 236 species collected (6.35%) were not able to be identified beyond genus or in some cases family level due to the lack of adequate material and dry seasonal conditions. While Stantec have captured many of the annuals of their Study Areas, these did not overlap with the Study Area for this project. This is considered a limitation in relation to some perennials and the majority of annual and geophytic species that may be present within the Study Area.
Completeness and further work which may be needed	Most of the Study Area was covered adequately to fulfil the scope and to adequately assess the perennial flora and vegetation associations. Two relatively homogeneous regions within the Study Area had vegetation within each extrapolated from accessible tracks on their margins due to limitations of timeframe in the field and the relative inaccessibility of these areas. The author is confident of having assessed perennial species well though annual and geophytic species were not adequately assessed due to the relatively dry seasonal conditions experienced in the months preceding each of the two field surveys.
Mapping reliability	Excellent quality 1:7,500 scale colour aerial photograph field maps were available for the southern portion of the Study area and allowed reasonably accurate mapping of vegetation associations. The field maps available northern portion of the Study Area inclusive of the linear proposed haul road alignment and adjacent old workings, were at 1:12,500 scale and of poorer quality, meaning definition of smaller units on hard copy maps was more challenging in this region. However, CAD Resources provided an electronic tablet with high resolution recent aerial photography of the entire Study Area which was extremely useful in interrogating areas at higher resolution that the hard copy maps allowed. In all cases, community boundaries are presented at +/- 50 to 100m accuracy. Therefore this is not considered a limitation.
Timing: weather, season	The weather immediately preceding both field surveys in late 2018 and early 2019 were during dry seasonal conditions. This meant that few perennial species were in flower, though this was not a limitation in most cases. However, annual species were generally not able to be

Limitation	Discussion
	assessed except in moisture gaining sites. This is considered a limitation for the assessment of annuals.
Disturbances	Substantial historical disturbance and some current and recently completed drilling was evident in some parts of the Study Area. These areas have been mapped as Disturbed. The bulk of the Study Area showed little evidence of historical or recent disturbance. This is not considered a limitation.
Intensity	The surveys relied on traverses and advanced Relevés (where projected foliar cover was estimated for each species encountered at each site) rather than quadrats. Seventy four relevés and many kilometres of traverses were undertaken within the Study Area as access allowed and was deemed necessary to confidently assess the vegetation and flora. The surveys were comprehensive and exceeded the requirements for a Targeted Survey but do not technically meet the requirements for a Detailed Survey as presented in the EPA Technical Guidance (2016). Survey intensity is not considered a limitation.
Resources	Adequate resources were made available by Kin for implementation of the survey at the intensity and survey design undertaken. This is not considered a limitation.
Access	Access to most of the Study Area was excellent and allowed a thorough and comprehensive assessment to be undertaken. Two relatively homogeneous areas with limited access were confidently extrapolated from their respective perimeters. This is not considered a limitation.
Experience levels	Geoff Cockerton, senior botanist, has had over 30 years' experience working with the flora and vegetation of the north-eastern Goldfields and is familiar with much of the flora of the region. He was assisted by Ms Gemma Grigg, an enthusiastic, competent and talented environmental technician with a keen eye for flora. This is not considered a limitation.

6. List of Participants

Staff Member	Field Surveys	Specimen Identification	Data Analysis	Report Preparation
Geoff Cockerton B.Sc. (Biology) *License No. – SL011924*	**1**	**1**	**1**	**1**
Gemma Grigg B.Sc.	**1**			
Dr. David Leach		**1**		
Mr. Jono Warden		**1**	**1**	
Ms Morgan Cockerton, Mr. Steven Cockerton		**1**		

7. Acknowledgements

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- Ms Anthea Pate, Environmental Coordinator, Kin Mining for site orientation and provision of guidance.
- Ms Gemma Grigg for competent field assistance during both field surveys.
- CAD Resources Pty Ltd for provision of electronic tablet with high resolution aerial photography and for preparation of maps.

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Western Botanical (2018c) *Regional survey for Acacia sp. Marshall Pool (G. Cockerton 3024).* Consultant's report to Stantec Pty Ltd and Kin Mining Pty Ltd.

Wilson & Albrecht (2002) *Notes on the genus Cratystylis (Asteraceae).* Nuytsia v14 No 3, 2002, pp. 445 – 452.

Appendix 1. Systematic Flora Species List of Those Collected in the 2018-19 Surveys

Note:

Asterisk * indicates a species reported by Stantec 2017, 2018 a, b has either undergone a name change and is now aligned with that currently accepted or is regarded as having been misidentified and is not aligned with a species currently reported.

Species with uncertain nomenclature or not adequately identified but reported in Stantec 2017-2018 have been omitted.

Family	Taxon	Status	Source	
			Western Botanical	Stantec
Aizoaceae	Sarcozona praecox	Range Extension	1	1*
Aizoaceae	Gunniopsis propinqua	Priority 3		1
Amaranthaceae	Alternanthera nodiflora		1	1
Amaranthaceae	Ptilotus aervoides			1
Amaranthaceae	Ptilotus divaricatus		1	1
Amaranthaceae	Ptilotus drummondii			1
Amaranthaceae	Ptilotus exaltatus		1	1*
Amaranthaceae	Ptilotus gaudichaudii subsp. gaudichaudii			1
Amaranthaceae	Ptilotus helipteroides			1
Amaranthaceae	Ptilotus macrocephalus		1	1
Amaranthaceae	Ptilotus obovatus (Typical Goldfields form) (G Cockerton et al 15213)	Undescribed, widespread	1	1
Amaranthaceae	Ptilotus obovatus (Upright form) (G Cockerton et al 15206)	Undescribed, widespread	1	
Amaranthaceae	Ptilotus roei		1	1
Amaranthaceae	Ptilotus schwartzii		1	
Amaranthaceae	Surreya diandra		1	1
Anacardiaceae	Schinus terebinthifolia *	Weed	1	
Apocynaceae	Marsdenia australis		1	1*
Asteraceae	Bidens bipinnata *	Weed	1	
Asteraceae	Brachyscome ciliaris sens. lat.	Indeterminate	1	1
Asteraceae	Calocephalus multiflorus			1
Asteraceae	Calotis hispidula			1
Asteraceae	Calotis multicaulis			1
Asteraceae	Centipeda minima			1
Asteraceae	Centipeda thespidioides		1	1
Asteraceae	Cephalipterum drummondii			1
Asteraceae	Chrysocephalum puteale		1	1
Asteraceae	Chthonocephalus pseudevax			1
Asteraceae	Cratystylis centralis	Priority 3	1	
Asteraceae	Cratystylis microphylla			1
Asteraceae	Cratystylis subspinescens		1	1

Family	Taxon	Status	Source	
			Western Botanical	Stantec
Asteraceae	Gnephosis arachnoidea			1
Asteraceae	Lemooria burkittii			1
Asteraceae	Minuria cunninghamii			1
Asteraceae	Myriocephalus pygmaeus			1
Asteraceae	Olearia muelleri		1	1
Asteraceae	Podolepis capillaris		1	
Asteraceae	Podolepis ?kendalii			1
Asteraceae	Podolepis lessonii			1
Asteraceae	Pterocaulon sphacelatum		1	
Asteraceae	Rhodanthe ?charsleyae			1
Asteraceae	Rhodanthe maryonii			1
Asteraceae	Rhodanthe propinqua			1
Asteraceae	Roebuckiella oncocarpa			1
Asteraceae	Senecio magnificus		1	1
Asteraceae	Sonchus oleraceus *	Weed	1	
Asteraceae	Streptoglossa liatroides		1	1
Asteraceae	Vittadinia eremaea		1	1*
Asteraceae	Vittadinia sulcata			1
Asteraceae	Waitzia acuminata			1
Brassicaceae	Brassicaceae sp. INDET	Indeterminate	1	
Brassicaceae	Lepidium didymum *	Weed	1	
Brassicaceae	Lepidium oxytrichum			1
Brassicaceae	Lepidium platypetalum		1	1
Brassicaceae	Sisymbrium erysimoides			1
Brassicaceae	Sisymbrium irio			1
Cactaceae	Cylindropuntia fulgida car. mamillata		1	1
Campanulaceae	Wahlenbergia queenslandica		1	1
Campanulaceae	Wahlenbergia tumidifructa			1
Caryophyllaceae	Polycarpon tetraphyllum *	Weed, Range Extension	1	
Casuarinaceae	Casuarina pauper		1	1
Chenopodiaceae	Atriplex bunburyana		1	1
Chenopodiaceae	Atriplex codonocarpa		1	1
Chenopodiaceae	Atriplex nummularia			1

Family	Taxon	Status	Source	
			Western Botanical	Stantec
Chenopodiaceae	Atriplex quinii		1	1
Chenopodiaceae	Atriplex vesicaria			1
Chenopodiaceae	Chenopodium curvispicatum		1	1
Chenopodiaceae	Dissocarpus paradoxus		1	1
Chenopodiaceae	Dysphania melanocarpa			1
Chenopodiaceae	Dysphania saxatilis			1
Chenopodiaceae	Einadia nutans subsp. eremaea		1	1
Chenopodiaceae	Enchylaena tomentosa		1	1
Chenopodiaceae	Eriochiton sclerolaenoides			1
Chenopodiaceae	Indet ? Chenopod, need more material	Indeterminate	1	
Chenopodiaceae	Maireana carnosa		1	1
Chenopodiaceae	Maireana convexa		1	1
Chenopodiaceae	Maireana georgei		1	1
Chenopodiaceae	Maireana glomerifolia		1	1
Chenopodiaceae	Maireana planifolia		1	
Chenopodiaceae	Maireana platycarpa sens. lat.		1	1
Chenopodiaceae	Maireana pyramidata		1	1
Chenopodiaceae	Maireana sedifolia		1	1
Chenopodiaceae	Maireana thesioides		1	
Chenopodiaceae	Maireana tomentosa (type 1 WB38650) complex	Taxonomic Interest	1	1
Chenopodiaceae	Maireana trichoptera		1	
Chenopodiaceae	Maireana triptera		1	1
Chenopodiaceae	Maireana villosa			1
Chenopodiaceae	Rhagodia drummondii		1	1
Chenopodiaceae	Salsola australis		1	1
Chenopodiaceae	Sclerolaena aff. cuneata	Indeterminate	1	
Chenopodiaceae	Sclerolaena cuneata		1	1
Chenopodiaceae	Sclerolaena densiflora		1	1
Chenopodiaceae	Sclerolaena diacantha		1	1
Chenopodiaceae	Sclerolaena drummondii			1
Chenopodiaceae	Sclerolaena eriacantha		1	1
Chenopodiaceae	Sclerolaena eurotioides		1	

Family	Taxon	Status	Source	
			Western Botanical	Stantec
Chenopodiaceae	Sclerolaena fusiformis			1
Chenopodiaceae	Sclerolaena lanicuspis			1
Chenopodiaceae	Sclerolaena patenticuspis		1	
Chenopodiaceae	Tecticornia disarticulata		1	1
Chenopodiaceae	Tecticornia indica			1
Chenopodiaceae	Tecticornia pergranulata subsp. pergranulata		1	1
Chenopodiaceae	Tecticornia pruinosa			1
Convolvulaceae	Cuscuta planiflora			1
Convolvulaceae	Convolvulus remotus		1	
Convolvulaceae	Duperreya commixta		1	1
Crassulaceae	Crassula colorata			1
Cucurbitaceae	Citrullus colocynthis *	Weed	1	
Cucurbitaceae	Citrullus myriocarpus *	Weed	1	
Cyperaceae	Bulbostylis / Fimbristylis sp. #202	Indeterminate	1	
Cyperaceae	Bulbostylis / Fimbristylis sp. #258	Indeterminate	1	
Cyperaceae	Centrolepis sp. Leonora (G. Cockerton & G. Grigg WB40071)	Taxonomic Interest	1	
Cyperaceae	Cyperus iria			1
Cyperaceae	Eleocahris pallens			1*
Cyperaceae	Isolepis congrua			1
Euphorbiaceae	Euphorbia drummondii		1	1
Fabaceae	Acacia aneura		1	1
Fabaceae	Acacia aptaneura		1	1
Fabaceae	Acacia ayersiana			1
Fabaceae	Acacia brachystachya		1	
Fabaceae	Acacia burkittii		1	1
Fabaceae	Acacia caesaneura		1	1
Fabaceae	Acacia coolgardiensis (doubtful)			1
Fabaceae	Acacia craspedocarpa (lanceolate phyllode form)		1	
Fabaceae	Acacia craspedocarpa (ovate phyllode form)		1	

Family	Taxon	Status	Source	
			Western Botanical	Stantec
Fabaceae	Acacia doreta (short phyllode form)	Typical form of the species	1	1
Fabaceae	Acacia duriuscula			1
Fabaceae	Acacia erinaceae (grey leaf form)		1	
Fabaceae	Acacia fuscaneura		1	
Fabaceae	Acacia incurvaneura		1	1
Fabaceae	Acacia kalgoorliensis			1
Fabaceae	Acacia kempeana		1	1
Fabaceae	Acacia macraneura		1	1
Fabaceae	Acacia masliniana		1	
Fabaceae	Acacia mulganeura		1	
Fabaceae	Acacia oswaldii typical form		1	1
Fabaceae	Acacia papyrocarpa		1	1*
Fabaceae	Acacia pteraneura		1	1
Fabaceae	Acacia quadrimarginea Narrow phyllode form (G. Cockerton WB38064)	Undescribed, widespread	1	
Fabaceae	Acacia quadrimarginea sens. str.	Typical form of the species	1	1
Fabaceae	Acacia ramulosa var. linophylla			1
Fabaceae	Acacia ramulosa var. ramulosa		1	
Fabaceae	Acacia sibirica		1	1
Fabaceae	Acacia sp. Marshall Pool (G. Cockerton 3024)	Priority 3, Undescribed, limited in distribution	1	1
Fabaceae	Acacia tetragonophylla		1	1
Fabaceae	Acacia victoriae		1	1
Fabaceae	Glycine canescens		1	1
Fabaceae	Indigofera georgei		1	
Fabaceae	Medicago sp. Indet. *	Weed	1	
Fabaceae	Senna artemisioides subsp. artemisioides		1	1
Fabaceae	Senna artemisioides subsp. filifolia		1	1
Fabaceae	Senna artemisioides subsp. helmsii		1	1

Family	Taxon	Status	Source	
			Western Botanical	Stantec
Fabaceae	Senna artemisioides subsp. X sturtii			1
Fabaceae	Senna cardiosperma		1	1
Fabaceae	Senna charlesiana			1
Fabaceae	Senna chatelainiana		1	
Fabaceae	Senna glaucophylla		1	
Fabaceae	Senna manicula		1	1
Fabaceae	Senna stowardii			1
Fabaceae	Senna sp. Meekatharra (E. Bailey 1-26)	Undescribed, widespread	1	1
Fabaceae	Templetonia incrassata		1	
Frankeniaceae	Frankenia cinerea		1	
Frankeniaceae	Frankenia fecunda		1	
Frankeniaceae	Frankenia laxiflora		1	
Frankeniaceae	Frankenia setosa (type 1)	Taxonomic Interest	1	1
Frankeniaceae	Frankenia setosa (type 2)	Taxonomic Interest	1	
Geraniaceae	Erodium sp.			1
Goodeniaceae	Brunonia australis			1
Goodeniaceae	Goodenia havilandii			1
Goodeniaceae	Goodenia triodiophila			1
Goodeniaceae	Goodenia sp. (?G. occidentalis)	Indeterminate	1	1
Goodeniaceae	Scaevola densiflora			1
Goodeniaceae	Scaevola spinescens (broad leaf non-spiny form)	Undescribed, widespread	1	1
Goodeniaceae	Scaevola spinescens (narrow leaved spiny form)	Undescribed, widespread	1	
Goodeniaceae	Velleia glabrata			1
Juncaceae	Juncus aridicola		1	1
Lamiaceae	Prostanthera albiflora		1	
Lamiaceae	Prostanthera althoferi subsp. althoferi		1	
Lamiaceae	Teucrium teucriflora		1	1
Lobeliaceae	Isotoma hypocrateriformis		1	

Family	Taxon	Status	Source	
			Western Botanical	Stantec
Loranthaceae	Amyema fitzgeraldii		1	1
Loranthaceae	Amyema miquellii			1
Loranthaceae	Amyema preissii			1
Loranthaceae	Lysiana aff. murrayi	Indeterminate	1	1
Malvaceae	Abutilon cryptopetalum		1	1
Malvaceae	Abutilon oxycarpum subsp. Prostrate (A.A. Mitchell PRP 1266)		1	1
Malvaceae	Brachychiton gregorii		1	1
Malvaceae	Hibiscus burtonii		1	1
Malvaceae	Hibiscus sp. Gardneri (A.L. Payne PRP 1435)	Undescribed, widespread	1	
Malvaceae	Hibiscus sp. Perrinvale (J. Warden & E. Ager WB10581)	Taxonomic and Conservation Interest	1	
Malvaceae	Lawrencia densiflora			1
Malvaceae	Malvastrum americanum *	Weed	1	1
Malvaceae	Sida aff. fibulifera	Indeterminate	1	
Malvaceae	Sida calyxhymenia		1	1
Malvaceae	Sida ectogamma		1	1
Malvaceae	Sida intricata		1	1
Malvaceae	Sida sp. dark green fruits (S. van Leeuwen 2260)	Undescribed, widespread	1	
Malvaceae	Sida sp. Excedentifolia (J.L. Egan 1925)	Undescribed, widespread	1	1
Malvaceae	Sida sp. Indet	Indeterminate	1	1
Malvaceae	Sida sp. Indet #12	Indeterminate	1	
Marsileaceae	Marsilea drummondii		1	1*
Marsileaceae	Marsilea hirsuta		1	
Myrtaceae	Calytrix desolata		1	
Myrtaceae	Eucalyptus gypsophila		1	1*
Myrtaceae	Eucalyptus lucasii		1	
Myrtaceae	Hysterobaeckea occlusa		1	
Nyctaginaceae	Boerhavia coccinea			1
Nyctaginaceae	Boerhavia repleta		1	1
Phyllanthaceae	Phyllanthus irwinii			1

Family	Taxon	Status	Source	
			Western Botanical	Stantec
Pittosporaceae	Pittosporum angustifolium		1	1
Poaceae	Aristida contorta		1	1
Poaceae	Aristida holathera		1	1
Poaceae	Aristida inaequiglumis		1	
Poaceae	Aristida obscura		1	1
Poaceae	Austrostipa elegantissima		1	1
Poaceae	Austrostipa scabra		1	
Poaceae	Austrostipa nitida			1
Poaceae	Austrostipa trichophylla			1
Poaceae	Austrostipa sp. #224 INDET	Indeterminate	1	
Poaceae	Cenchrus ciliaris *	Weed	1	
Poaceae	Cenchrus setiger *	Weed	1	
Poaceae	Cymbopogon ambiguus		1	1*
Poaceae	Cynodon prostratus			1
Poaceae	Dactyloctenium radulans		1	1
Poaceae	Dichanthium sericeum		1	
Poaceae	Digitaria brownii		1	1
Poaceae	Enneapogon avenaceus		1	1
Poaceae	Enneapogon caerulescens		1	1
Poaceae	Enneapogon cylindricus		1	
Poaceae	Enneapogon polyphyllus		1	1
Poaceae	Enteropogon ramosus		1	1
Poaceae	Eragrostis aff. kennedyae	Indeterminate	1	1
Poaceae	Eragrostis dielsii		1	1
Poaceae	Eragrostis eriopoda		1	1
Poaceae	Eragrostis lancunaria		1	1
Poaceae	Eragrostis leptocarpa		1	1
Poaceae	Eragrostis pergracilis			1
Poaceae	Eragrostis setifolia		1	1
Poaceae	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH 26770)	Taxonomic Interest, Range Extension, Undescribed, widespread	1	

Family	Taxon	Status	Source	
			Western Botanical	Stantec
Poaceae	Eragrostis xerophila		1	
Poaceae	Eriachne flaccida			1
Poaceae	Eriachne helmsii		1	1
Poaceae	Eriachne mucronata desert form glabrous (G. Cockerton & S. Cockerton WB40048)	Taxonomic Interest, Undescribed, widespread	1	
Poaceae	Eriachne ovata		1	
Poaceae	Eriachne pulchella subsp. pulchella		1	1
Poaceae	Iseilema eremaea		1	1
Poaceae	Monachather paradoxus		1	1
Poaceae	Neurachne munroi	Poorly Collected	1	
Poaceae	Paspalidium basicladum		1	
Poaceae	Poaceae sp. #197 INDET	Indeterminate	1	
Poaceae	Sporobolus actinocladus	Range Extension	1	1
Poaceae	Sporobolus caroli		1	1*
Poaceae	Themeda triandra		1	1
Poaceae	Thyridolepis multiculmis		1	1
Poaceae	Triodia basedowii (doubtful)			1
Poaceae	Tripogonella loliiformis		1	
Polygalaceae	Polygala isingii		1	
Polygalaceae	Rumex vesicarius *	Weed	1	
Polygoniaceae	Rumex hypogaeus *	Weed	1	
Portulacaceae	Calandrinia creethiae			1
Portulacaceae	Calandrinia eremaea			1
Portulacaceae	Calandrinia porifera			1
Portulacaceae	Calandrinia ptychosperma			1
Portulacaceae	Calandrinia sp. Black angular seeds (A.A. Mitchell PRP 1661)			1
Portulacaceae	Calandrinia translucens			1
Portulacaceae	Portulaca oleracea		1	1
Primulaceae	Lysimachia arvensis *	Weed	1	1
Proteaceae	Grevillea acuaria		1	1
Proteaceae	Grevillea berryana		1	1

Family	Taxon	Status	Source	
			Western Botanical	Stantec
Proteaceae	Grevillea extorris		1	1
Proteaceae	Hakea arida subsp. recurva		1	
Proteaceae	Hakea leucoptera subsp. sericipes		1	
Proteaceae	Hakea lorea subsp. lorea		1	1
Proteaceae	Hakea preissii		1	1
Pteridaceae	Cheilanthes lasiophyllum		1	
Pteridaceae	Cheilanthes sieberi		1	1
Rubiaceae	Alectryon oleifolius subsp. canescens	Limit of Range, Range Extension	1	
Rubiaceae	Psydrax latifolium		1	
Rubiaceae	Psydrax rigidula		1	1
Rubiaceae	Psydrax suaveolens		1	1
Rutaceae	Philotheca brucei subsp. brucei		1	
Santalaceae	Exocarpos aphyllus		1	1
Santalaceae	Santalum acuminatum		1	
Santalaceae	Santalum lanceolatum		1	1
Santalaceae	Santalum spicatum		1	1
Sapindaceae	Dodonaea lobulata		1	1
Sapindaceae	Dodonaea rigida		1	1
Scrophulariaceae	Eremophila alternifolia		1	1
Scrophulariaceae	Eremophila annoscaulis	Priority 3	1	
Scrophulariaceae	Eremophila clarkei		1	
Scrophulariaceae	Eremophila compacta subsp. compacta		1	
Scrophulariaceae	Eremophila exilifolia			1*
Scrophulariaceae	Eremophila forrestii		1	1
Scrophulariaceae	Eremophila georgei		1	1
Scrophulariaceae	Eremophila gilesii subsp. variabilis			1
Scrophulariaceae	Eremophila glabra subsp. glabra			1
Scrophulariaceae	Eremophila glandulifera			1
Scrophulariaceae	Eremophila granitica		1	
Scrophulariaceae	Eremophila hygrophana		1	
Scrophulariaceae	Eremophila homoplastica			1
Scrophulariaceae	Eremophila latrobei subsp. latrobei		1	1

Family	Taxon	Status	Source	
			Western Botanical	Stantec
Scrophulariaceae	Eremophila latrobei var. tuberculosa		1	
Scrophulariaceae	Eremophila longifolia		1	1
Scrophulariaceae	Eremophila mackinlayi subsp. spathulata		1	1
Scrophulariaceae	Eremophila margarethae		1	1
Scrophulariaceae	Eremophila oldfieldii subsp. angustifolia		1	1
Scrophulariaceae	Eremophila oppositifolia var. angustifolia		1	
Scrophulariaceae	Eremophila platycalyx subsp. Leonora (Morrisey J. 252)	Taxonomic Interest, Undescribed, Widespread in Leonora area	1	1*
Scrophulariaceae	Eremophila scoparia		1	1*
Scrophulariaceae	Eremophila serrulata		1	1
Scrophulariaceae	Eremophila simulans subsp. simulans		1	1
Scrophulariaceae	Eremophila sp. aff. simulans subsp. simulans INDET	Indeterminate	1	
Scrophulariaceae	Eremophila youngii subsp. youngii		1	1
Solanaceae	Nicotiana rosulata subsp. rosulata			1
Solanaceae	Solanum cleistogamum		1	1
Solanaceae	Solanum lasiophyllum		1	1
Solanaceae	Solanum nigrum *			1
Thymelaeaceae	Pimelea microcephala subsp. microcephala		1	
Verbenaceae	Salvia verbenacea *	Weed	1	
Zygophyllaceae	Roepera ?compressa			1*
Zygophyllaceae	Roepera eichleri			1*
Zygophyllaceae	Tribulus asterocarpus			1

Appendix 2. Vegetation Maps of the Study Area

Vegetation Group	Final Mapping Numeric Code	Vegetation Association Name	Veg Assoc Code
Mulga Woodlands over Perennial Non-Halophytic Shrubs on hills and plains	1.01	*Acacia aneura, A. ramulosa, Eremophila platycalyx* subsp. Leonora (Morrisey J. 252), *Ptilotus obovatus* (Upright form) Shrubland and grasses	AaArEpLPoU, Grasses
	1.02	*Acacia aneura* (forms), *Ptilotus obovatus* (Upright form), *Maireana triptera* Shrubland	AaPoUMt
	1.02D	Dead vegetation, formerly *Acacia aneura* (forms), *Ptilotus obovatus* (Upright form), *Maireana triptera* Shrubland	Dead AaPoUMt
	1.03	*Acacia aneura, Maireana sedifolia, Scaevola spinescens Narrow leaf spiny form Ptilotus obovatus* (typical Goldfields form) Shrubland	AaMsSsNPoG
	1.04	*Acacia burkittii, Senna artemisioides* subsp. *filifolia, Maireana* spp. Shrubland	AbSafAmpMt
	1.05	*Acacia aneura* (forms) over *Eremophila platycalyx* subsp. Leonora (Morrisey J. 252) *over Senna* spp. over *Ptilotus obovatus* (Upright form) and *Maireana triptera* Shrubland	AaEpLSsppPoUMt
	1.06	*Acacia aneura (forms)* over *Eremophila* spp. *(E. margarethae, E. compacta* subsp. *compacta, E. simulans subsp. simulans or E. annoscaulis P3* over *Ptilotus schwartzii* Shrubland	AaEmP
	1.07	Stony Ironstone Mulga Shrubland *Acacia aneura, Eremophila latrobei, Sida ectogamma* Shrubland on summits of chert, quartz hills and slopes	SIMS AaElSe
	1.08	Stony Ironstone Mulga Shrubland *Acacia aneura, Ptilotus obovatus* (Upright form), *Ptilotus schwartzii* Shrubland on midslopes of chert, quartz hills and slopes	SIMS AaPoUSe
	1.09	Stony Ironstone Mulga Shrubland *Acacia aneura* (forms) over *Eremophila clarkei, Eremophila forrestii* Shrubland on summit of low ferricrete hills	SIMS AaEcEf
	1.10	*Acacia aneura* over *Maireana sedifolia* over *Ptilotus obovatus* (Upright form) Shrubland over *Maireana triptera* Shrubland and grasses	AaMsPoUMt
	1.11	*Maireana pyramidata, Maireana sedifolia, Frankenia spp.* Open Low Shrubland and grasses	MpMsFspp
	1.12	*Acacia aneura (sens. lat.), Eremophila platycalyx* subsp. *Leonora* (Morrisey J. 252) over *Eremophila compacta* subsp. *compacta* and *Ptilotus obovatus* (Upright form) Shrubland	AaEpLEm
	1.13	*Acacia aneura (sens. lat.), Acacia ramulosa, Acacia quadrimarginea (sens. str.), Eremophila platycalyx* subsp. Leonora (Morrisey J. 252) Shrubland	AaArAqEp
	1.14	Stony *Acacia - Eremophila* Shrubland	SAES
	1.15	Hardpan Plain, deflation zone	HPDS
	1.16	Hardpan Mulga Shrubland	HPMS
	1.17	*Acacia aneura, Maireana triptera, Ptilotus obovatus (*Goldfields Form) Shrubland over *Aristida contorta*	AaPoGMt
Mulga Shrublands / Woodlands over Perennial Grasses on Plains	2.01	Mulga-Wanderrie *(Acacia aneura, Eragrostis eriopoda)* Grassland	MUWA
	2.02	Wanderrie Bank Grassy Shrublands *(Eragrostis eriopoda)* Grassland	WABS
Acacia Woodlands over Shrubs and Grasses in Major Drainage Lines and Groves	3.01	Drainage Line Mulga *Acacia aneura (sens. lat.)* Woodland	DRMS
	3.02	Drainage line *Acacia burkittii* Woodland	DRAbS
	3.03	Groved Mulga Woodland	GRMU
Acacia (other than Mulga) Shrublands on Stony Hills	4.01	*Acacia* sp. Marshall Pool (G. Cockerton 3024) Shrubland	Amp
	4.02	*Acacia* sp. Marshall Pool (G. Cockerton 3024), *A. sibirica, Acacia aneura, A. burkittii* Shrubland	AmpAsAa
	4.03	*Acacia doreta* short phyllode form, *Acacia sp. Marshall Pool* (G. Cockerton 3024) Open Woodland *Ptilotus obovatus* (Goldfields form) Shrubland	AdAspMPPoG
	4.04	*Acacia burkittii, Ptilotus obovatus* (Goldfields form) Shrubland	AbPoG
Acacia papyrocarpa Woodlands	5.01	*Acacia papyrocarpa* Open Low Woodland, *Tecticornia disarticulata* Shrubland	ApTdS
	5.02	*Acacia papyrocarpa* Open Low Woodland, *Eremophila scoparia* and *Maireana* spp. Shrubland	ApEsMspp
	5.03	*Acacia papyrocarpa* Open Low Woodland, *Ptilotus obovatus* (Upright form), *Maireana triptera* Shrubland and grasses	ApPoUMt
	5.04	*Acacia papyrocarpa* Open Low Woodland, *Maireana pyramidata* Shrubland	ApMt
Acacia victoria Shrubland over Chenopods on Calcrete Plains	6.01	*Acacia victoriae* Shrubland	AvS
Perennial Grasslands	7.01	*Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH 26770) Hummock Grassland on Calcrete	EyC
	7.02	*Neurachne munroi* Hummock Grassland on Mudstone	NmHG
Hakea preissii and/or Halophytic Chenopod Shrublands	8.01	*Hakea preissii, Maireana pyramidata, Tecticornia disarticulata* Shrubland	HpTdMpS
	8.02	*Hakea preissii, Maireana pyramidata, Cratystylis subspinescens* Shrubland	HpMpCs
	8.03	*Hakea preissii, Maireana pyramidata, Eremophila scoparia* Shrubland	HpMpEs
	8.04	*Hakea preissii, Ptilotus obovatus* (Goldfields form), *Maireana triptera* Shrubland	HpPoGMt
	8.05	*Hakea preissii, Maireana pyramidata, Maireana* sp. decussate leaves. (G. Cockerton & G. Grigg WB40064) Shrubland and grasses	HpMpMsp59
	8.06	*Hakea preissii, Eremophila scoparia, Maireana triptera* Shrubland	HpEsMt
	8.07	*Maireana triptera, Frankenia spp.* Low Open Shrubland	MtFsp
	8.08	*Maireana pyramidata, M. georgei* Shrubland	MpMg
	8.09	*Tecticornia disarticulata, Surreya diandra, Frankenia setosa, Maireana* sp. decussate leaves. (G. Cockerton & G. Grigg WB40064) Shrubland	TdFsppMsp#59
	8.10	*Maireana* sp. decussate leaves. (G. Cockerton & G. Grigg WB40064), *Tecticornia disarticulata* Shrubland	Msp59, Td
	8.11	*Frankenia* spp. Shrubland	Fspp
	8.12	*Acacia masliniana, Cratystylis subspinescens* Shrubland	AmCs
	8.13	*Bare claypan, no vegetation*	Cpn-B
Casuarina pauper Woodland on Calcrete Outcrops	9.01	*Casuarina pauper* Woodland over Chenopods on Calcrete outcrops	CpW
Claypans	10.01	*Grassy Claypan* (*Eragrostis xerophila* Grassland)	CPN-G
	10.02	Gilgai: *Pittosporum angustifolium, Acacia tetragonophylla* and *A. victoriae* Shrubland over Claypan Grasses	Gilgai
Breakaway Complex	11.01	*Eremophila scoparia, Frankenia spp.* Shrubland with *Sclerolaena diacantha*	EsFsppSspp
Mosaics	M1	4.02+1.10 mosaic	
	M2	1.06+2.01+1.15 mosaic	
	M3	1.06+2.01 mosaic	
	M4	8.09+7.01 mosaic	
Other	d	Dead Vegetation	
	dist	Disturbed	

Note:

Consultant: Western Botanical

CAD Ref: a2553_Veg_WB_04_01

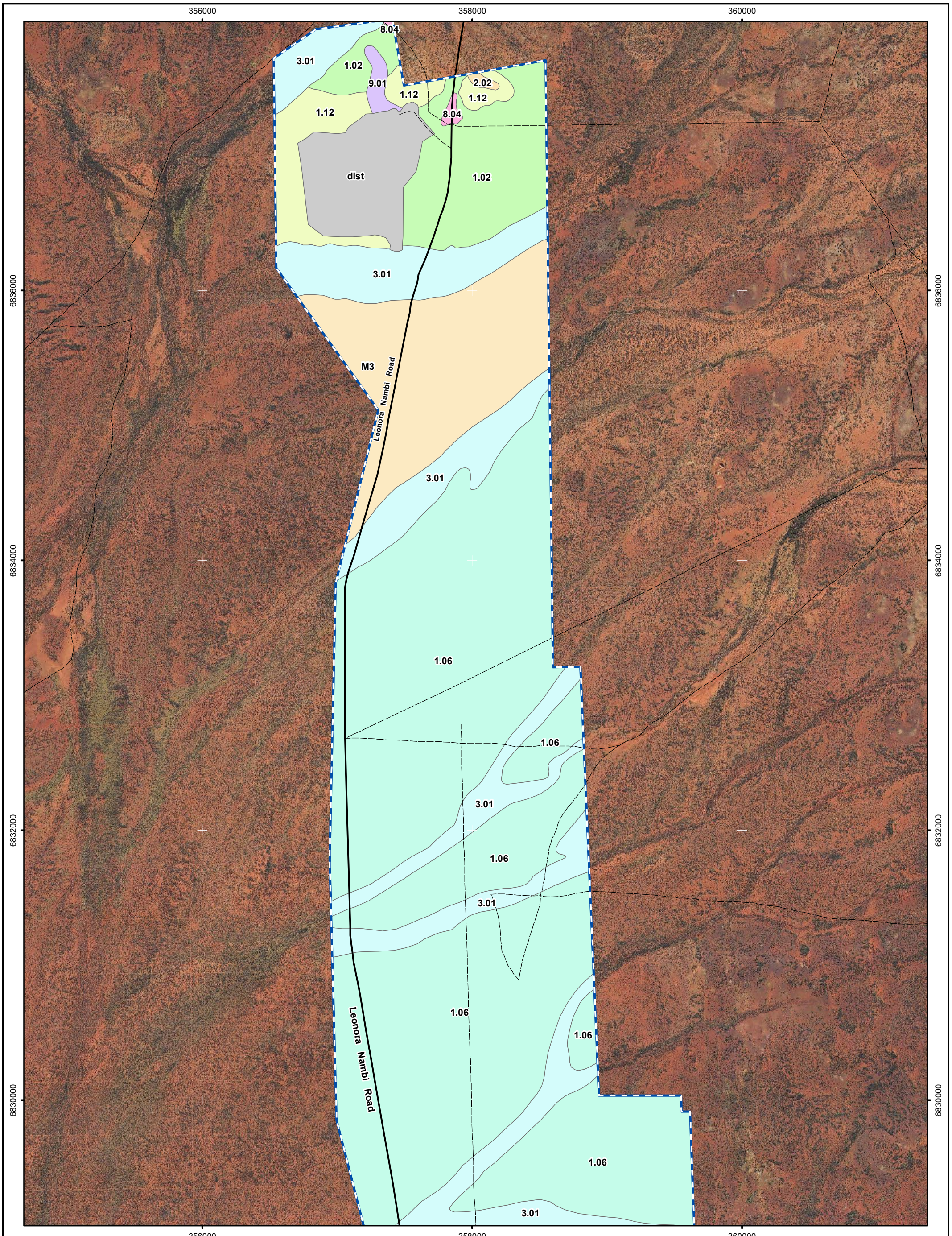
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Leonora Gold Project
Vegetation Associations
Legend



Source: Vegetation: Western Botanical, Tenements: DMIRS, Topography: Landgate, Image: Outline Imagery (09/07/2018

Consultant

Western Botanical

Sheet Layout

1 2 3 4 5 6

Layout

Leonora

N

0 310 620 m

Scale: 1:25,000
MGA94 (Zone 51)

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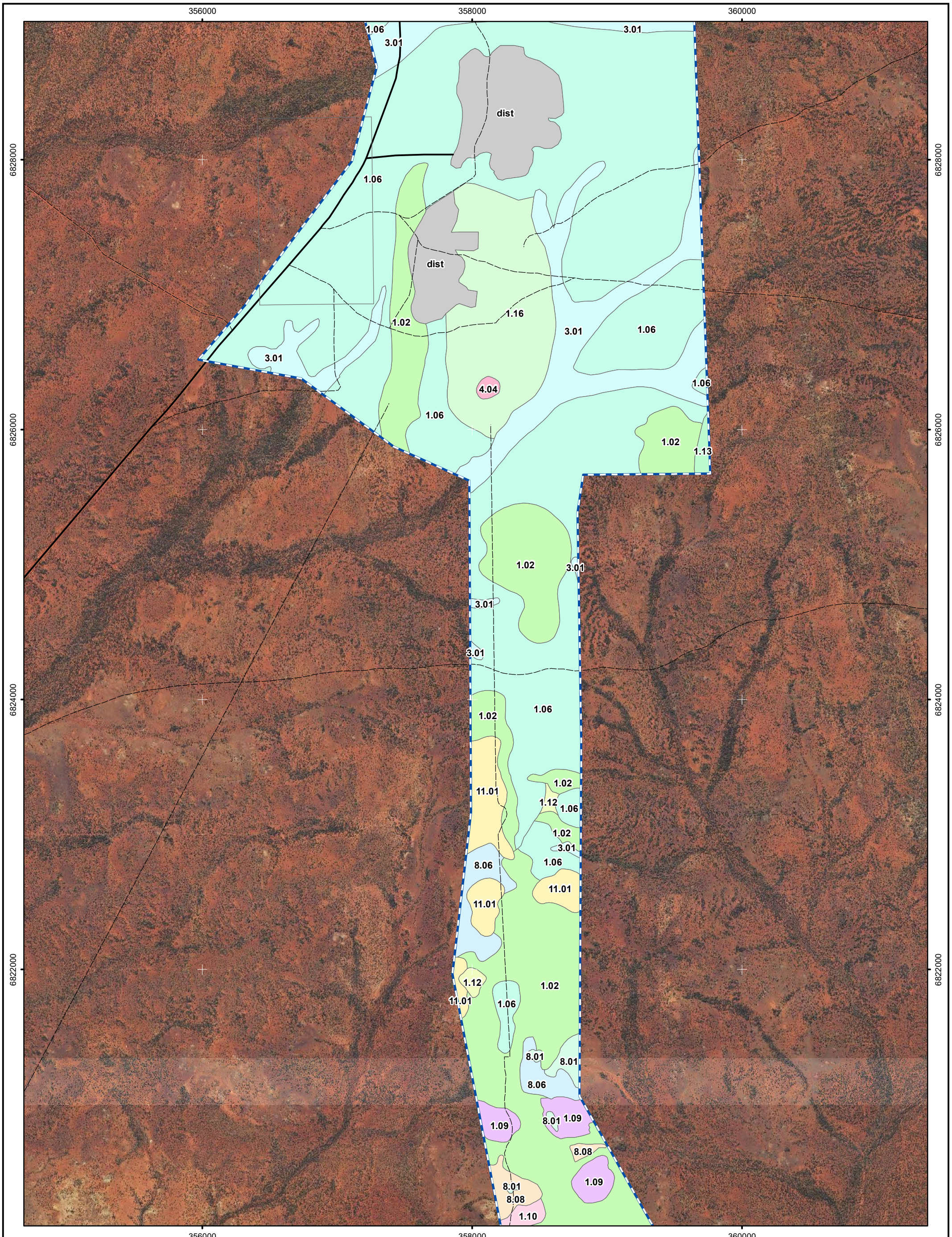
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Vegetation Associations

Sheet 1 of 6



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Consultant: Western Botanical

Sheet Layout

Layout

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0 310 620 m

Scale: 1:25,000
MGA94 (Zone 51)

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Vegetation Associations

Sheet 2 of 6

358000 360000 362000

6820000 6818000 6816000 6814000 6812000

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Consultant

Western Botanical

Sheet Layout

1 2 3 4 5 6

Layout

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Vegetation Associations

Sheet 3 of 6

364000 366000 368000 370000

6820000 6818000 6816000 6814000 6812000

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Consultant: Western Botanical

Sheet Layout: 1 2 3 4 5 6

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Vegetation Associations

Sheet 4 of 6

362000 364000 366000

6810000 6808000 6806000 6804000

8.06 4.03 8.02 3.01 1.01 4.01 4.01 1.03 4.02 8.01 8.06 4.01 4.02 4.02 4.01 8.03 7.01 8.05 1.02 8.09 8.03 6.01 8.09 M4 8.06 1.02 7:01 8.05 4.01 8.09 8.09 3.01 5.02 8.03 8.06 8.09 5.02 1.07 8.04 1.05 3.01 1.02 1.07 1.02 8.10 8.03 8.02 7.01 7.01 10.02 7.01 7.01 7.01 1.02 7.01 1.06 3.03 1.14 8.09 1.06 1.05 1.01 7.02 8.05 5.03 1.03 1.10 8.01 8.01 1.01 8.02 4.02 8.05 8.05 8.04 8.04 5.03 1.02 1.17 1.17 8.09 8.04 4.02 1.10 4.02 8.05 1.05 1.06 7.01 1.02 4.02 1.02 1.10 1.10 8.05 8.09 8.05 8.01 3.01 8.01 8.05 8.01 8.01 1.01 5.03 8.05 5.03 1.03 8.02 8.01 4.01 4.01 1.17 4.01 6.01 4.01 8.05 8.01 4.01 5.01 8.01 4.01 4.02 5.03 5.01 1.14 1.10 8.02 8.02 1.14 1.14 8.06 1.03 8.02 4.01 1.03 4.01 1.06 8.02 1.16 2.01 8.06 1.15 dist 1.06 1.15

Source: Vegetation: Western Botanical, Tenements: DMIRS, Topography: Landgate, Image: Outline Imagery (09/07/2018

Consultant: Western Botanical

Sheet Layout: 1 2 3 4 5 6

Layout: Leonora

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Scale: 1:25,000
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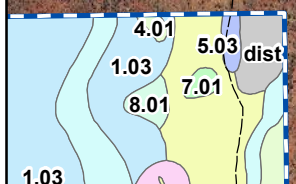
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Vegetation Associations

Sheet 5 of 6

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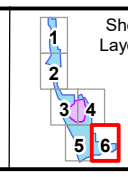
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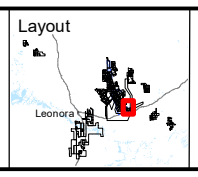


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Consultant

Western Botanical





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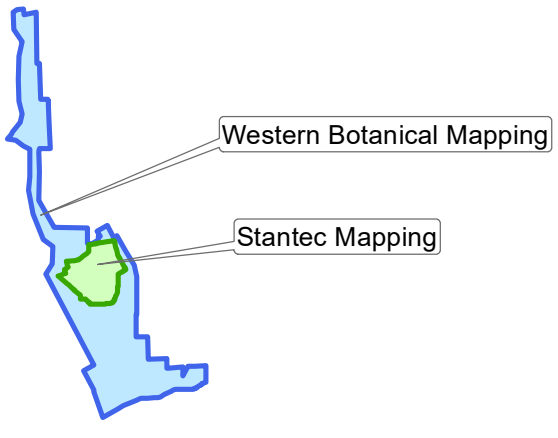
Leonora Gold Project

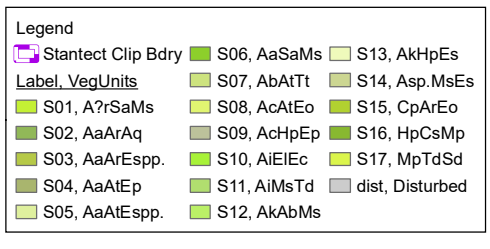
Vegetation Associations

Sheet 6 of 6

Habitat	MU	Code	Description (Table 5-2)	Sig Unit (Table 5-3)	Locally Restricted Distribution (Table 5-4)
Acacia Shrublands on Plains	S02	AaArAq	Acacia quadrimarginea, Acacia incurvaneura and Acacia aneura low woodland over Acacia ramulosa var. ramulosa and Acacia tetragonophylla tall to mid sparse shrubland over Eremophila spp. low isolated shrubs over Eragrostis eriopoda and Monachather paradoxus isolated tussock grasses		Yes
	S03	AaArEspp.	Acacia aneura, Acacia incurvaneura and Acacia caesaneura low open forest over Acacia ramulosa var. ramulosa tall isolated shrubs over Eremophila spp. mid isolated shrubs over low isolated mixed shrubs, herbs and grasses,		
	S04	AaAtEp	Acacia aneura, Acacia aptaneura and Acacia caesaneura low open woodland over Eremophila platycalyx subsp. platycalyx, Acacia ramulosa subsp. ramulosa and Acacia tetragonophylla tall to mid isolated shrubs over Ptilotus obovatus, Eremophila metallicorum and Eremophila margarethae low isolated shrubs, over mixed low grasses.		
	S05	AaAtEspp.	Acacia aneura, Acacia caesaneura and Acacia pteraneura low woodland over Acacia tetragonophylla tall isolated shrubs over mixed low isolated shrubs		
	S08	AcAtEo	Acacia craspedocarpa, Acacia aneura and Acacia caesaneura low woodland over Acacia tetragonophylla, Scaevola spinescens and Eremophila oldfieldii subsp. angustifolia mid isolated shrubs over Ptilotus obovatus and Maireana tomentosa subsp. tomentosa low isolated shrubs, over Ptilotus sp. Goldfields (R. Davis 10796), Enneapogon caerulescens and Aristida contorta low isolated forbs and grasses		
	S09	AcHpEp	Acacia craspedocarpa, Acacia aneura and Acacia incurvaneura low open woodland over Acacia oswaldii, Hakea preissii and Rhagodia drummondii mid isolated shrubs, over Eremophila pantonii, Maireana georgei and Atriplex nummularia subsp. spathulata low isolated shrubs over Sclerolaena densiflora, Enneapogon caerulescens and Ptilotus aervoides low isolated forbs and grasses		Yes
	S10	AiElEc	Acacia incurvaneura low open woodland over Eremophila latrobei subsp. latrobei, Solanum lasiophyllum and Ptilotus obovatus low sparse shrubland, over Enneapogon caerulescens low grassland over Sclerolaena diacantha isolated dwarf chenopod shrubs		Yes
	S11	AiMsTd	Acacia inceana subsp. conformis low woodland over Maireana sedifolia mid isolated shrubs over Maireana pyramidata and Tecticornia disarticulata low isolated chenopod shrubs	Yes	Yes
	S13	AkHpEs	Acacia kalgoorliensis, Acacia oswaldii and Hakea preissii low open woodland over Eremophila scoparia, Senna stowardii and Acacia craspedocarpa mid isolated shrubs over Ptilotus obovatus, Maireana triptera and Cratystylis subspinescens low isolated shrubs over Sclerolaena eriacantha, Sclerolaena densiflora and Ptilotus sp. Goldfields (R. Davis 10796) low isolated forbs on rocky plains		Yes
	S14	Asp.MsEs	Acacia sp. low open woodland over Maireana sedifolia and Eremophila scoparia mid open shrubland, over Sclerolaena diacantha sparse isolated dwarf chenopod shrubland		Yes
Chenopod Shrublands	S16	HpCsMp	Hakea preissii low isolated trees over Cratystylis subspinescens and Maireana pyramidata mid open shrubland over Tecticornia pruinosa, Tecticornia disarticulata and Tecticornia pergranulata subsp. pergranulata low open chenopod shrubland over Enneapogon caerulescens low isolated grasses	Yes	
	S17	MpTdSd	Maireana pyramidata and Tecticornia disarticulata low chenopod shrubland over Sclerolaena densiflora isolated dwarf chenopod shrubs with Aristida contorta, Enteropogon ramosus and Sporobolus actinocladus isolated tussock grasses		Yes
Drainage Line	S07	AbAtTt	Acacia burkittii and Acacia aptaneura low open woodland over Acacia tetragonophylla and Acacia burkittii mid sparse shrubland over Themeda triandra, Eriachne flaccida and Enteropogon ramosus low tussock grasses on sandy drainage line		Yes
Low Hills	S01	A?rSaMs	Acacia sp. nov. aff. resinimarginea, Acacia aneura and Acacia caesaneura tall open shrubland, over Senna artemisioides subsp. filifolia, Scaevola spinescens and Acacia tetragonophylla mid isolated shrubs over Ptilotus obovatus, Maireana sedifolia and Solanum lasiophyllum low isolated shrubs over Ptilotus helipteroides and Enneapogon caerulescens low isolated forbs and grasses on rocky hills	Yes	Yes
	S06	AaSaMs	Acacia aneura and Acacia caesaneura tall open woodland over Senna artemisioides subsp. filifolia, Maireana sedifolia and Ptilotus obovatus low open shrubland over low mixed chenopod shrubland on rocky hills		Yes
	S12	AkAbMs	Acacia kempeana low open woodland over Acacia burkittii, Maireana sedifolia and Eremophila scoparia mid open shrubland, over Ptilotus obovatus, Sida ectogama and Solanum lasiophyllum low isolated shrubs, over Enneapogon caerulescens and Sclerolaena eriacantha low isolated forbs and grasses on rocky hills		Yes
	S15	CpArEo	Casuarina pauper, Acacia caesaneura and Acacia aneura low woodland over Acacia ramulosa var. ramulosa and Acacia tetragonophylla tall isolated shrubs over Eremophila oldfieldii subsp. angustifolia mid isolated shrubs over Maireana triptera, Sclerolaena eriacantha and Sclerolaena densiflora low isolated forbs		Yes
Disturbed	dist	Disturbed	Areas of disturbance including historical and recent mining activities.		

Table reference from Stantec report LEVEL 1 FLORA, VEGETATION AND FAUNA ASSESSMENT dated Aug 2017







Note:

Consultant: Western Botanical

CAD Ref: a2553_Veg_WB_04_03

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Leonora Gold Project

Vegetation Associations

Stantec Legend

356000 358000 360000

6836000 6834000 6832000 6830000

8.04
3.01
1.02
9.01
1.12
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1.12
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Leonora Nambi Road
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Leonora Nambi Road
1.06
1.06
3.01

Source: Vegetation: Western Botanical (S codes Stantec), Tenements: DMIRS, Topography: Landgate, Image: Outline Imagery (09/07/2018

Consultant
Western Botanical

Sheet Layout
1 2 3 4 5 6

Layout
Leonora

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Scale: 1:25,000
MGA94 (Zone 51)
CAD Ref: a2553_Veg_WB_04_04
Date: May 2019 | Rev: B | A3

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Vegetation Associations
Western Botanical & Stantec Mapping - Sheet 1 of 6

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Source: Vegetation: Western Botanical (S codes Stantec), Tenements: DMIRS, Topography: Landgate, Image: Outline Imagery (09/07/2018

Consultant: Western Botanical

Sheet Layout: 1 2 3 4 5 6

Layout: Leonora

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Leonora Gold Project

Vegetation Associations

Western Botanical & Stantec Mapping - Sheet 2 of 6

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358000 360000 362000

Source: Vegetation: Western Botanical (S codes Stantec), Tenements: DMIRS, Topography: Landgate, Image: Outline Imagery (09/07/2018

Consultant

Western Botanical

Sheet Layout

1 2 3 4 5 6

Layout

Leonora

N

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Vegetation Associations

Western Botanical & Stantec Mapping - Sheet 3 of 6

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Source: Vegetation: Western Botanical (S codes Stantec), Tenements: DMIRS, Topography: Landgate, Image: Outline Imagery (09/07/2018

Consultant

Western Botanical

Sheet Layout

1 2 3 4 5 6

Layout

Leonora

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Scale: 1:25,000
MGA94 (Zone 51)

CAD Ref: a2553_Veg_WB_04_04

Date: May 2019 | Rev: B | A3

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Leonora Gold Project

Vegetation Associations

Western Botanical & Stantec Mapping - Sheet 4 of 6

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Source: Vegetation: Western Botanical (S codes Stantec), Tenements: DMIRS, Topography: Landgate, Image: Outline Imagery (09/07/2018

Consultant: Western Botanical

Sheet Layout: 1 2 3 4 5 6

Layout: Leonora

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Scale: 1:25,000
MGA94 (Zone 51)

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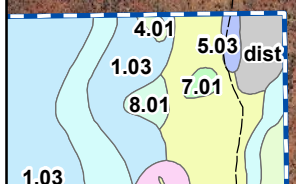
Leonora Gold Project

Vegetation Associations

Western Botanical & Stantec Mapping - Sheet 5 of 6

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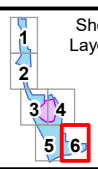
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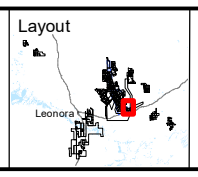


Source: Vegetation: Western Botanical (S codes Stantec), Tenements: DMIRS, Topography: Landgate, Image: Outline Imagery (09/07/2018

Consultant

Western Botanical





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Scale: 1:25,000
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Vegetation Associations

Western Botanical & Stantec Mapping - Sheet 6 of 6

Appendix 3. Keighery (1994) Vegetation Condition Scale

Summary of Vegetation Condition Scale as developed by Keighery (1994) and as summarized in Bush Forever (Government of Western Australia 2000) Condition Scale Description

Code	Description
Pristine (1)	Pristine or nearly so, no obvious signs of disturbance.
Excellent (2)	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good (3)	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback , logging and grazing.
Good (4)	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded (5)	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing
Completely Degraded (6)	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 or shrubs.

Appendix 4. DBCA Conservation Codes and Their Meanings

T: Threatened Flora (Declared Rare Flora — Extant)

Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such (Schedule 1 under the Wildlife Conservation Act 1950).

Threatened Flora (Schedule 1) are further ranked by the Department according to their level of threat using IUCN Red List criteria:

CR: Critically Endangered – considered to be facing an extremely high risk of extinction in the wild

EN: Endangered – considered to be facing a very high risk of extinction in the wild

VU: Vulnerable – considered to be facing a high risk of extinction in the wild.

X: Presumed Extinct Flora (Declared Rare Flora — Extinct)

Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such (Schedule 2 under the Wildlife Conservation Act 1950).

Taxa that have not yet been adequately surveyed to be listed under Schedule 1 or 2 are added to the Priority Flora List 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 flora or fauna. Taxa that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Conservation Dependent species are placed in Priority 5.

1: Priority One: Poorly-known taxa

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

2: Priority Two: Poorly-known taxa

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

3: Priority Three: Poorly-known taxa

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

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

Rare. Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.

Near Threatened. Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

5: Priority Five: Conservation Dependent taxa

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

Appendix 5. Vegetation Association Descriptions and Representative Photographs

Mulga Woodlands over Perennial Non-Halophytic Shrubs on hills and plains

Seventeen vegetation associations with a diverse range of Mulga species (*Acacia aneura, A. aptaneura, A. caesaneura, A. fuscaneura, A. incurvaneura, A. macraneura, A. mulganeura* and *A. pteraneura*) form the dominant upper stratum as trees and shrubs 4 to 6 m in height. The understorey varies considerably with geological substrate type, soil depth and landscape position, from *Eremophila clarkei, E. forrestii, E. platycalyx* subsp. Leonora (J. Morrisey 252), *E. simulans* subsp. *simulans*, *E. latrobei* or *E. annoscaulis* P3 on stony hill tops and slopes; to *Eremophila compacta* subsp. *compacta* on loamy wash plains; to *Eremophila galeata* scattered shrublands on skeletal soils on hardpan plains and granite platforms. Some areas of Mulga woodlands have an understorey dominated by two informally recognised species; either *Ptilotus obovatus* Upright form (G Cockerton et al 15206) or *Ptilotus obovatus* Typical Goldfields form (G Cockerton et al 15213) which reflect differing soil types with the former associated with calcareous soils and the latter with non-calcareous soils. Both species are common and widespread in the eastern Goldfields of W.A. and occasionally occur together within a Vegetation Association.

1.01	*Acacia aneura, A. ramulosa, Eremophila platycalyx* subsp. Leonora (Morrisey J. 252), *Ptilotus obovatus* (Upright form) Shrubland and grasses	AaArEpLPoU, Grasses

Small conical basalt outcrop supporting *Eremophila platycalyx* subsp. Leonora shrubland over *Digitaria brownii* grasses and occasional *Cheilanthes lasiophyllum* ferns between rocks on the southern side. Too small an area to map.



1.02	*Acacia aneura* (forms), *Ptilotus obovatus* (Upright form), *Maireana triptera* Shrubland	AaPoUMt

Low basalt hill supporting scattered *Acacia aneura* (2 varieties), *A. ramulosa* to 3.5m, PFC 15% over *Eremophila platycalyx* subsp. Leonora (J. Morrisey 252) 1.5m, PFC 5% over *Ptilotus obovatus* (both Upright and Typical Goldfields forms) 0.3 to 0.7m, PFC 3% over grasses dominated by *Digitaria brownii* 0.4m, *Aristida contorta* 0.2m, PFC 1.5 to 2%. Basalt is uniform fine grained dark grey)



1.02 D	Dead vegetation, formerly *Acacia aneura* (forms), *Ptilotus obovatus* (Upright form), *Maireana triptera* Shrubland	Dead AaPoUMt

No image. A small, well defined area that may have been burnt following a lightning strike or killed in a hail storm, no live Mulga and few live shrubs present.

1.03	*Acacia aneura, Maireana sedifolia, Scaevola spinescens Narrow leaf spiny form Ptilotus obovatus* (typical Goldfields form) Shrubland	AaMsSsNPoG

Mulga woodland on low rocky sandstone shale hill. *Acacia incurvaneura* 4m, *Acacia caesaneura* 4m, PFC 10% over *Sida calyxhymenia* 1m, *Scaevola spinescens* (narrow leaf spiny form) 1m, PFC 10%. Note, differs from adjacent Mulga woodland on plains in having fewer chenopods and *Sida* and *Scaevola* understorey.



1.04 *Acacia burkittii, Senna artemisioides* subsp. *filifolia, Maireana* spp. Shrubland AbSafAmpMt

No Image

1.05	*Acacia aneura* (forms) over *Eremophila platycalyx* subsp. Leonora (Morrisey J. 252) *over Senna* spp. over *Ptilotus obovatus* (Upright form) and *Maireana triptera* Shrubland	AaEpLSsppPoUMt

Acacia aneura forms 4 to 5m, PFC 10% over *Eremophila platycalyx* subsp. Leonora 1 to 2.5m, PFC 2% over *Senna* sp. Meekatharra (E. Bailey 1-26) 1.5m, *Senna artemisioides* subsp. *helmsii* 1.2m, *Maireana sedifolia* 1m, *Senna artemisioides* subsp. *filifolia* 1m, *Scaevola spinescens* (narrow leaf spiny form), PFC 7%, over *Ptilotus obovatus* (upright form) 0.8m, *Solanum lasiophyllum* 0.7m, *Atriplex bunburyana* 0.8m, PFC 2% over *Maireana triptera* 0.3m, *Sclerolaena cuneata* 0.2m, PFC 0.5%. Site is gently sloping to the east, ~ 2 degrees, and has a continuous mantle of ironstone, basalt and quartz stones 0.5 to 10 cm diameter over a red silty sand soil.



1.06	*Acacia aneura (forms)* over *Eremophila* spp. *(E. margarethae, E. compacta* subsp. *compacta, E. simulans subsp. simulans or E. annoscaulis P3* over *Ptilotus schwartzii* Shrubland	AaEmP

Mulga Shrubland over *Eremophila margarethae*. *Acacia aneura* 3 to 4m, PFC 15% over *Eremophila margarethae* 0.8m, PFC 5% over *Ptilotus schwartzii* 0.4m, PFC 4%. In moisture gaining sites, small groves of Mulga are present between sheet wash areas and support *Eremophila annoscaulis* P3 and denser vegetation to 6m high, PFC 70%. This community has been broadened to include a mid story of either/or *Eremophila margarethae, E. compacta*, *E. simulans subsp. simulans* or *E. annoscaulis* P3.



1.07	Stony Ironstone Mulga Shrubland *Acacia aneura, Eremophila latrobei, Sida ectogamma* Shrubland on summits of chert, quartz hills and slopes	SIMS AaElSe

Acacia burkittii 2.1m, PFC 5 to 15% over *Senna artemisioides* subsp. *filifolia* 0.5 to 1m, PFC 5% with a minor component of *Acacia* sp. Marshall Pool (G. Cockerton 3024) 1 to 3m, PFC 1% and *Scaevola spinescens* (narrow leaf spiny form) 1 to 2m, PFC 2% over *Maireana trichoptera, M. triptera, M. georgei, M. sedifolia* PFC 1 to 2%. Soil is a pale creamy carbonate-rich silty sand. Site is a stony hill with abundant tabular calcrete stones and subangular quartz stones to 10 cm diameter. Abundant dark algal soil crust is a prominent feature of this site.



1.08	Stony Ironstone Mulga Shrubland *Acacia aneura, Ptilotus obovatus* (Upright form), *Ptilotus schwartzii* Shrubland on midslopes of chert, quartz hills and slopes	SIMS AaPoUSe

Acacia caesaneura, A. incurvaneura, A. pteraneura 4 to 5m, PFC 10 to 15% over scattered shrubs of *Ptilotus obovatus* Upright form (G Cockerton et al 15206) 0.7m, *Sida ectogamma* 1m, PFC 3 to 5% over *Ptilotus schwartzii* 0.5m, PFC 2%. A mid slope position with much bare ground between plants. Site has a discontinuous mantle of subangular chert, ironstone and some gabbro rocks to 15 cm diameter. An unusual site with a chert and gabbro hill upslope, the SIMS community influenced by weathering of the quartz-rich rocks overlaying the gabbro, hence minor inclusion of *Acacia* sp. Marshall Pool (G. Cockerton 3024).



1.09	Stony Ironstone Mulga Shrubland *Acacia aneura* (forms) over *Eremophila clarkei, Eremophila forrestii* Shrubland on summit of low ferricrete hills	SIMS AaEcEf

Acacia aneura (forms), *Acacia caesaneura*, *Acacia mulganeura* 1.5 to 4m, PFC 5 to 15% over *Eremophila clarkei*, *Eremophila forrestii* 1.2m, PFC 5 to 6% over scattered *Eragrostis eriopoda* 0.3m, *Ptilotus schwartzii*, *Monachather paradoxus* 0.2m, PFC 1 to 2%. Outcropping geology is ferricrete capping. Site is similar to much SIMS in the area north of Leonora.



1.10	*Acacia aneura* over *Maireana sedifolia* over *Ptilotus obovatus* (Upright form) Shrubland over *Maireana triptera* Shrubland and grasses	AaMsPoUMt

Acacia incurvaneura 4m, PFC 1 to 5% over *Maireana sedifolia* 1.5m, PFC 10 to 15% over *Ptilotus obovatus* (Upright form) (G Cockerton et al 15206) over *Maireana triptera* and grasses dominated by *Enneapogon caerulescens*. Soil is a red-brown silty sand surface has a continuous mantle of subrounded ironstone, gabbro; angular quartz gravel and stones to 10 cm diameter. Southerly aspect at 1 to 2 degrees.



1.11	*Maireana pyramidata, Maireana sedifolia, Frankenia spp.* Open Low Shrubland and grasses	MpMsFspp

Chenopod shrubland of *Maireana pyramidata* 1.2m, *Maireana sedifolia* 1.2m, PFC 10 to 15% over *Frankenia cinerea* 0.2m, *Surreya diandra* 0.4m, PFC 1 to 5% with grasses dominated by *Enneapogon cylindricus* 0.3m, *Cymbopogon ambiguus* 0.5m, *Enneapogon caerulescens* 0.25m, PFC 2 to 10%. Occasional emergent *Hakea preissii, Eremophila oldfieldii* subsp. *angustifolia* to 3m, PFC < 1%. Level site where soil is red-brown silty sand with abundant quartz, ironstone, silcrete, sandstone fragments to 10 cm.



1.12	*Acacia aneura (sens. lat.), Eremophila platycalyx* subsp. *Leonora* (Morrisey J. 252) over *Eremophila compacta* subsp. *compacta* and *Ptilotus obovatus* (Upright form) Shrubland	AaEpLEm

Acacia pteraneura, A. caesaneura 4 to 6m, PFC 15 to 20% over *Eremophila platycalyx* subsp. *Leonora* (J. Morrissey 252) 1 to 2.4m, PFC 5% over *Eremophila compacta* subsp. *compacta* 0.8mPFC 10% and *Ptilotus o*bovatus (upright form) 0.6m PFC 1%. North facing slope at 3 to 4 degrees with a discontinuous mantle of subangular quartz (chert) stones to 20 cm. Few grasses, mostly Mulga over *Eremophila* shrubs.



1.13	*Acacia aneura (sens. lat.), Acacia ramulosa, Acacia quadrimarginea (sens. str.), Eremophila platycalyx* subsp. Leonora (Morrisey J. 252) Shrubland	AaArAqEp

Acacia aneura (sens. lat.) 2 to 5m PFC 5%, *Acacia ramulosa* 2m PFC 0.5%, *Acacia quadrimarginea* 4 to 6m PFC 2 to 3% over *Eremophila platycalyx* subsp. Leonora 2m PFC 1.5% over *Sida ectogamma* 1m, *Eremophila margarethae* 0.5m, *Ptilotus obovatus* (Goldfields form) 0.4m, *Ptilotus obovatus* (Upright form) 0.7m, PFC 5%. Site represents a stony granitic plain, gently inclined, dipping to the north-west at 1 to 2 degrees. Soil is a coarse gritty sand and has a discontinuous mantle of subangular quartz and granite rocks and gravel to 8 cm diameter.



1.14	Stony *Acacia* - *Eremophila* Shrubland	SAES

Acacia aptaneura, A. caesaneura, A. incurvaneura to 3m, *Eremophila platycalyx* subsp. Leonora 1.5m, PFC 1% over *Sida ectogamma* 0.8m, PFC < 1%, *Eremophila margarethae* 0.5m, PFC 3%, *Ptilotus schwartzii* 0.4m, PFC 1%. A stony plain gently inclined to the north-west at 0.5 degrees, with hardpan red-brown silty sandy soil and a continuous mantle of subangular to subrounded ironstone, quartz gravels and stones to 7 cm diameter.



1.15	Hardpan Plain, deflation zone	HPDS

Acacia incurvaneura, Acacia pteraneura to 6m, PFC 10 to 30% with a tall shrub stratum of *Eremophila platycalyx* subsp. Leonora 3m, *Santalum lanceolatum* 3m, and younger Mulga to 3m, PFC 5 to 15% over low shrubs *Ptilotus obovatus* Typical Goldfields form (G Cockerton et al 15213) 0.6m, *Maireana triptera* 0.5m, *Teucrium teucriflora* 1m, PFC 1% over scattered grasses *Eriachne ovata, Enteropogon ramosus* and occasional *Austrostipa elegantissima* 1m, PFC 0.5%.

A relatively level site representing a broad distributary fan subject to sheet flow (adjacent to the HPP community) with hardpan red silty sand soil and abundant but discontinuous lag quartz and basalt gravel with evidence of conglomerate Wiluna hardpan below the surface. Large amount of bare ground, > 80%.



1.16	Hardpan Mulga Shrubland	HPMS

Acacia aneura 4 to 6m, PFC 5% over scattered *Maireana pyramidata* 1m, PFC 1% over *Ptilotus obovatus* (Goldfields form) 0.5m, PFC 5% over *Aristida contorta* 0.3m, PFC 15%. A level broad valley floor, non-saline at surface, red silty sand with subrounded to subangular basalt tocks to 20 cm and quartz fragments.



1.17	*Acacia aneura, Maireana triptera, Ptilotus obovatus (*Goldfields Form) Shrubland over *Aristida contorta*	AaPoGMt

No photo taken

Mulga Shrublands / Woodlands over Perennial Grasses on Plains

Two vegetation associations, where silty-sandy soils over hardpan higher in the landscape are present. Here Mulga is associated with a grassy understorey of *Monachather paradoxus* and *Eragrostis eriopoda*, collectively known as Wanderrie grasses.

2.01	Mulga-Wanderrie (*Acacia aneura, Eragrostis eriopoda*) Grassland	MUWA

Acacia caesaneura, Acacia incurvaneura 4 to 8m, PFC 15% over shrubs *Eremophila compacta* subsp. *compacta* 0.8m, PFC 3% over *Ptilotus schwartzii* 0.5m, PFC < 1% and *Eragrostis eriopoda* 0.5M, PFC 5 to 15%. Site has a discontinuous mantle of quartz, chert, ironstone and basalt gravel and rocks to 5 cm diameter with a red silty sandy soil.



2.02	Wanderrie Bank Grassy Shrublands (*Eragrostis eriopoda*) Grassland	WABS

Acacia incurvaneura, *A. pteraneura* 4 to 5m, PFC 1 to 7% over *Eragrostis eriopoda* 0.4m, *Monachather paradoxus* 0.4m, PFC 1 to 10% with *Maireana triptera, Eremophila platycalyx* subsp. Leonora (J. Morrissey 252), *Solanum lasiophyllum, Maireana convexa, Ptilotus obovatus* (Goldfields form), *Scaevola spinescens* (narrow leaf, spiny form), PFC 1%.



Acacia Woodlands over Shrubs and Grasses in Major Drainage Lines and Groves

Two major drainage tracts and several minor drainage lines occur within the Study Area, draining from the north-east to the south-west. The vegetation of the major drainage line in the west of the Study Area, Cardinia Creek, with it's upper reaches draining from the Cardinia deposit areas in the Leonora and Gundockerta Land Systems, is dominated by Mulga species. Bummer Creek, with a small representation within the south-east of the Study Area, drains from the Violet Land System (the site of the Murrin Murrin minesite, east of the Study Area), and is dominated by *Acacia burkittii*. The vegetation of the minor drainage lines within the Study Area reflect on the vegetation adjacent hills and plains, but are denser and with a greater species representation due to the accumulation of resources.

3.01	Drainage Line Mulga Acacia aneura (sens. lat.) Woodland	DRMS

Major incised multi channelled braided Drainage Line supporting Mulga Woodland of *Acacia aneura* varieties 4 to 8m, PFC 10 to 20% over *Acacia burkittii* 3m, *A. tetragonophylla* 2.5m, PFC 10% over Shrubs of *Sida ectogamma* 1.5m, *Senna artemisioides* subsp. *artemisioides* 1.2m, *Maireana pyramidata* 1.2m, PFC 3 to 4% over grasses including *Digitaria brownii* 0.8m, *Enteropogon ramosus* 0.5m, PFC 25% and *Ptilotus obovatus* Typical Goldfields form (G Cockerton et al 15213) 0.5m, PFC 5 to 10%. Soils are colluvial sands, gravel and some clay with areas of exposed Wiluna Hardpan conglomerate in deeper channels with sandy slugs present.



3.02	Drainage line Acacia burkittii Woodland	DRAbS

A broad (500m) wide drainage line with numerous braided incised channels to 2m deep x 5 m wide. Vegetation is a dense Mulga Woodland with grassy understorey. *Acacia pteraneura*, 6 to 8m high, *Acacia tetragonophylla* 3m, *Acacia burkittii* 3 to 6m, PFC 50% to 75% over Buffel Grass (*Cenchrus ciliaris**) 1m, PFC 30 to 80%, *Themeda australis* 1m, PFC 1%, *Juncus aridicola* (only on margins of incised channels), *Enneapogon avenaceus* 0.3m, *Eragrostis setifolia* 0.4m, PFC 10% Occasional Ruby Dock (*Rumex vesicarius**) and Brazilian Pepper Tree (*Schinus terebinthifolia**) noted. The surface alluvium of red silty sand ranges from 0.4 to 1.5m in depth in the channels viewed with exposed Wiluna Hardpan conglomerate exposed on the margins and coarse sandy within the channel.



3.03	Groved Mulga Woodland	GRMU

An internally drained depression in the landscape, within a broad hardpan Mulga shrubland dense grove. No photograph taken.

Acacia (other than Mulga) Shrublands on Stony Hills

Four vegetation associations on stony hills within a large proportion of the Study Area are dominated by *Acacia* trees and shrubs other than Mulga. Here *Acacia* sp. Marshall Pool (G. Cockerton 3024) is the dominant shrub to small tree on the stony gabbro and basalt hills of the Leonora Land System. It may also be co-dominant with *Acacia sibirica* in some locations. *Acacia doreta* short phyllode form (M. Stone & S. Colwill WB34381), being the typical form of the species), is also present in association with *A*. sp. Marshall Pool on one small hill in the central-west of the Study Area. *Acacia burkittii* was found to be dominant in small, well defined areas of calcrete platform, higher in the landscape, presumably due to an elevated soil moisture availability in the calcrete.

4.01	Acacia sp. Marshall Pool (G. Cockerton 3024) Shrubland	Amp

Acacia sp. Marshall Pool (G. Cockerton 3024) 1.5 to 2m with occasional trees to 3.5m, PFC 25% with occasional *Acacia burkittii* 3 to 4m, PFC 3 %, *A. caesaneura* 0.1%, *Acacia quadrimarginea* narrow phyllode form 1.5m, PFC 0.1% over *Eremophila georgei* 0.4 to 1.8m, PFC 1% and *Senna cardiosperma* 1m, PFC 0.5%. A large and extensive stony gabbro range with a substantial population of *Acacia* sp. Marshall Pool (G. Cockerton 3024). Soil is a red silty sand amongst a continuous cover of rounded (occasionally freshly fractured) gabbro rocks.



4.02	Acacia sp. Marshall Pool (G. Cockerton 3024), A. sibirica, Acacia aneura, A. burkittii Shrubland	AmpAsAa

Acacia ramulosa subsp. *ramulosa*, *A.* sp. Marshall Pool to 3m, PFC 10% over *Acacia sibirica* to 1.2m, *Philotheca brucei* subsp. *brucei* to 1.2m, *Dodonaea lobulata* 1m, *Eremophila forrestii* 1m, PFC 15% over *Prostanthera albiflora* 0.7m, *Ptilotus obovatus* Upright form (G Cockerton et al 15206) 0.8m, *Ptilotus obovatus* Typical Goldfields form (G Cockerton et al 15213) 0.4m, *Cymbopogon ambiguus* 0.6m, PFC 10%. Stony basalt (fine grain) hilltop with fine red silty sandy soil, continuous mantle of subangular to subrounded basalt rocks and boulders.



4.03	Acacia doreta short phyllode form, Acacia sp. Marshall Pool (G. Cockerton 3024) Open Woodland Ptilotus obovatus (Goldfields form) Shrubland	AdAspMPPoG

Acacia doreta (short phyllode form) 1.5m to 6m, *Acacia* sp. Marshall Pool (G. Cockerton 3024) 0.5 to 3m, PFC 3 to 7%, *Ptilotus obovatus* Typical Goldfields form (G Cockerton et al 15213) 0.4m, PFC 5 to 10% over grasses *Enneapogon caerulescens* 0.15m, PFC 5 to 10%. A low basalt hill with subangular fragments to 20 cm diameter and extensive calcrete



4.04	Acacia burkittii, Ptilotus obovatus (Goldfields form) Shrubland	AbPoG

Low and isolated basalt hill supporting *Acacia burkittii* 2.4m, PFC 5 to 10% over scattered *Senna artemisioides* subsp. *filifolia*, S. artemisioides subsp. *artemisioides*, *Senna* sp. Meekatharra (E. Bailey 1-26) 0.5 to 1.2m, PFC 1 to 2% over *Ptilotus obovatus* Typical Goldfields form (G Cockerton et al 15213) 0.4m, PFC 5 to 10% over scattered grasses *Enneapogon caerulescens* 0.2m, PFC 1%. Entire surface of the hill is covered in outcropping basalt rocks with patches of tabular calcrete. Very similar to community 1.04, however, lacks occasional *Acacia* sp. Marshall Pool (G. Cockerton 3024).



Acacia papyrocarpa Woodlands

Four variants of the *Acacia papyrocarpa* woodland were observed. The dominant and defining understorey varies from *Tecticornia disarticulata* in more saline sites; to *Eremophila scoparia* where calcrete is present; to *Ptilotus obovatus* (Upright form), *Maireana triptera* and grasses where there is non-saline but mildly alkaline soil cover over underlying materials; to *Maireana pyramidata* in areas subject to some waterlogging and salinity. *Acacia papyrocarpa* is by far the largest and most prominent tall tree in the landscape within the Study Area.

5.01	Acacia papyrocarpa Open Low Woodland, Tecticornia disarticulata Shrubland	ApTdS

Low rise supporting *Acacia papyrocarpa* 5 to 7m, PFC 10% with occasional *Acacia sibirica* 2.5m, *A. aneura* (3 forms) 2 to 5m, PFC 1% total over medium shrubs *Tecticornia disarticulata* 1m, *Maireana sedifolia* 1.5m, *Lepidium platypetalum* 0.8m, PFC 5% over scattered low shrubs *Maireana georgei* 0.25m, *M. triptera* 0.25m, PFC < 1%. Site slopes at 2 to 3 degrees and has a continuous lateritic gravel mantle, 0.5cm to 6 cm diameter with conglomerate ferricrete boulders present, soil is a fine red silty sand.



5.02	Acacia papyrocarpa Open Low Woodland, Eremophila scoparia and Maireana spp. Shrubland	ApEsMspp

Acacia papyrocarpa 8 to 10m, PFC 7% over *Eremophila scoparia* 0.5 to 2.1m, PFC 5% over *Maireana georgei* 0.3m, *M. triptera* 0.3m, *M. glomerifolia* 0.4m, *Maireana tomentosa* (type 1 WB38650) complex 0.3m, PFC 5 to 10%. A low rounded hill with an extensive, continuous mantle of angular to subangular quartz, weathered gabbro gravel and stones to 15 cm diameter.



5.03	Acacia papyrocarpa Open Low Woodland, Ptilotus obovatus (Upright form), Maireana triptera Shrubland and grasses	ApPoUMt

Acacia papyrocarpa 3.5 to 5m with occasional *Casuarina pauper* 4m, PFC 5% over *Ptilotus obovatus* Upright form (G Cockerton et al 15206) 0.4 to 0.8m, PFC 7% with occasional *Maireana sedifolia* 1.2m, *Eremophila oldfieldii* (young plants) 1m and *Senna artemisioides* subsp. *filifolia* 1.5m, PFC 1% over *Maireana triptera* 0.3m, PFC 4% and grasses dominated by *Enneapogon caerulescens, E. polyphyllus* 0.25m, PFC 2%. Soil at surface is a red - brown silty sand with abundant but discontinuous subangular quartz sub rounded gabbro and subangular silcrete fragments to 8 cm diameter.



5.04	*Acacia papyrocarpa* Open Low Woodland, *Maireana pyramidata* Shrubland	ApMt

Open woodland of *Acacia papyrocarpa* 4 to 6m, PFC 10 to 15% over predominantly *Maireana pyramidata* 1m, PFC 10 to 15% with occasional patches of *Maireana sedifolia* 1m, *Tecticornia disarticulata* 0.4m, *Eremophila scoparia* 1.5m, occasional individuals of *Acacia aneura* (sens. lat.) 4m, *Hakea preissii* 3.5m on a level plain with abundant but discontinuous subangular quartz stones to 10 cm diameter over dark red-brown silty clay soil. A community subject to ecotonal inclusions from adjacent communities.



Acacia victoriae Shrubland over Chenopods on Calcrete Plains

The *Acacia victoriae* shrubland occurs on extensive alkaline calcrete plains in the southern part of the Study Area. It has a relatively diverse understorey dominated by chenopods (*Sclerolaena* and *Maireana* spp.) and may support patches of *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH26770).

6.01	*Acacia victoriae* Shrubland	AvS

Acacia victoriae 2 to 4m, PFC 10% over scattered *Maireana pyramidata* 1m, *M. triptera* 0.4m, *M. georgei* 0.4m, PFC 1.5%, over perennial grasses *Enneapogon caerulescens, E. cylindricus* 0.4m PFC 15% and *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH 26770) 0.2m, PFC 20%. Soil is a pale red brown silty sand with abundant carbonate subangular nodules to 10mm. Site has a discontinuous stony mantle of quartz, basalt stones 2 to 30cm. Site slopes at approximately 3 to 4 degrees to the east.



Perennial Grasslands

Two perennial grasslands were mapped. These are small, discrete patches of *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH26770) on calcrete platforms (relatively low in the landscape); and similarly small, discrete patches of *Neurachne munroi* Hummock Grassland on Mudstone on low rises.

7.01	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH 26770) Hummock Grassland on Calcrete	EyC

Hakea preissii 3.5m, *Acacia caesaneura* and *A. incurvaneura* 6m, PFC < 1%, *Eremophila scoparia* 1 to 2m, PFC 1% over *Maireana pyramidata* 0.8m, *Maireana sedifolia*, *Solanum lasiophyllum* 0.4m, *Maireana triptera* 0.3m, M. georgei 0.4m, PFC 2% over *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH26770) 0.15m, PFC 20%. Foot slope of a low gabbro hill with a southerly aspect, slope 1 to 2 degrees. Outcropping gabbro immediately north of this point and soil surface has a discontinuous lag of subrounded gabbro stones and subangular calcrete nodules.



7.02	Neurachne munroi Hummock Grassland on Mudstone	NmHG

Neurachne munroi 0.2 to 0.3m, PFC 15% hummock grassland with occasional emergent *Hakea preissii* 1m, *Maireana sedifolia* 1m, *Ptilotus obovatus* Typical Goldfields form (G Cockerton et al 15213) 0.5m, Ptilotus obovatus Upright form (G Cockerton et al 15206) 1m, PFC shrubs 1%. An east facing mid slope of a low stony rise with outcropping pale yellow-brown fine sandstone.



Hakea preissii and/or Halophytic Chenopod Shrublands

Thirteen topographically controlled variants of Chenopod Shrublands were recognised with a major distinction being those with *Hakea preissii* emergent above the lower shrubs in areas with a deeper soil profile vs. those lacking *H. preissii*, lower in the landscape and more frequently subject to inundation or waterlogging. These environments are all moderately to highly saline and support a largely well known group of *Maireana*, *Atriplex* (less tolerant of waterlogging) and *Tecticornia* (Samphire, more tolerant of waterlogging) species. They may also support species with conservation significance as identified in the Desktop Study, Table 7.

8.01	Hakea preissii, Maireana pyramidata, Tecticornia disarticulata Shrubland	HpTdMpS

Chenopod Shrubland of *Tecticornia disarticulata* 1m, *Maireana pyramidata* 1m, PFC 2 to 15% over *Maireana georgei* 0.2m, Sclerolaena spp. 0.2m, PFC 3% with occasional grasses *Enneapogon caerulescens*, *E. polyphyllus*, *Enteropogon ramosus* 0.4m, PFC 1%. Gently sloping site (1 deg) with a continuous mantle of ironstone and quartz pebbles to 5 cm over a hard setting fine sandy clay soil.



8.02	Hakea preissii, Maireana pyramidata, Cratystylis subspinescens Shrubland	HpMpCs

Hakea preissii 3m, occasional emergent *Pittosporum angustifolium* 4m, PFC 5% over chenopod shrubs *Maireana pyramidata* 1m, PFC 5%, *Cratystylis subspinescens* 1m, 1%, *Maireana georgei* and *M. triptera* 0.2m, PFC 4% with patches of grasses Aristida contorta 0.2m, PFC 1%. A upland site with red silty sand soil and a continuous mantle of subangular to subrounded ironstone and quartz gravel and stones to 10 cm with occasional chert outcrop to 1.5m above landscape supporting a few Acacia aneura (varieties).



8.03	Hakea preissii, Maireana pyramidata, Eremophila scoparia Shrubland	HpMpEs

Hakea preissii to 3m, PFC 1% over *Eremophila scoparia* 1.2m (2.1m), PFC 20% over scattered *Maireana tomentosa* (type 1 WB38650) complex, *M. triptera* 0.25m, *M. glomerifolia*, PFC < 1%. Site is the footslope of a low basalt range (with *Acacia* sp. Marshall Pool) and has angular to subangular basalt fragments to 10 cm diameter with abundant carbonates evident at surface.



8.04	Hakea preissii, Ptilotus obovatus (Goldfields form), Maireana triptera Shrubland	HpPoGMt

Hakea preissii 3m, PFC 7.5% over scattered mid shrubs *Maireana pyramidata* 1m, *Sida calyxhymenia* 1m, PFC 1, over *Maireana triptera* 0.2m, *Ptilotus obovatus* Typical Goldfields form (G Cockerton et al 15213) 0.3m, PFC 30 with *Enneapogon caerulescens* 0.3m, *E. cylindricus* 0.3m PFC 20% and occasional patches of *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH 26770) PFC 1%. Site represents a low hill with a continuous gravely to stony mantle of subangular weathered basalt, quartz and sandstone mantle to 15 cm with some calcrete evident. Soil profile as observed in drill spoil indicates kaolin clay at depth.



8.05	Hakea preissii, Maireana pyramidata, Maireana tomentosa (type 1 WB38650) complex Shrubland and grasses	HpMpMpl

Chenopod shrubland with occasional emergent *Hakea preissii* and *Acacia aneura* (sens. alt.). *Hakea preissii* 3m, PFC 1 to 2% over *Maireana pyramidata* 1.2m, PFC 10 to 15% over *Maireana tomentosa* (type 1 WB38650) complex 0.3m, PFC 10 to 15%. A wide range of annuals and herbaceous perennials also present with grasses prominent. May also include *Maireana sedifolia*.



8.06	Hakea preissii, Eremophila scoparia, Maireana triptera Shrubland	HpEsMt

Hakea preissii 3.5m, PFC 4% over *Eremophila scoparia* 0.7 to 2.5m, PFC 5 to 7% over *Atriplex bunburyana* 1m, *Maireana triptera* 0.4m or *Maireana tomentosa* (type 1 WB38650) complex PFC 5%. A relatively level site with red silty sandy soil and a discontinuous lag gravel of ironstone, basalt and quartz gravel and stones to 10 cm. Where drainage is concentrated within this community, *Eremophila scoparia* can assume a high density and cover of 50% with *Maireana triptera* 1.5m and *Tecticornia disarticulata* 0.8m, PFC 10%. This denser community not mapped separately.



8.07	Maireana triptera, Frankenia spp. Low Open Shrubland	MtFsp

Low Chenopod Shrubland of *Maireana triptera*, *M. georgei*, includes patches of *Frankenia* spp., occasional *Hakea preissii* shrubs, dead Mulga. Soil is a red-brown clayey sand with abundant discontinuous subangular quartz stones to 15 cm diameter.



8.08	Maireana pyramidata, M. georgei Shrubland	MpMg

Maireana pyramidata 1m, PFC 20% over *Maireana triptera* 0.3m, PFC 5% with scattered *Solanum lasiophyllum* 0.4m, *Ptilotus obovatus* Upright form (G Cockerton et al 15206) 0.9m, Ptilotus obovatus Typical Goldfields form (G Cockerton et al 15213) 0.4m, PFC 2% over grasses *Enneapogon caerulescens* 0.2m, PFC 2%. Occasional emergent *Acacia aneura* (sens. lat.) 3 to 6m, *A. craspedocarpa* 2m, *Hakea preissii* 2.5m, PFC < 1%. A level site with red clayey silty soil with a discontinuous mantle of ironstone pizolites.



8.09	*Tecticornia disarticulata, Surreya diandra, Frankenia setosa,* Maireana tomentosa (type 1 WB38650) complex Shrubland	TdFsppMt

Low lying stony plain supporting a low chenopod shrubland of *Tecticornia disarticulata* 0.3m, *Frankenia setosa* Type 1 0.25m, *Surreya diandra* 0.25m, PFC 25% with occasional emergent *Maireana pyramidata, Cratystylis subspinescens* and *Hakea preissii* 2m, PFC < 1%. A highly saline site where plants are small in comparison to other less stressful sites. Soil is a fine red silty sand and the surface is covered in a discontinuous mantle of subangular to subrounded quartz and ironstone gravel and stones to 10 cm diameter.



8.10	Maireana tomentosa (type 1 WB38650) complex), Tecticornia disarticulata Shrubland	Mt, Td

Low chenopod shrubland of *Maireana tomentosa* (type 1 WB38650) complex 0.3m, PFC 5 to 15% and *Tecticornia disarticulata* 0.4m, PFC 2 to 5%. A level site with clayey soil and a discontinuous lag gravel mantle of quartz and ironstone.



8.11	Frankenia spp. Shrubland	Fspp

Low shrubland of *Frankenia* sp. #145 0.15m, Frankenia sp. #65 0.3m, *Frankenia setosa* 0.3m , PFC 10 to 15%, with occasional *Maireana pyramidata* 1m, PFC < 1%. Site represents the breakaway footslope of a low (6 to 8m high) breakaway with quartz, ?basalt and sandstone shale rubble producing a kaolinitic soil, likely highly saline.



8.12	Acacia masliniana, Cratystylis subspinescens Shrubland	AmCs

Acacia masliniana 2.5m, PFC 10% over *Cratystylis subspinescens* 0.8m to 1.2m, PFC 10% with occasional *Maireana sedifolia* 1m, *M. georgei* 0.3m, PFC 1%. Site is downslope of a low granitic breakaway.



8.13	Bare claypan, no vegetation	Cpn-B

No perennial vegetation, no photo taken.

Casuarina pauper Woodland on Calcrete Outcrops

Casuarina pauper woodland is found in small, isolated and disjunct populations on calcrete platforms high in the landscape and a lower salinity with reliable soil moisture availability of the alkaline soils here is inferred.

9.01	Casuarina pauper Woodland over Chenopods on Calcrete outcrops	CpW

Casuarina pauper 6 to 8m, PFC 10 to 20% over *Hakea preissii* 1.5 to 2.5m and chenopods including *Maireana pyramidata* 1m, *Maireana sedifolia* 1.2m, *Maireana tomentosa* (type 1 WB38650) complex 0.3m, *Maireana. georgei* 0.4m, PFC 15 % over grasses including a prominent component of *Eragrostis* sp. Yeelirrie Calcrete 0.1m (S. Regan LCH26770), *Enneapogon caerulescens* 0.25m, PFC 5%. Site is the lower footslope of a gabbro hill, eastwards facing at slope of 2 to 3 degrees. Soil surface covered in discontinuous lag gravel and stones of basalt, gabbro, quartz



Claypans

Two types of grassy claypans were recognised: one supporting almost exclusively *Eragrostis xerophila*; while another forms Gilgais (with heaving clay soils) supporting emergent *Pittosporum angustifolium, Acacia tetragonophylla* and *A. victoriae* Shrubland over *Eragrostis setifolia, Themeda australis* and other claypan grasses. These are both non-saline environments with heavy clay soils and are internally drained sumps in the landscape. By virtue of their clay soils, high moisture retention and internal drainage, they typically provide refuge for burrowing frogs and support some flora that are not generally found outside these environments. These are small in area, disjunct from each other and uncommon in the landscape within the Study Area.

10.01	Grassy Claypan (Eragrostis xerophila Grassland)	CPN-G

A small, well defined and distinct Claypan with a grass dominant vegetation of *Eragrostis xerophila* to 0.3m, PFC 90% with occasional *Eremophila youngii* 1.6m, PFC 5%, occasional *Maireana pyramidata* and *Cratystylis subspinescens* margin of this site from adjacent community. Soil is a pale red-brown medium to heavy heaving clay with numerous small deep cracks present when dry.



10.02	Gilgai: Pittosporum angustifolium, Acacia tetragonophylla and A. victoriae Shrubland over Claypan Grasses	Gilgai

An internally drained non-saline claypan supporting a dense grove of *Pittosporum angustifolium* 8m, PFC 10% and *Acacia tetragonophylla* 2 to 3m and *Acacia victoriae* 2.5m, PFC 10% over grasses of *Dichanthium sericeum* to 1m, *Enteropogon ramosus* 0.3m. May also contain *Casuarina pauper*.



Breakaway Complex

The breakaway complex is represented in the northern part of the Study Area south of Mertondale where *Eucalyptus striaticalyx* is present at the leading edge of the low (5 to 10 m high) lateritised breakaway and a range of species tolerant of kaolin clay soils and some salinity are present in a changing mosaic pattern on the mid to lower slopes of the landscape. Groups of species such as *Frankenia* spp., *Eremophila scoparia*, *Maireana* and *Tecticornia disarticulata* are dominant while Stantec reported *Gunniopsis propinqua* P3 in this community type. The Breakaway Complex extends well outside the Study Area near the Mertondale deposit.

11.01	Eremophila scoparia, Frankenia spp. Shrubland with Sclerolaena diacantha	EsFsppSspp

A complex of (i) Breakaway slopes and saline plains and (ii) Breakaway Plateaux. Breakaway slopes and saline plains supporting a Chenopod dominated low shrublands of *Maireana triptera*, *Sclerolaena diacantha*, and *Frankenia setosa* (type 2), PFC 10 to 15%. Breakaway Plateaux and upper slopes with *Eremophila scoparia* PFC 5%, occasional tall *Eucalyptus gypsophila* to 8m, PFC < 1% on the upper slopes at the eastern side of the large eroded gully. Highly eroded gully system below low breakaways, ca 5 to 10m relief, with kaolinitic slopes and soils and with abundant continuous mantle of angular metamorphosed mudstone, ironstone, quartz gravel and stones to 10 cm diameter. Slopes form vertical to 15 - 20 degrees and a near-level valley floor with narrow unincised drainage channels. Breakaways on the margin have lateritised rocks and support *Acacia sibirica*, *A. craspedocarpa* (lanceolate phyllode form), *A. aneura* sens. lat., *Dodonaea viscosa* subsp. *mucronata* 2m, *Eremophila annoscaulis* P3 1m, *Senna manicula* 1.2m, *Ptilotus obovatus* Typical Goldfields form (G Cockerton et al 15213) 0.5m, PFC 5 to 10%, and occasional *Philotheca brucei* subsp. *brucei* and *Eragrostis lancunaria*.



Appendix 6. Records of Significant Flora Species Generated in this Study

Name	Taxon	Status	Zone	Zone	Easting	Northing	# Plants
Priority Flora							
Ea1	Eremophila annoscaulis	P3	51	J	364060	6807367	
Ea2	Eremophila annoscaulis	P3	51	J	363668	6807699	
Ea3	Eremophila annoscaulis	P3	51	J	363463	6807686	
Ea4	Eremophila annoscaulis	P3	51	J	356524	6837303	
Ea5	Eremophila annoscaulis	P3	51	J	358103	6837547	
Ea6	Eremophila annoscaulis	P3	51	J	358748	6827590	
Ea7	Eremophila annoscaulis	P3	51	J	359400	6826083	
Ea8	Eremophila annoscaulis	P3	51	J	364831	6818548	
Ea9	Eremophila annoscaulis	P3	51	J	358076	6837472	
AspMP1	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	365990	6814583	17
AspMP2	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	366019	6814442	10
AspMP3	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	366128	6814262	20
AspMP4	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	366148	6814350	12
AspMP5	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	366304	6814427	30
AspMP6	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	366273	6814130	20
AspMP7	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	366295	6814049	40
AspMP8	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	366333	6813884	20
AspMP9	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	367032	6814517	2
AspMP10	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	367074	6814468	2
AspMP11	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	367008	6814300	20
AspMP12	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	366977	6814310	20
AspMP13	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	366948	6814320	20
AspMP14	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	366926	6814339	20
AspMP15	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	366892	6814375	500

Name	Taxon	Status	Zone	Zone	Easting	Northing	# Plants
AspMP16	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	365167	6811933	400
AspMP17	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	365645	6812063	1000
AspMP18	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	363394	6811615	500
AspMP19	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	363191	6811868	50
AspMP20	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	370805	6804665	500
AspMP21	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	370578	6805286	2000
AspMP22	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	360181	6805123	150
AspMP23	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	369761	6804764	5000
AspMP24	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	368209	6803927	50
AspMP25	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	369296	6804669	150
AspMP26	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	369202	6806191	5000
AspMP27	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	366620	6808946	100+
AspMP28	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	363003	6811036	10
AspMP29	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	362999	6810824	50
AspMP30	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	363242	6810653	100
AspMP31	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	363302	6809819	10
AspMP32	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	363332	6806633	100
AspMP33	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	363942	6811028	50
AspMP34	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	364227	6810687	1
AspMP35	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	361069	6810949	200
AspMP36	Acacia sp. Marshall Pool (G. Cockerton 3024)	P3	51	J	370685	6806175	
Cc1	Cratystylis centralis	P3	51	J	359190	6811436	268

Name	Taxon	Status	Zone	Zone	Easting	Northing	# Plants
Range Extensions or Limits of Range							
Aoc1	Alectryon oleifolius subsp. canescens	RE	51	J	363227	6805904	1
Aoc2	Alectryon oleifolius subsp. canescens	RE	51	J	363211	6805932	1
Aoc3	Alectryon oleifolius subsp. canescens	RE	51	J	364205	6810623	1
Aoc4	Alectryon oleifolius subsp. canescens	RE	51	J	365725	6811135	1
Aoc5	Alectryon oleifolius subsp. canescens	RE	51	J	365731	6811137	1
Aoc6	Alectryon oleifolius subsp. canescens	RE	51	J	366598	6812635	2
Aoc7	Alectryon oleifolius subsp. canescens	RE	51	J	367165	6813054	1
Aoc8	Alectryon oleifolius subsp. canescens	RE	51	J	358360	6817917	5
Aoc9	Alectryon oleifolius subsp. canescens	RE	51	J	361814	6833380	1
Aoc10	Alectryon oleifolius subsp. canescens	RE	51	J	361463	6834273	1
Aoc11	Alectryon oleifolius subsp. canescens	RE	51	J	360760	6837749	1
Sp1	Sarcozona praecox	RE	51	J	366046	6816576	
Sp2	Sarcozona praecox	RE	51	J	366098	6815885	
PtW1	Polycarpon tetraphyllum *	W, RE	51	J	371679	6804641	
Species with Taxonomic Interest							
AqNP1	Acacia quadrimarginea narrow phyllode form (G. Cockerton WB38064)	TI	51	J	360704	6812526	3
AqNP2	Acacia quadrimarginea narrow phyllode form (G. Cockerton WB38064)	TI	51	J	369202	6806191	1
CspL	Centrolepis sp. Leonora (G. Cockerton & G. Grigg WB40071)	TI	51	J	364291	6818208	
HspP1	Hibiscus sp. Perrinvale Station (J. Warden & E. Ager WB10581)	TI	51	J	365172	6817562	

Name	Taxon	Status	Zone	Zone	Easting	Northing	# Plants
HspP2	Hibiscus sp. Perrinvale Station (J. Warden & E. Ager WB10581)	TI	51	J	365503	6817750	
HspP3	Hibiscus sp. Perrinvale Station (J. Warden & E. Ager WB10581)	TI	51	J	366082	6814363	
HspP4	Hibiscus sp. Perrinvale Station (J. Warden & E. Ager WB10581)	TI	51	J	366892	6814375	
?HspP5	? Hibiscus sp. Perrinvale Station (J. Warden & E. Ager WB10581)	TI	51	J	365167	6811933	
?HspP6	? Hibiscus sp. Perrinvale Station (J. Warden & E. Ager WB10581)	TI	51	J	365490	6812007	
?HspP7	? Hibiscus sp. Perrinvale Station (J. Warden & E. Ager WB10581)	TI	51	J	364400	6811875	
?HspP8	? Hibiscus sp. Perrinvale Station (J. Warden & E. Ager WB10581)	TI	51	J	363211	6810207	
?HspP9	? Hibiscus sp. Perrinvale Station (J. Warden & E. Ager WB10581)	TI	51	J	365478	6809735	
Poorly Collected Species							
Add1	Acacia doreta short phyllode form (M. Stone & S. Colwill WB34381)		51	J	361137	6810957	500
EspYC1	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	363780	6807066	5
EspYC2	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	364191	6815823	
EspYC3	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	364782	6818525	
EspYC4	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	362220	6811882	50
EspYC5	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	363838	6811569	200
EspYC6	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	363835	6811584	

Name	Taxon	Status	Zone	Zone	Easting	Northing	# Plants
EspYC7	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	363820	6811607	
EspYC8	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	363823	6811598	
EspYC9	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	363835	6811562	
EspYC10	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	363211	6810207	
EspYC11	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	362226	6809226	
EspYC12	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	362300	6809208	
EspYC13	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	362319	6809124	
EspYC14	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	362341	6809055	
EspYC15	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	362376	6809061	
EspYC16	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	363328	6808986	
EspYC17	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	363017	6805732	
EspYC18	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	363144	6805876	
EspYC19	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	363274	6805914	
EspYC20	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	363497	6805784	
EspYC21	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	364523	6811283	

Name	Taxon	Status	Zone	Zone	Easting	Northing	# Plants
EspYC22	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	364522	6811198	
EspYC23	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	363333	6808984	
EspYC24	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	365397	6809896	
EspYC25	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	365369	6809978	
EspYC26	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	364727	6811862	lots
EspYC27	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	364195	6815899	
EspYC28	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	366561	6813615	
EspYC29	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	366515	6813604	
EspYC30	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	365536	6812983	
EspYC31	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	367115	6815130	1
EspYC32	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	367243	6814955	5
EspYC33	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	365073	6813798	
EspYC34	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	365109	6813744	
EspYC35	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	365190	6813630	
EspYC36	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	360848	6812506	2

Name	Taxon	Status	Zone	Zone	Easting	Northing	# Plants
EspYC37	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	361532	6811051	20
EspYC38	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	371080	6804571	
EspYC39	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	373008	6804930	
EspYC40	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	371810	6805127	
EspYC41	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	371312	6805042	
EspYC42	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	367494	6807329	
EspYC43	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	367173	6807131	
EspYC44	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	362918	6811865	20
EspYC45	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	371519	6804771	10,000
EspYC46	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	373082	6804834	10,000
EspYC47	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	368764	6804058	10
EspYC48	Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH26770)		51	J	369140	6805120	1000
Nm1	Neurachne munroi		51	J	365806	6817370	
Nm2	Neurachne munroi		51	J	366511	6815363	
Nm3	Neurachne munroi		51	J	364756	6811024	125
Nm4	Neurachne munroi		51	J	364724	6811138	125
Nm5	Neurachne munroi		51	J	364696	6811187	125
Nm6	Neurachne munroi		51	J	364670	6811204	125
Nm7	Neurachne munroi		51	J	364289	6810527	100

Name	Taxon	Status	Zone	Zone	Easting	Northing	# Plants
Nm8	Neurachne munroi		51	J	366699	6813459	30
Nm9	Neurachne munroi		51	J	366685	6813555	50
Nm10	Neurachne munroi		51	J	366695	6813540	50
Nm11	Neurachne munroi		51	J	365679	6813481	300
Nm12	Neurachne munroi		51	J	362737	6816962	50
Nm13	Neurachne munroi		51	J	360482	6812523	20
Weeds							
BpW1	Bidens bipinnata *	W	51	J	371679	6804641	
BpW2	Bidens bipinnata *	W	51	J	356524	6837303	
BpW3	Bidens bipinnata *	W	51	J	356691	6837541	
BpW4	Bidens bipinnata *	W	51	J	362447	6811835	
CcilW1	Cenchrus ciliaris *	W	51	J	363151	6810803	
CcilW2	Cenchrus ciliaris *	W	51	J	362619	6811489	
CcilW3	Cenchrus ciliaris *	W	51	J	362200	6809254	
CcilW4	Cenchrus ciliaris *	W	51	J	363300	6805602	
CcilW5	Cenchrus ciliaris *	W	51	J	363293	6805838	
CcilW6	Cenchrus ciliaris *	W	51	J	365066	6808600	
CcilW7	Cenchrus ciliaris *	W	51	J	365478	6809735	
CcilW8	Cenchrus ciliaris *	W	51	J	365323	6810046	
CcilW9	Cenchrus ciliaris *	W	51	J	363898	6810845	4
CcilW10	Cenchrus ciliaris *	W	51	J	365362	6811234	10
CcilW11	Cenchrus ciliaris *	W	51	J	365900	6810952	
CcilW12	Cenchrus ciliaris *	W	51	J	366074	6811123	
CcilW13	Cenchrus ciliaris *	W	51	J	365898	6813576	
CcilW14	Cenchrus ciliaris *	W	51	J	371118	6804529	
CcilW15	Cenchrus ciliaris *	W	51	J	371220	6804866	
CcilW16	Cenchrus ciliaris *	W	51	J	371126	6805268	
CcilW17	Cenchrus ciliaris *	W	51	J	365307	6805602	
CcilW18	Cenchrus ciliaris *	W	51	J	363913	6804890	
CsetW1	Cenchrus setiger *	W	51	J	371679	6804641	
CsetW2	Cenchrus setiger *	W	51	J	371519	6804771	

Name	Taxon	Status	Zone	Zone	Easting	Northing	# Plants
CitColW1	Citrullus colocynthis *	W	51	J	363628	6814478	1
CucMyrW1	Cucumis myriocarpus *	W	51	J	365114	6813282	1
CucMyrW2	Cucumis myriocarpus *	W	51	J	358123	6828819	
CylFulMamWoNS1	Cylindropuntia fulgida var. mamillata *	W, WoNS	51	J	356653	6827254	
EmeuW1	Rumex hypogaeus *	W	51	J	371679	6804641	
LdW1	Lepidium didymum *	W	51	J	371679	6804641	
MaW1	Malvastrum americanum *	W	51	J	372821	6805171	10+
PtW1	Polycarpon tetraphyllum *	W, RE	51	J	371679	6804641	



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APPENDIX B

Stantec – Flora and Fauna Extrapolation Exercise Report, Leonora Gold Project 2018b



LEONORA GOLD PROJECT - FLORA AND FAUNA EXTRAPOLATION EXERCISE REPORT

PREPARED FOR **KIN MINING NL**

11 September 2018

Stantec

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Executive Summary

Kin Mining NL (Kin) plans to develop the Leonora Gold Project (LGP), located between seven and 40 kilometres (km) east of the town of Leonora, in the Murchison bioregion. The LGP comprises historically mined areas, a proposed haul road that links the three Mining Areas (Mertondale, Cardinia and Raeside) and a processing plant. Stantec Australia (Pty) Ltd (Stantec) completed the Level 1 Flora and Fauna assessment for the LGP in 2016 and 2017. Subsequently, there have been additions made to the proposed disturbance footprints at Cardinia and Raeside which extend outside the area surveyed (the Study Area). As a result, it became necessary to expand the Study Area to include the additional areas. Stantec was appointed to undertake the desktop extrapolation exercise of the additional areas, referred to as the Extrapolation Area, to support the ongoing approvals process of the LGP.

The extrapolation exercise made use of existing aerial imagery, photographs of specific areas, data collected from the original field surveys, as well as data collected from a short reconnaissance survey conducted in March 2018, to extend the vegetation mapping (for both vegetation units and condition) and fauna habitat mapping.

The extent of the Revised Study Area has increased from 2,288 ha to 3,545 ha with the inclusion of the Extrapolation Area. A total of 20 vegetation units were previously mapped at Cardinia and Raeside, comprising broadly of mixed Mulga shrublands over mixed shrubs dominated by *Eremophila* species, *Ptilotus obovatus*, *Scaevola spinescens* and *Rhagodia* species, also with large areas dominated by *Cratystylis subspinescens, Maireana pyramidata* and *Maireana sedifolia*. Each of the 20 vegetation types were extrapolated to the additional areas. A small additional area (4.53ha) of the Asp.MsEs vegetation unit was identified in the north of the Study Area, mapped previously as AiMsTd. No Further additions were made to the previously mapped vegetation units.

In summary, all vegetation units and fauna habitats mapped within the Extrapolation Area were representative of vegetation units and habitats in the Survey Area previously assessed by Stantec.

None of the vegetation units identified in the Extrapolation Area correspond the vegetation of any known Threatened or Priority Ecological Communities.

No flora or fauna taxa of conservation significance were identified during the ground truthing field survey. However, both conservation significant flora identified during the survey of the Survey Area have potential to occur in the Extrapolation Area due to the likely presence of the same vegetation units that support these taxa.

Vegetation units *HpCsMp* and *AiMsTd* that were mapped within the Extrapolation Area have the potential to contain *Gunniopsis propinqua* (P3). Similarly, the vegetation unit AaArAq was mapped within the Extrapolation Area and has the potential to contain *Grevillea ? inconspicua* (P4).

In addition, the putative hybrid and potential new species identified previously in the Revised Study Area, *Acacia* sp. nov. aff. *resinimarginea*, was identified in the A?rSaMs vegetation unit that was present in the Extrapolation Area. This taxon is currently under review as a potential new species.

Kin Mining NL

Leonora Gold Project - Flora and Fauna Extrapolation Exercise Report

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1. Introduction

1.1 Project Background

Kin Mining NL (Kin) plans to develop the Leonora Gold Project (LGP) which is located between seven and 40 kilometres (km) east of the town of Leonora. The LGP comprises historically mined areas (**Figure 1-1**), a proposed haul road that links the three Mining Areas (Mertondale, Cardinia and Raeside) and a processing plant.

Stantec Australia (Pty) Ltd (Stantec) completed the Level 1 Flora and Fauna assessment for the LGP in 2016 and 2017 (Stantec 2018). Subsequently, there have been additions made to the proposed disturbance footprints at Cardinia and Raeside which extend outside the area surveyed (the Study Area) (**Figure 1-1**). As a result, it became necessary to expand the Study Area to include the additional areas, hereon referred to as the Extrapolation Area. Consequently, three areas are referred to in this report:

- **Survey Area:** a 2, 287.6 hectare (ha) parcel of land that was surveyed by Stantec in 2016 and 2017 Stantec (2018);
- **Extrapolation Area:** a 1, 257.4 ha area that extends outside the Survey Area and requires extrapolation to encompass proposed disturbance footprints; and
- **Revised Study Area:** a 3, 545 ha area that encompasses both the Survey Area and the Extrapolation Area and will be used to support the approvals of the LGP.

Kin has appointed Stantec to undertake a desktop extrapolation exercise of additional areas, not previously surveyed in the field, to support the ongoing approvals process for Phase 2A and 2B of the Project. The extrapolation exercise has made use of existing aerial imagery, photographs of specific areas, data collected from the original field surveys, as well as data collected from a short reconnaissance survey conducted in March 2018, to extend the vegetation mapping (for both vegetation units and condition) and fauna habitat mapping to the extent of the Extrapolation Area.

This report details the results of the extrapolation exercise and includes mapping for the Extrapolation Area. The assessment was based primarily on the data collected and analysed from the following baseline survey conducted for the LGP:

- Leonora Gold Project: Level 1 Flora, Vegetation and Fauna Assessment (Stantec 2018).

1.2 Report Scope and Objectives

The overarching objective of this assessment is to extrapolate data collected from the previous surveys to the Extrapolation Area. The following figures were revised:

- Vegetation condition;
- Vegetation units; and
- Fauna habitats.

Further to this, this assessment was carried out in compliance to the following regulatory guidelines:

- Environmental Factor Guideline – Flora and Vegetation (EPA 2016f);
- Environmental Factor Guideline – Terrestrial Fauna (EPA 2016a);
- Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016b);
- Technical Guidance: Sampling methods for Terrestrial vertebrate fauna (EPA 2016c); and
- Technical Guidance: Terrestrial Fauna Surveys (EPA 2016d).

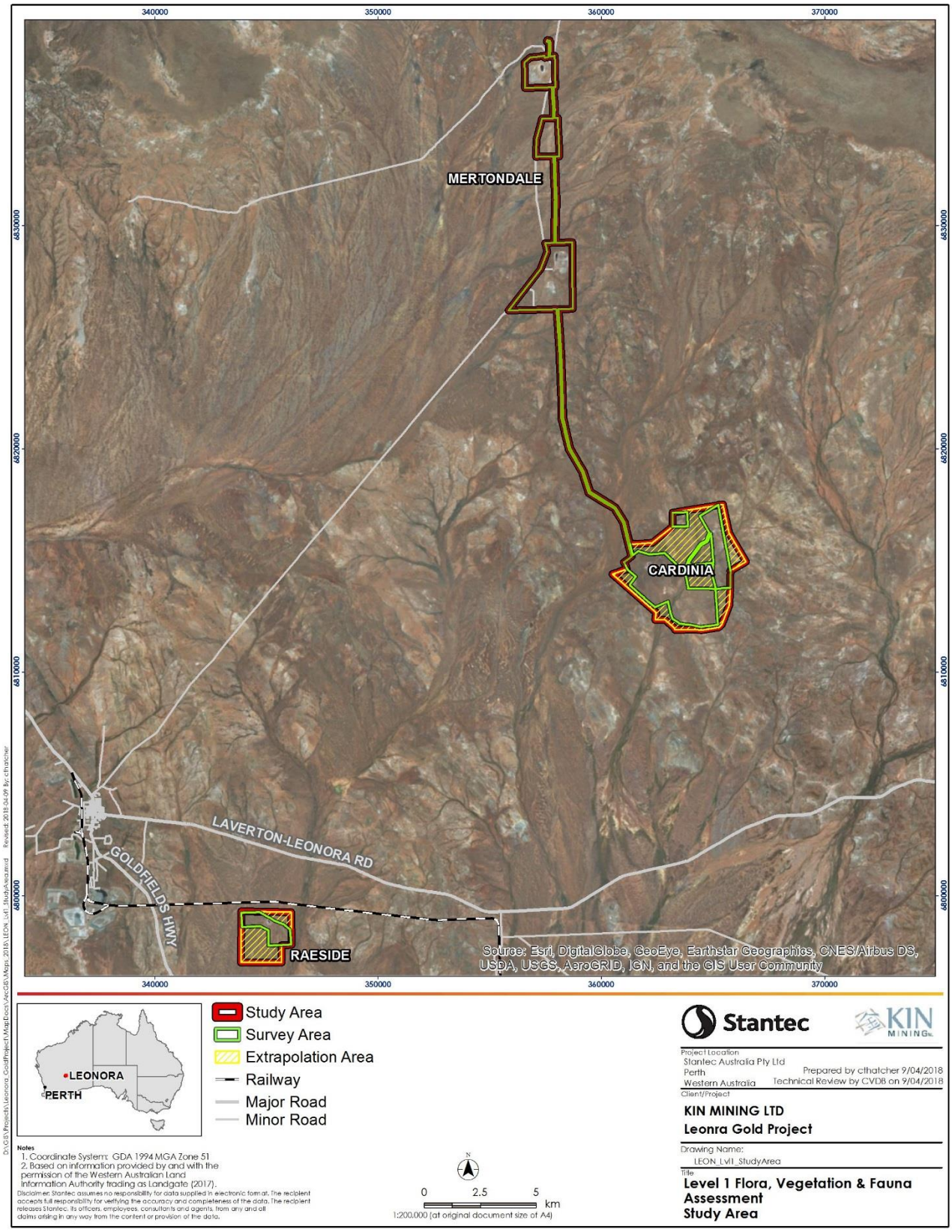


Figure 1-1: Study Area

2. Methodology and Approach

2.1 Survey Timing and Weather

The optimal timing for surveying flora and fauna in the Eremaean Province (where the Study Area is located) is six to eight weeks following the season which normally contributes the most rainfall (EPA 2016b, e). The reconnaissance field survey was conducted on the 17th and 18th of March 2018 to ground-truth habitats within the Extrapolation Area. Since the first significant rainfall event of the season took place on the 19th of February 2018, the field survey took place at least two weeks prior to the perceived optimal period for field surveys in the Eremaean Province. However, this timing was considered suitable due to the level of survey effort required for a reconnaissance-level assessment. **Table 2-1** represents summarises details of previous surveys undertaken for the LGP by Stantec, as well as the dates of the field survey for the reconnaissance survey.

Table 2-1: Field survey timing

Survey	Timing	Areas
Survey 1	28th of November to 5th December 2016	Mertondale, Cardinia and Raeside areas, as well as the proposed haul road, processing plant and accommodation camp.
Survey 2	10th-12th of May 2017	
Targeted survey for *Acacia* sp. nov. aff. *resinimarginea*	7th – 10th of August 2017	Cardinia and surrounding area.
Reconnaissance survey	17th and 18th of March 2018	Extrapolation Area

2.2 Survey Team and Licensing

The extrapolation exercise and reconnaissance survey were conducted by Stantec ecologists Crystal Heydenrych and Laura True. Both field members have knowledge and experience in Western Australia, specifically within the Murchison. All plant collections were taken under flora collecting permit SL012176 pursuant to the WC Act (Section 23C and Section 23F). Sharnya Thomson completed the identifications of the vascular flora specimens collected.

2.3 Extrapolation Exercise

The extrapolation exercise involved assigning vegetation units and fauna habitats to the Extrapolation Area on desktop level from areas that had been mapped previously in the Survey Area; as well as a short field ground-truthing survey. The Extrapolation Area was traversed on foot and photographs were taken of the landscape to supplement data collected from the ground-truthing field survey. A total of seven mapping notes were taken in the Extrapolation Area during the ground-truthing field survey (**Appendix B**). The following information was recorded at each mapping note:

- Mapping note number;
- Survey date;
- Personnel;
- GPS coordinates;
- Site photograph;

- Vegetation condition (based on Keighery (1994); (**Appendix C**); and
- Vegetation structure description (based on ESCAVI 2003) (**Appendix D**);

For the extrapolation of vegetation units on aerial imagery, vegetation composition that were characteristic of the existing vegetation type mapping were used to extrapolate to the additional areas. The vegetation condition for the areas previously assessed ranged from Excellent to Completely Degraded (Keighery 1994). In order to extrapolate the vegetation condition mapping, landscape features such as tracks, cleared areas, infrastructure and existing operational areas and drill lines were identified on aerial imagery to determine the extent of disturbance of vegetation.

Broad fauna habitats identified in areas previously surveyed were comprised of; Acacia Shrublands on plains, drainage Lines, low hills and chenopod shrublands. Fauna habitats were distinguished based on changes in substrate composition (i.e. rock, sand or alluvial based), as well as vegetation density and structure. Aerial imagery was analysed to detect characteristics related to substrate composition and vegetation structure in order to map fauna habitats and extrapolate from the existing data.

2.1 Survey Limitations and Constraints

There are a number of possible limitations and constraints that can reduce the adequacy of vegetation, flora and fauna surveys (EPA 2016b, d). The extrapolation of vegetation units was completed with a low to moderate confidence level. Particularly, where vegetation mapping was more complex due to the presence of geological features and micro-scale changes across the vegetation across hill crests, slopes, and swales between the crests. The extrapolated vegetation mapping should be regarded as a broad indication of habitats and patterns present in the Extrapolation Area only. Given that broad habitats had been identified in the previous survey (Stantec 2018) and due to the availability of regional information pertaining to biodiversity, the level of survey effort was considered appropriate.

3. Results

No additional vegetation units, vegetation condition or fauna habitats were identified during the reconnaissance field survey that were not previously described in the Level 1 Flora and Fauna survey (Stantec 2018).

3.1 Revisions to Vegetation Unit Mapping

The vegetation recorded broadly comprised mixed Mulga shrublands over mixed shrubs dominated by *Eremophila* species, *Ptilotus obovatus*, *Scaevola spinescens* and *Rhagodia* species, also with large areas dominated by *Cratystylis subspinescens, Maireana pyramidata* and *Maireana sedifolia* (Stantec 2018).

Table 3-1 represents a summary of each of the vegetation units recorded within the Study Area and lists their extent in the Survey Area, as well as their extent within the Revised Study Area which includes the Extrapolation Area. The distribution of the vegetation units recorded within the revised Study Area is represented in **Figure 3-1** and **Figure 3-2** for Cardinia and Raeside respectively and show that the vegetation is dominated by the HPCsMp vegetation unit, comprising just under 20% of the total Study Area. Over 16% of the Study Area is occupied by the AaAtEspp vegetation unit which was found to be extensive in the Extrapolation Area and is dominant at Raeside.

A small additional area (4.53ha) of the Asp.MsEs vegetation unit was identified in the north of Cardinia during the field survey, mapped previously as AiMsTd (**Figure 3-1**). This area was comprised of *Acacia* sp. low open woodland over mixed mid shrubland dominated by *Marieana sedifolia* over chenopod shrubland. No Further additions were made to the previously mapped vegetation units.

Table 3-1: Areas of each Vegetation Unit within the Study Area including the Extrapolation Area

Code	Description	Area (ha/%)					
		Survey Area		Extrapolation Area		Study Area	
		ha	%	ha	%	ha	%
AiElEc	*Acacia incurvaneura* low open woodland over *Eremophila latrobei* subsp. *latrobei, Solanum lasiophyllum* and *Ptilotus obovatus* low sparse shrubland, over *Enneapogon caerulescens* low grassland over *Sclerolaena diacantha* isolated dwarf chenopod shrubs.	13.56	0.59	2.65	0.22	16.21	0.46
AiMsTd	*Acacia inceana* subsp. *conformis* low woodland over *Maireana sedifolia* mid isolated shrubs over *Maireana pyramidata* and *Tecticornia disarticulata* low isolated chenopod shrubs.	65.05	2.84	183.66	14.06	295.6	8.34
Asp.MsEs	*Acacia* sp. low open woodland over *Maireana sedifolia* and *Eremophila scoparia* mid open shrubland, over *Sclerolaena diacantha* sparse isolated dwarf chenopod shrubland.	18.96	0.83	10.38	0.83	33.87	0.96
AaAtEspp.	*Acacia aneura, Acacia caesaneura* and *Acacia pteraneura* low woodland over *Acacia tetragonophylla* tall isolated shrubs over mixed low isolated shrubs.	253.5	11.08	321.19	25.54	568.46	16.04
AbArEp	*Acacia burkittii, Acacia aneura* and *Acacia craspedocarpa* low open woodland over *Grevillea extorris, Acacia ramulosa* var. *ramulosa* and *Eremophila platycalyx* subsp. *platycalyx* mid isolated shrubs over *Monachather paradoxus* low isolated grasses on rocky drainage line	0.87	0.04	3.65	0.30	0.87	0.02
AbAtTt	*Acacia burkittii* and *Acacia aptaneura* low open woodland over *Acacia tetragonophylla* and *Acacia burkittii* mid sparse shrubland over *Themeda triandra*, *Eriachne flaccida* and *Enteropogon ramosus* low tussock grasses on sandy drainage line.	75.28	3.29	169.35	13.47	243.87	6.88
AbEpPo	*Acacia burkittii* tall open shrubland over *Eremophila platycalyx* subsp. *platycalyx*, *Eremophila forrestii* subsp. *forrestii* and *Senna artemisioides* subsp. *artemisioides* mid isolated shrubs over *Ptilotus obovatus* low isolated shrubs, over *Aristida contorta* low isolated grasses on hills	6.65	0.29	0.00	0.00	6.65	0.19
AaAtEp	*Acacia aneura, Acacia aptaneura* and *Acacia caesaneura* low open woodland over *Eremophila platycalyx* subsp. *platycalyx, Acacia ramulosa* subsp. *ramulosa* and *Acacia tetragonophylla* tall to mid isolated shrubs over *Ptilotus obovatus, Eremophila*	239.27	10.46	4.49	0.37	243.76	6.88

Code	Description	Area (ha/%)					
		Survey Area		Extrapolation Area		Study Area	
		ha	%	ha	%	ha	%
	metallicorum and *Eremophila margarethae* low isolated shrubs, over mixed low grasses.						
AaArAq	*Acacia quadrimarginea, Acacia incurvaneura* and *Acacia aneura* low woodland over *Acacia ramulosa* var. *ramulosa* and *Acacia tetragonophylla* tall to mid sparse shrubland over Eremophila spp. low isolated shrubs over *Eragrostis eriopoda* and *Monachather paradoxus* isolated tussock grasses	71.52	3.13	20.08	1.60	91.6	2.58
AaArEspp.	*Acacia aneura, Acacia incurvaneura* and *Acacia caesaneura* low open forest over *Acacia ramulosa* var. *ramulosa* tall isolated shrubs over *Eremophila* spp. mid isolated shrubs over low isolated mixed shrubs, herbs and grasses,	265.54	11.61	39.68	3.15	305.89	8.63
AkAbMs	*Acacia kempeana* low open woodland over *Acacia burkittii, Maireana sedifolia* and *Eremophila scoparia* mid open shrubland, over *Ptilotus obovatus, Sida ectogama* and *Solanum lasiophyllum* low isolated shrubs, over *Enneapogon caerulescens* and *Sclerolaena eriacantha* low isolated forbs and grasses on rocky hills	44.04	1.93	64.76	5.30	108.74	3.06
A?rSaMs	*Acacia* sp. nov. aff. *resinimarginea, Acacia aneura* and *Acacia caesaneura* tall open shrubland, over Senna *artemisioides* subsp. *filifolia*, *Scaevola spinescens* and *Acacia tetragonophylla* mid isolated shrubs over Ptilotus *obovatus, Maireana sedifolia* and *Solanum lasiophyllum* low isolated shrubs over *Ptilotus helipteroides* and *Enneapogon caerulescens* low isolated forbs and grasses on rocky hills	70.6	3.09	22.67	1.80	89.54	2.53
AaSaMs	*Acacia aneura* and *Acacia caesaneura* tall open woodland over *Senna artemisioides* subsp. *filifolia, Maireana sedifolia* and *Ptilotus obovatus* low open shrubland over low mixed chenopod shrubland on rocky hills	111.66	4.88	5.65	0.46	150.01	4.23
AkHpEs	*Acacia kalgoorliensis, Acacia oswaldii* and *Hakea preissii* low open woodland over *Eremophila scoparia*, *Senna stowardii* and *Acacia craspedocarpa* mid isolated shrubs over *Ptilotus obovatus, Maireana triptera* and *Cratystylis subspinescens* low isolated shrubs over *Sclerolaena eriacantha, Sclerolaena densiflora* and *Ptilotus* sp. Goldfields (R. Davis 10796) low isolated forbs on rocky plains	36.11	1.58	4.49	0.36	40.45	1.14
AcHpEp	*Acacia craspedocarpa*, *Acacia aneura* and *Acacia incurvaneura* low open woodland over *Acacia oswaldii*, *Hakea preissii* and *Rhagodia drummondii* mid	19.09	0.83	9.16	0.01	28.25	0.8

Code	Description	Area (ha/%)					
		Survey Area		Extrapolation Area		Study Area	
		ha	%	ha	%	ha	%
	isolated shrubs, over *Eremophila pantonii, Maireana georgei* and *Atriplex nummularia* subsp. *spathulata* low isolated shrubs over *Sclerolaena densiflora, Enneapogon caerulescens* and *Ptilotus aervoides* low isolated forbs and grasses						
AcArSe	*Acacia craspedocarpa* and *Acacia aneura* low woodland over *Acacia ramulosa* var. *ramulosa* tall open shrubland, over *Sida ectogama* and *Eremophila* spp. mid isolated shrubs over low isolated mixed forbs and grasses			43.18	3.54	43.18	1.22
AcAtEo	*Acacia craspedocarpa*, *Acacia aneura* and *Acacia caesaneura* low woodland over *Acacia tetragonophylla*, *Scaevola spinescens* and *Eremophila oldfieldii* subsp. *angustifolia* mid isolated shrubs over *Ptilotus obovatus* and *Maireana tomentosa* subsp. *tomentosa* low isolated shrubs, over Ptilotus sp. Goldfields (R. Davis 10796), *Enneapogon caerulescens* and *Aristida contorta* low isolated forbs and grasses	157.4	6.88	105.52	8.40	262.48	7.4
AcAtEm	*Acacia craspedocarpa* low open forest over *Acacia tetragonophylla* tall open shrubland over *Eremophila metallicorum* low isolated shrubs over low isolated mixed forbs and grasses	71.31	3.12	0.00	0.00	71.16	2.00
AcAtEp	*Acacia craspedocarpa* and *Acacia caesaneura* low open woodland over *Acacia tetragonophylla* and *Eremophila platycalyx* subsp. *platycalyx* tall isolated shrubs, over *Ptilotus obovatus* and *Eremophila* spp. mixed low isolated shrubs over low isolated mixed forbs and grasses	45.81	2.00	0.00	0.00	45.81	1.29
CpArEo	*Casuarina pauper, Acacia caesaneura* and *Acacia aneura* low woodland over *Acacia ramulosa* var. *ramulosa* and Acacia tetragonophylla tall isolated shrubs over Eremophila oldfieldii subsp. angustifolia mid isolated shrubs over *Maireana triptera, Sclerolaena eriacantha* and *Sclerolaena densiflora* low isolated forbs	11.11	0.49	5.74	0.47	16.85	0.48
EsEsPo	*Eucalyptus striaticalyx* and *Acacia aneura* low open woodland over *Eremophila scoparia* and *Eremophila glabra* subsp. *glabra* mid isolated shrubs, over *Ptilotus obovatus*, *Scaevola spinescens* and *Lepidium platypetalum* low isolated shrubs on rocky outcrops	0.4	0.02	7.65	0.63	0.4	0.01
HpCsMp	*Hakea preissii* low isolated trees over *Cratystylis subspinescens* and *Maireana pyramidata* mid open shrubland over *Tecticornia pruinosa, Tecticornia disarticulata*	434.85	19.01	242.74	19.30	680.95	19.21

Code	Description	Area (ha/%)					
		Survey Area		Extrapolation Area		Study Area	
		ha	%	ha	%	ha	%
	and *Tecticornia pergranulata* subsp. *pergranulata* low open chenopod shrubland over *Enneapogon caerulescens* low isolated grasses						
MpTdSd	*Maireana pyramidata* and *Tecticornia disarticulata* low chenopod shrubland over *Sclerolaena densiflora* isolated dwarf chenopod shrubs with *Aristida contorta*, *Enteropogon ramosus* and *Sporobolus actinocladus* isolated tussock grasses	5.23	0.23	12.39	0.99	19.83	0.56
Disturbed	Areas of disturbance including historical and recent mining activities.	216.7	9.47	0.00	0.00	216.13	6.10
Revegetation	Previously disturbed areas which have been revegetated	9.9	0.43	8.65	0.71	9.9	0.28
Total	**-**	**2,287.6**	**100**	**1,257.55**	**100**	**3545.19**	**100**

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

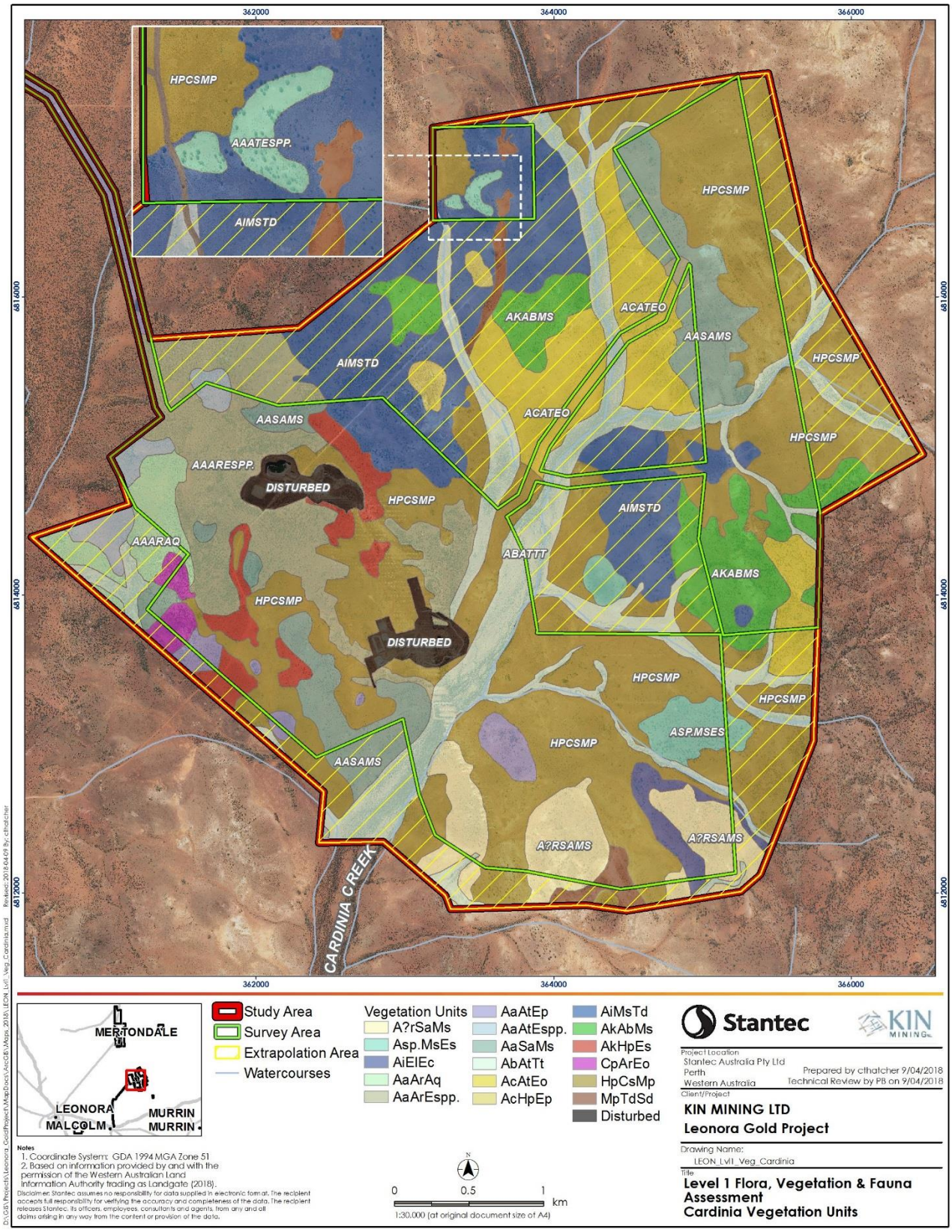


Figure 3-1: Vegetation Units – Cardinia

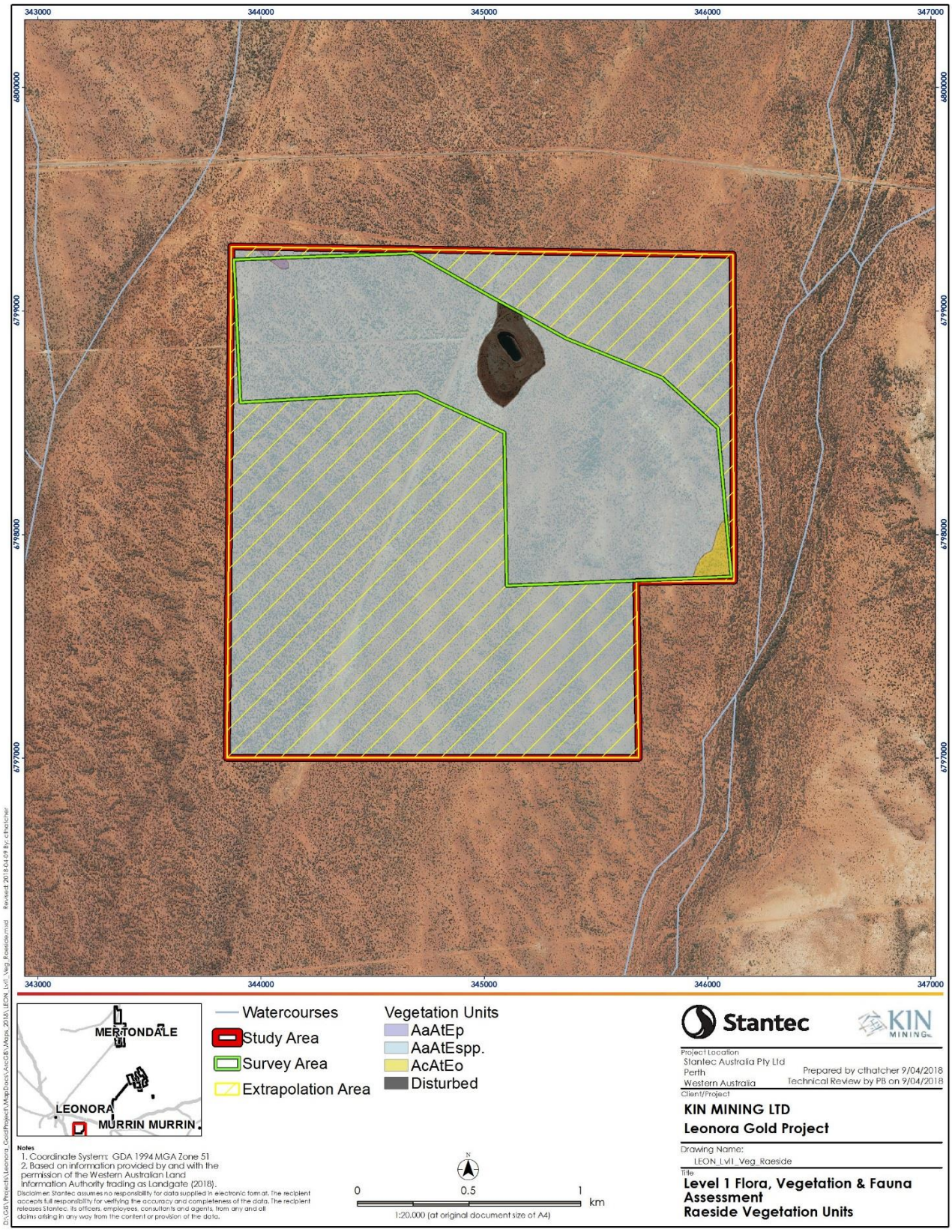


Figure 3-2: Vegetation Units – Raeside

3.1 Revisions to Vegetation Condition Mapping

Vegetation condition within the Study Area ranged from Excellent to Completely Degraded (**Table 3-2**, **Figure 3-3** and **Figure 3-4**). Over 70% of Cardinia was in a Very Good or Excellent condition, whereas the majority of Raeside was in a Good condition. This is consistent with what was mapped previously in the Level 1 Flora and Fauna survey (Stantec 2018).

Table 3-2: Areas of Vegetation Condition of the Study Area

Condition	Area (ha/%)					
	Survey Area		Extrapolation Area		Study Area	
	ha	%	ha	%	ha	%
Excellent	825.98	36.11	304.67	22.63	1110.55	31.33
Very Good	787.79	34.44	582.25	47.90	1390.23	39.23
Good	334.44	14.62	342.99	27.25	677.18	19.10
Degraded	132.40	5.79	23.28	1.86	155.73	4.39
Completely Degraded	195.65	8.55	4.37	0.36	200.16	5.65
Revegetation	11.34	0.5	0	0.00	11.34	0.32
Total	**2,287.6**	**100**	**1,257.55**	**100**	**3545.19**	**100**

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

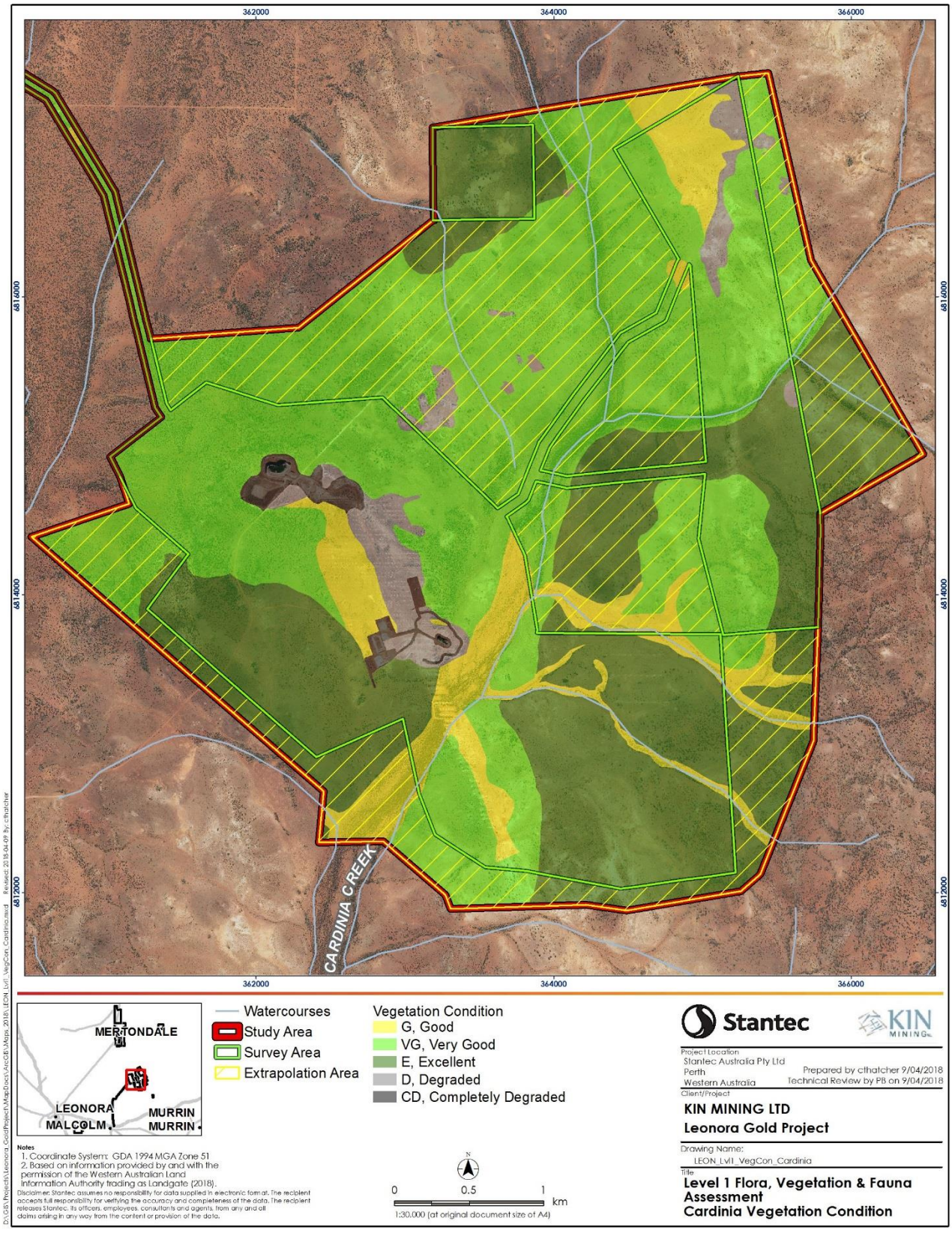


Figure 3-3: Vegetation Condition –Cardinia

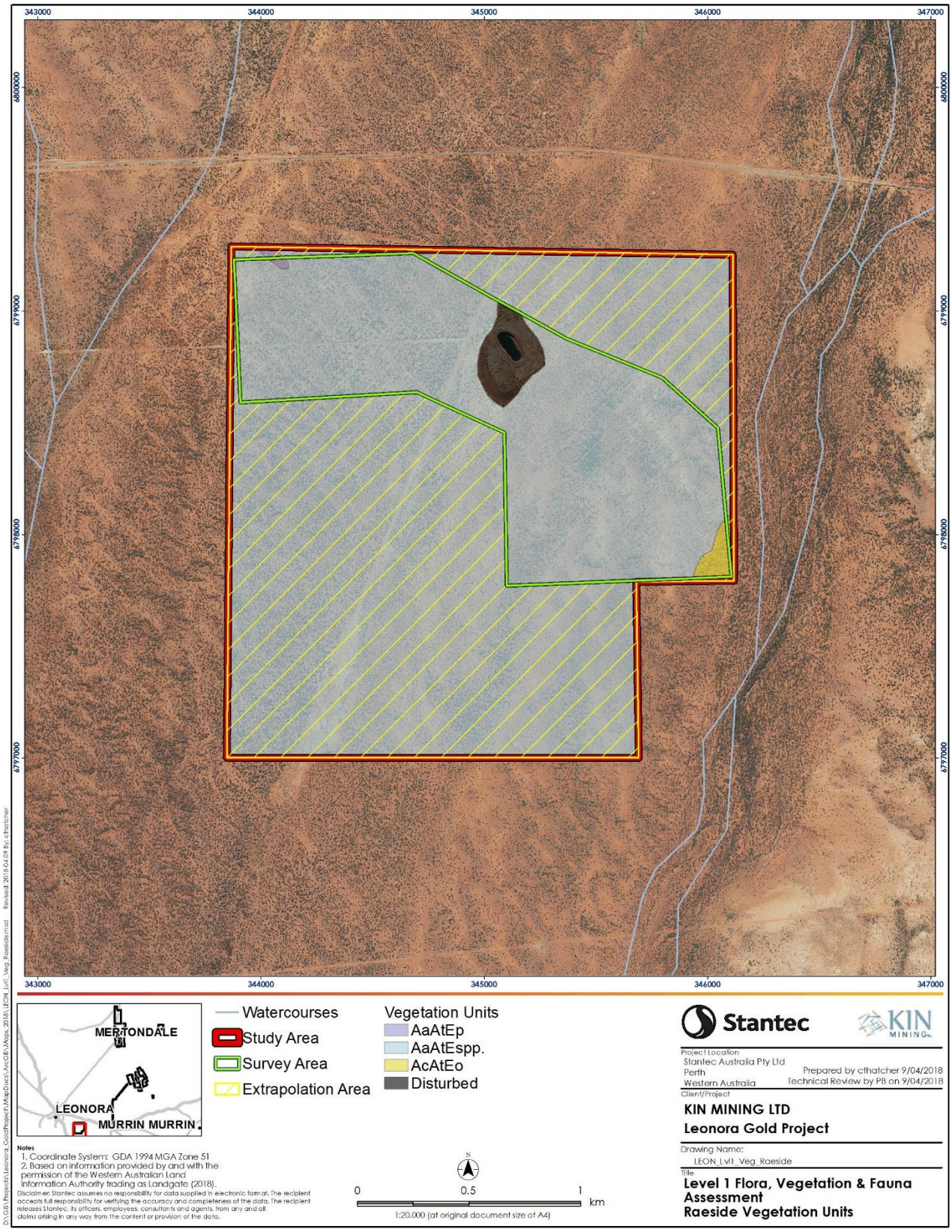


Figure 3-4: Vegetation Condition –Raeside

3.2 Revisions to Fauna Habitat Mapping

Table 3-3 represents a summary of each of the fauna habitat units recorded within the Extrapolation Area and lists their extent within the Survey Area and the Revised Study Area which includes the Extrapolation Area. The distribution of the fauna habitats recorded within the Revised Study Area is presented in **Figure 3-5** and **Figure 3-6.** Acacia shrublands on plains occupies just under 60% of the previous and current extents of the Study Area.

Table 3-3: Fauna habitat recorded within the Study Area

Fauna Habitat	Area (ha/%)					
	Survey Area		Extrapolation Area		Study Area	
	ha	%	ha	%	ha	%
Acacia shrublands on plains	1,300.30	56.84	701.50	55.78	2,062.81	58.03
Drainage Lines	76.15	3.33	169.35	13.47	244.74	6.90
Low Hills	244.46	10.69	131.58	10.46	320.64	9.02
Chenopod shrublands	440.08	19.24	255.12	20.29	700.78	19.77
Disturbed	226.60	9.91	0	0	216.13	6.10
Total	**2,287.6**	**100**	**1,257.55**	**100**	**3545.19**	**100**
Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of individual values.						

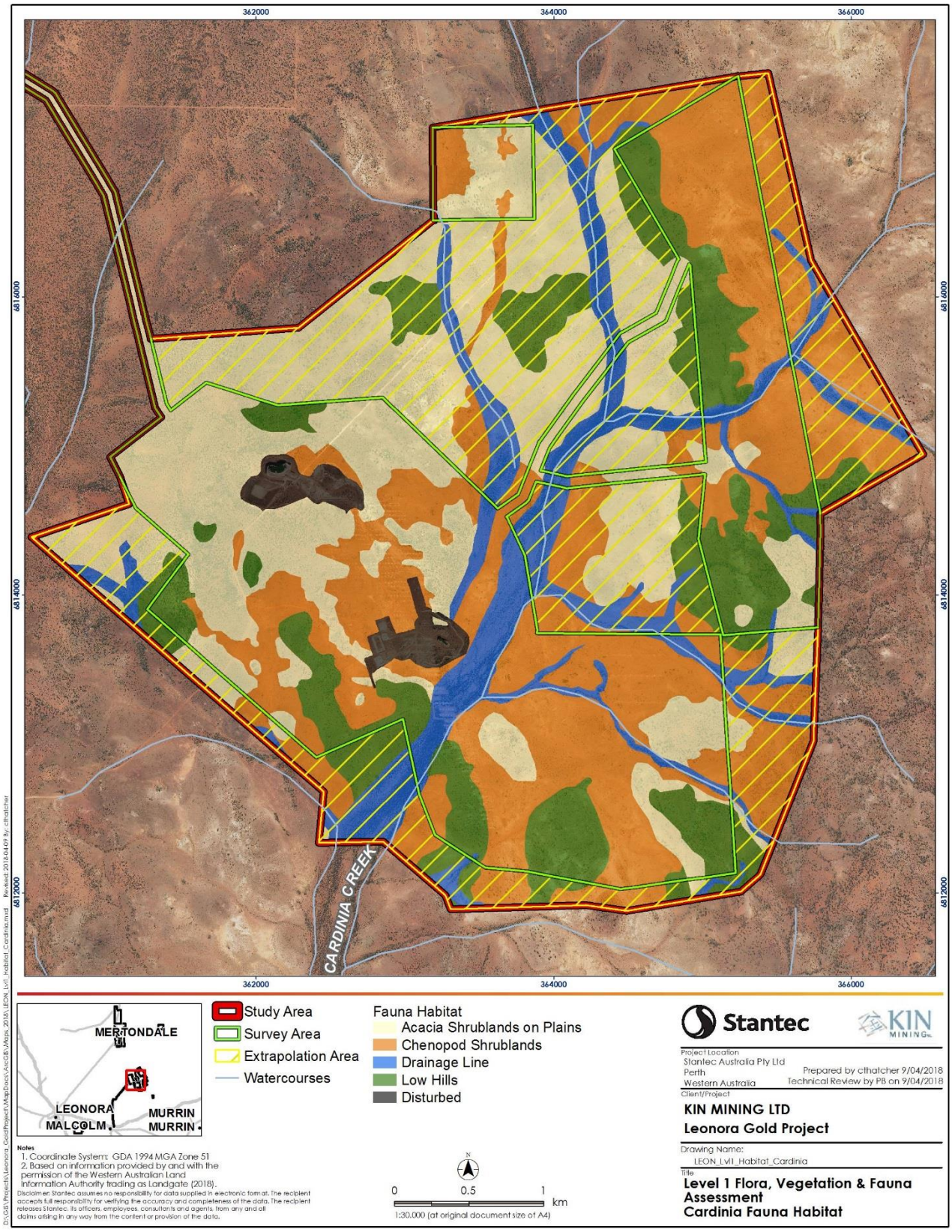


Figure 3-5: Fauna Habitat – Cardinia

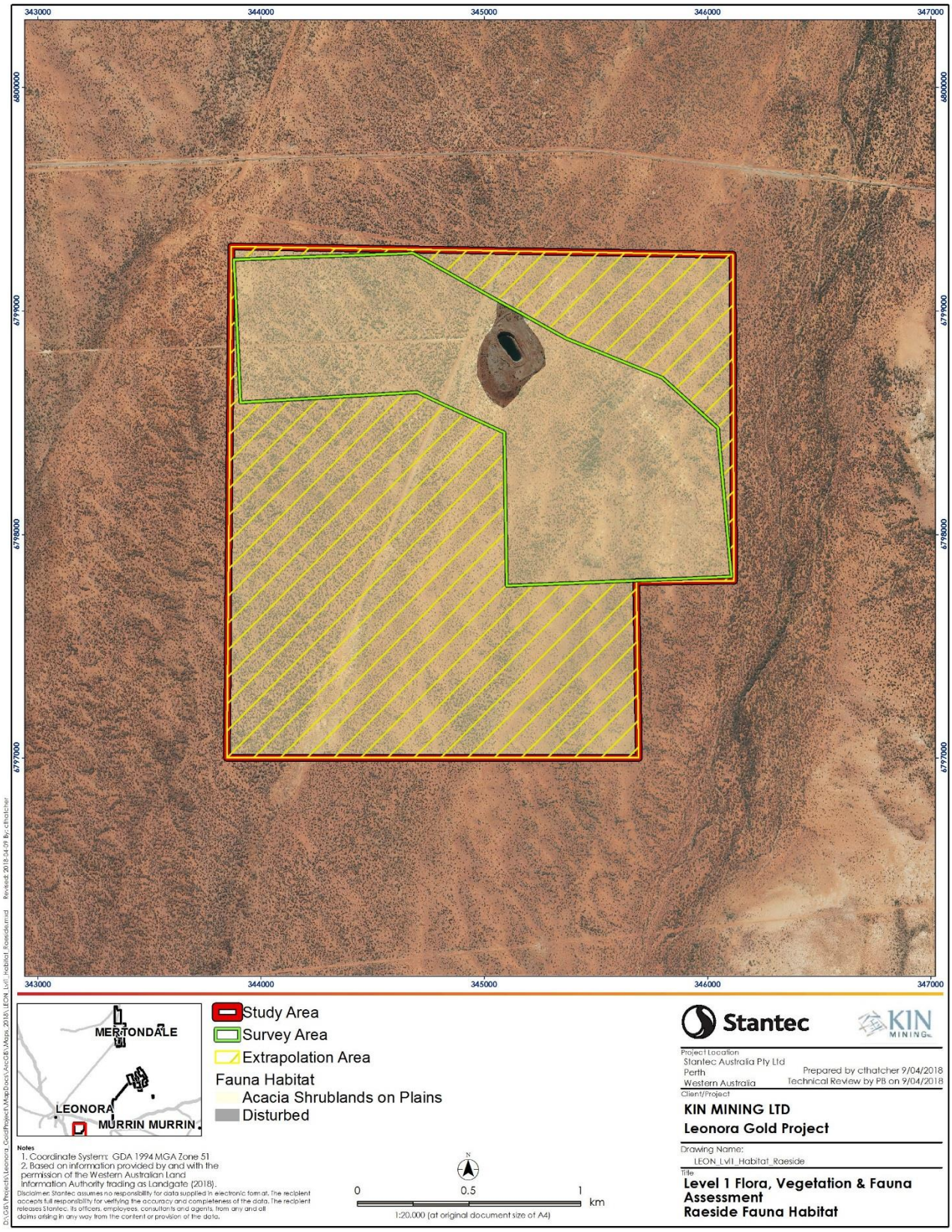


Figure 3-6: Fauna Habitat –Raeside

4. Conclusions

This extrapolation exercise utilised existing mapping (the Survey Area), aerial imagery and a ground truthing survey to map the extents of vegetation units, their condition and fauna habitats within the Extrapolation Area.

In summary, all vegetation units and fauna habitats mapped within the Extrapolation Area were representative of vegetation units and habitats in the Survey Area previously assessed by Stantec. None of the vegetation units identified in the Extrapolation Area correspond the vegetation of any known Threatened or Priority Ecological Communities.

No flora or fauna taxa of conservation significance were identified during the ground truthing field survey. However, both conservation significant flora identified during the survey of the Survey Area have potential to occur in the Extrapolation Area due to the likely presence of the same vegetation units that support these taxa.

Vegetation units *HpCsMp* and *AiMsTd* that were mapped within the Extrapolation Area have the potential to contain *Gunniopsis propinqua* (P3) which may be present within these vegetation units.

In addition, the putative hybrid and potential new species identified previously in the Revised Study Area, *Acacia* sp. nov. aff. *resinimarginea*, was identified in the A?rSaMs vegetation unit that was present in the Extrapolation Area. This taxon is currently under review as a potential new species.

5. References

EPA, Environmental Protection Authority. (2016a) *Environmental Factor Guideline - Terrestrial Fauna*, Perth, Western Australia.

EPA, Environmental Protection Authority. (2016b) *Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment* Environmental Protection Authority, Western Australia.

EPA, Environmental Protection Authority. (2016c) *Technical Guidance: Sampling methods for Terrestrial vertebrate fauna.* Environmental Protection Authority, Perth, Western Australia.

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Appendices



Appendix A Codes and Terms used to describe Species of Conservation Significance

Flora and fauna may be accorded legislative protection by being listed under the Environment Protection and Biodiversity Conservation Act 1999 (Cwlth) (EPBC Act) and/or the Wildlife Conservation Act 1950 (WA) (WC Act), or by being listed on the WA Department of Environment and Conservation's Priority Species List. This Appendix presents a summary of the different rankings and listings used to describe conservation status. Some categories, such as 'extinct', 'extinct in the wild' and 'conservation dependent' (EPBC Act) are not presented here, as the table includes only the information needed to fully understand the codes presented in the preceding report. Refer to the relevant legislation for a full description of all codes in use, as well as their associated criteria.

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

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

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

Priorities assigned under the DBCA Priority Taxa List		
Priority 1	**P1**	Taxa with few, poorly known populations on threatened lands. These are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened taxa
Priority 2	**P2**	Taxa with few, poorly known populations on conservation lands. These are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened taxa
Priority 3	**P3**	Taxa with several, poorly known populations, some on conservation lands. These are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened taxa
Priority 4	**P4**	Taxa in need of monitoring. These are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands
Priority 5	**P5**	Taxa in need of monitoring. These are not considered threatened but are subject to a specific conservation programme, the cessation of which would result in the species becoming threatened within five years

Appendix B Mapping Notes

Leonora Gold – LEXM01

Site Details:

Described by: Crystal Heydenrych

Date: 18-03-2018

Type: Mapping note

MGA Zone: 51J 363373 mE 6816318 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Flora and Vegetation:

Vegetation condition: Very Good

Vegetation description: *Cratystylis subspinescens, Maireana pyramidata* mid sparse shrubland over low *Maireana tomentosa* chenopod shrubland



Leonora Gold – LEXM02

Site Details:

Described by: Crystal Heydenrych

Date: 18-03-2018

Type: Mapping note

MGA Zone: 51J 363374 mE 6816629 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Flora and Vegetation:

Vegetation condition: Very Good

Vegetation description: Acacia sp. low isolated trees over *Eremophila scoparia* mid open shrubland over *Maireana sedifolia* sparse chenopod shrubland.



Leonora Gold – LEXM03

Site Details:

Described by: Crystal Heydenrych

Date: 17-03-2018

Type: Mapping note

MGA Zone: 51J 363673 mE 6816321 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Flora and Vegetation:

Vegetation condition: Very Good

Vegetation description: *Tecticornia ? disarticulata*, *Maireana pyramidata*, *Cratystylis subspinescens* low open chenopod shrubland.



Leonora Gold – LEXM04

Site Details:

Described by: Crystal Heydenrych

Date: 17-03-2018

Type: Mapping note

MGA Zone: 51J 364021 mE 6812054 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Flora and Vegetation:

Vegetation condition: Very Good

Vegetation description: *Hakea preissii* low open woodland over *Cratystylis subspinescens*, *Maireana pyramidata* low open chenopod shrubland.



Leonora Gold – LEXM05

Site Details:

Described by: Crystal Heydenrych

Date: 17-03-2018

Type: Mapping note

MGA Zone: 51J 364394 mE 364394 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Flora and Vegetation:

Vegetation condition: Excellent

Vegetation description: *Acacia aneura*, *Acacia incurvaneura* mid open woodland over Scaevola spinescens, *Hakea preissii*, *Ptilotus obovatus* subsp. *obovatus* low shrubland over *Triodia basedowii* and chenopod shrubland.



Leonora Gold – LEXM06

Site Details:

Described by: Crystal Heydenrych

Date: 18-03-2018

Type: Mapping note

MGA Zone: 51J 364394 mE 6811972 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Flora and Vegetation:

Vegetation condition: Very Good

Vegetation description: *Acacia aneura*, *Hakea preissii*, *Acacia ramulosa* var. *ramulosa* low open woodland over *Senna artemisioides* subsp. *filifolia, Scaevola spinescens* sparse mid open shrubland over *Triodia basedowii* hummock grassland.



Leonora Gold – LEXM07

Site Details:

Described by:

Date: 18-03-2018

Type: Mapping note

MGA Zone: 51J 360958 mE 6814165 mN

Environmental variables:

Landform: Slope

Slope: Level (0-3°)

Flora and Vegetation:

Vegetation condition: Very Good

Vegetation description: *Acacia aneura* tall open shrubland over *Acacia ramulosa* var. *ramulosa, Acacia ? duriscula, Acacia craspedocarpa* (hybrid) mid to tall sparse shrubland over *Ptilotus schwartzii*, *Dodonaea rigida*, Eremophila youngii subsp. youngii low isolated shrubs.



Appendix C Vegetation Condition Scale

Code	Description
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
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 or shrubs.

Appendix D Vegetation Structure Classification

NVIS Vegetation Structural Classifications

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

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

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

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

APPENDIX C

Stantec – Level 1 Flora, Vegetation and Fauna Assessment, Leonora Gold Project 2018c

MWH now part of Stantec

REPORT

LEONORA GOLD PROJECT:

LEVEL 1 FLORA, VEGETATION AND FAUNA ASSESSMENT

Prepared for Kin Mining NL

January 2018



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REVISION SCHEDULE

Rev No.	Date	Description	Signature or Typed Name (documentation on file)			
			Prepared by	Checked by	Reviewed by	Approved by
V1.0	10/02/17	Draft report	SF	CvdB	PB & MS	PdsM
V2.0	12/06/17	Draft report	SF	CvdB	PB	SO
V3.0	17/08/17	Draft report	PB	PdsM	PdsM	PdsM
V4.0	12/01/18	Final report	CvdB	PdsM	PdsM	PdsM

Executive Summary

Kin Mining NL is evaluating options to develop the Leonora Gold Project (LGP) which comprises the historically mined areas of Mertondale, Cardinia and Raeside. Additionally, Kin Mining intends to establish a haul road that links the three mining areas, a processing plant and an accommodation camp. The components of the LGP are located between seven and 40 kilometres from the town of Leonora. Kin Mining commissioned MWH Australia Pty Ltd (now Stantec Australia Pty Ltd) to undertake a Level 1 Flora, Vegetation and Fauna assessment of the Mertondale, Cardinia and Raeside areas, and the proposed Haul Road, processing plant and accommodation camp.

Kin have proposed a two (2) phased approach for the approvals for the LGP:

- Phase 1 will allow for the construction of the Processing Plant up to a dry commissioning phase and for the installation of the Processing Plant access roads and a surface water diversion bund on the northern boundary of the Processing Plant (LGP Phase 1 Project or Phase 1). Phase 1 also includes the construction of administration offices, a workshop, and a stores and laydown area.
- Phase 2 of the Project will include development of existing and new open pits and associated waste rock landforms (WRLs), tailings storage facilities (TSF), and construction of a camp facility. Separate environmental approvals will be submitted in Quarter 1, 2018 to facilitate the Phase 2 development (LGP Phase 2 Project or Phase 2).

The overarching objectives for the assessment were to undertake a Level 1 Flora, Vegetation and Fauna survey and assess potential impacts of the whole Project i.e. Phase 1 and Phase 2, to native flora, vegetation and fauna occurring, and with the potential to occur, within the Study Area. The specific objectives of the assessment were to:

- Complete a desktop study of relevant literature and databases for the Study Area;
- Describe and map vegetation types, fauna habitats and their condition within the Study Area by means of a field survey; and
- Assess potential impacts of the Project against the *Environmental Protection Act 1986* ten native vegetation clearing principles.

The objectives were addressed by way of a desktop survey and a field survey to ground-truth desktop results. The field survey was conducted in two parts; Survey 1 was completed between the 28th of November and the 5th of December 2016, and Survey 2 was completed between the 10th and the 12th of May 2017. Flora and vegetation was sampled by way of opportunistic collections, vegetation mapping and the use of 66 unbounded sampling sites (relevés). Terrestrial fauna and fauna habitat was sampled via standardised habitat assessments, at the same flora and vegetation sites, plus targeted searches and opportunistic sightings. Following the completion of the two field surveys, a further targeted flora survey was completed between the 7th and 10th of August 2017. The putative Acacia hybrid, *Acacia* sp. nov. aff. *resinimarginea* was targeted during the August 2017 survey to further define population size, extents and taxonomic verification.

Overall vegetation condition ranged from Excellent to Completely Degraded, with the majority of the vegetation considered to be in Excellent condition. Degraded and Completely Degraded areas were as a direct result of historical and recent mining and drilling activities within the Study Area. Vegetation considered to be Very Good included some evidence of mining activity or was partially compromised by grazing from introduced herbivores.

A total of 23 vegetation units were recorded across the Study Area, not including two additional vegetation units which were areas considered to be Disturbed or Revegetated. The vegetation of the Study Area was broadly comprised of mixed Mulga shrublands over mixed shrubs that are representative of the dominant vegetation types throughout the region. No vegetation units are considered analogous to any Threatened or Priority Ecological Communities, and none are considered regionally significant. Four vegetation units may be considered locally significant as three were found to support the Priority flora species *Gunniopsis propinqua* (Priority 3), and one supports *Acacia* sp. nov. aff. *resinimarginea*, a taxon currently considered to be a putative hybrid, which may represent a currently unrecognised *Acacia* species.

A total of 257 flora taxa (including subspecies and variants) from 37 families and 103 genera were recorded within the Study Area. The most frequently occurring families were Chenopodiaceae (goosefoot family), Fabaceae (wattle family) and Poaceae (grass family). The floral diversity and composition recorded from the Study Area is consistent with Mulga shrublands of the Murchison bioregion.

No Threatened Flora species and 35 Priority Flora species were recorded from the desktop study with four considered Very Likely to occur, and seven considered Likely to occur within the Study Area. Of these, only one, *Gunniopsis propinqua* (Priority 3), was recorded during the field survey. The putative Acacia hybrid, *Acacia* sp. nov. aff. *resinimarginea* was recorded from 26 populations totalling in excess of 10,000 individuals. The populations were recorded from Cardinia and to the south and south-east of Cardinia. Eight introduced flora taxa were recorded within the Study Area, including one Weed of National Significance, which is also listed as a Declared Plant under the *Biosecurity and Agriculture Management Act 2007*, **Cylindropuntia fulgida* var. *mamillata*. The eight introduced taxa were either recorded sporadically or as isolates within degraded or adjacent to degraded vegetation.

Four broad fauna habitat types were identified within the Study Area; Acacia Shrublands on plains, Drainage Lines, Low Hills and Chenopod Shrublands. All habitat types are considered widespread and common throughout the region, none are considered to be of local or regional significance and all are considered to have low potential to support SRE invertebrate fauna.

A total of 65 vertebrate fauna species were recorded during the field survey, comprising nine mammals (three native), 48 birds and eight reptile species. No fauna of conservation significance were recorded. Two fauna species of conservation significance were considered Likely to occur (Rainbow Bee-eater and the Peregrine Falcon) and four species were considered Possible to occur (Long-tailed Dunnart, Malleefowl, Fork-tailed Swift and Grey Falcon). The Rainbow Bee-eater is listed as Schedule 5 (Migratory) under the *Wildlife Conservation Act 1950* and may utilise the sandy substrate of the Minor Drainage habitat for breeding and the remaining habitats for foraging. The Peregrine Falcon is listed as Schedule 7 (Taxa

in need of special protection) under the *Wildlife Conservation Act 1950* and may fly-over the Study Area infrequently while dispersing or during foraging but is unlikely to breed due to a lack of suitable habitat. Neither species is likely to be significantly impacted by the Project as neither species is dependent on the Study Area or habitats contained within it.

The proposed Project disturbance footprint is still being finalised following resource identification and Project design. Assessment against the ten Clearing Principles listed under Schedule 5 of the Environmental Protection Act 1986 was based on a precautionary approach that assumed all habitats within the Study Area may be exposed to clearing. Based on this assumption, the proposed Project is not at variance to principles (b), (c), (d), (e), (g), (h), (i) and (j). However, clearing may be at variance with principles (a): *Native vegetation should not be cleared if it comprises a high level of biological diversity,* and (f): *Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland*.

The presence of the priority listed *Gunniopsis propinqua* (P3) and the putative hybrid *Acacia* sp. nov. aff. *resinimarginea* may represent high biological diversity. Although the Study Area is not considered to be biologically diverse with regards to the floristic composition and fauna assemblage, the presence of the priority taxon and the putative hybrid needs to be considered in the assessment. If impacts to the priority taxon and putative hybrid are minimised or avoided, then the proposed Project would avoid being at variance to this principle.

Although, Drainage Line habitat is present within the Study Area, it did not contain vegetation communities or species that are confined to watercourses or wetlands, or are groundwater dependent. Additionally, the drainage lines within the Study Area are not considered regionally prominent and are not listed within the Directory of Important Wetlands in Australia or listed as an Environmentally Sensitive Area (ESA) under the *Environmental Protection Act 1986*. Provided that clearing is minimised within and adjacent to Drainage Line habitat and/or standard drainage control strategies are implemented whereby natural hydrological regimes are maintained, the proposed Project would avoid being at variance to this principle.

Kin Mining NL

Leonora Gold Project:
Level 1 Flora, Vegetation and Fauna Assessment

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1 Introduction

1.1 Project Background and Location

Kin Mining NL (Kin) is evaluating options to develop the Leonora Gold Project (the Project) which is located between seven and 40 kilometres (km) east of the town of Leonora. The Project comprises three historically mined areas (Mertondale, Cardinia and Raeside), a proposed haul road that links the three mining areas, a processing plant and an accommodation camp. Collectively, these areas comprise the Study Area for the assessment, which encompasses a package of land totalling 2,287.6 hectares (ha) (**Figure 1-1**). Kin commissioned MWH Australia Pty Ltd (MWH, now Stantec Australia Pty Ltd) to undertake a Level 1 Flora, Vegetation and Fauna assessment of the Study Area. The field surveys were undertaken in two parts; Survey 1 was completed in November to December 2016, and Survey 2 was completed in May 2017 (**Figure 1-1**).

KIN have proposed a two (2) phased approach for the approvals for the LGP:

- Phase 1 will allow for the construction of the Processing Plant up to a dry commissioning phase and for the installation of the Processing Plant access roads and a surface water diversion bund on the northern boundary of the Processing Plant (LGP Phase 1 Project or Phase 1). Phase 1 also includes the construction of administration offices, a workshop, and a stores and laydown area.
- Phase 2 of the Project will include development of existing and new open pits and associated waste rock landforms (WRLs), tailings storage facilities (TSF), and construction of a camp facility. Separate environmental approvals will be submitted in Quarter 4, 2017 to facilitate the Phase 2 development (LGP Phase 2 Project or Phase 2).

1.2 Report Scope and Objectives

The overarching objectives for the study was to undertake a Level 1 Flora, Vegetation and Fauna assessment and to assess potential impacts of the whole Project i.e. Phase 1 and Phase 2, to native flora, vegetation and fauna occurring, and with the potential to occur, within the Study Area. The specific objectives of the Survey were to:

- Complete a desktop study of relevant literature and databases for the Study Area;
- Describe and map vegetation types, fauna habitats and their condition by means of a field survey; and
- Assess potential impacts of the Project against the ten Native Vegetation Clearing Principles.

The objectives and survey methods adopted for this survey were aligned with relevant regulatory guidelines including:

- Environmental Protection Authority (EPA) Position Statement No. 2 Environmental Protection of Native Vegetation in Australia (EPA 2000);

- EPA Position Statement No. 3 Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002);
- EPA Guidance Statement No. 51 Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004b);
- EPA Guidance Statement No. 56 Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004a);
- EPA and Department of Environment and Conservation (DEC) Technical Guide –Fauna Surveys (EPA and DEC 2010);
- EPA and Department of Parks and Wildlife (Parks and Wildlife) Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA and DPaW 2015a);
- EPA Guidance Statement No. 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009); and
- EPA Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016a)

Survey 1 was completed prior to the completion of the legal and governance review into the EPA's internal practices for policy and guideline development. A key outcome of the legal and governance review was the simplification of policies and guidelines, with a new framework launched in December 2016. As a result of the new framework, Survey 2 was completed under the directorship of new technical guidelines (EPA 2016a) for flora and vegetation surveys, while Survey 1 was completed under the directorship of outdated and superseded guidance statements and technical guides (EPA 2004b, EPA and DPaW 2015a).

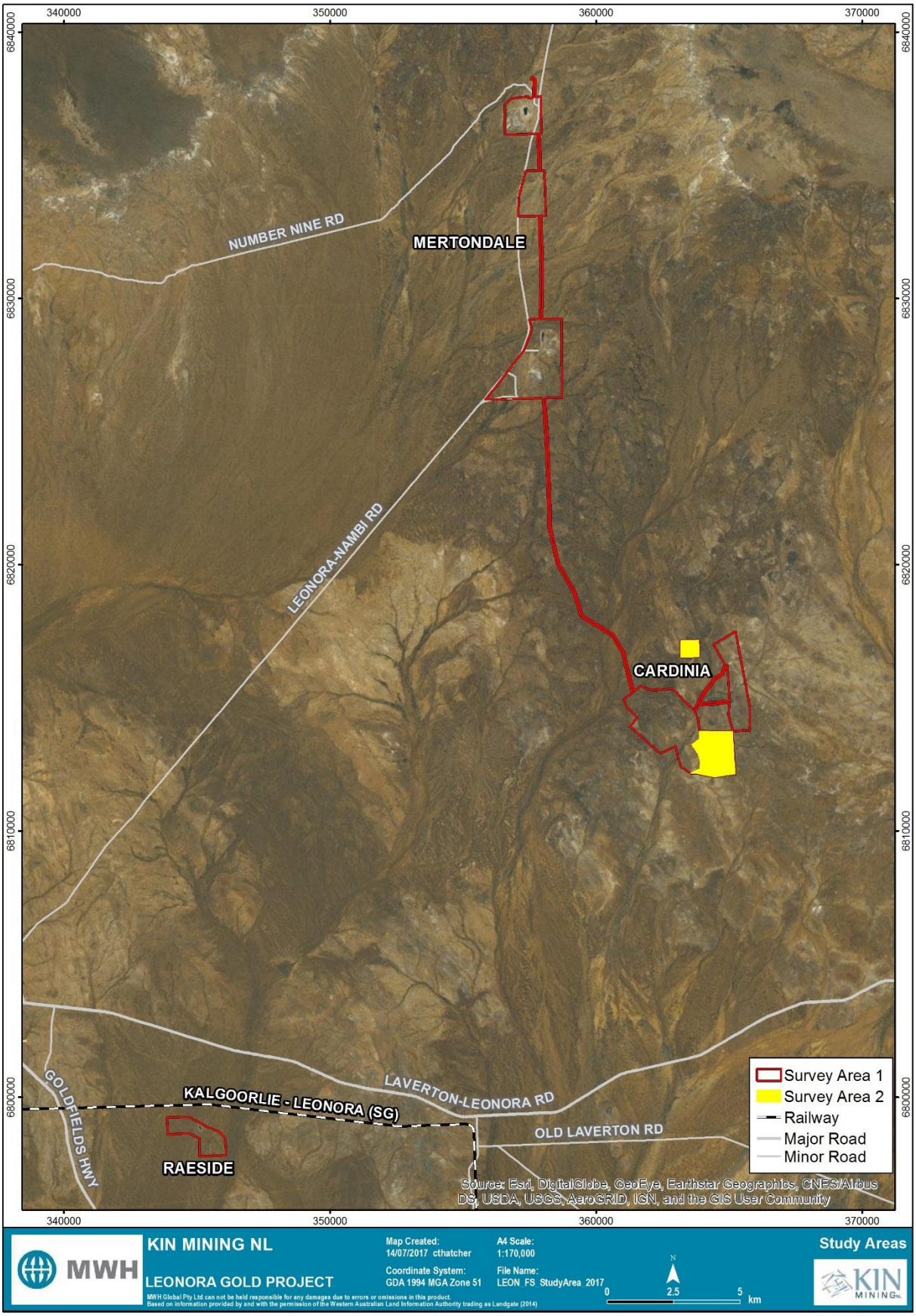


Figure 1-1: The Study Area

2 Existing Environment

2.1 Biogeography

The Study Area is located within the Murchison biogeographic region (bioregion), as defined by the Interim Biogeographic Regionalisation for Australia (IBRA) classification system (Thackway and Cresswell 1995).

The Murchison bioregion comprises the northern part of the Yilgarn Craton and includes two major subregions, the Eastern Murchison (MUR01) and the Western Murchison (MUR02). The Project is located within the Southern Eremaean Province, in the Eastern Murchison (MUR01) subregion, which is characterised by its internal drainage, areas of red sandplains, salt lake systems associated with an occluded Palaeodrainage system, broad plains of red-brown soils and breakaway complexes (Desmond *et al.* 2001). Vegetation is dominated by low Mulga woodlands (*Acacia aneura* complex) on plains, and thick woodland with *Tecticornia* in the Palaeodrainage, with some local areas of spinifex grassland, shrublands and mosaic units related to the underlying geology (Pringle *et al.* 1994). The bioregion is rich and diverse in both its flora and fauna although most species are wide-ranging and usually occur in adjoining regions (McKenzie *et al.* 2003).

2.2 Land Systems

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

Table 2-1: Land systems mapped over the Study Area

Land system	Description	Portion of Study Area	
		ha	%
Gundockerta System	Extensive, gently undulating calcareous stony plains supporting bluebush shrublands.	469.14	20.51
Jundee System	Hardpan plains with variable gravelly mantles and minor sandy banks supporting weakly groved mulga shrublands.	370.52	16.20
Leonora System	Low greenstone hills and stony plains supporting mixed chenopod shrublands.	48.09	2.10
Monk System	Hardpan plains with occasional sandy banks supporting mulga tall shrublands and wanderrie grasses.	30.89	1.35
Nubev System	Gently undulating stony plains, minor limonitic low rises and drainage floors supporting mulga and halophytic shrublands.	837.1	36.59
Tiger System	Gravelly hardpan plains and sandy banks with mulga shrublands and wanderrie grasses.	171.07	7.48

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.	313.14	13.69
Wyarri System	Granite domes, hills and tor fields with gritty-surfaced fringing plains supporting mulga and granite wattle shrublands.	47.65	2.08
	Total	2,287.6	100

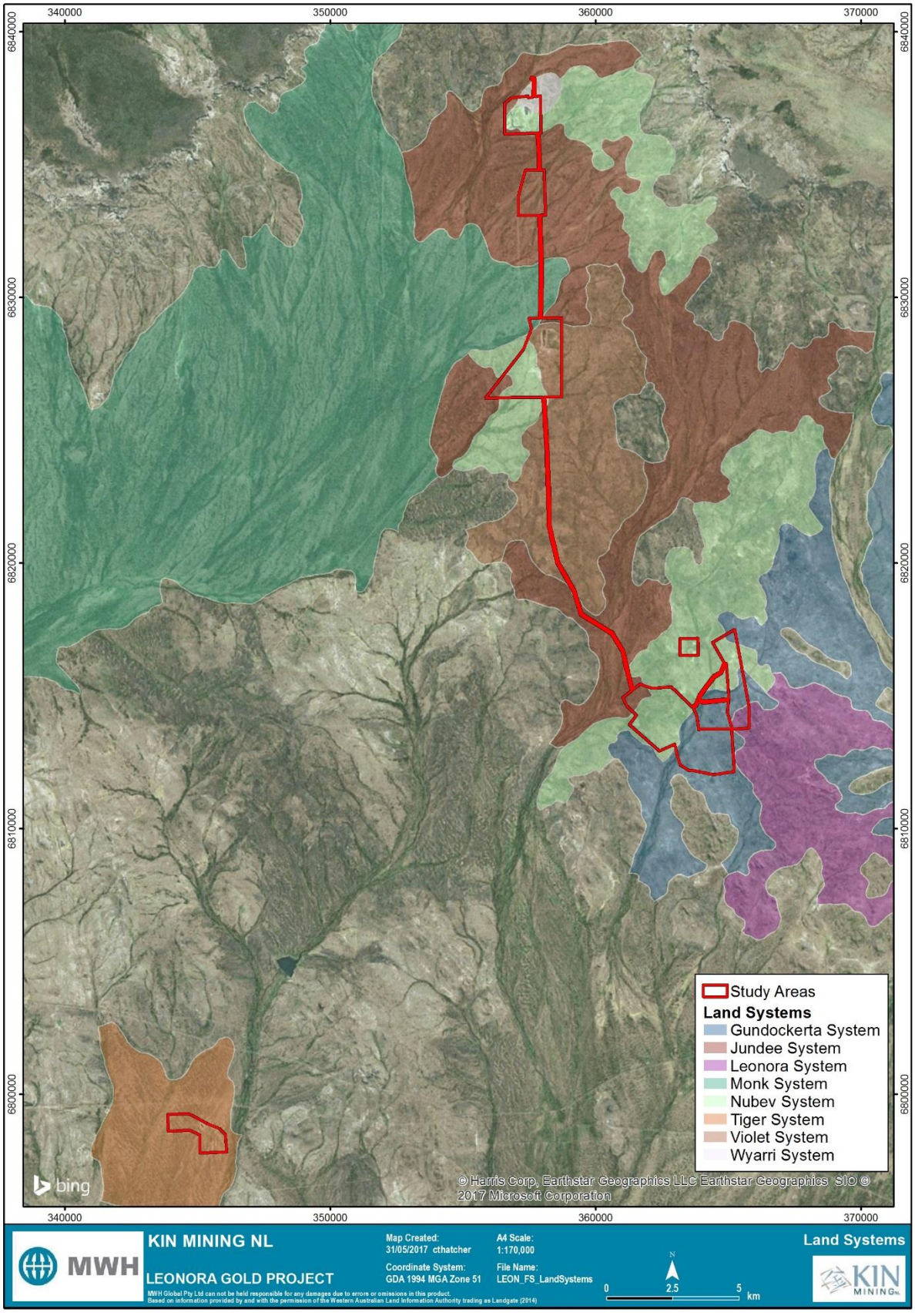


Figure 2-1: Land systems of the Study Area

2.3 Pre-European Vegetation

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

The Study Area occurs within the Laverton Botanical Districts of the Eremaean Province (Beard 1990a). The Laverton Botanical District corresponds broadly to the Murchison region which was mapped by Beard (1976) at a 1:1,000,000 scale. Two vegetation system associations mapped by Beard (1976), and reinterpreted by Shepherd *et al.* (2002), intersect the Study Area (**Table 2-2**, **Table 2-3** and **Figure 2-2**), Laverton 18 and Laverton 39.

Table 2-2: Pre-European vegetation associations of the Study Area (Beard 1976)

Vegetation system association	Description	Portion of Study Area	
		Ha	%
Laverton 18	Shrublands, Mulga scrub	1415.51	61.88
Laverton 39	Low woodland; mulga, *Acacia aneura*	872.09	38.12
	Total	2,287.6	100

The current extent remaining of the vegetation system associations are more than 99% across three regional scales (State, bioregion and subregion), and above 97% at the Local Government Authority (LGA) scale (**Table 2-3**) (Government of Western Australia 2015). The current extent remaining is well above the advised threshold for biodiversity conservation of 30% remaining (EPA 2000).

Table 2-3: Pre-European extent of vegetation system associations remaining

Code	Scale	Pre-European extent (ha)	Current extent (ha)	Current extent remaining (%)	Current extent protected (%)
Laverton_18	State	2,353,515	2,342,968	99.55	0.45
	Bioregion	2,349,889	2,339,342	99.55	0.45
	Subregion	2,349,889	2,339,342	99.55	0.45
	LGA	1,216,599	1,216,599	99.72	0
Laverton_39	State	155,416	151,580	97.53	2.5
	Bioregion	155,416	151,580	97.53	2.5
	Subregion	155,416	151,580	97.53	2.5
	LGA	141,819	138,361	97.56	0

NB: Hectares have been rounded to the nearest whole number

Source: Government of Western Australia (2015)

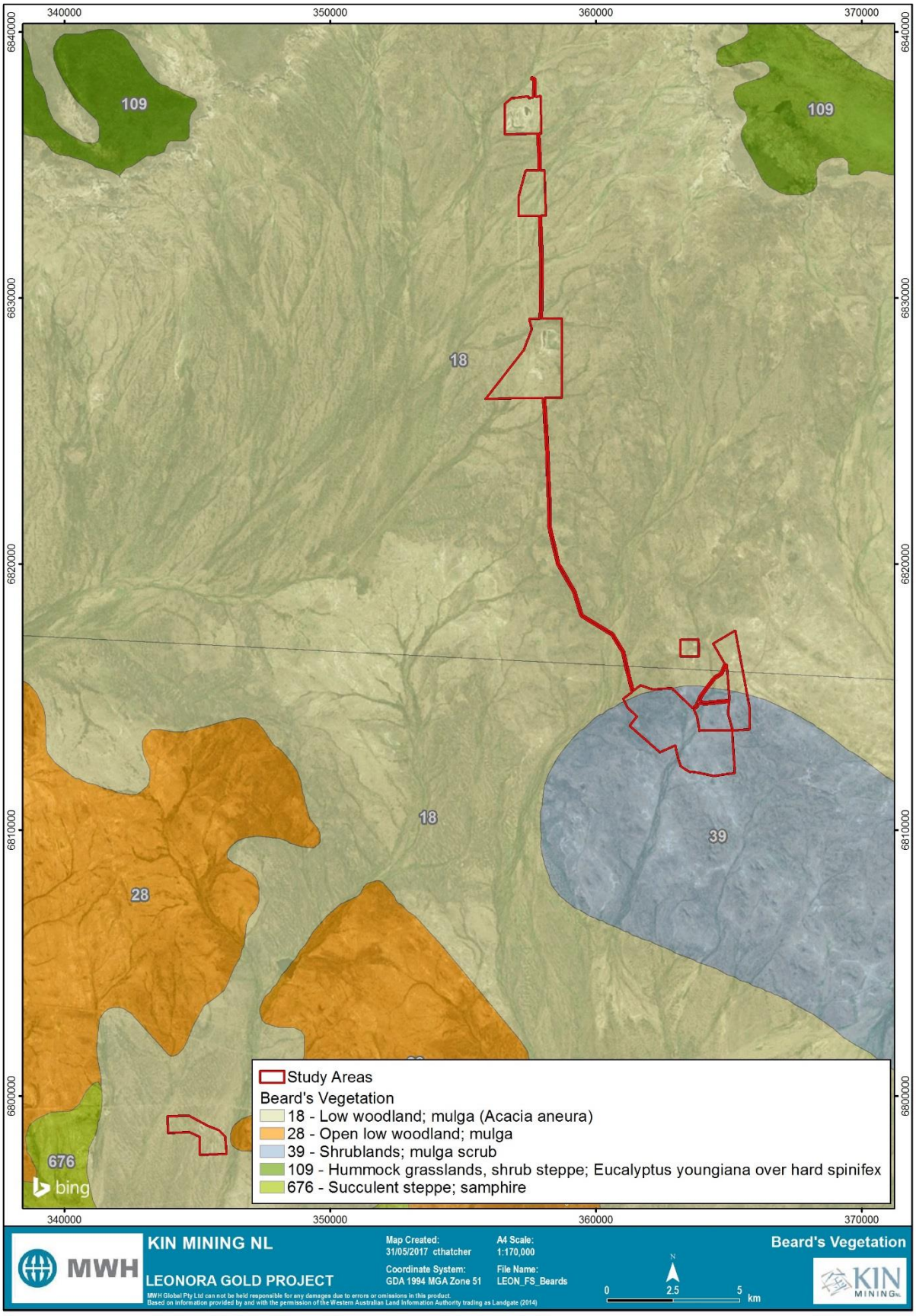


Figure 2-2: Pre-European vegetation associations of the Study Area

2.4 Land Use

The vast majority, of the Eastern Murchison subregion is used for grazing of native pasture. The remainder comprises Unallocated Crown Land, and a small amount, only 1.4%, is allocated to conservation (Cowan 2001). The land is also used for mining, particularly gold and nickel, however most mining leases fall under the pastoral lands act and remain stocked (Cowan 2001). The Study Area is located on the Clover Downs, Minara and Mertondale Pastoral Leases (**Figure 2-3**).

The Study Area is not located within or immediately adjacent to a National Park or conservation reserve and operations within the Study Area are highly unlikely to impact on any National Parks or conservation reserves. The nearest national parks and conservation reserves are:

- Ex-Goongarrie Pastoral Lease (former leasehold proposed for conservation) – 100 km south;
- Ex-Credo Pastoral Lease (former leasehold proposed for conservation) – 120 km south west;
- Ex-Bulga downs Pastoral Lease (former leasehold proposed for conservation) – 126 km west;
- Wanjarri Nature Reserve (Class A) – 150 km north west;
- De La Poer Range Nature Reserve (Class C) – 160 north east;
- Ex-Mt Elvire Pastoral Lease (former leasehold proposed for conservation) – 170 km south west
- Ex-cashmere downs Pastoral Lease (former leasehold proposed for conservation) - 190 km west;
- Ex-Lake Mason Pastoral Lease (former leasehold proposed for conservation) – 195 km north west
- Yeo Lake Nature Reserve (Class A) – 250 north east; and
- Plumridge Lakes Nature Reserve (Class A) – 300 south east.

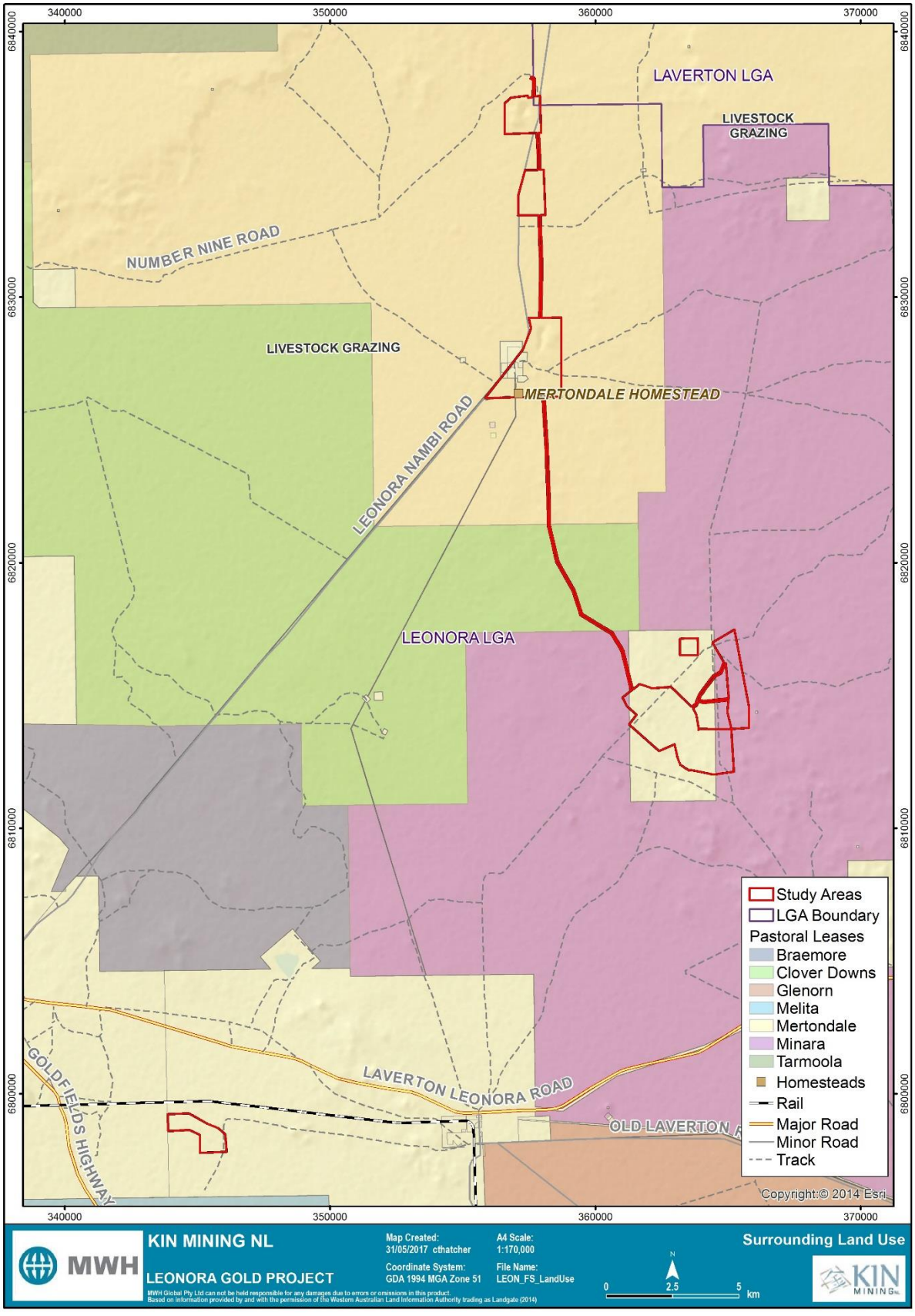


Figure 2-3: Land Use in the Study Area

2.5 Climate

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

Leonora Aero (station number 012241) is the nearest Bureau of Meteorology (BoM) weather station to the site with the most recent climatic conditions for Leonora (BoM 2017). The mean historical annual rainfall recorded between 2007 and May 2017 at Leonora Aero is 258.9 mm with the majority received between January and March each year. Peak rainfall is recorded between January and March (BoM 2017) (**Figure 2-4**). The hottest maximum temperatures occur between November and March, with the coolest minimum temperatures occurring between May and August (**Figure 2-4**).

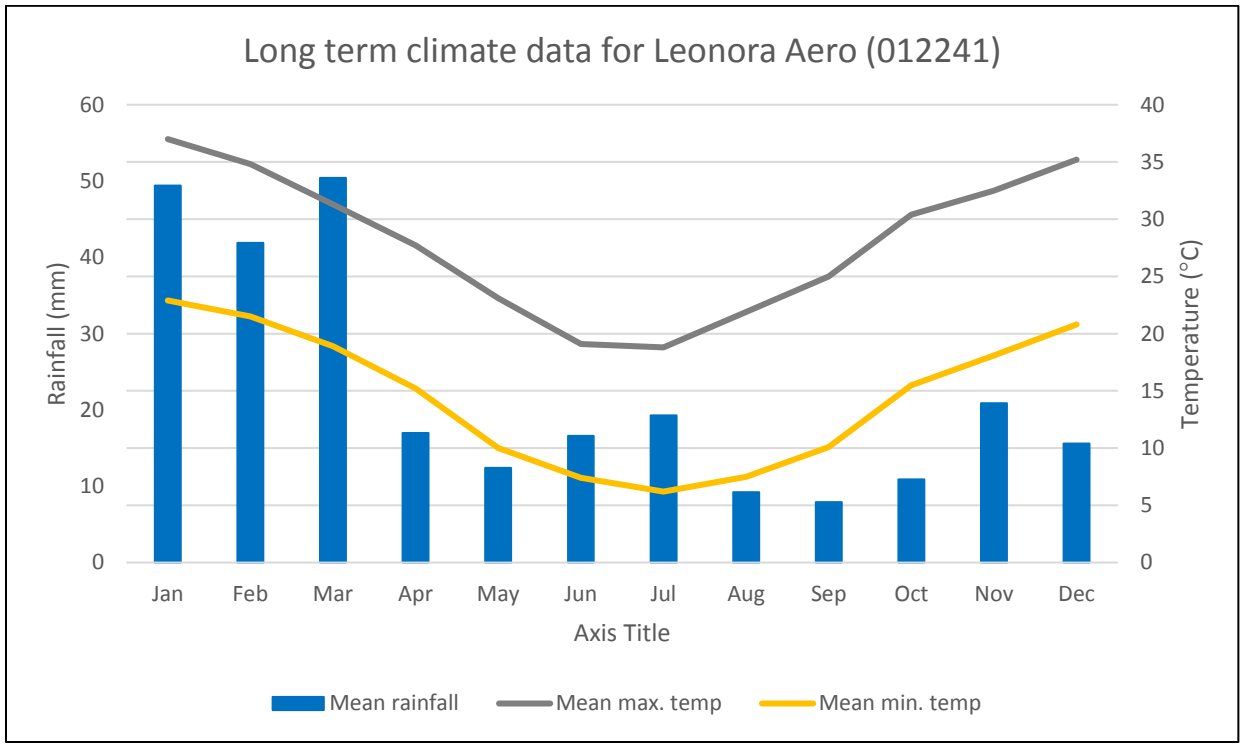


Figure 2-4: Long-term climate data recorded at Leonora Aero Weather Station (Station number 012241)

3 Desktop Study

A desktop study, comprising database searches and a literature review, was undertaken prior to the field survey. The purpose of the desktop study was to identify flora, vegetation and terrestrial fauna potentially occurring in the Study Area, in particular, species of conservation significance. Conservation significance and conservation rankings used under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Wildlife Conservation Act 1950* (WC Act), as well as the Department of Parks and Wildlife's (Parks and Wildlife) Priority list, are defined in **Appendix A**.

3.1 Database Searches

Database searches were undertaken to generate a list of vascular flora and vertebrate fauna previously recorded within, and within the vicinity of, the Study Area – with an emphasis on species of conservation significance and introduced species. Six database searches were conducted around a central coordinate within the Study Area (51J 357273 E, 6812438 S). The distance of each search buffer around the central co-ordinate was adjusted to the most appropriate distance for each database (**Table 3-1**).

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

Custodian	Database	Taxonomic Group	Reference	Buffer (km)
DoEE	Protected Matters	Flora and Fauna	DoEE (2016)	80
Parks and Wildlife	NatureMap	Flora and Fauna	DPaW (2016a)	40
Parks and Wildlife	Threatened and Priority Ecological Communities	Flora and Fauna	DPaW (2016b)	40
Parks and Wildlife	Threatened and Priority Flora	Flora	DPaW (2016d)	40
Parks and Wildlife	Threatened and Priority Fauna	Fauna	DPaW (2016c)	100
Birdlife Australia	Birdlife Bird data	Fauna	Birdlife Australia (2016)	80

3.2 Literature Review

The literature review considered six previous reports of relevance to the Study Area, comprising three flora and vegetation reports (**Table 3-2**), and two fauna reports (**Table 3-3**) and one combined flora and fauna report. Additionally, the following regional documents were also considered as part of this assessment:

- Biological survey of the eastern Goldfields of Western Australia Part 5: vertebrate fauna (Dell and How 1988).
- Biological survey of the eastern Goldfields of Western Australia Part 7: vertebrate fauna (Dell and How 1992).

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

Reference	Study Details	Proximity to Study Area	Vegetation Units	Flora Recorded	Vegetation Condition	Species and communities of conservation significance
(Outback Ecology 2009a)	Location: Leonora Gold Project Study Type: Level 1 Flora and Vegetation Survey Survey Date: February 2009	Coincident with Study Area	11 Vegetation units including: • Mertondale Drainage areas – Acacia shrublands, AcEr; AcErM; AcErP; AcErE • Maireana Shrublands – Acacia or Eremophila shrubland over Maireana; AcAcM; ErCr; Ma • Creekline vegetation – Acacia shrubland; AcAccW; AcAccF; AcAcG • Rocky Hilltop vegetation – Acacia shrublands; AcSe	98 taxa: ○ 30 families ○ 50 genera	Vegetation condition ranged from 'Excellent' to 'Degraded' condition. Disturbances included grazing, tracks, exploration and historic mining.	None
Outback Ecology (2009b)	Location: Leonora Gold Project Study Type: Level 1 Flora and Vegetation Survey Survey Date: April 2008	Coincident with Study Area	Four vegetation units including: • Mertondale Drainage areas • Maireana Shrubland • Creekline vegetation • Rocky Hilltop vegetation	81 taxa ○ 26 families ○ 34 genera	Vegetation condition ranged from /'Excellent' to 'Degraded' condition. Disturbances included grazing, tracks, exploration and historic mining.	None

Reference	Study Details	Proximity to Study Area	Vegetation Units	Flora Recorded	Vegetation Condition	Species and communities of conservation significance
Mattiske Consulting (2002)	Location: Cardinia and Proposed Haul Road Study Type: Flora and Vegetation Survey Survey Date: October 2002	Coincident with Study Area: focus on Cardinia mine area	Four vegetation units: • Open Scrub of *Acacia aneura – Acacia minyura* on the flats and plains • Low Open Forest to Low Open Woodland of *Acacia aneura* on the drainage lines • Open Scrub of *Acacia* species on the ridges and breakaways • Low Open Scrub to Low Shrubland of *Maireana triptera* on the saline depressions	55 taxa: ○ 28 families ○ 37 genera	Disturbance from grazing and vehicle tracks in vicinity of proposed pit	None
GHD (2007)	Location: Borrow pits within 30 km of Leonora Study Type: Level 1 Flora and Fauna survey Survey Date: April 2007	5 km west and 30 km south of Study Area	Three vegetation units: • Low Woodland (Mulga) • Open Low Woodland (Mulga) • Open Mulga Shrubland	64 taxa: 23 families	Excellent to Completely Degraded	None

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

Reference	Study details	Proximity to Study Area	Broad habitats	Fauna assemblage recorded	Species of conservation significance	Notes
Outback Ecology (2009c)	Location: Leonora Gold Project Study Type: Level 1 Vertebrate Fauna and Level 2 (trapping) SRE invertebrate fauna survey SRE component involved 8 sampling sites. Methods at each site included: • dry-pitfall trapping (5 traps over 7 nights) • targeted searching (2hrs) • leaf litter collection (5 samples) • soil sieving (5 samples); and • ultraviolet spotlighting (1 hr) Survey Date: September 2008	Coincident with Study Area	6 broad fauna habitats including: • Stony Plains • Loamy surfaced plains • Low rises supporting Mulga • Saline alluvial plains • Wash plains and drainage lines • Breakaways	58 vertebrate taxa: ○ 2 native mammals ○ 4 introduced mammals ○ 46 birds ○ 5 reptiles 10 taxa from SRE groups: ○ 3 mygalomorph spiders ○ 1 scorpion: ○ 4 pseudoscorpion ○ 2 Molluscs	No Vertebrate Fauna No known SRE invertebrate fauna. Four potential SRE invertebrate fauna: ○ *Idiommata* sp. (drainage line) ○ Pseudoscorpion: *Austrohorus* sp. (wash plains) ○ *Beierolpium* 'sp. 8/3' (stony plains) ○ Terrestrial mollusc: *Succinea* sp. (stony plain)	Habitats present were considered to have low potential to support SRE species
GHD (2007)	Location: Main Roads Western Australia (borrow pits within 30 km of Leonora) Study Type: Level 1 Flora and Fauna Survey Survey Date: April 2007	5 km west and 30 km south of Study Area	Mulga woodlands and shrublands	30 taxa: ○ 2 native mammal ○ 3 introduced mammal ○ 22 bird ○ 3 reptile	None	None

Reference	Study details	Proximity to Study Area	Broad habitats	Fauna assemblage recorded	Species of conservation significance	Notes
Ninox Wildlife Consulting (2011)	Location: Proposed Rail Siding near Menzies Study Type: Level 1 fauna survey Survey Date: September 2011	97 km south of Study Area	Two broad fauna habitats: • Shrublands • Woodlands	1 native mammal 2 introduced mammal 18 bird 2 reptile	None	None

3.3 Desktop Results

3.3.1 Flora

Thirty five (35) flora taxa of conservation significance were identified from the database searches. However, no flora of conservation significance were identified during previous surveys undertaken in the Study Area (**Table 3-4**). None of the conservation significant flora species are listed as Threatened under the WC Act, or listed under the EPBC Act. Of the 35 priority listed flora species, ten are listed as Priority 1, two are listed as Priority 2, 19 are listed as Priority 3 and four are listed as Priority 4 (**Table 3-4**).

Table 3-4: Flora species of conservation significance identified during the desktop assessment

Species	Source	Parks and Wildlife Priority Status
Acacia websteri	Parks and Wildlife, NatureMap	P1
Eremophila arachnoides subsp. *tenera*	Parks and Wildlife	P1
Eremophila eversa	Parks and Wildlife	P1
Lechenaultia aphylla	Parks and Wildlife	P1
Micromyrtus chrysodema	Parks and Wildlife	P1
Persoonia leucopogon	Parks and Wildlife	P1
Philotheca tubiflora	Parks and Wildlife	P1
Ptilotus tetrandrus	Parks and Wildlife, NatureMap	P1
Stenanthemum patens	Parks and Wildlife	P1
Vittadinia cervicularis var. *oldfieldii*	Parks and Wildlife	P1
Eremophila mirabilis	Parks and Wildlife	P2
Thryptomene eremaea	Parks and Wildlife	P2
Angianthus prostratus	Parks and Wildlife, NatureMap	P3
Calytrix praecipua	Parks and Wildlife, NatureMap	P3
Calytrix verruculosa	Parks and Wildlife	P3
Cratystylis centralis	Parks and Wildlife, NatureMap	P3
Eremophila annosocaulis	Parks and Wildlife	P3
Eremophila shonae subsp. *diffusa*	Parks and Wildlife	P3
Eremophila simulans subsp. *megacalyx*	Parks and Wildlife, NatureMap	P3
Goodenia lyrata	Parks and Wildlife	P3
Grevillea obliquistigma subsp. *cullenii*	Parks and Wildlife	P3
Gunniopsis propinqua	Parks and Wildlife	P3
Hybanthus floribundus subsp. *chloroxanthus*	Parks and Wildlife, NatureMap	P3
Micromyrtus serrulata	Parks and Wildlife	P3
Philotheca coateana	Parks and Wildlife	P3

Species	Source	Parks and Wildlife Priority Status
Phyllanthus baeckeoides	Parks and Wildlife	P3
Sauropus sp. Woolgorong (M. Officer s.n. 10/08/94)	Parks and Wildlife	P3
Thryptomene nealensis	Parks and Wildlife	P3
Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362)	Parks and Wildlife	P3
Triglochin protuberans	Parks and Wildlife, NatureMap	P3
Eremophila pungens	Parks and Wildlife	P4
Eucalypts jutsonii subsp. *jutsonii*	Parks and Wildlife	P4
Grevillea inconspicua	Parks and Wildlife	P4
Hemigenia exilis	Parks and Wildlife, NatureMap	P4

3.3.2 Vegetation

No Threatened Ecological Communities (TEC's) were identified from the Parks and Wildlife Threatened and Priority Ecological Community database or the Department of the Environment and Energy's (DoEE) Protected Matters Database Search (DoEE 2016) as occurring within or near to the Study Area. One Priority Ecological Community (PEC) was identified as occurring within 10 km of the Study Area, however, the PEC community identified by the database search refers to assemblages of subterranean invertebrate fauna, which are not part of the scope for this assessment, and are therefore not discussed within this report (**Table 3-5**).

Table 3-5: Priority Ecological Communities identified by the desktop assessment

Community Name	Description	Conservation Status	Distance from Study Area (direction)
Melita Calcrete	Melita calcrete groundwater assemblage	P1	Approx. 6.07 km (West)

3.3.3 Fauna

The desktop study identified a total of 300 species of vertebrate fauna that have been recorded and/or have the potential to occur within the Study Area (**Appendix B**). This total comprises 29 native mammals, 12 introduced mammals, 164 native birds, three introduced birds, 83 reptile and nine amphibian species. Many of these species are considered unlikely to occur in the Study Area because these records have been collated from a large area, numerous reports, and encompass a wide variety of habitats, many of which do not occur within the Study Area. Furthermore, some small, common, ground-dwelling reptile and mammal species tend to be patchily, meaning that even where suitable habitat is present they may not occur, and many species of bird can occur as regular migrants, occasional visitors or vagrants.

Of the 300 species of vertebrate fauna identified during the desktop study, 26 species are listed as being of conservation significance comprising four mammals and 20 bird species (**Table 3-6**). In addition, two invertebrate species of conservation significance were identified, the fairy shrimps *Branchinella apophysata* and *Branchinella simplex* (**Table 3-6**).

Table 3-6: Fauna species of conservation significance identified during the desktop assessment

Conservation Status		Common Name	Species Name
EPBC Act	WC Act		
En; Mi	S5	Red Knot	*Calidris canutus*
En	S1	Night Parrot	*Pezoporus occidentalis*
	S2	Carnaby's Cockatoo	*Calyptorhynchus latirostris*
Vu	S2	Numbat	*Myrmecobius fasciatus*
	S3	Malleefowl	*Leipoa ocellata*
		Bilby	*Macrotis lagotis*
	P4	Princess Parrot	*Polytelis alexandrae*
Mi	S5	Fork-tailed Swift	*Apus pacificus*
		Grey Wagtail	*Motacilla cinerea*
		Yellow Wagtail	*Motacilla flava*
		Oriental Plover	*Charadrius veredus*
		Sharp-tailed Sandpiper	*Calidris acuminata*
		Red-necked Stint	*Calidris ruficollis*
		Glossy Ibis	*Plegadis falcinellus*
		Pacific Golden Plover	*Pluvialis fulva*
		Wood Sandpiper	*Tringa glareola*
		Common Greenshank	*Tringa nebularia*
-		Eastern Great Egret	*Ardea modesta*
		Rainbow Bee-eater	*Merops ornatus*
-	S3	Grey Falcon	*Falco hypoleucos*
	S3	Banded Hare-wallaby	*Lagostrophus fasciatus fasciatus*
	S7	Peregrine Falcon	*Falco peregrinus*
	P1	a fairy shrimp	*Branchinella apophysata*
	P1	a fairy shrimp	*Branchinella simplex*
	P4	Long-tailed Dunnart	*Sminthopsis longicaudata*
	P4	Hooded Plover	*Thinornis cucullatus*

4 Survey Methodology

4.1 Survey Timing and Weather

The optimal timing for surveying flora and fauna in the Eremaean Province (where the Study Area is located) is 6-8 weeks following the season which normally contributes the most rainfall (EPA 2016a, b). For the Murchison bioregion, the season of highest rainfall is summer (Section 2.5, BoM 2016). Survey 1 was conducted between the 28th of November and the 5th of December 2016. This field survey occurred outside of the perceived optimal period (i.e. summer/autumn, 6 to 8 weeks following a significant rainfall event). However, with average rainfall preceding the survey, the timing was considered adequate for the purposes of a Level 1 flora, vegetation and fauna assessment. Survey 2 was conducted between the 10th and the 12th of May 2017. This field survey occurred within the perceived optimal period and followed good rainfall.

At the completion of the first two surveys, a follow-up targeted survey was completed between the 7th and the 10th of August 2017. The targeted survey was completed during the optimal time for a targeted *Acacia* sp. nov. aff. *resinimarginea* survey, with flowers and fruits present on the individuals within the populations.

In the three months (August to October 2016) preceding the field survey for Survey 1, the Leonora Aero Weather Station (Station number 012241) received 16.4 mm of rainfall, which is slightly lower than the long term average of 28 mm for the same period (BoM 2016) (**Figure 4-1**). For the Eremaean Province, field surveys should occur approximately 4 to 6 weeks after sufficient rainfall (i.e. greater than 15 mm) to allow annuals and ephemerals to germinate and flower, as well as perennials (EPA and DPaW 2015b). Survey 1 occurred approximately 12 weeks after winter rainfall. At the time of the field survey many of the annual species were dead, or sterile with no flowering or fruiting material, indicating that the field survey occurred after the optimal timing for the region in 2016. Despite this, there was evidence of prolific spring flowering evidenced by the presence of dry and old annual species, and seeding and fruiting perennial plants. Overall, the prevailing climatic conditions ensured the vegetation types and fauna habitats were able to be adequately described and delineated. The climatic conditions did not unduly compromise the ability to assess the likelihood of species of conservation significance occurring.

In the three months (February to April 2017) preceding Survey 2 in May 2017, Leonora Aero Weather Station received 286.2 mm of rainfall (**Figure 4-2**), which is substantially higher than the long term average of 109.3 mm for the same period (BOM 2017). The timing of Survey 2 was considered to be optimal for the identification of annual and ephemeral species, if present.

In the three months (May to July 2017) preceding the targeted survey in August 2017, Leonora Aero Weather Station received 8.8 mm of rainfall (**Figure 4-3**), which is lower than the long term average of 44.7 mm for the same period. However, substantial rainfall has been received during the year 2017 (389.8 mm) compared to the long term average (203.4 mm) (BOM 2017). The timing of the targeted survey was considered optimal for the identification of *Acacia* specimens with flowers and fruits present.

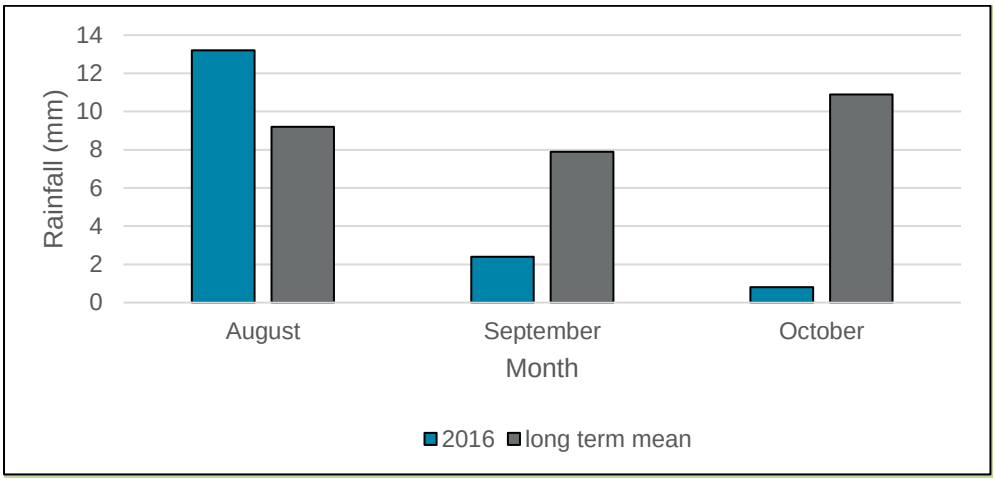


Figure 4-1: Rainfall recorded at Leonora Aero weather station (station number 012241) three months prior to Survey 1 (BoM 2017)

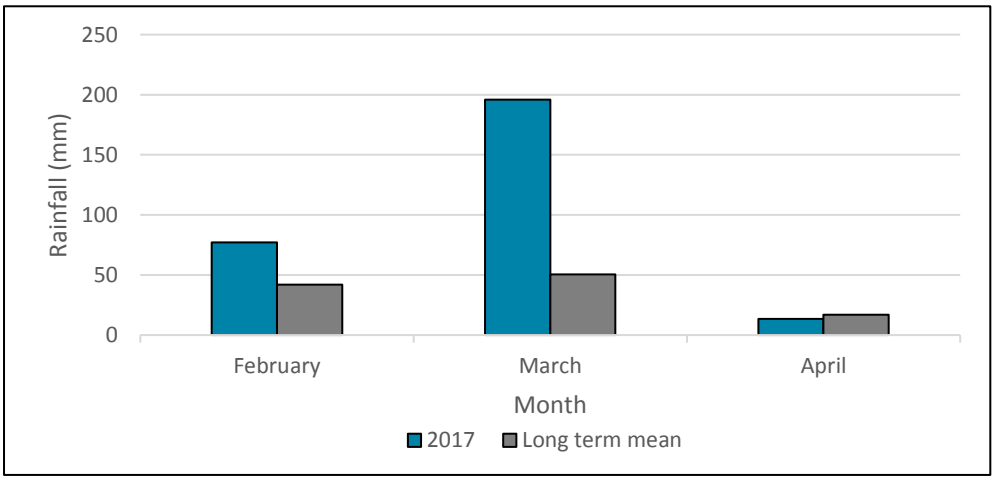


Figure 4-2: Rainfall recorded at the Leonora Aero weather station (station number 012241) three months prior to Survey 2 (BOM 2017)

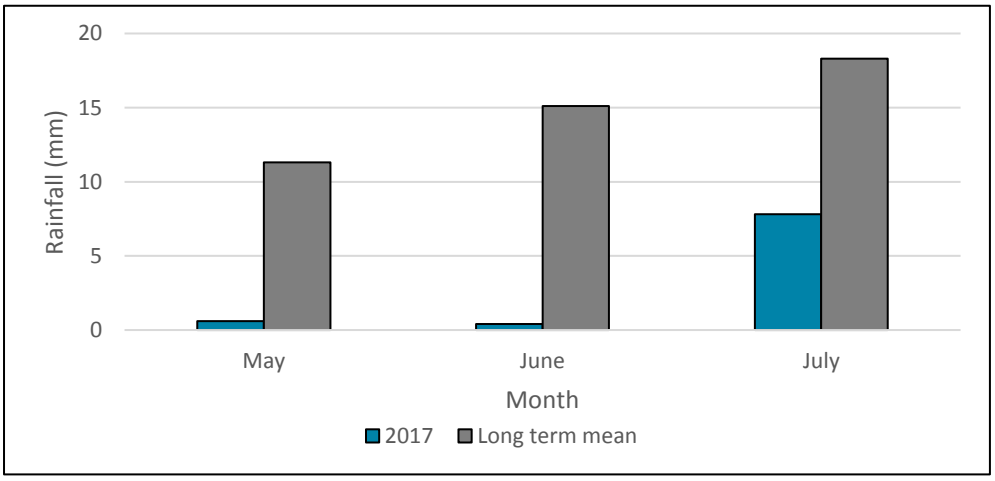


Figure 4-3: Rainfall recorded at the Leonora Aero weather station (station number 012241) three months prior to Survey 3 (BOM 2017)

Weather experienced during Survey 1 was considered sub-optimal for fauna sampling. Day time temperatures were very hot, which may have limited the activity of some fauna groups, particularly birds. The weather during Survey 2 was cooler than Survey 1, and considered good for sampling a variety of fauna groups. During Survey 1, the maximum and minimum temperatures were 42.0°C and 19.1°C (**Table 4-1**), with 4.2 mm of rainfall. During Survey 2, the maximum temperatures were 27.6°C and 9.8°C with 0.2 mm of rainfall. However the focus of the Level 1 fauna component was to identify habitats and assess for their likelihood of supporting fauna of conservation significance, which was possible despite the weather conditions. The weather during the targeted survey was considered to be fine to cool and did not hinder the targeted survey for *Acacia* sp. nov. aff. *resinimarginea*. A fauna survey was not a requirement of the targeted survey.

Table 4-1: Daily weather observations at Leonora Aero station (012241) for the field survey period

Date	Temperature (°C)		Rainfall (mm)
	Minimum	Maximum	
Survey 1			
28/11/16	23.5	41.8	0
29/11/16	23.9	42.0	4.2
30/11/16	19.1	37.6	0
1/12/16	22.7	36.2	0
2/12/16	18.6	36.6	0
3/12/16	23.5	41.8	0
4/12/16	19.8	34.5	0
5/12/16	20.4	36.3	0
Survey 2			
10/05/17	12.5	27.6	0
11/05/17	11.3	24.5	0.2
12/05/17	9.8	19.6	0
Targeted Survey			
07/08/17	2.8	27.8	0
08/08/17	8.0	24.1	0
09/08/17	13.1	17.5	3.0
10/08/17	3.6	15.7	0.2

4.2 Survey Team and Licensing

Survey 1 was conducted by experienced zoologists and botanists of MWH. The field survey was undertaken by Senior Zoologist Chris Knuckey, Terrestrial Ecology lead Paul Bolton, and experienced Botanists Sophie Fox and Brian Morgan. Survey 2 was conducted by Botanist Sophie Fox and Ecologist Megan Stone. The targeted survey was completed by Clinton van den Bergh, with assistance from Ian Pryor (Kin) throughout the survey and Geoff Cockerton and Jonathan Warden (Western Botanical) during the afternoon of the first day of the survey (7 August 2017). All plant collections were made under flora collecting permits SL011963, SL011731 and SL011883 pursuant to the WC Act Section 23C and Section 23F.

4.3 Flora and Vegetation Assessment

Relevés (unbounded floristic sampling sites) were sampled to characterise vegetation types and condition, and ensure appropriate representation of the flora and vegetation present. A total of 66 relevés were sampled within the Study Area, 56 relevés during Survey 1 and 10 relevés during Survey 2. Out of the 66 relevés sampled, six were within the Raeside area, 24 within the Cardinia area, 21 within the Mertondale area and 15 within the Haul Road alignment (**Figure 4-4** and **Appendix D**). Indicative site locations were identified prior to commencement of the field survey using aerial photography, topographic maps and existing vegetation maps, to ensure that all broad vegetation types and landforms within the Study Area would be sampled. At each relevé the following information was recorded:

- GPS Location (recorded in GDA94 UTM 51J);
- a colour photograph of the vegetation;
- habitat type;
- vegetation condition;
- vegetation description;
- dominant species present;
- average percentage cover of leaf litter;
- average percentage cover of bare ground; and
- disturbance details including fire history (time since last fire), physical disturbance, including evidence of erosion, grazing and weed invasion.

An inventory of flora within the Study Area was developed by recording vascular flora taxa encountered at each of the 66 relevés and opportunistically between sites within the Study Area. Flora taxa not identified in the field were collected and pressed for identification at the Western Australian Herbarium (WAH). Identifications were carried out by MWH botanists Sophie Fox, Brian Morgan, Sharnya Thomson and Udani Sirisena. The nomenclature and taxonomy of all vascular flora taxa in this report follows that of the WAH. All taxa were checked against FloraBase to ensure their currency and validity (WAH 2016).

Broad vegetation mapping was conducted in the field, with vegetation boundaries delineated over aerial photography, and later refined based on field survey data. Vegetation condition was assessed based on the Keighery (1994) vegetation condition scale (**Appendix C**). The vegetation types were described based on the floristic data recorded from the relevés and visual observations while traversing the Study Area. The vegetation classifications were delineated and described based on the National Vegetation Information System (NVIS) to hierarchical level V (ESCAVI 2003). Hierarchical level V requires the dominant growth form, cover, height and dominant species (three for each stratum) for each of the three traditional strata (i.e. upper, mid and ground to a maximum of nine taxa) to be detailed, where present.

Prior to Survey 1, flora of conservation significance with potential to occur within the Study Area were identified (**Table 3-1**) from the desktop study. Field personnel familiarised themselves with photographs, descriptions of these taxa, and the habitat in which they might occur, and actively searched for them while traversing the Study Area during both Survey 1 and Survey 2. Any flora taxa of conservation significance,

or species that showed similarities to such species, that were identified in the field were recorded, and detailed.

4.4 Targeted *Acacia* sp. nov. aff. *resinimarginea* Survey

Following the completion of Survey 1 and Survey 2, an *Acacia* specimen (*Acacia* ? *resinimarginea*) was considered to display unusual or unique features that may warrant formal identification of a new species, or the reinstatement of a previously excluded name (i.e. *Acacia* sp. Marshall Pool (G. Cockerton 3024)). To accurately determine the identification of *Acacia ? resinimarginea*, better quality flowering and fruiting material was required. In the circumstances that *Acacia* ? *resinimarginea* is of conservation importance, new populations and an estimate of individuals was required to determine the level of impact the Project may have on *Acacia ? resinimarginea*.

The known locations of *Acacia ? resinimarginea* were revisited to familiarise the field team on the identification of the Acacia and to determine if flowers and fruits are present. Following the familiarisation, the known locations were traversed in transects by Clinton van den Bergh and Ian Pryor (Kin) to determine the size of the populations and the number of individuals.

The known locations of *Acacia ? resinimarginea* were recorded on basalt low rises and hills during Survey 1 and Survey 2. Prior to the targeted field survey, geological maps were reviewed to determine appropriate basalt landforms that may support additional population within Kin's tenements and in close proximity to the Project (**Figure 4-5**). Basalt low rises and hills and potential deposits within the Project were initial traversed to determine the presence or absence of *Acacia ? resinimarginea*. Following review of the potential sites within the Project, the targeted survey was expanded to the south of the Project to determine additional populations.

During the targeted survey, the large size and extent of populations was sufficient to warrant a change in the methods originally employed. Initially, transects were walked across the population to determine the size and extent, however, this was not considered to be an efficient manner to determine extent of populations. The revised methodology involved traversing around the outer perimeter of the population to determine the area of occupancy, while random transects were traversed across the populations to determine the density of the population. The revised method (area of occupancy) was considered to be sufficient for determining the size and extent of the populations.

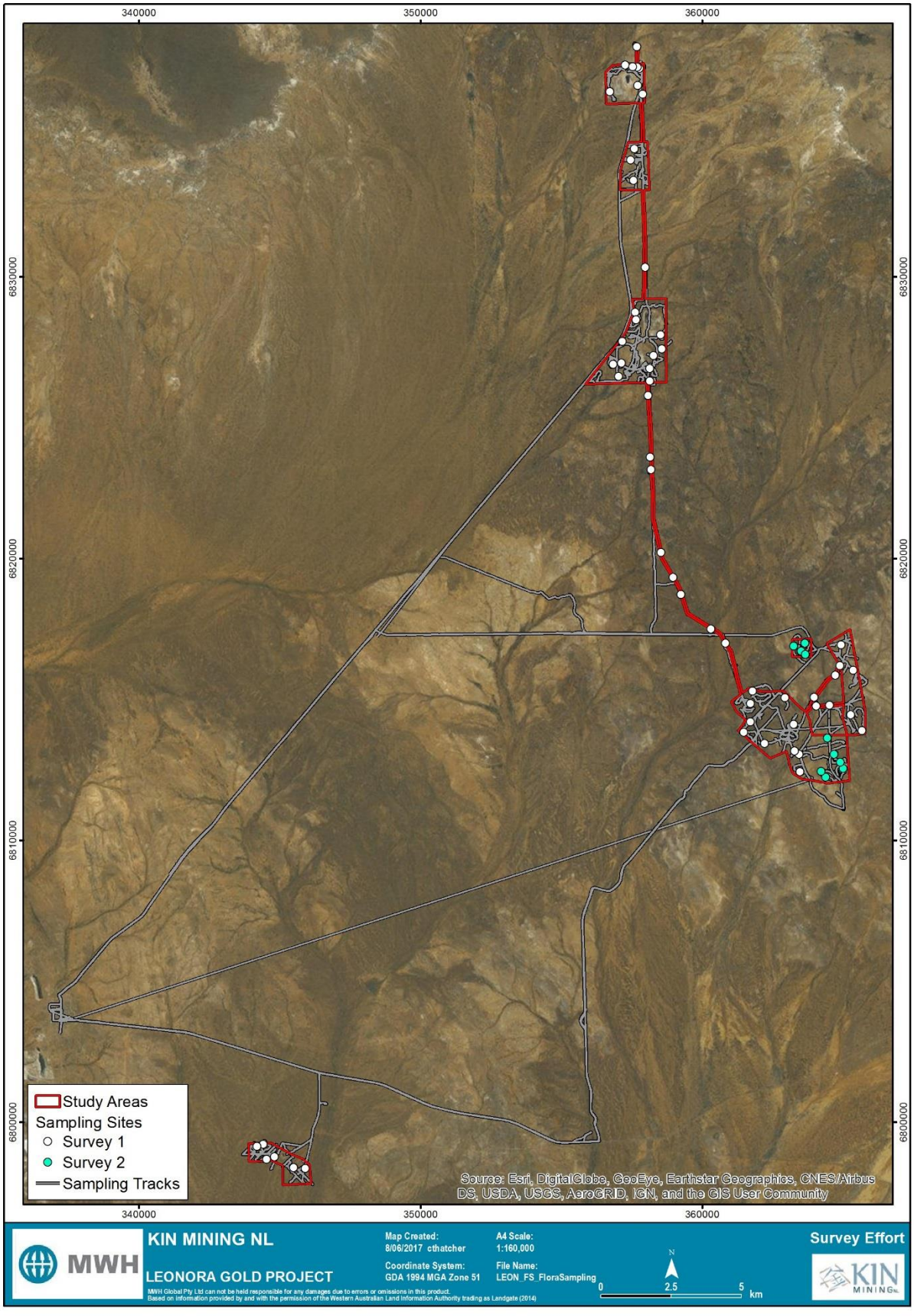


Figure 4-4: Survey effort across the Study Area

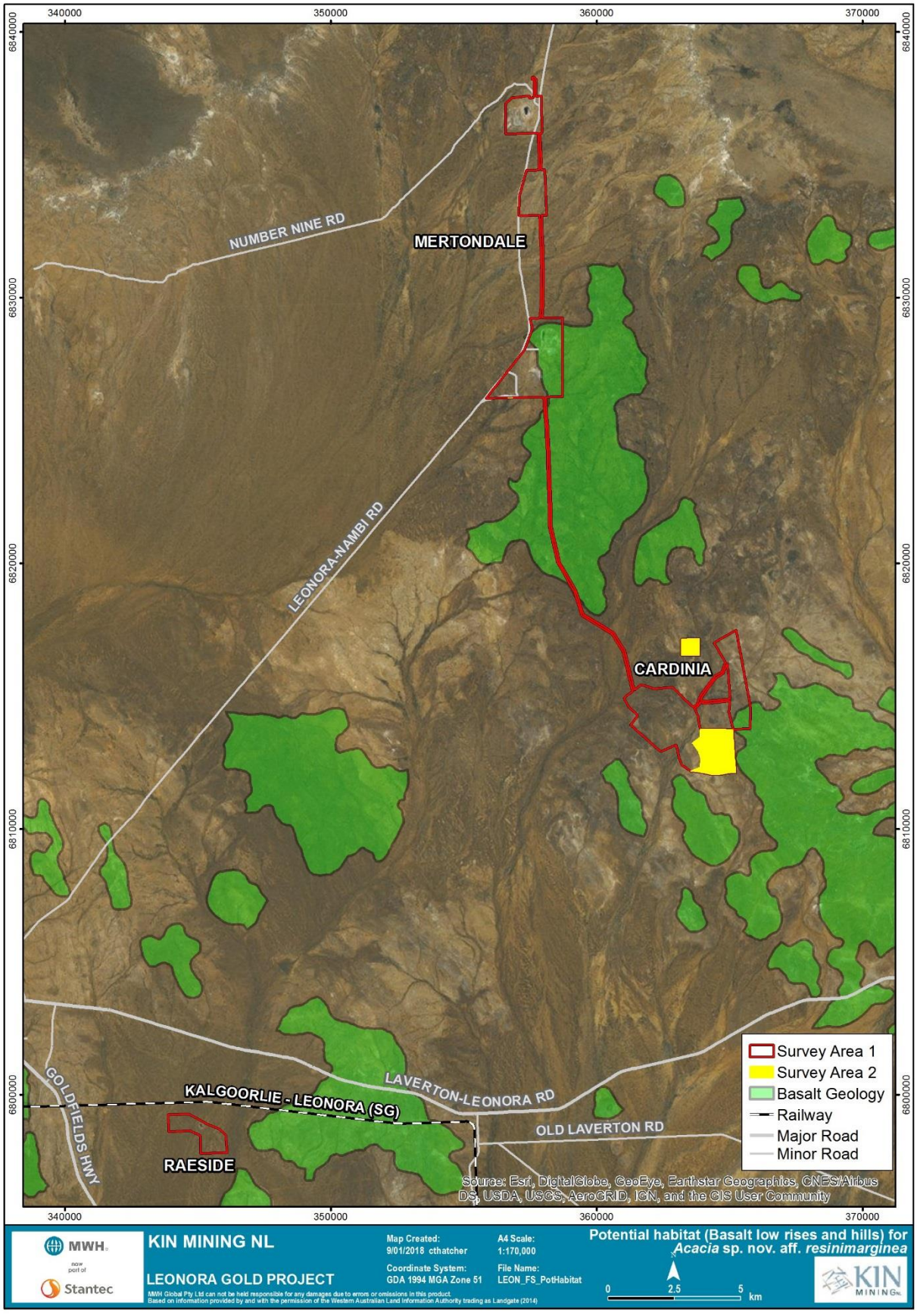


Figure 4-5: Potential habitat (Basalt low rises and hills) for *Acacia* sp. nov. aff. *resinimarginea* to be searched during the Targeted Survey

4.5 Terrestrial Fauna Assessment

Fauna habitat assessments were undertaken at 66 locations throughout the Study Area concurrent with the flora relevés (**Figure 4-4**). At each location, the following key habitat parameters were recorded:

- description of broad vegetation community;
- hollow bearing trees and dead stag trees (average size and abundance);
- rocky outcrops (average rock size and extent);
- coarse woody debris, i.e. logs and fallen timber (abundance and size);
- substrate (description of composition, presence of algal crust and % cover of leaf litter);
- wetland habitats and water courses including drainage lines, billabongs, floodplains, etc.; and
- any nest, roosts or other evidence of breeding habitat present.

Searches were conducted across all habitats types to identify possible fauna taxa of conservation significance and to develop a fauna species list for the Study area. Additional field survey effort focused on habitat likely to support fauna of conservation significance, such as dense shrublands and thickets potentially supporting Malleefowl. Potential wetlands or temporary water bodies with the capacity to support waterbirds or migratory waders were also targeted. Searching methods included:

- hand-searching for cryptic species, for example by overturning logs and stones;
- searching beneath the bark of dead trees;
- investigating crevices; and
- searching for burrows, tracks, diggings, scats, and other signs of fauna.

Aural surveys for avifauna were also carried out. All vertebrate fauna seen or heard, or whose presence was inferred from secondary evidence was documented.

The nomenclature and taxonomy of mammals, birds, reptiles and amphibians within this report follow the Checklist of the Vertebrates of Western Australia (WAM 2017). Relevant texts, from which information on habitat preferences and general patterns of distribution are available, were also considered for:

- mammals (van Dyck *et al.* 2013, Woinarski *et al.* 2014);
- birds (Johnstone and Storr 1998b, 2004, Morcombe 2003, Pizzey and Knight 2007)
- reptiles (Cogger 2014, Storr *et al.* 1999, 2002, Wilson and Swan 2013); and
- amphibians (Cogger 2014, Tyler and Doughty 2009).

4.6 Likelihood of the Occurrence for Flora and Fauna

The likelihood of occurrence of each species of conservation significance in the Study Area was assessed and ranked. The rankings were assigned using the following definitions:

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

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

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

a) the Study Area is likely to contain only a small area of suitable habitat, or habitat that is only marginally suitable; or

b) the species is generally rare and patchily distributed in suitable habitat;

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

c) the Study Area is just outside the known distribution of the species, but is likely to contain suitable and sufficient habitat (the species may be common, rare, or patchily distributed); or

d) the Study Area lies within the known distribution of the species, but the species is very rare and/or patchily distributed; or

e) the Study Area lies on the edge of, or within, the known distribution and is likely to contain suitable habitat, but the species has not been recorded in the area for over 20 years.

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

5 Results and Discussion

5.1 Vegetation

5.1.1 Vegetation Condition

Vegetation condition within the Study Area ranged from Excellent to Completely Degraded (**Table 5-1, Appendix E**). The majority was assessed as Excellent (36.11%), or Very Good (34.44%) where only minor disturbances such as very occasional access tracks or weeds were observed. Areas with evidence of feral grazing and trampling, higher presence of weeds, and clearing for tracks were assessed as Good (14.62%). Areas classified as Degraded were those that had been subject to disturbance from mining and exploration, but still supported some native vegetation (5.79%), while Completely Degraded (8.55%), areas had been completely cleared and no longer supported any native vegetation. The remaining areas classified as Revegetation, comprised historic mining areas such as waste landforms that had been rehabilitated.

Table 5-1: Vegetation condition in the Study Area

Vegetation condition	Portion of the Study Area	
	ha	%
Excellent	825.98	36.11
Very Good	787.79	34.44
Good	334.44	14.62
Degraded	132.40	5.79
Completely Degraded	195.65	8.55
Revegetation	11.34	0.50
Total	**2,287.6**	**100**

5.1.2 Vegetation Units

A total of 23 vegetation units were recorded across the Study Area (**Table 5-2** and **Appendix F**). The vegetation recorded broadly comprised mixed Mulga shrublands over mixed shrubs dominated by *Eremophila* species, *Ptilotus obovatus*, *Scaevola spinescens* and *Rhagodia* species, also with large areas dominated by *Cratystylis subspinescens*, *Maireana pyramidata* and *Maireana sedifolia*.

It was difficult to accurately map vegetation to a fine scale in some areas due to intergrading vegetation, geology and disturbance. This was pertinent in the Cardinia area and a section of the Haul Road. The vegetation in these locations consisted of a mosaic of vegetation across micro-scales, including hill crests, slopes, and swales between the crests. The dominant species were *Acacia* spp., *Maireana sedifolia*, *Ptilotus obovatus*, *Senna* spp., and *Eremophila scoparia*.

In addition to the 23 vegetation units described, two additional units, Disturbed and Revegetation, were mapped within the Study Area. The Disturbed area comprises historical mine pits, infrastructure, waste

rock landforms and associated tracks, and surrounding areas previously cleared and left to regenerate. Disturbed and Revegetation areas were not sampled as the vegetation composition had been severely altered and no longer reflected the native vegetation composition and structure of the area.

Table 5-2: Vegetation units recorded within the Study Area

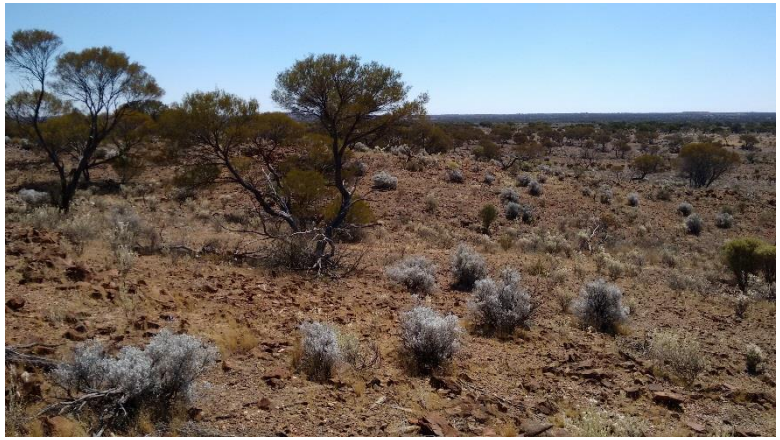
Code	Description	Relevés	Portion of Study Area (ha / %)	Photograph
AiElEc	*Acacia incurvaneura* low open woodland over *Eremophila latrobei* subsp. *latrobei*, *Solanum lasiophyllum* and *Ptilotus obovatus* low sparse shrubland, over *Enneapogon caerulescens* low grassland over *Sclerolaena diacantha* isolated dwarf chenopod shrubs	LGR107	13.56ha 0.59%	
AiMsTd	*Acacia inceana* subsp. *conformis* low woodland over *Maireana sedifolia* mid isolated shrubs over *Maireana pyramidata* and *Tecticornia disarticulata* low isolated chenopod shrubs	LGR10 LGR28 LGR102	65.05ha 2.84%	

Code	Description	Relevés	Portion of Study Area (ha / %)	Photograph
Asp.MsEs	*Acacia* sp. low open woodland over *Maireana sedifolia* and *Eremophila scoparia* mid open shrubland, over *Sclerolaena diacantha* sparse isolated dwarf chenopod shrubland	LGR109	18.96ha 0.83%	
AaAtEspp.	*Acacia aneura, Acacia caesaneura* and *Acacia pteraneura* low woodland over *Acacia tetragonophylla* tall isolated shrubs over mixed low isolated shrubs	LGR17 LGR32 LGR41 LGR43 LGR45 LGR47 LGR51 LGR55	253.5ha 11.08%	

Code	Description	Relevés	Portion of Study Area (ha / %)	Photograph
AbArEp	*Acacia burkittii, Acacia aneura* and *Acacia craspedocarpa* low open woodland over *Grevillea extorris, Acacia ramulosa* var. *ramulosa* and *Eremophila platycalyx* subsp. *platycalyx* mid isolated shrubs over *Monachather paradoxus* low isolated grasses on rocky drainage line	LGR38	0.87ha 0.04%	
AbAtTt	*Acacia burkittii* and *Acacia aptaneura* low open woodland over *Acacia tetragonophylla* and *Acacia burkittii* mid sparse shrubland over *Themeda triandra, Eriachne flaccida* and *Enteropogon ramosus* low tussock grasses on sandy drainage line	LGR12 LGR24 LGR108	75.28ha 3.29%	

Code	Description	Relevés	Portion of Study Area (ha / %)	Photograph
AbEpPo	*Acacia burkittii* tall open shrubland over *Eremophila platycalyx* subsp. *platycalyx*, *Eremophila forrestii* subsp. *forrestii* and *Senna artemisioides* subsp. *artemisioides* mid isolated shrubs over *Ptilotus obovatus* low isolated shrubs, over *Aristida contorta* low isolated grasses on hills	LGR37	6.65ha 0.29%	
AaAtEp	*Acacia aneura, Acacia aptaneura* and *Acacia caesaneura* low open woodland over *Eremophila platycalyx* subsp. *platycalyx*, *Acacia ramulosa* subsp. *ramulosa* and *Acacia tetragonophylla* tall to mid isolated shrubs over *Ptilotus obovatus, Eremophila metallicorum* and *Eremophila margarethae* low isolated shrubs, over mixed low grasses.	LGR05 LGR21 LGR29 LGR33 LGR36 LGR49 LGR58	239.27ha 10.46%	

Code	Description	Relevés	Portion of Study Area (ha / %)	Photograph
AaArAq	*Acacia quadrimarginea, Acacia incurvaneura* and *Acacia aneura* low woodland over *Acacia ramulosa* var. *ramulosa* and *Acacia tetragonophylla* tall to mid sparse shrubland over *Eremophila* spp. low isolated shrubs over *Eragrostis eriopoda* and *Monachather paradoxus* isolated tussock grasses	LGR09 LGR13 LGR15	71.52ha 3.13%	
AaArEspp.	*Acacia aneura, Acacia incurvaneura* and *Acacia caesaneura* low open forest over *Acacia ramulosa* var. *ramulosa* tall isolated shrubs over *Eremophila* spp. mid isolated shrubs over low isolated mixed shrubs, herbs and grasses,	LGR18 LGR25 LGR27 LGR34 LGR39 LGR50 LGR52	265.54ha 11.61%	

Code	Description	Relevés	Portion of Study Area (ha / %)	Photograph
AkAbMs	*Acacia kempeana* low open woodland over *Acacia burkittii*, *Maireana sedifolia* and *Eremophila scoparia* mid open shrubland, over *Ptilotus obovatus*, *Sida ectogama* and *Solanum lasiophyllum* low isolated shrubs, over *Enneapogon caerulescens* and *Sclerolaena eriacantha* low isolated forbs and grasses on rocky hills	LGR16	44.04ha 1.93%	
A?rSaMs	*Acacia* sp. nov. aff. *resinimarginea*, *Acacia aneura* and *Acacia caesaneura* tall open shrubland, over *Senna artemisioides* subsp. *filifolia*, *Scaevola spinescens* and *Acacia tetragonophylla* mid isolated shrubs over *Ptilotus obovatus, Maireana sedifolia* and *Solanum lasiophyllum* low isolated shrubs over *Ptilotus helipteroides* and *Enneapogon caerulescens* low isolated forbs and grasses on rocky hills	LGR20 LGR106	70.6ha 3.09%	

Code	Description	Relevés	Portion of Study Area (ha / %)	Photograph
AaSaMs	*Acacia aneura* and *Acacia caesaneura* tall open woodland over *Senna artemisioides* subsp. *filifolia*, *Maireana sedifolia* and *Ptilotus obovatus* low open shrubland over low mixed chenopod shrubland on rocky hills	LGR44	111.66ha 4.88%	
AkHpEs	*Acacia kalgoorliensis, Acacia oswaldii* and *Hakea preissii* low open woodland over *Eremophila scoparia*, *Senna stowardii* and *Acacia craspedocarpa* mid isolated shrubs over *Ptilotus obovatus*, *Maireana triptera* and *Cratystylis subspinescens* low isolated shrubs over *Sclerolaena eriacantha*, *Sclerolaena densiflora* and *Ptilotus* sp. Goldfields (R. Davis 10796) low isolated forbs on rocky plains	LGR26	36.11ha 1.58%	

Code	Description	Relevés	Portion of Study Area (ha / %)	Photograph
AcHpEp	*Acacia craspedocarpa, Acacia aneura* and *Acacia incurvaneura* low open woodland over *Acacia oswaldii, Hakea preissii* and *Rhagodia drummondii* mid isolated shrubs, over *Eremophila pantonii*, *Maireana georgei* and *Atriplex nummularia* subsp. *spathulata* low isolated shrubs over *Sclerolaena densiflora, Enneapogon caerulescens* and *Ptilotus aervoides* low isolated forbs and grasses	LGR07	19.09ha 0.83%	
AcArSe	*Acacia craspedocarpa* and *Acacia aneura* low woodland over *Acacia ramulosa* var. *ramulosa* tall open shrubland, over *Sida ectogama* and *Eremophila* spp. mid isolated shrubs over low isolated mixed forbs and grasses	LGR01 LGR31	43.18ha 1.89%	

Code	Description	Relevés	Portion of Study Area (ha / %)	Photograph
AcAtEo	*Acacia craspedocarpa, Acacia aneura* and *Acacia caesaneura* low woodland over *Acacia tetragonophylla, Scaevola spinescens* and *Eremophila oldfieldii* subsp. *angustifolia* mid isolated shrubs over *Ptilotus obovatus* and *Maireana tomentosa* subsp. *tomentosa* low isolated shrubs, over *Ptilotus* sp. Goldfields (R. Davis 10796), *Enneapogon caerulescens* and *Aristida contorta* low isolated forbs and grasses	LGR02 LGR35 LGR57	157.4ha 6.88%	
AcAtEm	*Acacia craspedocarpa* low open forest over *Acacia tetragonophylla* tall open shrubland over *Eremophila metallicorum* low isolated shrubs over low isolated mixed forbs and grasses	LGR23 LGR54	71.31ha 3.12%	

Code	Description	Relevés	Portion of Study Area (ha / %)	Photograph
AcAtEp	*Acacia craspedocarpa* and *Acacia caesaneura* low open woodland over *Acacia tetragonophylla* and *Eremophila platycalyx* subsp. *platycalyx* tall isolated shrubs, over *Ptilotus obovatus* and *Eremophila* spp. mixed low isolated shrubs over low isolated mixed forbs and grasses	LGR03 LGR04 LGR14 LGR19 LGR48 LGR54 LGR56	45.81ha 2.00%	
CpArEo	*Casuarina pauper, Acacia caesaneura* and *Acacia aneura* low woodland over *Acacia ramulosa* var. *ramulosa* and *Acacia tetragonophylla* tall isolated shrubs over *Eremophila oldfieldii* subsp. *angustifolia* mid isolated shrubs over Maireana *triptera, Sclerolaena eriacantha* and *Sclerolaena densiflora* low isolated forbs	LGR11 LGR30	11.11ha 0.49%	

Code	Description	Relevés	Portion of Study Area (ha / %)	Photograph
EsEsPo	*Eucalyptus striaticalyx* and *Acacia aneura* low open woodland over *Eremophila scoparia* and *Eremophila glabra* subsp. *glabra* mid isolated shrubs, over *Ptilotus obovatus*, *Scaevola spinescens* and *Lepidium platypetalum* low isolated shrubs on rocky outcrops	LGR46	0.4ha 0.02%	
HpCsMp	*Hakea preissii* low isolated trees over *Cratystylis subspinescens* and *Maireana pyramidata* mid open shrubland over *Tecticornia pruinosa*, *Tecticornia disarticulata* and *Tecticornia pergranulata* subsp. *pergranulata* low open chenopod shrubland over *Enneapogon caerulescens* low isolated grasses	LGR06 LGR08 LGR22 LGR53 LGR104 LGR110	434.85ha 19.01%	

Code	Description	Relevés	Portion of Study Area (ha / %)	Photograph
MpTdSd	*Maireana pyramidata* and *Tecticornia disarticulata* low chenopod shrubland over *Sclerolaena densiflora* isolated dwarf chenopod shrubs with *Aristida contorta, Enteropogon ramosus* and *Sporobolus actinocladus* isolated tussock grasses	LGR101 LGR103 LGR105	5.23ha 0.23%	
Disturbed	Areas of disturbance including historical and recent mining activities.	N/A	216.7ha 9.47%	
Revegetation	Previously disturbed areas which have been revegetated	N/A	9.9ha 0.43%	

5.1.3 Vegetation of Conservation Significance

None of the vegetation units within the Study Area are analogous to any TECs under the EPBC Act, or listed by Parks and Wildlife, which qualify for special protection.

There were no PECs directly related to terrestrial vegetation recorded within the Study Area. The vegetation units described from the Study Area are not considered to represent any PECs known to occur in the Murchison bioregion.

The EPA (EPA 2004b) advises that vegetation may be considered to be of significance for a range of reasons, other than a listing as a TEC or a PEC, including:

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

There were no vegetation units recorded from within the Study Area that would be considered to be of regional significance. Four vegetation units within the Study Area were considered to be of local significance, three for supporting the priority listed flora, *Gunniopsis propinqua* (P3) (AaAtEp, AiMsTd and HpCsMp) and one for supporting the putative hybrid *Acacia* sp. nov. aff. *resinimarginea* (A?rSaMs), a taxon currently under review as a potentially new species.

Table 5-3: Locally significant vegetation units

Vegetation unit	Study Area coverage (ha / %)	Comment
EsEsPo *Eucalyptus striaticalyx* and *Acacia aneura* low open woodland over *Eremophila scoparia* and *Eremophila glabra* subsp. *glabra* mid isolated shrubs, over *Ptilotus obovatus*, *Scaevola spinescens* and *Lepidium platypetalum* low isolated shrubs on rocky outcrops.	0.4ha 0.02%	Supports populations of *Gunniopsis propinqua* (P3)
HpCsMp *Hakea preissii* low isolated trees over *Cratystylis subspinescens* and *Maireana pyramidata* mid open shrubland over *Tecticornia pruinosa*, *Tecticornia disarticulata* and *Tecticornia pergranulata* subsp. *pergranulata* low open chenopod shrubland over *Enneapogon caerulescens* low isolated grasses	434.85ha 19.01%	
AiMsTd *Acacia inceana* subsp. *conformis* low woodland over *Maireana sedifolia* mid isolated shrubs over *Maireana pyramidata* and *Tecticornia disarticulata* low isolated chenopod shrubs	65.05ha 2.84%	

Vegetation unit	Study Area coverage (ha / %)	Comment
A?rSaMs *Acacia* sp. nov. aff. *resinimarginea*, *Acacia aneura* and *Acacia caesaneura* tall open shrubland, over *Senna artemisioides* subsp. *filifolia*, *Scaevola spinescens* and *Acacia tetragonophylla* mid isolated shrubs over *Ptilotus obovatus, Maireana sedifolia* and *Solanum lasiophyllum* low isolated shrubs over *Ptilotus helipteroides* and *Enneapogon caerulescens* low isolated forbs and grasses on rocky hills	70.6ha 3.09%	Supports populations of the putative hybrid *Acacia* sp. nov. aff. *resinimarginea*, a taxon currently under review as a potential new species

In addition to the four locally significant vegetation units (supporting taxa of conservation significance), 18 of the 23 vegetation units may be considered to be locally restricted in distribution (**Table 5-4**). Each of these 18 units represent less than 5% of the Study Area, with eight of the 18 units mapped as occurring across less than 1% of the Study Area. The limited extent of most of these vegetation units within the Study Area is most likely an artefact of the shape and large surface area of the Study Area. Based on aerial imagery, all of these vegetation units appear to extend well outside the Study Area, with the possible exception of EsEsPo. The vegetation unit EsEsPo occurs as a small portion (0.4ha) of the Haul Road in association with low outcropping.

Table 5-4: Vegetation units with restricted distribution in the Study Area

Vegetation Unit	Study Area	
	ha	%
EsEsPo	0.40	0.02
AbArEp	0.87	0.04
MpTdSd	5.23	0.23
AbEpPo	6.65	0.29
CpArEo	11.11	0.49
AiElEc	13.56	0.59
Asp.MsEs	18.96	0.83
AcHpEp	19.09	0.83
AkHpEs	36.11	1.58
AcArSe	43.18	1.89
AkAbMs	44.04	1.93
AcAtEp	45.81	2.00
AiMsTd	65.05	2.84
A?rSaMs	70.60	3.09
AcAtEm	71.31	3.12
AaArAq	71.52	3.13
AbAtTt	75.28	3.29
AaSaMs	111.66	4.88

5.2 Flora

5.2.1 Flora Assemblages

A total of 257 vascular flora taxa (including subspecies and variants) from 37 families and 103 genera were recorded within the Study Area (**Appendix G**). The total number of vascular flora taxa included 249 native taxa and eight introduced (weed) taxa. The most frequently occurring families were Chenopodiaceae (39 taxa), Fabaceae (36 taxa) and Poaceae (30 taxa), which, together represented 40.9% of the species recorded (**Table 5-5**). Fifty-one (51) of the 257 genera recorded, were represented by two taxa (*Acacia* and *Eremophila*), which represented 19.8% of the total taxa recorded from the Study Area.

Table 5-5: Dominant families recorded from the Study Area

Family	Number of species in subregion (WAH 2016)	Species recorded in field survey	
		Number	% of subregion
Chenopodiaceae	145	39	26.9
Fabaceae	239	36	15.1
Poaceae	117	30	25.6
Asteraceae	200	27	13.5
Scrophulariaceae	129	26	20.2
Amaranthaceae	45	11	24.4

The floral diversity and composition recorded from the Study Area is consistent with the Murchison bioregion, the landforms present, the season of the field survey, and the sampling intensity (i.e. Level 1 and relevés). The flora taxa recorded (**Appendix G**) is consistent with Mulga shrublands of the bioregion. These shrublands consist of a tall shrub layer of *Acacia aneura* and it's close relatives over undershrubs (typically *Senna* spp. and/or *Eremophila* spp.), sparse perennial and annual grasses and a ground layer of ephemeral herbs, which may be closed in a favourable season (Beard 1990b).

Of the 519 specimens collected in total (481 from Survey 1, and 38 from Survey 2), 33 specimens were unable to be confidently identified (6.35%) to family, genera, species or infraspecific level (**Table 5-6**) due to the quality of the specimens and a lack of flowering and/or fruiting material. Due to the timing of Survey 1 being late spring, flowering and/or fruiting material was not present, and annual species were dead and very dry. The 33 specimens with tentative identifications are not considered to be analogous with any of the 'Likely' or 'Possible' priority flora potentially occurring in the Study Area. The implications for potential Threatened or Priority annual flora taxa being misidentified or not identified during the field survey due to timing are discussed in **Section 5.2.2** below.

Table 5-6: Tentative identifications split between groups and reasoning

Group	No. of tentative identifications	Comment
Family	2	Specimens were annual species (Poaceae sp.) and too dry and sterile to identify beyond family level
Genera	1	Specimen sterile therefore unable to be identified confidently to genus level
Species	30	Specimens included dry, dead or sterile plants. They were confidently identified to genus level but had insufficient material present to identify them to species level.
Total	33	

5.2.2 Threatened and Priority Listed Flora

No Threatened flora species were recorded within the Study Area, and none are expected to occur based on the results of the desktop assessment (see **Section 3.3**) and the field survey.

The database search identified thirty-five (35) Parks and Wildlife listed Priority flora taxa (**0**). Of these, one species, *Gunniopsis propinqua* (P3) was collected and identified, and confirmed as occurring within the Study Area (**Table 5-7**, **Figure 5-1**).

Table 5-7: Flora of conservation significance recorded within the Study Area

Species	Status	Site	GPS Co-ordinate (GDA 94 Zone 51J)	
			Easting	Northing
Gunniopsis propinqua	P3	LGR06	365359	6816059
		LGR10	364525	6814803
		LGR22	363434	6813056
		LGR46	358158	6823614

Gunniopsis propinqua is a Priority 3 taxon (**Figure 5-2**) known to occur in the Murchison, Gascoyne, Pilbara and Yalgoo regions (WAH 2017). It is a succulent prostrate annual or perennial herb 0.03 to 0.1 m high with white or pink flowers from August to September (WAH 2017). It is known from habitat comprising stony, sandy loam, lateritic outcrops and winter-wet sites (WAH 2017). *Gunniopsis propinqua* is restricted to Western Australia and is known from a number of localities in the eastern part of the Austin Botanical District, and one locality in the extreme north-west of the Ashburton District. This species grows in less saline situations than its closest relative, *Gunniopsis septifraga*, favouring lateritic outcrops or sandy stony loams (Chinnock 1983). One of the known locations is from Kennedy Range National Park. The nearest record of *Gunniopsis propinqua* is 30 km east of the Study Area.

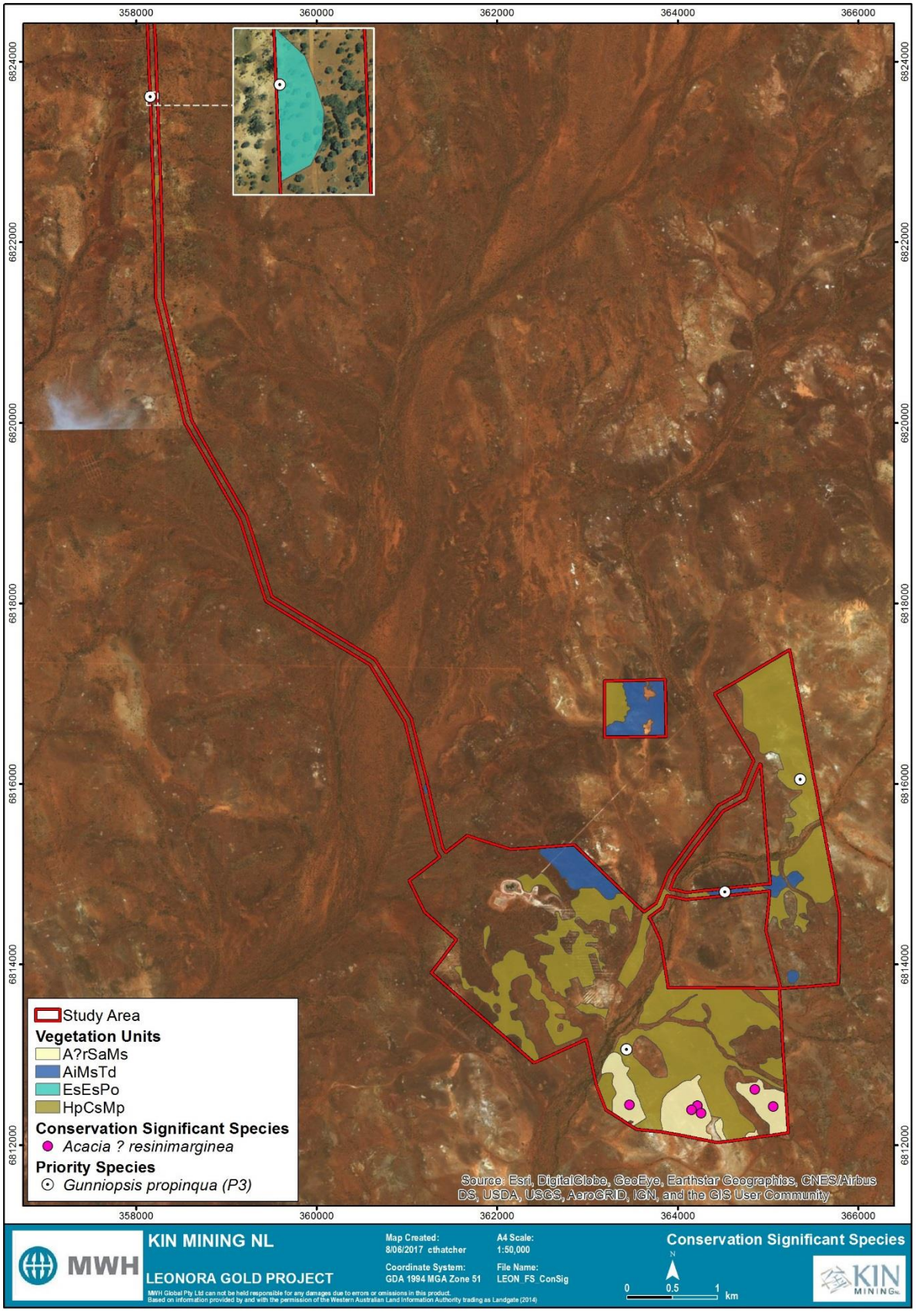


Figure 5-1: Conservation Significant Flora occurring within the Study Area



Figure 5-2: *Gunniopsis propinqua* specimen

In addition to the Confirmed taxa, four species, *Acacia websteri* (P1), *Angianthus prostratus* (P3), *Calytrix praecipua* (P3) and *Cratystylis centralis* (P3), were assessed as Very likely to occur based on the Study Area containing suitable habitat for that species, and proximity of previous records occurring close to the Study Area. Another seven, *Ptilotus tetrandrus* (P1), *Stenanthemum patens* (P1), *Eremophila mirabilis* (P2), *Eremophila annosocaulis* (P3), *Triglochin protuberans* (P3), *Grevillea inconspicua* (P4) and *Hemigenia exilis* (P4) were considered Likely to occur due to the Study Area possibly containing suitable habitat for the species, and previous record occurring close to the Study Area. Seven were considered Possible to occur, due to the Study Area containing suitable habitat but occurring just outside the known location of the species. The remaining 15 were considered Unlikely to occur due to a lack of known suitable habitat within the Study Area, and/or occurring outside the known distribution.

Due to the timing of Survey 1 being late spring most of the annual species observed were dead and very dry, while other annual flora were likely to be completely gone. Based on database search results no Threatened flora taxa are likely to occur within the Study Area, thus it is highly unlikely that any Threatened annuals were missed due to the timing of the survey. Of the 35 Priority flora taxa identified by the desktop study three annuals were considered possible and may have been missed at the time of the survey:

- *Angianthus prostratus* (P3) was considered Very Likely to occur because the Study Area contains suitable habitat of red clay or loamy soils, and saline depressions, and lies within 13 km of its nearest population;
- *Triglochin protuberans* (P3) was considered Likely to occur because the Study Area contains suitable habitat of winter-wet sites, and claypans, and is within 15 km of the nearest known population; and

- *Goodenia lyrata* (P3) was considered Possible because it contains suitable habitat of red sandy loam near claypans, with the nearest known population recorded 60 km away, but just outside the known distribution of the species.

Survey 2 was undertaken following significantly above average rainfall and would have increased the likelihood of identifying the conservation significant annual species considered very likely, likely or possible to occur. Survey 2 was only completed within a subset of the Study Area and may have limited the likelihood of recording conservation significant annual species if the preferred habitat was not present.

All of these taxa are widespread across several IBRA sub-regions and it is unlikely the proposed Project would have any significant impact to the occurrence of these species in the sub-region.

5.2.3 Flora of Other Significance

The EPA (2004b) advises that flora species, subspecies, varieties, hybrids and ecotypes may be considered significant for reasons other than listing as a Threatened or Priority Flora taxa, and may include the following:

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

Based on these parameters one flora species, *Acacia* sp. nov. aff. *resinimarginea* (previously referred to as *Acacia ? resinimarginea*), may be considered to be of 'other conservation significance' as it has anomalous features that indicate a potential new discovery. Currently the *Acacia* sp. nov. aff. *resinimarginea* is considered to represent a putative hybrid, requiring further taxonomic revision. Collections were made from six locations within the Cardinia survey area (**Table 5-8** and **Figure 5-1**), within the vegetation unit A?rSaMs. In excess of 116 individuals have been recorded from the six locations, with a high likelihood that the extent would increase considering the putative hybrid is the dominant Acacia in the upper stratum. It is likely that this species will be present in additional areas within this vegetation unit, and potentially within other rocky hill top vegetation units in the general proximity of the Study Area.

The putative hybrid was recorded from the basaltic, stony low hills along the Archaean greenstone belt. The greenstone belt extends to the north and south, indicating that the putative hybrid may be present outside of the Study Area.

Table 5-8: *Acacia* sp. nov. aff. *resinimarginea* locations and population extents

Species	Status	Count	GPS Co-ordinate (GDA 94 Zone 51J)	
			Easting	Northing
Acacia sp. nov. aff. *resinimarginea*	Putative Hybrid	unknown	363465	6812443
		25	364154	6812388
		16	364218	6812433
		25	364258	6812351
		30	365058	6812426
		20	364854	6812614

Voucher specimens collected from the Study Area were lodged with the Western Australian Herbarium (WAH) to assist in the determination of the specimens. One specimen was lodged following Survey 1, while an additional two specimens were lodged following Survey 2.

The specimen lodged after Survey 1 did not fit well with any described Acacia species and it was determined that the specimen may well represent a currently unrecognised Acacia taxon or a hybrid, with *Acacia jamesiana* being a likely parent (M. Hislop, email correspondence 15/02/2017). Survey 2 allowed for additional specimens to be collected to assist in the determination of the taxon. Following further review, taxonomists at WAH determined that the specimens are almost certainly not accommodated by any current known *Acacia* entity, however the circumscription of the taxon is unclear (M. Hislop, email correspondence 22/06/2017). As the circumscription is unclear, the distribution and conservation status of the specimens are unclear.

An *Acacia* specimen (formally referred to as *Acacia* sp. Marshall Pool (G. Cockerton 3024)) located within the indeterminate folder within the research collection of WAH is considered to be similar to the specimens collected from the Study Area. This additional specimen has previously been shown to *Acacia* specialist Bruce Maslin, along with material of two or three very similar, currently unrecognised taxa. Mr Bruce Maslin was inclined to agree in principle but insisted that more collections were needed before any decisions could be taken in regard to the boundaries of these putative taxa.

Additional targeted surveys were undertaken in August 2017 across the known locations and additional suitable habitat within the Project and to the south of the Project. A total of 26 populations and 10,368 individuals were recorded during the August 2017 targeted survey (**Figure 5-3**). The 10,368 individuals are considered to be a lower estimate of population sizes as not all individuals were counted from each population. The 26 populations covered an area of occupancy of approximately 175 ha

It is possible that *Acacia* sp. nov. aff. *resinimarginea* is present outside of the Study Area (near Marshall Pool, north of Leonora), however further fruiting material is required to assist in recognising the putative hybrid. Western Botanical have completed additional targeted surveys for numerous Acacia species, including *Acacia* sp. nov. aff. *resinimarginea*, in the region to determine the taxonomic identities and conservation significance of these Acacia species. The work is currently ongoing with no firm results yet available.

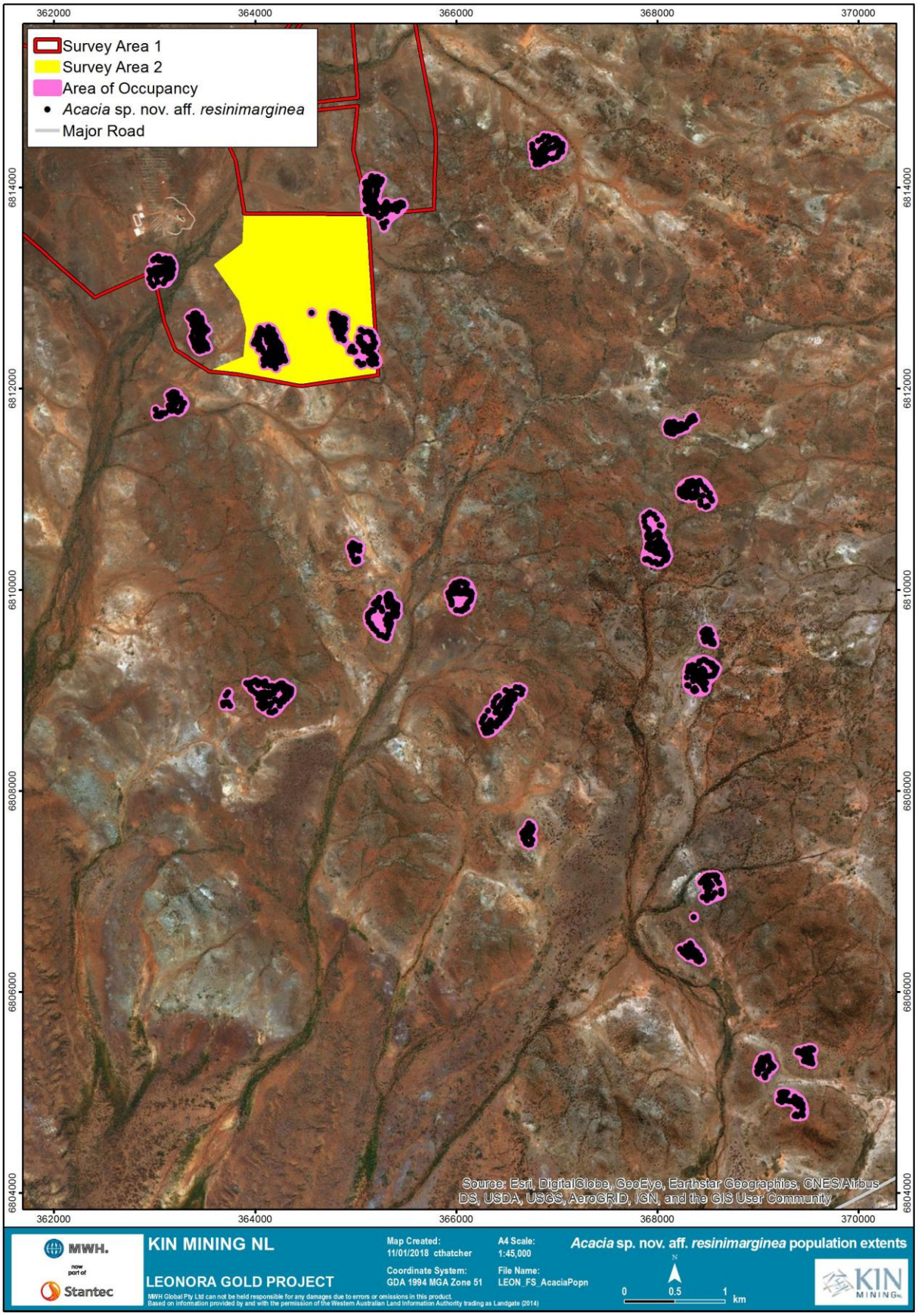


Figure 5-3: *Acacia* sp. nov. aff. *resinimarginea* population extents

5.2.4 Introduced Flora

Eight introduced taxa (**Table 5-9**) were recorded within the Study Area during Survey 1. Of these, one is considered to be an environmentally significant weeds. **Cylindropuntia fulgida* var. *mamillata* is classed as a Declared Pest (DP) under Section 22 of the *Biosecurity and Agriculture Management Act 2007* (BAM Act). **Cylindropuntia fulgida* var. *mamillata*, along with all *Cylindropuntia* spp., is also classified as a Weed of National Significance (WoNS).

Table 5-9: Introduced flora recorded within the Study Area

Species	Common Name	Status	Site	GPS Co-ordinate (GDA 94 Zone 51J)	
				Easting	Northing
**Carpobrotus aequilaterus*	Angular Pigface	-	LGR06	365358	6816048
**Cuscuta planiflora*	Small Seeded Dodder	-	LGR24	363279	6813174
**Cylindropuntia fulgida* var. *mamillata*	Coral Cactus	WoNS, DP	LGR35 LGR56 LGR58	357136 357026 357160	6826939 6626474 6827719
**Malvastrum americanum*	Spiked Malvastrum	-	LGR24	363279	6813174
**Rumex hypogaeus*	Doublegee	-	LGR24	363279	6813174
**Rumex vesicarius*	Ruby Dock	-	LGR24	363279	6813174
**Sisymbrium erysimoides*	Smooth Mustard	-	LGR24	363279	6813174
**Sisymbrium irio*	London Rocket	-	LGR56	357026	6626474

Cylindropuntia fulgida var. *mamillata* (**Figure 5-4**) is an erect fleshy perennial cactus shrub to 1 m tall, bearing numerous crowded cylindrical stem segments, densely covered with elongated lumps, each with a cluster of three rear pointing spines (Hussey *et al.* 2007). Native to Arizona, this species was originally cultivated as a garden ornamental in Australia and has since naturalised on numerous pastoral stations in the Gascoyne and Pilbara (Hussey *et al.* 2007). This species was recorded from two locations within the Study Area, from a drainage line, and from near the old town site both in the Mertondale area.



Figure 5-4: *Cylindropuntia fulgida* var. *mamillata in situ*

5.3 Terrestrial Fauna

5.3.1 Fauna Habitats

Broad fauna habitats were identified and delineated from fauna habitat assessments conducted across the Study Area (**Table 5-10**). Four broad fauna habitat types were identified within the Study Area (**Appendix I**):

- Acacia Shrublands on plains;
- Drainage Lines;
- Low Hills; and
- Chenopod Shrublands.

These habitats differed in the composition of substrate (i.e. rock, sand or alluvial based), as well as vegetation density and structure. Variability in the middle and upper strata in particular was insignificant. Only one small area had a few trees suited to providing hollows (see vegetation unit EsEsPo). Rocky outcrops were uncommon and occurred only occasionally within the Low Hills habitat. Based on aerial imagery of the area, rocky outcrops in the form of breakaways are likely to be common outside the Study Area approximately 5-10 km to the east and west of the northern end of the Study Area. Soil types across the vast majority of the Study Area consistently comprised of red to orange clay loams with ironstone/quartzite gravel, with occasional sandy alluviums scattered through the Mulga Shrublands on Plains and within the Drainage Lines.

The habitat types in the Study Area were assessed on their extents and levels of significance according to the following criteria:

- Distribution: those habitats widespread and common within the surrounding regions were categorised as widespread; otherwise they were categorised as limited. All habitat types within the Study Area were considered widespread.
- Significance: those habitats considered important to species of conservation significance or distinct fauna assemblages are deemed significant; otherwise they were categorised as limited significance. All habitats were considered to be of limited significance.
- SRE potential: habitats were categorised as having a high, medium or low potential to support SRE invertebrate fauna, based on the presence of microhabitats, whether the habitat was restricted or widespread in the landscape, and whether the habitat formed isolates or was well connected in the landscape. All habitats within the Study Area were considered to have low potential to support SRE species.

Table 5-10: Fauna habitats recorded within the Study Area

Habitat Type	Total Ha (%)	Vegetation Units	Disturbance and Condition	Value to Fauna
Acacia Shrublands on Plains • Widespread • Limited Significance • Low SRE potential	1,300.30 ha 56.84%	AiMsTd, AaAtEspp, AcArSe, AaAtEp, AkHpEs, AcHpEp, AcAtEo, AcAtEm, AcAtEp, AaArEspp, AaArAq, AiEkEc, Asp.MsEs	Good to Excellent: Clearing, feral grazing, logging and tracks	The *Acacia* Shrublands on Plain habitat occurred throughout the Study Area. Dominant vegetation varied within this habitat from low open Mulga with limited understorey through to lower shrubs of *Acacia* spp. over *Eremophila* spp. and *Senna* spp. These changes in vegetation are mapped and described in greater detail in **Section 5.1.2**. Broadly, this habitat offered similar habitat qualities to fauna across much of its range however there were some variation in topography and substrate. The southwest of the Study Area (Raeside) comprised hardpan plains which broadly aligned with the Tiger Land System, the central areas of the Study Area comprised stony plains which broadly aligned with the Violet and Nubev Land Systems and the northern portions of the Study Area comprised hardpan plains areas of shallow depressions which broadly align with the Jundee and Monk Land System (**Section 2.2**). Soils broadly comprised red/brown sandy clays and sandy loams often with occasional scattered ironstone or quartz stony fragments. Leaf litter and woody debris tended to be rare to moderately common. The vegetation was suitable for supporting small birds, reptiles and mammals and has high foraging potential for nectivorous birds when in flower. The substrate was suitable for burrowing and fossorial species. This habitat is unlikely to support high species diversity and is largely composed of generalist species and is unlikely to support fauna species of conservation significance.

Habitat Type	Total Ha (%)	Vegetation Units	Disturbance and Condition	Value to Fauna
Drainage Line • Widespread • Limited Significance • Low SRE potential	76.15 ha 3.33%	AbArEp, AbAtTt	Good to Very Good: Feral grazing	Drainage Line habitat intersects the *Acacia* Shrubland on Plains habitats and occurred predominantly in the Cardinia area in association with the main drainage feature that drains south through the Study Area from the northeast. This habitat differed from the surrounding habitats due to the high density of vegetation, generally comprised of Mulga and a mixture of smaller shrubs. The substrate which was comprised of red/orange sandy clay loam and alluvial sand and stones. Leaf litter was generally higher in this habitat than in the adjacent habitats as a result of the higher density of vegetation. After periods of rainfall, this habitat would likely support a higher density of annual flora species which would be attractive for native and non-native grazing species. This habitat has potential to support conservation significant fauna species such as the Rainbow Bee-eater, however they are unlikely to be solely reliant on this habitat.
Low Hills • Widespread • Limited Significance • Low SRE potential	244.46 ha 10.69%	CpArEo, AbEpPo, EsEsPo, AkAbMs, AaSaMs, AcAtEo	Very Good to Excellent: Logging evident by old stumps, feral grazing, tracks	The Low Hills in the Study Area occurred predominantly in the Cardinia area and broadly aligned with the Leonora Land System (**Section 2.2**), however areas of this habitat also occurred in the southern regions of the Mertondale area. The Low Hills had a high (up to 90%) covering of medium to large (20-200mm) sized fragments comprising ironstone and basalt. Some minor areas of outcropping occurred intermittently, but was not a typical feature of this habitat. It is unlikely that the habitat will support fauna species of conservation significance.

Habitat Type	Total Ha (%)	Vegetation Units	Disturbance and Condition	Value to Fauna
Chenopod Shrubland • Widespread • Limited Significance • Low SRE potential	440.08 ha 19.24%	HpCsMp, MpTdSd	Good to Excellent: Logging, clearing for exploration, tracks	The Chenopod Shrubland habitat occurred predominantly in the Cardinia area in association with low lying areas often with saline influences. Chenopods in these areas comprised species from the following genera: *Tecticornia* spp., *Mariana* spp., *Atriplex* spp. and *Cratystylis subspinescens*. Upper and mid story vegetation tended to be sparse, often dominant with *Hakea preissii*. Soils comprised brown clay and clay loams often with moderate amount of surface fragments ranging from 2-60mm in size. Leaf litter and woody debris were rare owing to the lack of mid and upper storey vegetation. This habitat broadly occurred in association with the Gundockerta Land System (**Section 2.2**). It is unlikely that the habitat will support fauna species of conservation significance.
Disturbed	226.60 ha 9.91%	Rehabilitation, Disturbed	Degraded to Completely Degraded Historical and recent mining and exploration	The Disturbed areas occurred in each of the components of the overarching Study Area and were associated with recent and historical mining activities and exploration. Some areas had been rehabilitated, but differed from the native vegetation and habitats that occur in the area.

5.3.2 Fauna Assemblages

A total of 65 vertebrate fauna species were recorded during the field survey (**Table 5-11**), comprising nine mammals (three native), 48 birds and eight reptile species. Six introduced vertebrate fauna species were recorded during the field survey; European Cattle (*Bos taurus*), Donkey (*Equus asinus*), Horse (*Equus caballus*), Dog (*Canis familiaris*), Cat (*Felis catus*) and Rabbit (*Oryctolagus cuniculus*). No fauna of conservation significance were recorded.

Table 5-11: Vertebrate fauna species recorded during the field survey

Family and Species Name	Common Name	Conservation Status	
		EPBC Act	In WA
Mammals			
Felis catus	Cat	-	-
Canis dingo	Dingo	-	-
Canis familiaris	Dog	-	-
Equus asinus	Donkey	-	-
Macropus robustus	Euro	-	-
Bos taurus	European Cattle	-	-
Equus caballus	Horse	-	-
Oryctolagus cuniculus	Rabbit	-	-
Macropus rufus	Red Kangaroo	-	-
Birds			
Acanthiza apicalis	Inland Thornbill	-	-
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	-	-
Acanthiza robustirostris	Slaty-backed Thornbill	-	-
Acanthiza uropygialis	Chestnut-rumped Thornbill	-	-
Accipiter cirrocephalus	Collared Sparrowhawk	-	-
Accipiter fasciatus	Brown Goshawk	-	-
Aphelocephala leucopsis	Southern Whiteface	-	-
Aquila audax	Wedge-tailed Eagle	-	-
Artamus cinereus	Black-faced Woodswallow	-	-
Artamus minor	Little Woodswallow	-	-
Cheramoeca leucosternus	White-backed Swallow	-	-
Cinclosoma clarum	Western Chestnut Quail-thrush	-	-
Colluricincla harmonica	Grey Shrike-thrush	-	-
Coracina novaehollandiae	Black-faced Cuckoo-shrike	-	-
Corvus bennetti	Little Crow	-	-
Corvus orru	Torresian Crow	-	-
Cracticus nigrogularis	Pied Butcherbird	-	-
Cracticus tibicen	Australian Magpie	-	-
Daphoenositta chrysoptera	Varied Sittella	-	-
Dicaeum hirundinaceum	Mistletoebird	-	-

Family and Species Name	Common Name	Conservation Status	
		EPBC Act	In WA
Dromaius novaehollandiae	Emu	-	-
Elanus axillaris	Black Shouldered-Kite	-	-
Eurostopodus argus	Spotted Nightjar	-	-
Gavicalis virescens	Singing Honeyeater	-	-
Geopelia cuneata	Diamond Dove	-	-
Grallina cyanoleuca	Magpie-lark	-	-
Hirundo neoxena	Welcome Swallow	-	-
Malurus lamberti	Variegated Fairy-wren	-	-
Malurus leucopterus	White-winged Fairy-wren	-	-
Malurus splendens	Splendid Fairy-wren	-	-
Manorina flavigula	Yellow-throated Minor	-	-
Melanodryas cucullata	Hooded Robin	-	-
Melopsittacus undulatus	Budgerigar	-	-
Neophema bourkii	Bourke's Parrot	-	-
Ocyphaps lophotes	Crested Pigeon	-	-
Oreoica gutturalis	Crested Bellbird	-	-
Pachycephala rufiventris	Rufous Whistler	-	-
Petroica goodenovii	Red-capped Robin	-	-
Phaps chalcoptera	Common Bronzewing	-	-
Platycercus zonarius	Australian Ringneck	-	-
Platycercus varius	Mulga Parrot	-	-
Pomatostomus superciliosus	White-browed Babbler	-	-
Petrochelidon nigricans	Tree Martin	-	-
Ptilonorhynchus maculatus guttatus	Western Bowerbird	-	-
Pyrrholaemus brunneus	Redthroat	-	-
Rhipidura leucophrys	Willie Wagtail	-	-
Strepera versicolour	Grey Currawong	-	-
Taeniopygia guttata	Zebra Finch	-	-
Reptiles			
Ctenotus leonhardii		-	-
Diporiphora amphiboluroides		-	-
Egernia depressa	Southern Pygmy Spiny-tailed Skink	-	-
Gehyra variegata		-	-
Heteronotia binoei	Bynoe's Gecko	-	-
Strophurus wellingtonae		-	-
Varanus caudolineatus		-	-
Varanus panoptes	Yellow-spotted Monitor	-	-

5.3.3 Fauna of Conservation Significance

Of the 300 species of vertebrate fauna identified during the desktop study, 26 species are listed as being of conservation significance, comprising four mammals and 20 bird species (**Table 3-6**). In addition, two invertebrate species of conservation significance were identified, the fairy shrimps *Branchinella apophysata* and *Branchinella simplex* (**Table 3-6**). Of the 26 species recorded from the desktop study:

- eight species are listed as Threatened under the EPBC Act and/or WC Act (**Table 3-6**). Legislation has been developed at national (EPBC Act) and state (WC Act) levels to protect species of fauna that have been formally recognised as rare, threatened with extinction or having high conservation value (**Appendix A**);
- five are recognised by Parks and Wildlife as Priority fauna. Parks and Wildlife recognises several species that are not listed under the WC Act or the EPBC Act but for which there is some conservation concern, and has produced a supplementary list of Priority fauna (**Appendix A**);
- one species is listed as recognised by state (WC Act) to be in need of special protection; and
- 13 species are listed as Migratory under the EPBC Act and Schedule 5 under the WC Act. Many species of migratory bird are listed under the EPBC Act, the WC Act and international agreements (**Appendix A**).

Some of the species referred to above, listed as Threatened, Migratory and/or Priority fauna, may be included in multiple groups.

Of the conservation listed species identified from the desktop study, 11 are waterbirds that rely on aquatic environments (such as Malcom Dam, ~15 km southwest) that do not occur within the Study Area. These species are therefore deemed Unlikely to occur. This includes the following Migratory or Priority listed species from the families Anatidae, Ardeidae, Charadriidae, Glareolidae, Motacillidae and Scolopacidae:

- Red Knot (*Calidris canutus*);
- Yellow Wagtail (*Motacilla flava*);
- Oriental Plover (*Charadrius veredus*);
- Sharp-tailed Sandpiper (*Calidris acuminata*);
- Red-necked Stint (*Calidris ruficollis*);
- Glossy Ibis (Plegadis falcinellus);
- Pacific Golden Plover (*Pluvialis fulva*);
- Wood Sandpiper (*Tringa glareola*);
- Common Greenshank (*Tringa nebularia*);
- Eastern Great Egret (*Ardea modesta*); and
- Hooded Plover (Thinornis cucullatus).

Three mammal species were identified from the desktop study from historical records, but are now considered extinct from the Murchison bioregion; the Numbat (*Myrmecobius fasciatus*), Banded Hare-wallaby (*Lagostrophus fasciatus fasciatus*) and the Bilby (*Macrotis lagotis*) (Woinarski *et al.* 2014). In addition, fairy-shrimps *Branchinella apophysata* and *Branchinella simplex* are confined solely to salt lakes

of the region, as such these species are Unlikely to occur within the Study Area. Each of these species is no longer assessed in this report.

The likelihood for each of the remaining species of conservation significance occurring in the Study Area was assessed and ranked (**Table 5-12**). The rankings were assigned definitions described in **Section 4.6**. Two fauna species of conservation significance were considered Likely to occur, four species were considered Possible to occur and the remaining 20 were assessed as Unlikely to occur (**Table 5-12**).

Table 5-12: Likelihood of occurance for fauna of conservation significance

Common Name (Scientific Name)	Conservation status		Broad Habitat Type	Likelihood of Occurrence Reason for Likelihood
	EPBC Act	In WA		
Mammals				
Long-tailed Dunnart (*Sminthopsis longicaudata*)	-	P4	Rocky, hilly areas, breakaways, occasionally open areas with a stony, rocky mantle (van Dyck and Strahan 2008).	**Possible** There have been recent records in the region with the closest record from approximately 25km southeast of the Study Area in 2011 (DPaW 2016c). Additionally, there is some marginal habitat for the species in the small areas of outcropping and in rocky areas associated with the Low Hills habitat within the SA.
Birds				
Night Parrot (*Pezoporus occidentalis*)	En	S1	Known to inhabit treeless or sparsely wooded long unburnt spinifex hummock plains often interspersed with chenopods (Pyke and Ehrlich 2014).	**Unlikely** Species only identified by DoEE (2016) because 'species habitat may occur within area'. Species unknown from the Murchison region and suitable habitat not present within Study Area.
Carnaby's Cockatoo (*Calyptorhynchus latirostris*)	En	S2	Proteaceous scrubs and heaths and adjacent eucalypt woodlands and forests (Johnstone and Storr 1998a).	**Unlikely** The Study Area is well outside the natural distribution of the species. These records returned from the DPaW (2016c) database are likely to be a projection error and are erroneous.
Princess Parrot (*Polytelis alexandrae*)	Vu	P4	Spinifex with eucalypts and acacias, and succulents around salt lakes (often far from fresh water) (Pizzey and Knight 2007).	**Unlikely** Historical record from Laverton (unknown year) (DPaW 2016c). Species identified by DoEE (2016) because 'species habitat may occur within area'. Species sparsely distributed in Murchison region and suitable habitat is not present within Study Area.

Common Name (Scientific Name)	Conservation status		Broad Habitat Type	Likelihood of Occurrence Reason for Likelihood
	EPBC Act	In WA		
Malleefowl (*Leipoa ocellata*)	Vu	S3	Mainly scrubs and thickets of mallee, boree and bowgada, but also other litter forming shrublands (Johnstone and Storr 1998b).	**Possible** Species has been recorded within 25 km east of the Study Area in 2011 and within 30 km south of the Study Area in 2009 (DPaW 2016c). The species is only thought to be scattered throughout the region (Benshemesh 2007) with the majority of records occurring further to the south (DoEE 2016). The species tends to occur in dense shrublands and low woodlands which may provide leaf litter suitable for use in the construction of nesting mounds (DoEE 2016). If the species does occur, it is likely to be at low densities. Habitat within the Study Area was marginal for the species and no evidence of nesting mounds were discovered during the survey, however given the recent records in relatively close proximity, it is possible that the species occurs.
Fork-tailed Swift (*Apus pacificus*)	Mi	S5	Aerial species, which forages high above the tree canopy and rarely lower (Johnstone and Storr 1998b).	**Possible** No records were found in the Parks and Wildlife or Birdlife database searches. Species identified by DoEE (2016) because 'species habitat may occur within area'. The species is a migratory aerial species not common within the Murchison (Johnstone and Storr 1998b). The species may infrequently overfly the Study Area without utilising any particular habitats present.
Grey Wagtail (*Motacilla cinerea*)	Mi	S5	Grey Wagtails are listed as rare vagrants to the Australian continent from the North.	**Unlikely** Species identified by DoEE (2016) because 'species habitat may occur within area'. Species sparsely distributed in Murchison region and suitable habitat not present within Study Area.

Common Name (Scientific Name)	Conservation status		Broad Habitat Type	Likelihood of Occurrence Reason for Likelihood
	EPBC Act	In WA		
Grey Falcon (*Falco hypoleucos*)	-	S3	Lightly treed inland plains, gibber deserts, sandridges, pastoral lands, timbered watercourses (Pizzey and Knight 2007).	**Possible** Species identified from one record 30 km east of the Study Area in 1996 (DPaW 2016c). Species is not common in the Murchison region. The species may infrequently overfly the Study Area without utilising any particular habitats present.
Rainbow Bee-eater (*Merops ornatus*)	-	S5	Occurs in numerous habitats including open woodlands, sand ridges, riverbanks, road cuttings, beaches, dunes, cliffs, mangroves and rainforests (Johnstone and Storr 1998b).	**Likely** Species recorded just outside the northern boundary of the Study Area during a fauna survey in 2009 (DPaW 2016a). Species identified by DoEE (2016) because 'species habitat may occur within area'. The species is a migratory aerial species not common within the Murchison (Johnstone and Storr 1998b). The species may utilise the sandy substrates of the Drainage habitat for breeding and foraging, and the remaining habitats for foraging.
Peregrine Falcon (*Falco peregrinus*)	-	S7	The species occurs along coastal cliffs, rivers and ranges as well as wooded watercourses and lakes nesting on cliffs, granite outcrops, quarries (Johnstone and Storr 1998b).	**Likely** Species recorded just outside the northern boundary of the Study Area during a fauna survey in 2009 (DPaW 2016a). Additionally, there are a number of other records from the region. The species may fly-over the Study Area infrequently while dispersing or during foraging but is unlikely to breed due to a lack of suitable habitat.

6 Survey Limitations and Constraints

There are a number of possible limitations and constraints that can impinge on the adequacy of vegetation, flora and fauna surveys (EPA 2004a, b). These are discussed with respect to the survey of the Study Area (**Table 6-1**).

Table 6-1: Potential limitations and contraints of the field survey

Factor	Constraint	Comments
Competency and experience of consultants	No	The field personal have appropriate qualifications and several years' experience undertaking flora and fauna surveys of this nature within the Murchison region. The vegetation and flora survey was conducted by Brian Morgan who has 19 years' experience, Sophie Fox who has eight years' experience and Megan Stone who has eight years' experience conducting flora surveys within Western Australia. The fauna component of the Survey was conducted by Chris Knuckey who has over five years' experience, Megan Stone who has over 6 years' experience and Paul Bolton who has over 10 years' experience undertaking fauna surveys within Western Australia
Scope	No	The scope was well defined. Flora, fauna and their habitats were surveyed using standardised and well-established techniques. Relevant databases and previous studies surrounding the Study Area were reviewed.
Proportion of species identified	No	The desktop and field species inventories are comparable to counts obtained during previous surveys of a similar size and scope. Of the 519 specimens collected during this survey, 33 specimens were unable to be confidently identified (6.35%) to family, genera, species or infraspecific level. This was largely due to the lack of reproductive material and or dry and old nature of the specimen. All of the unidentifiable species are unlikely to represent taxa of conservation significance or represent species of local significance. Sixty-five vertebrate fauna were encountered and identified. Although a comprehensive fauna inventory is not a vital component for this level of survey (Level 1).
Information sources (e.g. historic or recent)	No	The Study Area is located in a relatively well-surveyed region with data available from previous surveys and records from database searches. Six previous studies were available for review during the assessment. Two regional documents were also considered as part of this assessment.
Proportion of task achieved, and further work which might be needed	No	Planned survey works were conducted and completed as per the scope. The area was traversed thoroughly.
Timing / weather / season / cycle	No	Survey 1 occurred outside of the perceived optimal period (i.e. summer/autumn, 6 to 8 weeks following a significant rainfall event), however, with average rainfall preceding the survey, the timing was considered adequate for the purposes of the Level 1 assessment. Despite this, annual and ephemeral flora taxa were observed that could not be identified as they had already senesced or finished their reproductive cycle. Additional annual and ephemeral taxa were observed during Survey 2, which was conducted following a high rainfall event.

Factor	Constraint	Comments
Disturbances	No	The majority of the Study Area was considered to be in 'Excellent' or 'Very Good' condition, with disturbances primarily being from historic clearing, historic mining and grazing by cattle. Although some areas were Degraded or Completely Degraded, this did not form a limitation to completing the assessment throughout the remainder of the Study Area.
Intensity	No	Access to the site was good, and the entire area was able to be traversed by foot. 66 flora relevé sites were sampled, habitat assessments were conducted and data from eight mapping notes were recorded within the Study Area. This level of on-ground survey effort is appropriate for a Level 1 flora, vegetation and fauna assessment.
Completeness	No	The survey was conducted at 66 sites chosen to ensure adequate representative coverage of the Study Area. A large proportion of the Study Area was sampled on foot.
Resources	No	Resources were adequate to carry out the survey and the survey participants were competent in identification of species present. WAH specimens, taxonomic guides, Parks and Wildlife database searches and the *FloraBase* database were all used to prepare for the survey and used for the confirmation of any flora species where identification was uncertain.
Remoteness / access	No	All survey sites were easily accessible by vehicle or on foot.
Availability of contextual information	No	The data available for the Western Murchison subregion was adequate for the level of survey work undertaken during this assessment.

7 Assessment against the Native Vegetation Clearing Principles

Assessment against the ten Clearing Principles listed under Schedule 5 of the EP Act was based on a precautionary approach that assumed all habitats within the Study Area may be exposed to clearing. The proposed Project disturbance footprint is still being finalised following resource identification and Project design.

Principle (a) Native vegetation should not be cleared if it comprises a high level of biological diversity

A total of 257 flora taxa (including subspecies and variants) were recorded from 23 vegetation units within the Study Area. The floral diversity and composition recorded from the Study Area is consistent with the Murchison bioregion, the landforms, the season of field survey, and the level of sampling intensity. Native vegetation of the Study Area was comprised broadly of open Mulga shrublands and open *Acacia* shrublands and is considered to contain a low level of biological diversity. The Study Area occurs within the Laverton 18 and Laverton 39 Botanical Districts of the Eremaean Province (Beard 1990a). Both of these are widespread and well represented within the Murchison bioregion (Government of Western Australia 2015). None of the vegetation units described within the Study Area represent any known TEC's or PEC's.

No Threatened flora species were recorded within the Study Area, and none are expected to occur based on the results of the desktop assessment and the field survey. The database search identified 35 Parks and Wildlife listed Priority flora taxa (**Appendix H**). Of these, one species, *Gunniopsis propinqua* (P3) was confirmed as occurring within the Study Area. An additional flora species, *Acacia* sp. nov. aff *resinimarginea,* is considered to be of 'other conservation significance' as it has anomalous features that indicate a potential new discovery. The species is currently considered to be a putative hybrid and is the dominant Acacia in the upper stratum of vegetation unit A?rSaMs. In excess of 10,000 individuals, from 26 locations, has been recorded from the south-east of the Cardinia survey area. A specimen held by WAH and collected from Marshall Pool to the north of Leonora is analogous with *Acacia* sp. nov. aff. *resinimarginea*, potentially indicating that the putative hybrid is widespread in the immediate region. Further fruiting material is required to better understand the taxonomic identify and significance of the putative hybrid.

A total of 65 vertebrate fauna species were recorded from four broad fauna habitats within the Study Area. The faunal habitats and assemblage recorded from the Study Area are consistent with the Murchison bioregion, the landforms present, the season of the field survey, and the level of sampling intensity. The habitats identified within the Study Area are common, widespread and considered to be of limited significance. The fauna assemblage expected to occur within these habitats, consists of largely generalist species that are widely distributed throughout the region.

Although the Study Area is not considered to be biologically diverse with regards to the floristic composition and fauna assemblage, the presence of the priority taxon (*Gunniopsis propinqua*, P3) and the putative hybrid (*Acacia* sp. nov. aff. *resinimarginea*) indicates biological diversity that is higher than the adjoining landscape. If impacts to the priority taxon and putative hybrid are minimised or avoided, then the proposed Project would avoid being at variance to this principle.

The proposed clearing *may* be at variance with this principle

Principle (b) ***Native vegetation should not be cleared if it comprises the whole, or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia***

The habitat types recorded within the Study Area are typical of the Murchison bioregion and are well represented within the bioregion. These habitats do not form significant areas of habitat for native fauna.

Although habitats recorded may be suitable for fauna of conservation significance, none of the species identified from the desktop study are reliant on the habitats present nor do they form a significant proportion of the suitable habitat for these species within the region. Species considered likely to occur comprise the Rainbow Bee-eater and Peregrine Falcon. The Peregrine Falcon may overfly the Study Area only as there is no breeding habitat (large Eucalypts or cliffs). The Rainbow Bee-eater is a common migratory bird that occupies numerous habitats including open woodlands with sandy loamy soil, sandridges, sandpits, riverbanks, road cuttings, beaches, dunes, cliffs, mangroves and rainforests.

The clearing of native vegetation within the Study Area will not significantly impact habitat for fauna of conservation significance, or significant habitat for fauna more broadly, and the impacts to significant fauna are expected to be minimal.

The proposed clearing is *not* at variance with this principle.

Principle (c) ***Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.***

No Threatened flora listed under the WC Act 1950, or listed under the EPBC Act 1999, have previously been recorded within the Study Area, nor were any recorded during the field survey. No species listed as Threatened flora taxa are Likely to occur within the Study Area.

The proposed clearing is *not* at variance with this principle.

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.***

No Threatened Ecological Communities listed by Parks and Wildlife, or Threatened under the EPBC Act 1999 were recorded during the field survey nor are any likely to occur. No Threatened Ecological Communities, relevant to terrestrial environments, were identified as occurring within 40 km of the Study Area. Additionally, no Priority Ecological Communities were recorded from the Study Area.

The proposed clearing in *not* at variance with this principle.

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.***

The Project may require the clearing of native vegetation consistent with Beard's vegetation association of Shrublands, Mulga scrub (Laverton_18) and Low woodland; mulga, *Acacia aneura* (Laverton_39). Both associations are well represented in Western Australia (DPaW 2014), with greater than 99% (Laverton_18) and 97% (Laverton_39) of their pre-European extent remaining within both the Murchison bioregion and the Eastern Murchison subregion (Government of Western Australia 2015). If it is assumed that the entire Study Area will be cleared or indirectly impacted, the current extent of the vegetation association will not fall below the 30% threshold where species loss increases exponentially as determined by (EPA 2000).

The proposed clearing in *not* at variance with this principle

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.***

Drainage Line habitat is present within the Study Area however it did not contain vegetation communities or species that are confined to watercourses or wetlands, or are groundwater dependent. The drainage lines within the Study Area are not considered regionally prominent and are not listed within the *Directory of Important Wetlands in Australia* (DoE 2015) or listed as an Environmentally Sensitive Area (ESA) under the Environmental Protection Act 1986. The nearest ESA or Important wetland is Lake Ballard, 65 km south of the Study Area. Drainage lines within the Study Area may be related to hydrological regimes of this area. If the natural hydrological regimes are maintained during and following vegetation clearing, then the Project is considered not to be at variance to this principle.

The proposed clearing *may* be at variance with this principle

Principle (g) ***Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation.***

The terrain of the Study Area is relatively level aside from some low hills, with no permanent surface water features. The soil substrate is firm, with areas of continuous gravel maintaining structure. Any clearing of native vegetation is unlikely to increase soil erosion or nutrient export within the landscape due to the already low density of vegetation and firm soil structure. The Study Area is not within a salinity risk area and the site would not be expected to be vulnerable to salinity even following proposed clearing.

The proposed clearing is *not* at variance with this principle

Principle (h) ***Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area***

There are no National Parks within 300 km of the Study Area. The nearest Nature Reserve, Wanjarri Nature Reserve (Class A), is located 150 km north west of the Study Area, and the nearest Parks and Wildlife managed land is Ex-Goongarrie Pastoral Lease, currently UCL but managed by Parks and Wildlife for conservation purposes is 100 km south of the Study Area. The Study Area does not overlap with any National Parks or any conservation areas. The nearest Environmentally Sensitive Area (ESA), Lake Ballard is approximately 65 km south west of the Study Area, and is also a Nationally Important Wetland (DIWA). Two other ESAs and DIWAs, Lake Marmion and Lake Barlee, are located 70 km south west, and 153 km west south west, of the Study Area respectively. Minor drainage lines within the Study Area may be broadly related to hydrological regimes of this area.

Based on aerial imagery, drainage from the Project appears to flow southwards into the Raeside Palaeoriver and then onto Lake Raeside to the southeast of Leonora. Given topographical relief of the area, any flows from this point should be in a southeast direction along the Raeside Palaeoriver, away from the ESAs or DIWAs of Lake Ballard, Lake Marmion and Lake Barlee. Although impacts to the hydrological regimes of the area should be minimised where possible during construction, impacts to ESAs or DIWAs are unlikely.

The proposed clearing is *not* at variance with this principle

Principle (i) ***Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water***

No permanent surface water features were observed in the Study Area however drainage lines are present. Clearing and/or construction should not impact on drainage or surface water quality, provided sediments are controlled during construction and operation by implementing standard management procedures

Currently, no information is available on the extent and quality of the groundwater and whether the Project will require any groundwater drawdown and release into the natural environment however significant impacts are considered unlikely.

The proposed clearing is *not* at variance with this principle

Principle (j) ***Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding***

The incidence of flooding in the Study Area is not anticipated to be exacerbated by clearing of the vegetation due to the fact that the Study Area occurs on free draining soils and is relatively flat in terrain. The minor drainage lines that flow through the Study Area would not carry a high volume of surface water during standard rainfall events. The implementation of standard surface water management strategies during construction and operations would mitigate any likelihood of flooding. A surface modelling assessment will be undertaken for future approvals associated with the Project so that appropriate mitigation strategies can be implemented during construction of the Project.

The proposed clearing in *not* at variance with this principle

8 Conclusions

The vegetation condition ranged from Excellent to Completely Degraded, with the majority of the vegetation considered to be Excellent or Very Good. Degraded and Completely Degraded areas were a direct result of the historical mining, and recent drilling activities and the remaining vegetation was impacted by grazing by introduced mammals (i.e. European Cattle). A total of 23 vegetation units were recorded across the Study Area, comprising six within the Raeside area, 24 within the Cardinia area, 21 within the Mertondale area and 15 within the Haul Road alignment. The vegetation of the Study Area was broadly comprised of mixed Mulga shrublands over mixed shrubs that are representative of the dominant vegetation types throughout the region. No vegetation units are considered analogous to any TEC or PEC's, and none are considered regionally significant. Four vegetation units may be considered locally significant as three were found to support the Priority flora species *Gunniopsis propinqua* (P3), and one supports the putative hybrid *Acacia* sp. nov. aff. *resinimarginea*.

A total of 257 vascular flora taxa (including subspecies and variants) from 37 families and 103 genera were recorded within the Study Area. The most frequently occurring families were Chenopodiaceae, Fabaceae and Poaceae. The floral diversity and composition recorded from the Study Area is consistent with Mulga shrublands of the Murchison bioregion. No Threatened flora species were recorded within the Study Area, and none are expected to occur based on the results of the field survey. One Priority 3 species, *Gunniopsis propinqua*, was confirmed to occur in four locations within the Study Area. Additionally, the putative hybrid, *Acacia* sp. nov. aff. *resinimarginea*, was recorded as occurring within the Cardinia area and further to the south and south-east. The putative hybrid Acacia was recorded as the dominant upper stratum species and occurred on the basaltic, stony low hills in the south-east of the Cardinia survey area. Voucher specimens have been lodged with WAH for further taxonomic review. A further four Priority flora species are considered Very Likely to occur and seven were assessed as Likely to occur in the Study Area. Each of these species was targeted during the field survey but were not recoded.

Eight introduced flora taxa were recorded within the Study Area during the field survey. Of these, **Cylindropuntia fulgida* var. *mamillata* is classed as a Declared Pest (DP) under Section 22 of the *Biosecurity and Agriculture Management Act 2007* (BAM Act). **Cylindropuntia fulgida* var. *mamillata*, along with all *Cylindropuntia* spp., is also classified as a Weed of National Significance. The other weeds recorded from the Study Area during the field survey comprised: **Carpobrotus aequilaterus* (Angular Pigface), **Cuscuta planiflora* (Small Seeded Dodder), **Malvastrum americanum* (Spiked Malvastrum), **Rumex hypogaeus* (Doublegee), **Rumex vesicarius* (Ruby Dock), **Sisymbrium erysimoides* (Smooth Mustard) and **Sisymbrium irio* (London Rocket). The eight introduced taxa were either recorded sporadically or as isolates within degraded or adjacent to degraded vegetation.

Four broad fauna habitat types were identified within the Study Area; Acacia Shrublands on Plains, Drainage Lines, Low Hills and Chenopod Shrublands. All habitat types are considered widespread and common throughout the region, none are considered to be of local or regional significance and all are

considered to have low potential to support SRE invertebrate fauna. A total of 65 vertebrate fauna species were recorded during the field survey, comprising nine mammals (three native), 48 birds and eight reptile species. No fauna species of conservation significance were recorded during the field survey, however two fauna of conservation significance were considered likely to occur; the Rainbow Bee-eater and Peregrine Falcon. The Rainbow Bee-eater is listed as Schedule 5 (Migratory) under the WC Act and may utilise the sandy substrate of the Minor Drainage habitat for breeding and the remaining habitats for foraging. The Peregrine Falcon is listed as Schedule 7 (Taxa in need of special protection) under the WC Act and may fly-over the Study Area infrequently while dispersing or during foraging but is unlikely to breed due to a lack of suitable habitat. Neither species is likely to be significantly impacted by the Project as neither species is dependent on the Study Area or habitats contained within it.

It is not yet clear to what extent of native vegetation clearing will be required for the Project. Assessment against the ten Clearing Principles was based on a precautionary approach that assumed all habitats within the Study Area may be exposed to clearing. Based on this assumption, the proposed Project is not at variance to principles (b), (c), (d), (e), (g), (h), (i) and (j). However, clearing may be at variance with principle (a): *Native vegetation should not be cleared if it comprises a high level of biological diversity,* and (f): *Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland*.

The presence of the priority listed *Gunniopsis propinqua* (P3) and the putative hybrid *Acacia* sp. nov. aff. *resinimarginea* may represent high biological diversity. Although the Study Area is not considered to be biologically diverse with regards to the floristic composition and fauna assemblage, the presence of the priority taxon and the putative hybrid needs to be considered in the assessment. If impacts to the priority taxon and putative hybrid are avoided, then the proposed Project would avoid being at variance to this principle.

Although, Drainage Line habitat is present within the Study Area, it did not contain vegetation communities or species that are confined to watercourses or wetlands, or are groundwater dependent. Additionally, the drainage lines within the Study Area are not considered regionally prominent and are not listed within the Directory of Important Wetlands in Australia (DoE 2015b) or listed as an Environmentally Sensitive Area (ESA) under the Environmental Protection Act 1986. Provided that clearing is minimised within and adjacent to Drainage Line habitat and/or standard drainage control strategies are implemented whereby natural hydrological regimes are maintained, the proposed Project would avoid being at variance to this principle.

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Appendices

Appendix A Codes and Terms used to describe Species of Conservation Significance

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

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

Priorities assigned under the DPaW Priority Taxa List		
Priority 1	**P1**	Taxa with few, poorly known populations on threatened lands. These are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened taxa
Priority 2	**P2**	Taxa with few, poorly known populations on conservation lands. These are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened taxa
Priority 3	**P3**	Taxa with several, poorly known populations, some on conservation lands. These are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened taxa
Priority 4	**P4**	Taxa in need of monitoring. These are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands
Priority 5	**P5**	Taxa in need of monitoring. These are not considered threatened but are subject to a specific conservation programme, the cessation of which would result in the species becoming threatened within five years

Appendix B Vertebrate Fauna identified from the Desktop Assessment

Code	Source
a.	This Survey
b.	DPaW Threatened Fauna Database
c.	DPaW NatureMap Database
d.	Birdlife Australia Database
e.	DoEE Protected Matters Search
f.	Outback Ecology (2009) Leonora Gold Project Terrestrial Fauna Assessment
g.	GHD (2007) Main Roads Western Australia
h.	Dell & How (1988) Part 5: Biological survey of the eastern Goldfields
i.	Dell & How (1992) Part 7: Biological survey of the eastern Goldfields
j.	Ninox (2011) Level 1 Vertebrate Fauna Assessment of a Proposed Rail Siding Near Menzies

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Mammalia													
Tachyglossidae													
Tachyglossus aculeatus	Short-beaked Echidna					x				x	x		x
Dasyuridae													
Antechinomys laniger	Kultarr					x						x	
Ningaui ridei	Wongai Ningaui					x					x	x	
Sminthopsis crassicaudata	Fat-tailed Dunnart					x					x	x	
Sminthopsis dolichura	Little long-tailed Dunnart					x					x	x	
Sminthopsis hirtipes	Hairy-footed Dunnart											x	
Sminthopsis longicaudata	Long-tailed Dunnart		P4		x	x							
Sminthopsis macroura	Stripe-faced Dunnart					x						x	
Sminthopsis ooldea	Ooldea Dunnart											x	
Myrmecobiidae													
Myrmecobius fasciatus	Numbat	Vu	S2		x								
Thylacomyidae													
Macrotis lagotis	Bilby	Vu	S3		x								
Macropodidae													
Lagostrophus fasciatus fasciatus	Banded Hare-wallaby		S3		x								
Macropus fuliginosus	Western Grey Kangaroo										x		
Osphranter robustus	Euro			x		x			x		x	x	
Osphranter rufus	Red Kangaroo			x		x			x		x	x	
Muridae													
Mus musculus	*House Mouse					x		x			x	x	
Notomys alexis	Spinifex Hopping-mouse					x					x	x	
Notomys mitchellii	Mitchell's Hopping-mouse										x		
Pseudomys bolami	Bolam's Mouse										x		
Pseudomys hermannsburgensis	Sandy Inland Mouse					x					x	x	

Leporidae													
Oryctolagus cuniculus	*Rabbit			x		x		x	x	x	x	x	x
Emballonuridae													
Taphozous hilli	Hill's Sheathtail-bat					x							
Molossidae													
Austronomus australis	White-striped Freetail-bat					x					x		
Ozimops kitcheneri	South-western Free-tailed Bat										x		
Vespertilionidae													
Chalinolobus gouldii	Gould's Wattled Bat					x					x	x	
Nyctophilus geoffroyi	Lesser Long-eared Bat					x					x	x	
Scotorepens balstoni	Inland Broad-nosed Bat					x					x		
Scotorepens greyii	Little Broad-nosed Bat											x	
Vespadelus baverstocki	Inland Forest Bat					x					x		
Vespadelus finlaysoni	Finlayson's Cave Bat					x							
Vespadelus regulus	Southern Forest Bat											x	
Canidae													
Canis lupus	*Dog			x					x		x		
Vulpes vulpes	*Red Fox							x			x		
Felidae													
Felis catus	*Cat			x		x		x			x	x	
Equidae													
Equus asinus	*Donkey			x				x	x				
Equus caballus	*Horse			x									
Suidae													
Sus scrofa	*Pig					x							
Camelidae													
Camelus dromedarius	*Camel							x			x		
Bovidae													
Bos taurus	*European Cattle			x						x		x	x

Capra hircus	*Goat							x	x		x	x	
Ovis aries	*Sheep										x	x	
Birds													
Dromaiidae													
Dromaius novaehollandiae	Emu			x		x	x		x		x	x	
Anatidae													
Anas gracilis	Grey Teal					x	x				x	x	
Anas rhynchotis	Australasian Shoveler						x						
Anas superciliosa	Pacific Black Duck					x	x				x		
Aythya australis	Hardhead					x	x						
Biziura lobata	Musk Duck					x	x						
Chenonetta jubata	Australian Wood Duck					x	x				x	x	
Cygnus atratus	Black Swan					x	x						
Malacorhynchus membranaceus	Pink-eared Duck						x						
Tadorna tadornoides	Australian Shelduck					x	x				x	x	
Megapodiidae													
Leipoa ocellata	Malleefowl	Vu	S3		x	x		x			x		
Phasianidae													
Coturnix pectoralis	Stubble Quail										x		
Podicipedidae													
Podiceps cristatus	Great Crested Grebe					x	x						
Poliocephalus poliocephalus	Hoary-headed Grebe					x	x					x	
Tachybaptus novaehollandiae	Australasian Grebe					x	x						
Threskiornithidae													
Platalea flavipes	Yellow-billed Spoonbill					x	x						
Plegadis falcinellus	Glossy Ibis	Mi	S5		x		x						
Threskiornis molucca	Australian White Ibis						x						
Threskiornis spinicollis	Straw-necked Ibis					x	x						
Ardeidae													

Ardea modesta	Eastern Great Egret		S5		x	x	x	x					
Ardea novaehollandiae	White-faced Heron					x	x				x	x	
Ardea pacifica	White-necked Heron					x	x				x	x	
Pelecanidae													
Pelecanus conspicillatus	Australian Pelican					x	x						
Phalacrocoracidae													
Phalacrocorax carbo	Great Cormorant					x	x						
Phalacrocorax melanoleucos	Little Pied Cormorant					x	x						
Phalacrocorax sulcirostris	Little Black Cormorant					x	x						
Anhingidae													
Anhinga novaehollandiae	Australiasian Darter					x	x						
Accipiter cirrocephalus	Collared Sparrowhawk			x		x	x		x		x	x	
Accipiter fasciatus	Brown Goshawk			x		x	x				x	x	
Aquila audax	Wedge-tailed Eagle			x		x	x		x		x	x	
Circus approximans	Swamp Harrier					x	x						
Circus assimilis	Spotted Harrier					x					x		
Elanus axillaris	Black-shouldered Kite			x		x	x						
Haliastur sphenurus	Whistling Kite					x	x		x			x	
Hieraaetus morphnoides	Little Eagle						x				x	x	
Milvus migrans	Black Kite					x	x						
Otididae													
Ardeotis australis	Australian Bustard					x					x		
Rallidae													
Fulica atra	Eurasian Coot					x	x						
Tribonyx ventralis	Black-tailed Native-hen					x	x				x		
Turnicidae													
Turnix velox	Little Button-quail					x					x	x	
Burhinidae													
Burhinus grallarius	Bush Stone-curlew					x	x						

Recurvirostridae													
Cladorhynchus leucocephalus	Banded Stilt						x				x		
Himantopus himantopus	Black-winged Stilt					x	x						
Recurvirostra novaehollandiae	Red-necked Avocet					x	x				x		
Charadriidae													
Charadrius melanops	Black-fronted Dotterel					x	x				x		
Charadrius ruficapillus	Red-capped Plover					x	x				x		
Charadrius veredus	Oriental Plover	Mi	S5					x					
Erythrogonys cinctus	Red-kneed Dotterel					x	x						
Peltohyas australis	Inland Dotterel						x						
Pluvialis fulva	Pacific Golden Plover	Mi	S5		x								
Thinornis cucullatus	Hooded Plover		P4			x	x	x					
Vanellus tricolor	Banded Lapwing					x	x				x	x	
Scolopacidae													
Calidris acuminata	Sharp-tailed Sandpiper	Mi	S5		x								
Calidris canutus	Red Knot	En; Mi	S5		x								
Calidris ruficollis	Red-necked Stint	Mi	S5		x								
Tringa glareola	Wood Sandpaper	Mi	S5		x		x						
Tringa hypoleucos	Common Sandpiper	Mi	S5			x	x						
Tringa nebularia	Common Greenshank	Mi	S5		x	x	x	x					
Laridae													
Larus novaehollandiae	Silver Gull					x	x						
Sterna hybrida	Whiskered Tern					x					x		
Sterna nilotica	Gull-billed Tern	Mi	S5				x						
Columbidae													
Columba livia	*Domestic Pigeon					x							
Geopelia cuneata	Diamond Dove			x		x	x				x		
Ocyphaps lophotes	Crested Pigeon			x		x	x		x		x	x	

Phaps chalcoptera	Common Bronzewing			x		x	x		x		x	x	
Streptopelia chinensis	*Spotted Turtle-Dove						x						
Streptopelia senegalensis	*Laughing Turtle-Dove					x	x						
Cuculidae													
Cacomantis pallidus	Pallid Cuckoo					x	x				x	x	
Chrysococcyx basalis	Horsfield's Bronze Cuckoo					x	x			x	x	x	x
Chrysococcyx osculans	Black-eared Cuckoo						x				x		
Tytonidae													
Tyto alba	Barn Owl					x							
Strigidae													
Ninox boobook	Boobook Owl						x				x		
Podargidae													
Podargus strigoides	Tawny Frogmouth					x	x				x	x	
Caprimulgidae													
Eurostopodus argus	Spotted Nightjar			x		x	x		x		x	x	
Aegothelidae													
Aegotheles cristatus	Australian Owlet-nightjar					x	x		x		x	x	
Apodidae													
Apus pacificus	Fork-tailed Swift	Mi	S5					x					
Alcedinidae													
Todiramphus pyrrhopygius	Red-backed Kingfisher					x	x		x		x	x	
Todiramphus sanctus	Sacred Kingfisher					x	x						
Meropidae													
Merops ornatus	Rainbow Bee-eater		S5		x	x	x	x			x		
Falconidae													
Falco berigora	Brown Falcon					x	x		x		x	x	
Falco cenchroides	Australian Kestrel					x	x				x	x	
Falco hypoleucos	Grey Falcon		S3		x	x							
Falco longipennis	Australian Hobby					x	x				x	x	

Falco peregrinus	Peregrine Falcon		S7		x	x	x					x	
Cacatuidae													
Cacatua roseicapilla	Galah					x	x		x		x	x	
Nymphicus hollandicus	Cockatiel					x	x				x	x	
Psittacidae													
Melopsittacus undulatus	Budgerigar			x		x	x				x	x	
Neophema bourkii	Bourke's Parrot			x		x	x				x	x	
Neophema splendida	Scarlet-chested Parrot										x		
Pezoporus occidentalis	Night Parrot	En	S1					x					
Platycercus varius	Mulga Parrot			x		x	x				x	x	
Platycercus zonarius	Australian Ringneck			x		x	x		x		x	x	
Polytelis alexandrae	Princess Parrot	Vu	P4		x			x					
Ptilonorhynchidae													
Ptilonorhynchus maculatus guttatus	Western Bowerbird			x		x	x				x	x	
Climacteridae													
Climacteris affinis	White-browed Treecreeper					x					x	x	
Maluridae													
Malurus lamberti	Variegated Fairy-wren			x		x	x		x				
Malurus leucopterus	White-winged Fairy-wren			x		x	x		x		x	x	
Malurus pulcherrimus	Blue-breasted Fairy-wren										x		
Malurus splendens	Splendid Fairy-wren			x		x	x		x	x	x		x
Meliphagidae													
Acanthagenys rufogularis	Spiny-cheeked Honeyeater					x	x		x	x	x	x	x
Anthochaera carunculata	Red Wattlebird					x	x				x		
Certhionyx variegatus	Pied Honeyeater					x	x		x		x	x	
Epthianura albifrons	White-fronted Chat					x	x				x		
Epthianura aurifrons	Orange Chat					x	x				x	x	
Epthianura tricolor	Crimson Chat					x	x				x	x	
Gavicalis virescens	Singing Honeyeater			x			x		x	x	x	x	x

Lichenostomus leucotis	White-eared Honeyeater										x		
Lichmera indistincta	Brown Honeyeater					x	x		x	x	x		x
Manorina flavigula	Yellow-throated Miner			x		x	x		x		x	x	
Melithreptus brevirostris	Brown-headed Honeyeater										x		
Ptilotula ornatus	Yellow-plumed Honeyeater						x				x		
Ptilotula penicillatus	White-plumed Honeyeater						x						
Ptilotula plumulus	Grey-fronted Honeyeater						x				x		
Purnella albifrons	White-fronted Honeyeater					x	x		x		x	x	
Sugomel niger	Black Honeyeater						x				x		
Pardalotidae													
Pardalotus rubricatus	Red-browed Pardalote					x							
Pardalotus striatus	Striated Pardalote					x	x				x	x	
Acanthizidae													
Acanthiza apicalis	Inland Thornbill			x		x	x		x	x	x	x	x
Acanthiza chrysorrhoa	Yellow-rumped Thornbill			x		x	x		x		x	x	
Acanthiza iredalei	Slender-billed Thornbill										x		
Acanthiza robustirostris	Slaty-backed Thornbill			x		x	x		x		x		
Acanthiza uropygialis	Chestnut-rumped Thornbill			x		x	x		x	x	x	x	x
Aphelocephala leucopsis	Southern Whiteface			x		x	x		x		x		
Calamanthus campestris	Rufous Fieldwren											x	
Gerygone fusca	Western Gerygone						x		x			x	
Pyrrholaemus brunneus	Redthroat			x		x	x				x		
Smicrornis brevirostris	Weebill					x	x				x	x	
Pomatostomidae													
Pomatostomus superciliosus	White-browed Babbler			x		x	x		x		x	x	
Psophodidae													
Cinclosoma clarum	Western Chestnut Quail-thrush			x		x	x				x		
Cinclosoma marginatum	Western Quail-thrush						x						
Psophodes occidentalis	Western Wedgebill					x	x						

Artamidae													
Artamus cinereus	Black-faced Woodswallow			x		x	x		x		x	x	
Artamus minor	Little Woodswallow			x		x							
Artamus personatus	Masked Woodswallow					x	x				x	x	
Artamus superciliosus	White-browed Woodswallow										x		
Cracticidae													
Cracticus nigrogularis	Pied Butcherbird			x		x	x		x	x	x	x	x
Cracticus tibicen	Australian Magpie			x		x	x		x	x	x	x	x
Cracticus torquatus	Grey Butcherbird					x	x		x		x	x	
Strepera versicolor	Grey Currawong			x		x	x				x		
Campephagidae													
Coracina maxima	Ground Cuckoo-shrike					x	x				x	x	
Coracina novaehollandiae	Black-faced Cuckoo-shrike			x		x	x		x	x	x	x	x
Lalage tricolor	White-winged Triller					x	x				x		
Neosittidae													
Daphoenositta chrysoptera	Varied Sittella			x			x				x		
Oreoicidae													
Oreoica gutturalis	Crested Bellbird			x		x	x		x	x	x	x	x
Pachycephalidae													
Colluricincla harmonica	Grey Shrike-thrush			x		x	x		x	x	x		x
Pachycephala pectoralis	Golden Whistler					x	x						
Pachycephala rufiventris	Rufous Whistler			x		x	x		x	x	x	x	x
Rhipiduridae													
Rhipidura albiscapa	Grey Fantail						x			x	x		x
Rhipidura leucophrys	Willie Wagtail			x		x	x		x	x	x	x	x
Monarchidae													
Grallina cyanoleuca	Magpie-lark			x		x	x		x		x	x	
Corvidae													
Corvus bennetti	Little Crow			x		x	x		x		x	x	

Corvus coronoides	Australian Raven					x	x						
Corvus orru	Torresian Crow			x		x	x		x	x	x	x	x
Petroicidae													
Melanodryas cucullata	Hooded Robin			x			x		x		x	x	
Microeca fascinans	Jacky Winter					x	x				x		
Petroica goodenovii	Red-capped Robin			x		x	x				x	x	
Hirundinidae													
Cheramoeca leucosternus	White-backed Swallow			x		x	x		x		x		
Hirundo neoxena	Welcome Swallow			x		x	x		x	x	x		x
Petrochelidon ariel	Fairy Martin						x				x		
Petrochelidon nigricans	Tree Martin			x		x	x		x		x	x	
Locustellidae													
Megalurus cruralis	Brown Songlark					x	x				x	x	
Megalurus mathewsi	Rufous Songlark					x	x			x	x		x
Dicaeidae													
Dicaeum hirundinaceum	Mistletoebird			x		x	x		x		x	x	
Estrildidae													
Taeniopygia guttata	Zebra Finch			x		x	x				x	x	
Motacillidae													
Anthus australis	Australian Pipit					x	x		x		x	x	
Motacilla cinerea	Grey Wagtail	Mi	S5					x					
Motacilla flava	Yellow Wagtail	Mi	S5					x					
Reptiles													
Cheluidae													
Chelodina steindachneri	Flat-shelled Turtle											x	
Carphodactylidae													
Nephrurus laevissimus											x		
Nephrurus vertebralis						x					x	x	
Nephrurus wheeleri						x							

Underwoodisaurus milii	Southern Barking Gecko					x					x		
Diplodactylidae													
Diplodactylus conspicillatus	Variable Fat-tailed Gecko					x					x	x	
Diplodactylus granariensis						x					x		
Diplodactylus pulcher						x					x	x	
Lucasium maini											x		
Lucasium squarrosum						x					x	x	
Rhynchoedura ornata	Western Beaked Gecko					x					x	x	
Strophurus assimilis	Goldfields Spiny-tailed Gecko					x					x		
Strophurus ciliaris											x		
Strophurus elderi												x	
Strophurus strophurus											x		
Strophurus wellingtonae				x		x							
Gekkonidae													
Gehyra purpurascens											x	x	
Gehyra variegata				x		x			x		x	x	
Heteronotia binoei	Bynoe's Gecko			x		x			x		x	x	
Pygopodidae													
Aprasia picturata						x							
Delma butleri												x	
Delma nasuta											x		
Lialis burtonis											x	x	
Pygopus nigriceps						x					x	x	
Agamidae													
Ctenophorus caudicinctus	Ring-tailed Dragon										x	x	
Ctenophorus cristatus	Bicycle Dragon										x		
Ctenophorus fordi	Mallee Sand Dragon										x	x	
Ctenophorus isolepis	Military Dragon					x						x	
Ctenophorus nuchalis	Central Netted Dragon					x					x	x	

Ctenophorus reticulatus	Western Netted Dragon					x					x	x	
Ctenophorus salinarum	Salt Pan Dragon										x	x	
Ctenophorus scutulatus						x				x	x		x
Diporiphora amphiboluroides				x									
Moloch horridus	Thorny Devil										x	x	
Pogona minor						x					x	x	
Tympanocryptis pseudopsephos	Goldfields Pebble-mimic dragons					x					x		
Scincidae													
Cryptoblepharus australis						x							
Cryptoblepharus buchananii						x					x		
Cryptoblepharus plagiocephalus											x		
Ctenotus atlas											x	x	
Ctenotus brooksi											x		
Ctenotus calurus											x		
Ctenotus grandis												x	
Ctenotus greeri											x		
Ctenotus helenae											x	x	
Ctenotus leonhardii				x		x					x	x	
Ctenotus pantherinus	Leopard Ctenotus					x					x		
Ctenotus quattuordecimlineatus											x	x	
Ctenotus schomburgkii											x	x	
Ctenotus severus						x					x		
Ctenotus uber						x					x		
Cyclodomorphus branchialis			S3								x		
Egernia depressa	Southern Pygmy Spiny-tailed Skink			x		x					x	x	
Egernia formosa											x	x	
Eremiascincus richardsonii	Broad-banded Sand Swimmer					x					x		
Lerista desertorum						x			x		x	x	
Lerista macropisthopus											x		

Lerista picturata											x		
Lerista timida						x					x	x	
Liopholis inornata						x					x	x	
Liopholis striata	Night Skink										x	x	
Menetia greyii						x					x	x	
Morethia butleri						x					x	x	
Tiliqua occipitalis	Western Bluetongue										x		
Varanidae													
Varanus caudolineatus				x		x					x	x	
Varanus eremius	Pygmy Desert Monitor											x	
Varanus giganteus	Perentie										x	x	
Varanus gouldii	Sand Monitor					x			x		x	x	
Varanus panoptes	Yellow-spotted Monitor			x		x					x	x	
Varanus tristis	Racehorse Monitor										x	x	
Typhlopidae													
Anilios hamatus											x	x	
Anilios waitii											x	x	
Pythonidae													
Antaresia stimsoni	Stimson's Python					x							
Elapidae													
Brachyurophis fasciolatus											x		
Brachyurophis semifasciatus												x	
Demansia psammophis	Yellow-faced Whipsnake										x		
Parasuta monachus						x					x		
Pseudechis australis	Mulga Snake					x							
Pseudechis butleri	Spotted Mulga Snake					x							
Pseudonaja mengdeni	Western Brown Snake					x					x	x	
Pseudonaja modesta	Ringed Brown Snake					x					x	x	
Simoselaps bertholdi	Jan's Banded Snake										x		

Suta fasciata	Rosen's Snake					x					x		
Amphibians													
Hylidae													
Cyclorana maini	Sheep Frog					x						x	
Cyclorana platycephala	Western Water-holding Frog					x							
Litoria rubella	Little Red Tree Frog					x							
Limnodynastidae													
Neobatrachus kunapalari	Kunapalari Frog					x						x	
Neobatrachus sutor	Shoemaker Frog					x					x		
Neobatrachus wilsmorei	Plonking Frog										x	x	
Notaden nichollsi	Desert Spadefoot					x							
Platyplectrum spenceri	Centralian Burrowing Frog										x	x	
Myobatrachidae													
Pseudophryne occidentalis	Western Toadlet					x					x		

Appendix C Vegetation Condition Scale

Code	Description
Pristine	Pristine or nearly so. No obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
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 or shrubs.

Appendix D Flora Relevés

Leonora Gold – LGR01

Site Details:

Described by: Sophie Fox

Date: 28/11/2016

Type: Relevé

MGA Zone: 51 357730 mE 6837402 mN

Environmental Variables:

Landform: Slope

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Brown

Rock Type: Basalt,Quartzite

Coarse Surface Particles:

Site coverage: 20-50

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

Outcropping: >90

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: N/A

FLORA AND VEGETATION DATA

Description: *Acacia craspedocarpa, Acacia ramulosa* var. li*n*ophylla and *Hakea preissii* low open woodland over *Eremophila latrobei* subsp. *latrobei*, *Sida ectogama* and *Scaevola spinescens* mid isolated shrubs over *Ptilotus obovatus, Maireana georgei* and *Atriplex quinii* low sparse shrubland over *Enteropogon ramosus* low isolated tussock grasses

Species List

Species Name	Cover (%)	Height (m)
Abutilon oxycarpum subsp. *Prostrate* (A.A. Mitchell PRP 1266)	0.1	0.05
Acacia caesaneura	0.1	2
Acacia craspedocarpa	1	2.5
Acacia ramulosa var. *linophylla*	2	2
Acacia tetragonophylla	0.1	0.5
Aristida contorta	0.1	0.05
Atriplex quinii	2	0.3
Calandrinia eremaea	0.1	0.05
Enteropogon ramosus	3	0.1
Eremophila latrobei subsp. *latrobei*	0.1	1.2
Hakea preissii	5	3.3

Species Name	Cover (%)	Height (m)
Maireana carnosa	0.1	0.05
Maireana georgei	2	0.2
Maireana tomentosa subsp. *tomentosa*	0.1	0.2
Ptilotus aervoides	0.1	0.05
Ptilotus helipteroides	0.5	0.1
Ptilotus obovatus	5	0.5
Ptilotus sp. *Goldfields* (R. Davis 10796)	0.1	0.2
Rhodanthe sp.	0.1	0.1
Scaevola spinescens	1	1.1
Sclerolaena densiflora	0.1	0.05
Sclerolaena densiflora	0.1	0.2
Sclerolaena eriacantha	0.1	0.1
Senna artemisioides subsp. *filifolia*	0.1	0.6
Sida ectogama	0.1	1.3

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
60	2	35

Veg Condition: Excellent

Fire Age: 3-5

Weeds: N/A

Fire Notes: Dead branches

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR01

Photo Number: LGR01



Leonora Gold – LGR02

Site Details:

Described by: Sophie Fox

Date: 29/11/2016

Type: Relevé

MGA Zone: 51 365667 mE 6813901 mN

Environmental Variables:

Landform: Hill

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Clay loam

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: >90

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

Outcropping: 2-10

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia craspedocarpa, Acacia aneura* and *Acacia caesaneura* low woodland over *Scaevola spinescens*, *Acacia tetragonophylla*, *Eremophila oldfieldii* subsp. *angustifolia* mid isolated shrubs over *Maireana tomentosa* subsp. *tomentosa, Ptilotus obovatus* and *Ptilotus* sp. Goldfields (R. Davis 10796) low open shrubland

General Notes: Low Rocky hills

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	10	6
Acacia caesaneura	2	5
Acacia craspedocarpa	2	5
Acacia tetragonophylla	0.5	1.2
Enneapogon caerulescens	0.1	0.1
Eremophila georgei	0.1	0.2
Eremophila oldfieldii subsp. *angustifolia*	0.1	2
Hakea preissii	0.1	3
Maireana tomentosa subsp. *tomentosa*	6	0.3
Ptilotus helipteroides	0.1	0.1

Species Name	Cover (%)	Height (m)
Ptilotus obovatus	4	0.5
Scaevola spinescens	0.5	1.2
Sclerolaena eriacantha	2	0.1
Senna artemisioides subsp. *helmsii*	0.2	0.6

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
5	1	4

Veg Condition: Excellent

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR02

Photo Number: LGR02



Leonora Gold – LGR03

Site Details:

Described by: Brian Morgan

Date: 29/11/2016

Type: Relevé

MGA Zone: 51 357889 mE 6836490 mN

Environmental Variables:

Landform: Drainage Line

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Brown

Rock Type: Ironstone,Quartzite

Coarse Surface Particles:

Site coverage: 50-90

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

Outcropping: <2

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: N/A

FLORA AND VEGETATION DATA

Description: *Acacia craspedocarpa, Acacia aneura* and *Acacia caesaneura* low woodland over *Acacia tetragonophylla*, *Sida ectogama*, *Eremophila forrestii* subsp. *forrestii* mid isolated clumps of shrubs over *Ptilotus obovatus, Eremophila platycalyx* subsp., platycalyx and *Enchylaena tomentosa* low isolated shrubs over *Rhodanthe* ? *charsleyae*, *Podolepis lessonii* and *Gnephosis arachnoidea* low isolated forbs

Species List

Species Name	Cover (%)	Height (m)
Abutilon sp.	0.2	0.35
Acacia aneura	1	6.5
Acacia caesaneura	15	6.5
Acacia craspedocarpa	10	2.8
Acacia tetragonophylla	1	2.2
Aristida contorta	0.1	0.1
Aristida obscura	0.1	0.25
Austrostipa elegantissima	0.5	0.4
Calotis hispidula	0.1	0.1
Cephalipterum drummondii	0.1	0.1
Cheilanthes sieberi subsp. *sieberi*	0.1	0.2

Species Name	Cover (%)	Height (m)
Enchylaena tomentosa	0.1	0.5
Eremophila forrestii subsp. *forrestii*	0.5	1
Eremophila georgei	0.1	0.3
Eremophila latrobei subsp. *latrobei*	0.1	1.1
Eremophila metallicorum	0.1	1.2
Eremophila platycalyx subsp. *platycalyx*	0.1	0.9
Gnephosis arachnoidea	0.5	0.1
Marsdenia australis	0.1	0.9
Podolepis lessonii	0.5	0.15
Psydrax rigidula	0.5	1.1
Ptilotus aervoides	0.1	0.15
Ptilotus obovatus	1	0.5
Rhodanthe ? charsleyae	6	0.2
Sclerolaena densiflora	0.1	0.1
Sida ectogama	1	1.3
Solanum lasiophyllum	0.1	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
73	2	5

Veg Condition: Excellent

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR03

Photo Number: LGR03



Leonora Gold – LGR04

Site Details:

Described by: Sophie Fox

Date: 29/11/2016

Type: Relevé

MGA Zone: 51 364725 mE 6815862 mN

Environmental Variables:

Landform: Hill

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Clay loam

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: >90

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

Outcropping: 2-10

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia craspedocarpa*, *Acacia aneura* and *Acacia caesaneura* low open woodland over *Acacia tetragonophylla, Sida ectogama* and *Scaevola spinescens* mid isolated shrubs over Ma*ireana sedifolia, Ptilotus obovatus* and *Maireana triptera* low open shrubland over *Enneapogon caerulecsens* low isolated grasses

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	20	6
Acacia caesaneura	1	5
Acacia craspedocarpa	1	5
Acacia tetragonophylla	1	1.8
Aristida contorta	0.1	0.1
Cratystylis subspinescens	0.5	1
Enneapogon caerulescens	5	0.2
Eriachne pulchella subsp. *pulchella*	0.1	0.05
Hakea preissii	0.1	3
Maireana ? tomentosa	0.1	0.1
Maireana sedifolia	10	0.8
Maireana trichoptera	0.5	0.1

Species Name	Cover (%)	Height (m)
Maireana triptera	6	0.1
Ptilotus aervoides	0.1	0.5
Ptilotus helipteroides	0.1	0.1
Ptilotus obovatus	2	0.5
Ptilotus sp. *Goldfields* (R. Davis 10796)	0.5	0.1
Salsola australis	0.1	0.5
Santalum ? lanceolatum	0.1	1.2
Scaevola spinescens	0.5	1.2
Sclerolaena densiflora	0.1	0.1
Sclerolaena eriacantha	0.2	0.05
Sida ectogama	0.5	1.4
Solanum cleistogamum	0.1	0.2
Solanum cleistogamum	0.1	0.1
Solanum lasiophyllum	0.1	0.2

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
35	2	3

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR04

Photo Number: LGR04



Leonora Gold – LGR05

Site Details:

Described by: Brian Morgan

Date: 29/11/2016

Type: Relevé

MGA Zone: 51 357702 mE 6836801 mN

Environmental Variables:

Landform: Alluvial Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Orange

Rock Type: Ferricrete,Shale

Coarse Surface Particles:

Site coverage: 50-90

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

Outcropping: <2

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Horse

FLORA AND VEGETATION DATA

Description: *Acacia pteraneura, Acacia aneura* low open woodland over *Eremophila platycalyx* subsp. *platycalyx* and *Acacia aneura* tall sparse shrubland over *Acacia aptaneura, Scaevola spinescens* and *Psydrax rigidula* mid isolated shrubs over *Ptilotus obovatus, Hakea preissii* and *Sida ectogama* low isolated shrubs over *Enneapogon caerulescens* and *Aristida contorta* low isolated grasses

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	1	2
Acacia aptaneura	0.2	1.9
Acacia pteraneura	6	5.5
Acacia pteraneura	2	4
Acacia tetragonophylla	0.5	0.9
Aristida contorta	1	0.2
Atriplex quinii	0.1	0.2
Austrostipa elegantissima	0.1	0.3
Enneapogon caerulescens	1	0.3
Eremophila forrestii subsp. *forrestii*	0.5	0.7
Eremophila latrobei subsp. *latrobei*	0.1	0.9
Eremophila platycalyx	0.25	2.5
Hakea preissii	0.2	0.5

Species Name	Cover (%)	Height (m)
Maireana georgei	0.1	0.3
Maireana georgei	0.1	0.3
Maireana pyramidata	0.1	0.6
Maireana tomentosa subsp. *tomentosa*	0.1	0.3
Maireana triptera	0.1	0.2
Psydrax rigidula	0.1	1.6
Ptilotus obovatus	3	0.5
Ptilotus sp. *Goldfields* (R. Davis 10796)	1	0.2
Scaevola spinescens	0.5	1.1
Sclerolaena densiflora	1	0.1
Sclerolaena diacantha	0.1	0.12
Sclerolaena diacantha	0.1	0.12
Sclerolaena fusiformis	0.1	0.2
Sida ectogama	0.2	0.4
Solanum lasiophyllum	0.1	0.5
Zygophyllum eichleri	0.1	0.3

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
70	2	8

Veg Condition: Excellent

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR05

Photo Number: LGR05



Leonora Gold – LGR06

Site Details:

Described by: Sophie Fox

Date: 29/11/2016

Type: Relevé

MGA Zone: 51 365359 mE 6816059 mN

Environmental Variables:

Landform: Slope

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Clay loam

Soil Colour: Brown

Rock Type: Ironstone,Quartzite

Coarse Surface Particles:

Site coverage: >90

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

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: N/A

FLORA AND VEGETATION DATA

Description: *Hakea preissii* low isolated trees over *Exocarpos aphyllus* and *Eremophila oldfieldii* subsp. *angustifolia* tall isolated shrubs over *Cratystylis subspinescens* and *Scaevola spinescens* mid open shrubland over *Maireana pyramidata, Tecticornia disarticulata* and *Tecticornia pergranulata* subsp. *pergranulata* low open shrubland over *Enteropogon ramosus, Enneapogon caerulescens* and *Eragrostis eriopoda* low isolated grasses

Species List

Species Name	Cover (%)	Height (m)
Acacia burkittii	0.1	1.8
Aristida contorta	0.1	0.5
Atriplex codonocarpa	0.1	0.1
Carpobrotus aequilaterus	0.1	0.1
Cratystylis subspinescens	1	1
Cratystylis subspinescens	15	1
Einadia nutans subsp. *eremaea*	0.1	0.2
Enneapogon caerulescens	1	0.2
Enteropogon ramosus	1	0.2
Eragrostis dielsii	0.1	0.5
Eragrostis eriopoda	0.2	0.2
Eragrostis lacunaria	0.1	0.1
Eremophila oldfieldii subsp. *angustifolia*	0.1	2.5

Species Name	Cover (%)	Height (m)
Exocarpos aphyllus	1	3
Gunniopsis propinqua	0.2	0.05
Hakea preissii	3	5
Maireana ? platycarpa	0.1	0.1
Maireana pyramidata	0.5	0.6
Maireana tomentosa subsp. *tomentosa*	0.2	0.2
Maireana triptera	2	0.3
Pittosporum angustifolium	0.1	2.2
Ptilotus obovatus	0.1	0.3
Scaevola spinescens	1	1
Sclerolaena cuneata	0.2	0.2
Sclerolaena eriacantha	0.1	0.1
Solanum lasiophyllum	0.1	0.2
Tecticornia disarticulata	6	0.4
Tecticornia pergranulata subsp. *pergranulata*	6	0.4
Tecticornia pergranulata subsp. *pergranulata*	3	0.4
Vittadinia sp.	0.1	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
24	1	10

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR06

Photo Number: LGR06



Leonora Gold – LGR07

Site Details:

Described by: Brian Morgan

Date: 29/11/2016

Type: Relevé

MGA Zone: 51 356724 mE 6836578 mN

Environmental Variables:

Landform: Alluvial Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Orange

Rock Type: Granite,Ironstone,Quartzite

Coarse Surface Particles:

Site coverage: 20-50

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

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Acacia craspedocarpa, Acacia aneura* and *Acacia incurvaneura* low open woodland *over Acacia oswaldii, Hakea preissii* and *Rhagodia drummondii* mid isolated shrubs over *Eremophila pantonii*, *Maireana georgei* and *Atriplex nummularia* subsp. *spathulata* low isolated shrubs over *Sclerolaena densiflora, Enneapogon caerulescens* and *Ptilotus aervoides* low isolated forbs and grasses

General Notes: Adjacent to waste dump

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	5	5.5
Acacia craspedocarpa	3	2.5
Acacia incurvaneura	2	5
Acacia oswaldii	0.5	1.9
Aristida holathera	1	0.3
Atriplex codonocarpa	0.1	0.1
Atriplex nummularia subsp. *spathulata*	1.2	3
Atriplex quinii	0.1	0.3
Atriplex sp.	5	0.4
Enneapogon caerulescens	3	0.25
Eremophila pantonii	1	0.7

Species Name	Cover (%)	Height (m)
Goodenia havilandii	0.1	0.2
Hakea preissii	0.1	1.8
Maireana carnosa	1	0.6
Maireana georgei	1	0.4
Maireana georgei	0.1	0.3
Maireana georgei	0.5	2
Maireana pyramidata	0.1	1
Ptilotus aervoides	2	0.2
Ptilotus obovatus	0.5	0.3
Rhagodia ? drummondii	1.1	1.2
Rhodanthe ? charsleyae	0.1	0.1
Santalum acuminata	0.1	0.6
Sclerolaena densiflora	10	0.1
Sclerolaena fusiformis	0.5	0.14
Senna artemisioides subsp. *filifolia*	0.1	0.6

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
70	2	5

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR07

Photo Number: LGR07



Leonora Gold – LGR08

Site Details:

Described by: Sophie Fox

Date: 29/11/2016

Type: Relevé

MGA Zone: 51 364933 mE 6816946 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Brown

Rock Type: Ironstone,Quartzite

Coarse Surface Particles:

Site coverage: 50-90

Size: 20-60,60-200

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: N/A

FLORA AND VEGETATION DATA

Description: *Hakea preissii* low isolated trees over *Cratystylis subspinescens* and *Maireana pyramidata* mid open shrubland over *Solanum lasiophyllum*, *Maireana georgei* and *Ptilotus obovatus* low shrubs over *Aristida contorta* and *Enneapogon caerulescens* low open grassland.

Species List

Species Name	Cover (%)	Height (m)
Aristida contorta	20	0.05
Atriplex ? nummularia	0.1	1
Atriplex codonocarpa	0.1	0.1
Cratystylis subspinescens	8	1.5
Cratystylis subspinescens	2	1
Enneapogon caerulescens	5	0.1
Enteropogon ramosus	0.1	0.2
Hakea preissii	2	3
Maireana georgei	1	0.2
Maireana pyramidata	10	1
Maireana tomentosa subsp. *tomentosa*	0.2	0.2
Maireana triptera	0.1	0.3

Species Name	Cover (%)	Height (m)
Ptilotus obovatus	0.1	0.3
Rhodanthe sp.	0.1	0.2
Sclerolaena densiflora	0.1	0.1
Sclerolaena eriacantha	0.1	0.1
Solanum lasiophyllum	1	0.4
Vittadinia sp.	0.1	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
35	5	20

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR08

Photo Number: LGR08



Leonora Gold – LGR09

Site Details:

Described by: Brian Morgan

Date: 29/11/2016

Type: Relevé

MGA Zone: 51 356609 mE 6837245 mN

Environmental Variables:

Landform: Alluvial Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Ironstone,Quartzite

Coarse Surface Particles:

Site coverage: 50-90

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

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Acacia incurvaneura, Acacia pteraneura* and *Acacia ramulosa* var. *ramulosa* low woodland over *Eremophila margarethae* mid isolated shrubs over *Ptilotus obovatus, Ptilotus schwartzii* and *Solanum lasiophyllum* low isolated shrubs over *Eragrostis eriopoda* and *Monachather paradoxus* isolated tussock grasses

General Notes: Adjacent to mining area, Acacia quadrimarginea, another dominant species in the east of vegetation unit

Species List

Species Name	Cover (%)	Height (m)
Acacia incurvaneura	1	4
Acacia pteraneura	15	3.5
Acacia ramulosa var. *ramulosa*	5	2
Calandrinia porifera	0.1	0.05
Eragrostis eriopoda	3	0.4
Eremophila margarethae	3	1.3
Monachather paradoxus	0.1	0.3
Ptilotus obovatus	0.5	0.4
Ptilotus schwartzii	1	0.4
Solanum lasiophyllum	0.1	0.3

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
75	5	10

Veg Condition:	Very Good	Fire Age:	>15
Weeds:	N/A	Fire Notes:	N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR09

Photo Number: LGR09



Leonora Gold – LGR10

Site Details:

Described by: Sophie Fox

Date: 30/11/2016

Type: Relevé

MGA Zone: 51 364525 mE 6814803 mN

Environmental Variables:

Landform: Hill

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: >90

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

Outcropping: 2-10

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia inceana* subsp. *conformis* low woodland over *Maireana sedifolia* and *Eremophila scoparia* mid isolated shrubs over *Maireana pyramidata* and *Maireana georgei* low isolated chenopod shrubs with *Tecticornia disarticulata* low isolated samphire shrubs

Species List

Species Name	Cover (%)	Height (m)
Acacia inceana subsp. *conformis*	15	6
Calandrinia sp.	0.1	0.05
Eremophila scoparia	0.1	1
Gunniopsis propinqua	0.1	0.05
Lawrencia densiflora	0.1	0.1
Maireana carnosa	0.1	0.1
Maireana georgei	0.5	0.2
Maireana pyramidata	2	0.3
Maireana sedifolia	4	1
Olearia muellerii	0.1	0.4
Ptilotus aervoides	0.1	0.05
Sclerolaena densiflora	0.1	0.1

Species Name	Cover (%)	Height (m)
Sclerolaena eriacantha	0.1	0.1
Sclerolaena sp.	0.1	0.1
Tecticornia disarticulata	8	0.6

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
5	1	10

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR10

Photo Number: LGR10



Leonora Gold – LGR11

Site Details:

Described by: Brian Morgan

Date: 29/11/2016

Type: Relevé

MGA Zone: 51 357270 mE 6837532 mN

Environmental Variables:

Landform: Slope

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Clay loam

Soil Colour: Brown

Rock Type: Granite,Quartzite

Coarse Surface Particles:

Site coverage: >90

Size: 20-60,60-200

Outcropping: <2

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Acacia pteraneura, Acacia caesaneura* and *Casuarina pauper* low woodland over *Acacia ramulosa* var. *ramulosa* and *Acacia tetragonophylla* tall isolated shrubs over *Eremophila oldfieldii* subsp. *angustifolia* and *Rhagodia drummondii* mid isolated shrubs over Ptilotus obovatus, Scaevola *spinescens* and *Sida ectogama* low shrubland over *Enneapogon caerulescens, Sclerolaena lanicuspis* and *Rhodanthe* sp. low isolated forbs and grasses

Species List

Species Name	Cover (%)	Height (m)
Acacia caesaneura	10	4.5
Acacia pteraneura	6	6.5
Acacia ramulosa var. *ramulosa*	3	4
Acacia tetragonophylla	0.2	2.2
Calandrinia creethiae	0.1	0.1
Calandrinia eremaea	0.1	0.1
Casuarina pauper	5	5.5
Cheilanthes sieberi subsp. *sieberi*	0.1	0.3
Enneapogon caerulescens	2	0.3
Eremophila oldfieldii subsp. *angustifolia*	0.2	1.9
Eremophila platycalyx	0.1	0.3

Species Name	Cover (%)	Height (m)
Maireana georgei	0.1	0.4
Maireana tomentosa subsp. *tomentosa*	0.1	0.3
POACEAE sp.	0.5	0.02
Ptilotus obovatus	10	0.5
Rhagodia drummondii	0.1	1.4
Rhodanthe sp.	0.2	0.3
Scaevola spinescens	0.5	0.7
Sclerolaena densiflora	0.1	0.2
Sclerolaena lanicuspis	0.2	0.3
Sida ectogama	0.2	0.5
Solanum lasiophyllum	0.1	0.3

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
35	10	15

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR11

Photo Number: LGR11



Leonora Gold – LGR12

Site Details:

Described by: Sophie Fox

Date: 30/11/2016

Type: Relevé

MGA Zone: 51 364047 mE 6814767 mN

Environmental Variables:

Landform: Drainage Line

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Clay loam

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 20-50

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

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle,Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia aptaneura*, *Acacia burkittii* and *Eremophila longifolia* low open woodland over *Acacia tetragonophylla, Acacia burkittii* and *Acacia victoriae* mid sparse shrubland over *Eremophila forrestii* subsp. *forrestii*, *Eremophila glabra* subsp. *glabra* and *Eremophila youngii* subsp. *youngii* low isolated shrubs over Eriach*ne flaccida, Themeda triandra* and *Enteropogon ramosus* low tussock grassland

Species List

Species Name	Cover (%)	Height (m)
Acacia aptaneura	1	1
Acacia aptaneura	10	6
Acacia burkittii	6	5
Acacia burkittii	5	2
Acacia tetragonophylla	2	2
Acacia victoriae	0.1	1.5
Amyema fitzgeraldii		
Aristida contorta	0.05	0.1
Atriplex ? nummularia	1	0.6
Enteropogon ramosus	1	0.2
Eremophila forrestii subsp. *forrestii*	2	0.6

Species Name	Cover (%)	Height (m)
Eremophila glabra subsp. *glabra*	0.5	1.2
Eremophila longifolia	0.5	6
Eremophila youngii subsp. *youngii*	0.5	1.2
Eriachne flaccida	40	0.2
Maireana pyramidata	1	0.5
Ptilotus drummondii	0.5	1.2
Ptilotus obovatus	0.1	0.3
Rhodanthe sp.	0.1	0.5
Senna charlesiana	0.1	1
Themeda triandra	0.5	0.5

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
40	5	30

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR12

Photo Number: LGR12



Leonora Gold – LGR13

Site Details:

Described by: Brian Morgan

Date: 30/11/2016

Type: Relevé

MGA Zone: 51 357694 mE 6837453 mN

Environmental Variables:

Landform: Hill,Slope

Slope: Moderately inclined (5-15°)

Soils:

Soil Texture: Clay loam

Soil Colour: Orange

Rock Type: Quartzite

Coarse Surface Particles:

Site coverage: >90

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

Outcropping: 2-10

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia aneura, Acacia aptaneura* and *Acacia caesaneura* low isolated trees over *Acacia ramulosa* var. *ramulosa* and *Acacia quadrimarginea* tall sparse shrubland over *Scaevola spinescens* and *Acacia tetragonophylla* mid isolated shrubs over *Eremophila platycalyx* subsp. *platycalyx, Ptilotus obovatus* and *Eremophila latrobei* subsp. *latrobei* low isolated shrubs

General Notes: Mid slope

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	2	4
Acacia aptaneura	0.5	6
Acacia caesaneura	1	4
Acacia quadrimarginea	1	2.5
Acacia ramulosa var. *ramulosa*	6	2.5
Acacia tetragonophylla	0.1	1
Casuarina pauper	0.1	0.3
Eremophila latrobei subsp. *latrobei*	1	0.6
Eremophila platycalyx	0.1	0.9
Eriachne helmsii	0.1	0.4

Species Name	Cover (%)	Height (m)
Maireana carnosa	0.1	0.1
Maireana georgei	0.2	0.3
Marsdenia australis	0.1	0.1
Psydrax suaveolens	0.1	2.6
Ptilotus helipteroides	0.1	0.3
Ptilotus obovatus	1	0.5
Scaevola spinescens	1	1.2
Sclerolaena eriacantha	0.1	0.2
Senna artemisioides subsp. *x artemisioides*	0.1	0.5
Senna sp. *Meekatharra* (E. Bailey 1-26)	0.1	0.5
Sida ectogama	0.1	0.5
Solanum lasiophyllum	0.1	0.3
Spartothamnella teucriiflora	0.1	0.4

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
15	5	10

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR13

Photo Number: LGR13



Leonora Gold – LGR14

Site Details:

Described by: Sophie Fox

Date: 30/11/2016

Type: Relevé

MGA Zone: 51 363973 mE 6815075 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 50-90

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

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Acacia craspedocarpa, Eremophila platycalyx* subsp. *platycalyx* and *Acacia aneura* Low Woodland over *Acacia caesaneura, Hakea preissii* and *Eremophila platycalyx* subsp. *platycalyx* tall isolated shrubs over *Maireana pyramidata, Ptilotus obovatus* and *Acacia aptaneura* low isolated shrubs over mixed forbs and grasses

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	1	5
Acacia aptaneura	0.1	0.6
Acacia caesaneura	1	5
Acacia caesaneura	2	2
Acacia craspedocarpa	8	5
Acacia craspedocarpa	1	1
Acacia tetragonophylla	0.1	1
Aristida contorta	0.1	0.5
Enteropogon ramosus	0.1	0.1
Eremophila platycalyx subsp. *platycalyx*	10	3
Eremophila platycalyx subsp. *platycalyx*	1.5	4
Eremophila platycalyx subsp. *platycalyx*	1	1.8

Species Name	Cover (%)	Height (m)
Hakea preissii	0.1	2
Maireana pyramidata	1	0.5
Maireana tomentosa subsp. *tomentosa*	0.1	0.2
Maireana triptera	0.05	0.2
Marsdenia australis	0.1	1.5
Monachather paradoxus	0.1	0.1
Ptilotus aervoides	0.1	0.05
Ptilotus obovatus	0.2	0.4
Sclerolaena densiflora	0.1	0.1
Sclerolaena eriacantha	0.1	0.1
Solanum lasiophyllum	0.1	0.3

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
39	1	10

Veg Condition: Very Good

Fire Age: 5-15

Weeds: N/A

Fire Notes: Dead branches

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR14

Photo Number: LGR14



Leonora Gold – LGR15

Site Details:

Described by: Brian Morgan

Date: 30/11/2016

Type: Relevé

MGA Zone: 51 357535 mE 6837461 mN

Environmental Variables:

Landform: Crest

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Clay loam

Soil Colour: Orange

Rock Type: Ferricrete,Quartzite

Coarse Surface Particles:

Site coverage: >90

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

Outcropping: 10-20

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia incurvaneura, Acacia quadrimarginea* low isolated trees over *Sida ectogama, Ptilotus obovatus* and *Eremophila latrobei* subsp. *latrobei* low isolated shrubs over mixed forbs

General Notes: Close to revegetation

Species List

Species Name	Cover (%)	Height (m)
Acacia incurvaneura	2	2.8
Acacia incurvaneura	2	2.6
Acacia quadrimarginea	1	2.5
Aristida contorta	0.1	0.1
Baeckea sp. Melita Station (H. Pringle 2738)	1	2.2
Calocephalus multiflorus	0.1	0.05
Eremophila latrobei subsp. *latrobei*	0.1	0.5
Eremophila mackinlayi subsp. *spathulata*	0.1	0.3
Goodenia occidentalis	0.5	0.2
Ptilotus obovatus	0.1	0.5

Species Name	Cover (%)	Height (m)
Ptilotus schwartzii	0.1	0.3
Scaevola densifolia	0.1	0.1
Sclerolaena fusiformis	0.1	0.1
Sida ectogama	0.1	0.8
Sida sp. Excedentifolia (J.L. Egan 1925)	0.2	0.3
Solanum lasiophyllum	0.1	0.2
Velleia glabrata	0.1	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
40	2	8

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR15

Photo Number: LGR15



Leonora Gold – LGR16

Site Details:

Described by: Sophie Fox

Date: 30/11/2016

Type: Relevé

MGA Zone: 51 365279 mE 6814455 mN

Environmental Variables:

Landform: Hill

Slope: Moderately inclined (5-15°)

Soils:

Soil Texture: Sandy loam

Soil Colour: Brown

Rock Type: Ironstone,Quartzite

Coarse Surface Particles:

Site coverage: >90

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

Outcropping: 10-20

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: N/A

FLORA AND VEGETATION DATA

Description: *Acacia kempiana* low open woodland over *Acacia burkittii, Maireana sedifolia* and *Eremophila scoparia* mid open shrubland over *Ptilotus obovatus, Sida ectogama* and *Solanum lasiophyllum* low isolated shrubs over *Enneapogon caerulescens* and *Sclerolaena eriacantha* low isolated forbs and grasses

Species List

Species Name	Cover (%)	Height (m)
Acacia burkittii	1	2
Acacia kempeana	6	6
Enneapogon caerulescens	5	0.1
Eremophila oldfieldii subsp. *angustifolia*	0.1	1
Eremophila scoparia	2	1
Hakea preissii	0.1	0.4
Lepidium platypetalum	0.1	0.1
Maireana sedifolia	10	1.2
Maireana tomentosa subsp. *tomentosa*	0.1	0.2
Maireana triptera	0.1	0.2
Pittosporum angustifolium	0.1	1.5
Ptilotus helipteroides	0.1	0.1

Species Name	Cover (%)	Height (m)
Ptilotus obovatus	2	0.2
Ptilotus sp. *Goldfields* (R. Davis 10796)	0.1	0.2
Scaevola spinescens	0.1	1
Sclerolaena eriacantha	1	0.1
Sida ectogama	0.1	0.2
Solanum lasiophyllum	0.1	0.2

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
5	2	3

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

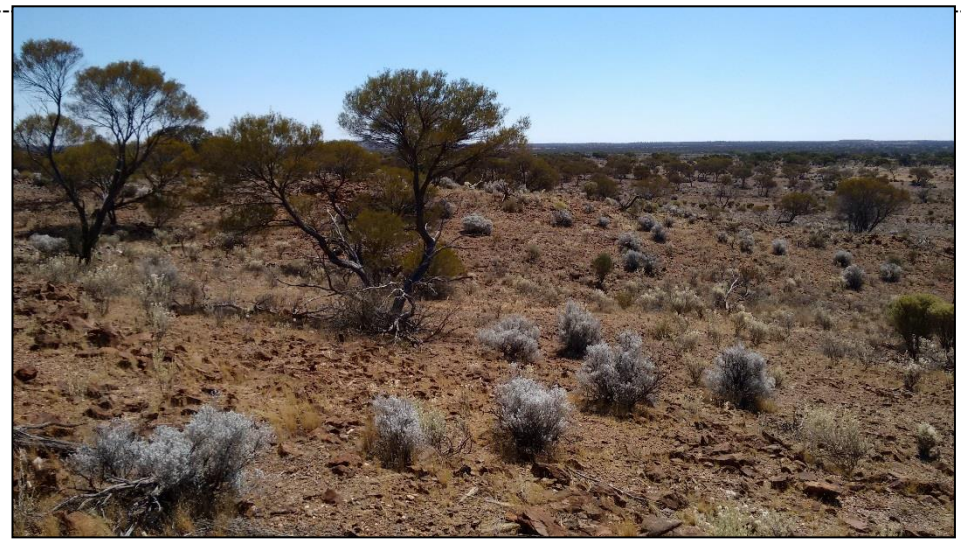
Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR16

Photo Number: LGR16



Leonora Gold – LGR17

Site Details:

Described by: Brian Morgan

Date: 30/11/2016

Type: Relevé

MGA Zone: 51 357684 mE 6838182 mN

Environmental Variables:

Landform: Drainage Line

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Quartzite

Coarse Surface Particles:

Site coverage: 2-10

Size: 6-20,20-60

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Acacia aneura, Acacia aptaneura* and *Acacia tetragonophylla* low open forest over *Santalum spicatum*, *Sida ectogama* and *Senna artemisioides* subsp. *artemisioides* mid isolated shrubs over *Ptilotus obovatus, Maireana georgei* and *Eremophila georgei* low isolated shrubs over *Rhodanthe ? charsleyae*, *Triodia basedowii* and *Ptilotus aervoides* low isolated forbs and grasses

Species List

Species Name	Cover (%)	Height (m)
Abutilon cryptopetalum	0.1	0.4
Acacia aneura	12	7
Acacia aneura	10	7
Acacia aptaneura	5	7
Acacia aptaneura	4	6.5
Acacia tetragonophylla	2	2.8
Enchylaena tomentosa	0.1	1
Eremophila forrestii subsp. *forrestii*	0.1	0.8
Eremophila georgei	0	0.7
Eremophila platycalyx	0.1	0.7
Eremophila simulans	0.1	1.1

Species Name	Cover (%)	Height (m)
Maireana georgei	0.1	0.3
Maireana tomentosa subsp. *tomentosa*	0.1	0.3
Marsdenia australis	0.1	1.9
Nicotiana rosulata subsp. *rosulata*	0.1	0.3
Psydrax suaveolens	0.1	1.8
Ptilotus aervoides	0.1	0.1
Ptilotus obovatus	3	0.5
Rhagodia drummondii	1	0.7
Rhagodia drummondii	0.1	0.5
Rhodanthe ? charsleyae	3	0.2
Rhodanthe maryonii	0.1	0.3
Santalum spicatum	0.25	1.7
Sclerolaena diacantha	0.1	0.6
Senna artemisioides subsp. *artemisioides*	0.1	1.1
Sida ectogama	0.2	1.2
Triodia basedowii	0.1	0.4
Triodia basedowii	0.1	0.2

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
10	30	50

Veg Condition: Excellent

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR17

Photo Number: LGR17



Leonora Gold – LGR18

Site Details:

Described by: Sophie Fox

Date: 30/11/2016

Type: Relevé

MGA Zone: 51 363250 mE 6814118 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 50-90

Size: 2-6,6-20

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Acacia aneura, Acacia aptaneura* and *Acacia caesaneura* low open woodland over *Acacia ramulosa* var. *ramulosa, Acacia tetragonophylla, Acacia craspedocarpa* and *Eremophila platycalyx* subsp. *platycalyx* tall isolated shrubs over *Sida ectogama, Ptilotus obovatus* and *Scaevola spinescens* low isolated shrubs over *Aristida obscura*, *Monachather paradoxus* and *Aristida contorta* low isolated grasses

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	5	6
Acacia aptaneura	2	5
Acacia caesaneura	2	2.5
Acacia craspedocarpa	1	2
Acacia ramulosa var. *ramulosa*	3	2
Acacia tetragonophylla	1	2.2
Aristida contorta	0.1	0.1
Aristida obscura	1	0.2
Eremophila platycalyx subsp. *platycalyx*	1	2.2
Eremophila youngii subsp. *youngii*	5	1.8
Maireana triptera	0.1	0.2

Species Name	Cover (%)	Height (m)
Monachather paradoxus	0.2	0.2
Psydrax rigidula	0.1	0.2
Ptilotus aervoides	0.1	0.05
Ptilotus obovatus	0.5	0.3
Rhodanthe sp.	1	0.2
Santalum ? lanceolatum	0.5	3.5
Scaevola spinescens	0.1	0.8
Sclerolaena sp.	1	0.2
Sclerolaena sp.	0.1	0.5
Sida ectogama	0.5	1
Solanum lasiophyllum	0.1	0.2

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
50	5	7

Veg Condition: Very Good

Fire Age: 5-15

Weeds: N/A

Fire Notes: Dead branches

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR18

Photo Number: LGR18



Leonora Gold – LGR19

Site Details:

Described by: Brian Morgan

Date: 30/11/2016

Type: Relevé

MGA Zone: 51 357596 mE 6834548 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: >90

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

Outcropping: 10-20

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: N/A

FLORA AND VEGETATION DATA

Description: *Acacia pteraneura, Acacia craspedocarpa* and *Acacia burkittii* low isolated trees over *Eremophila pantonii, Eremophila platycalyx* subsp. *platycalyx* and *Acacia tetragonophylla* mid isolated shrubs over *Scaevola spinescens, Ptilotus obovatus* and *Eremophila* spp. low isolated shrubs over *Sclerolaena fusiformis, Sclerolaena eriacantha* and *Ptilotus* sp. Goldfields low isolated forbs

General Notes: *Eremophila pantonii* isn't a consist part of the unit; *Acacia ramulosa* var. *ramulosa* occurs sparsely in unit

Species List

Species Name	Cover (%)	Height (m)
Acacia burkittii	0.1	2.2
Acacia craspedocarpa	4	2.2
Acacia pteraneura	0.1	4.5
Acacia tetragonophylla	1	1
Eremophila latrobei subsp. *latrobei*	0.1	0.4
Eremophila margarethae	0.1	0.4
Eremophila pantonii	5	1.7
Eremophila platycalyx subsp. *platycalyx*	0.1	1.1
Ptilotus helipteroides	0.1	0.2

Species Name	Cover (%)	Height (m)
Ptilotus obovatus	0.1	0.5
Ptilotus sp. *Goldfields* (R. Davis 10796)	0.1	0.3
Scaevola spinescens	0.5	0.7
Sclerolaena densiflora	0.1	0.1
Sclerolaena eriacantha	0.1	0.12
Sclerolaena fusiformis	0.2	0.15

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
45	1	9

Veg Condition: Excellent

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR19

Photo Number: LGR19



Leonora Gold – LGR20

Site Details:

Described by: Sophie Fox

Date: 1/12/2016

Type: Relevé

MGA Zone: 51 363465 mE 6812443 mN

Environmental Variables:

Landform: Hill

Slope: Moderately inclined (5-15°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Brown

Rock Type: Basalt

Coarse Surface Particles:

Site coverage: >90

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

Outcropping: 10-20

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia ?resinimarginea, Acacia aneura, Acacia caesaneura* tall open shrubland over *Senna artemisioides* subsp. *filifolia, Scaevola spinescens* and *Acacia tetragonophylla* mid isolated shrubs over *Ptilotus obovatus, Maireana sedifolia* and *Solanum lasiophyllum* low isolated shrubs over *Ptilotus helipteroides* and *Enneapogon caerulescens* low isolated forbs and grasses

Species List

Species Name	Cover (%)	Height (m)
Acacia ? resinimarginea	15	2.5
Acacia aneura	1	2.5
Acacia caesaneura	1	2
Acacia tetragonophylla	0.1	1
Austrostipa ? nitida	0.1	0.3
Enneapogon caerulescens	3	0.1
Eremophila forrestii subsp. *forrestii*	0.1	0.1
Eremophila sp.	0.1	0.8
Eriachne pulchella	0.1	0.1
Exocarpos aphyllus	0.1	1
Hakea preissii	0.1	0.4

Species Name	Cover (%)	Height (m)
Hibiscus burtonii	0.1	0.2
Maireana sedifolia	0.1	0.5
Maireana trichoptera	0.1	0.2
Maireana triptera	0.1	0.3
Psydrax rigidula	0.1	0.7
Ptilotus aervoides	0.1	0.05
Ptilotus helipteroides	3	0.1
Ptilotus obovatus	4	0.3
Scaevola spinescens	1	1
Senna artemisioides subsp. *filifolia*	1	1
Senna manicula	0.1	0.6
Sida ectogama	0.01	0.4
Solanum cleistogamum	0.1	0.05
Solanum lasiophyllum	0.2	0.3
Stenopetalum anfractum	0.1	0.1
Velleia glabrata	0.1	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
5	5	5

Veg Condition: Very Good

Fire Age: 5-15

Weeds: N/A

Fire Notes: Dead branches

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR20

Photo Number: LGR20



Leonora Gold – LGR21

Site Details:

Described by: Brian Morgan

Date: 1/12/2016

Type: Relevé

MGA Zone: 51 357453 mE 6834150 mN

Environmental Variables:

Landform: Alluvial Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Orange

Rock Type: Quartzite

Coarse Surface Particles:

Site coverage: 50-90

Size: 6-20,20-60

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle,Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia incurvaneura* low woodland over *Hakea recurva* subsp. *arida* and *Eremophila platycalyx* subsp. *platycalyx* tall isolated shrubs over *Acacia tetragonophylla, Acacia craspedocarpa* and *Santalum acuminatum* mid isolated shrubs over *Eremophila metallicorum, Eremophila margarethae* and *Ptilotus obovatus* low isolated shrubs over *Sclerolaena densiflora* and *Aristida contorta* low isolated forbs and grasses

General Notes: *Acacia quadrimarginea* and *Acacia ramulosa var. ramulosa* occur nearby scattered, not consistent in unit

Species List

Species Name	Cover (%)	Height (m)
Acacia craspedocarpa	1	1.6
Acacia incurvaneura	6	4
Acacia incurvaneura	7	4
Acacia tetragonophylla	3	1.8
Aristida contorta	0.5	0.2
Eremophila georgei	0.1	1.2
Eremophila margarethae	0.1	0.5
Eremophila metallicorum	0.2	0.6
Eremophila platycalyx subsp. *platycalyx*	2.5	2.7

Species Name	Cover (%)	Height (m)
Goodenia occidentalis	0.1	0.15
Hakea recurva subsp. *arida*	1	3.5
Lemooria burkittii	0.1	0.01
Maireana carnosa	0.1	0.15
Maireana georgei	0.1	0.3
Maireana tomentosa	0.1	0.3
Ptilotus obovatus	0.1	0.5
Ptilotus schwartzii	0.1	0.3
Rhagodia drummondii	0.1	1.6
Santalum acuminatum	0.5	1.6
Sclerolaena densiflora	0.1	0.3
Sclerolaena fusiformis	0.1	0.15
Spartothamnella teucriiflora	0.1	0.4

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
60	5	10

Veg Condition: Excellent

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR21

Photo Number: LGR21



Leonora Gold – LGR22

Site Details:

Described by:

Date: 1/12/2016

Type: Relevé

MGA Zone: 51 363434 mE 6813056 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Brown

Rock Type: Ironstone,Quartzite

Coarse Surface Particles:

Site coverage: 50-90

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

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Hakea preissii* low open woodland over *Cratystylis subspinescens* and *Maireana pyramidata* mid open shrubland over *Tecticornia pruinosa* and *Tecticornia pergranulata* subsp. *pergranulata* low open samphire shrubland over *Surreya diandra, Frankenia setosa* and *Maireana tomentosa* subsp. *tomentosa* low isolated shrubs

General Notes: Previous drilling in area. Generally successful revegetation.

Species List

Species Name	Cover (%)	Height (m)
Atriplex codonocarpa	0.1	0.2
Cratystylis subspinescens	7	1.4
Cratystylis subspinescens	7	1.1
Frankenia setosa	2	0.2
Gunniopsis propinqua	0.1	0.05
Hakea preissii	8	3
Maireana carnosa	0.1	0.1
Maireana pyramidata	5	1
Maireana tomentosa subsp. *tomentosa*	1	0.2
Maireana triptera	0.1	0.2

Species Name	Cover (%)	Height (m)
Scaevola spinescens	1	1
Sclerolaena cuneata	0.1	0.1
Sclerolaena densiflora	0.1	0.1
Sclerolaena eriacantha	0.1	0.1
Solanum lasiophyllum	0.1	0.1
Surreya diandra	3	0.2
Tecticornia pergranulata subsp. *pergranulata*	0.1	0.4
Tecticornia pruinosa	0.1	0.4
Tecticornia pruinosa	10	0.4

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
43	2	10

Veg Condition: Good

Fire Age: 5-15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR22

Photo Number: LGR22



Leonora Gold – LGR23

Site Details:

Described by: Brian Morgan

Date: 1/12/2016

Type: Relevé

MGA Zone: 51 357553 mE 6833435 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Quartzite

Coarse Surface Particles:

Site coverage: 50-90

Size: 6-20,20-60

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle,Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia aneura* low isolated trees over *Acacia craspedocarpa* and *Acacia tetragonophylla* tall open shrubland over *Spartothamnella teucriiflora*, *Eremophila margarethae* and *Eremophila metallicorum* low isolated shrubs over *Rhodanthe ? charsleyae* low isolated forbs

General Notes: Elsewhere in unit, Acacia pteraneura and Acacia ? incurvaneura are present as scattered low trees

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	5	7
Acacia craspedocarpa	15	2.5
Acacia sibirica	0.1	2.2
Acacia tetragonophylla	1	3.3
Eremophila margarethae	0.2	0.5
Eremophila metallicorum	0.1	0.6
Eremophila metallicorum	0.1	0.3
Eremophila oldfieldii subsp. *angustifolia*	0.1	0.3
Gnephosis arachnoidea	0.1	0.1
Psydrax rigidula	0.1	1.1

Species Name	Cover (%)	Height (m)
Ptilotus obovatus	0.1	0.4
Rhodanthe ? charsleyae	3	0.2
Sclerolaena densiflora	0.1	0.06
Solanum lasiophyllum	0.1	0.3
Spartothamnella teucriiflora	0.5	0.9

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
75	5	10

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR23

Photo Number: LGR23



Leonora Gold – LGR24

Site Details:

Described by: Paul Bolton

Date: 1/12/2016

Type: Relevé

MGA Zone: 51 363279 mE 6813174 mN

Environmental Variables:

Landform: Drainage Line

Slope: Level (0-3°)

Soils:

Soil Texture: Medium clay

Soil Colour: Brown

Rock Type: Ironstone,Quartzite

Coarse Surface Particles:

Site coverage: 10-20

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

Outcropping: <2

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Acacia aneura, Acacia aptaneura* and *Acacia burkittii* low open forest over *Acacia caesaneura, Acacia tetragonophylla* and *Acacia burkittii* tall sparse shrubland over *Themeda triandra* mid isolated hummock grasses over *Eriachne flaccida* low isolated grasses and low mixed forbs

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	2	8
Acacia aptaneura	20	8
Acacia burkittii	2	4
Acacia burkittii	2	2
Acacia burkittii	20	5
Acacia burkittii	0.5	6
Acacia caesaneura	2	6
Acacia craspedocarpa	2	6
Acacia tetragonophylla	2	5
Alternanthera nodiflora	0.1	0.05
Amyema fitzgeraldii	1	2
Atriplex ? nummularia	0.5	0.6

Species Name	Cover (%)	Height (m)
Centipeda thespidioides	0.1	0.5
Cuscuta planiflora	0.1	0.05
Enchylaena ? tomentosa var. *tomentosa*	0.5	1.1
Enteropogon ramosus	0.5	0.2
Eragrostis dielsii	0.1	0.05
Eremophila longifolia	2	6
Eriachne flaccida	1	0.2
Juncus aridicola	0.1	1
Lysiana murrayi	0.1	2
Lysimachia arvensis	0.1	0.05
Malvastrum americanum	0.1	0.6
Marsilea drummondii	0.1	0.1
Rumex hypogaeus	0.1	0.05
Rumex vesicarius	0.1	1.2
Santalum lanceolatum	0.1	1
Santalum spicatum	0.1	3
Santalum spicatum	0.1	1
Sisymbrium erysimoides	0.1	0.1
Themeda triandra	2	1
Wahlenbergia tumidifructa	0.1	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
10	40	40

Veg Condition: Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR24

Photo Number: LGR24



Leonora Gold – LGR25

Site Details:

Described by: Brian Morgan

Date: 1/12/2016

Type: Relevé

MGA Zone: 51 357621 mE 6828746 mN

Environmental Variables:

Landform: Slope

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Ironstone,Quartzite

Coarse Surface Particles:

Site coverage: >90

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

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle,Native,Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia incurvaneura* and *Hakea recurva* subsp. *arida* low woodland over *Acacia ramulosa* var. *ramulosa* tall isolated shrubs over *Eremophila platycalyx* subsp. *platycalyx* and *Eremophila simulans* subsp. *simulans* mid isolated shrubs over mixed low isolated forbs and grasses

General Notes: *Acacia ramulosa* var. *ramulosa* scattered in parts of unit.

Species List

Species Name	Cover (%)	Height (m)
Acacia incurvaneura	15	4
Acacia ramulosa var. *ramulosa*	3	2.6
Calocephalus multiflorus	0.1	0.2
Eragrostis eriopoda	0.1	0.3
Eremophila margarethae	0.1	0.4
Eremophila platycalyx subsp. *platycalyx*	2	1.9
Eremophila simulans subsp. *simulans*	2	1.4
Goodenia occidentalis	0.1	0.1
Hakea recurva subsp. *arida*	0.1	4.5
Maireana georgei	0.1	0.5

Species Name	Cover (%)	Height (m)
POACEAE sp.	0.1	0.05
Ptilotus obovatus	0.1	0.7
Ptilotus schwartzii	0.2	0.5
Sclerolaena fusiformis	0.1	0.1
Sida ectogama	0.1	0.5

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
80	5	10

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR25

Photo Number: LGR25



Leonora Gold – LGR26

Site Details:

Described by: Paul Bolton

Date: 1/12/2016

Type: Relevé

Environmental Variables:

Landform: Slope

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: >90

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

Outcropping: <2

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: N/A

FLORA AND VEGETATION DATA

Description: *Acacia kalgoorliensis, Acacia oswaldii* and *Hakea preissii* low open woodland over *Eremophila scoparia*, *Senna stowardii* and *Acacia craspedocarpa* mid isolated shrubs over *Ptilotus obovatus, Maireana triptera* and *Cratystylis subspinescens* low isolated shrubs over *Sclerolaena eriacantha, Sclerolaena densiflora* and *Ptilotus* sp. Goldfields low isolated forbs

Species List

Species Name	Cover (%)	Height (m)
Acacia caesaneura	0.1	1
Acacia craspedocarpa	0.1	2
Acacia kalgoorliensis	5	4
Acacia tetragonophylla	0.1	0.3
Cratystylis subspinescens	0.2	0.6
Eremophila scoparia	2	1.2
Eremophila sp.	0.1	1
Hakea preissii	2	3
Maireana glomerifolia	0.1	0.3
Maireana pyramidata	0.1	0.5

Species Name	Cover (%)	Height (m)
Maireana triptera	3	0.2
Ptilotus obovatus	5	0.3
Ptilotus sp. *Goldfields* (R. Davis 10796)	0.1	0.2
Scaevola spinescens	0.2	0.8
Sclerolaena densiflora	0.1	0.1
Sclerolaena eriacantha	0.5	0.1
Senna stowardii	1	1.2
Solanum lasiophyllum	0.1	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
13	3	5

Veg Condition: Excellent

Fire Age: 5-15

Weeds: N/A

Fire Notes: Dead branches

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR26

Photo Number: LGR26



Leonora Gold – LGR27

Site Details:

Described by: Brian Morgan

Date: 2/12/2016

Type: Relevé

MGA Zone: 51 357646 mE 6828487 mN

Environmental Variables:

Landform:

Slope: Level (0-3°)

Soils:

Soil Texture: Loam

Soil Colour: Red

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 50-90

Size: 2-6

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Native,Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia aptaneura, Acacia incurvaneura* and *Acacia caesaneura* low open forest over *Acacia ramulosa* var. *ramulosa* tall isolated shrubs over *Eremophila simulans* subsp. *simulans, Sida ectogama* and *Eremophila latrobei* subsp. *latrobei* mid sparse shrubland over *Eragrostis eriopoda, Eriachne* ? *helmsii* and *Monachather paradoxus* low isolated tussock grasses

General Notes: Forms a mosaic with LGR25. LGR25 in patches between this vegetation type (mulga groves)

Species List

Species Name	Cover (%)	Height (m)
Acacia aptaneura	35	5.5
Acacia caesaneura	3	5
Acacia incurvaneura	5	5
Acacia ramulosa var. *ramulosa*	0.5	2.5
Aristida contorta	0.1	0.5
Cheilanthes sieberi subsp. *sieberi*	0.1	0.2
Chthonocephalus pseudevax	0.1	0.01
Crassula colorata var. *acuminata*	0.1	0.03

Species Name	Cover (%)	Height (m)
Duperreya commixta	0.1	0.3
Eragrostis eriopoda	2	0.4
Eremophila latrobei subsp. *latrobei*	0.1	1.3
Eremophila simulans subsp. *simulans*	6	1.4
Eriachne ? helmsii	2	0.6
Marsdenia australis	0.1	0.5
Monachather paradoxus	0.1	0.3
Rhodanthe propinqua	0.1	0.15
Rhodanthe sp.	0.1	0.2
Roebuckiella oncocarpa	0.1	0.1
Sida ectogama	1	1.6
Sida sp.	0.1	0.5
Solanum lasiophyllum	0.1	0.3
Thyridolepis multiculmis	0.1	0.4
Wahlenbergia queenslandica	0.1	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
50	30	15

Veg Condition: Excellent

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR27

Photo Number: LGR27



Leonora Gold – LGR28

Site Details:

Described by: Paul Bolton

Date: 1/12/2016

Type: Relevé

MGA Zone: 51 362942 mE 6815061 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: >90

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

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: N/A

FLORA AND VEGETATION DATA

Description: *Acacia inceana* subsp. *conformis* low woodland over *Maireana sedifolia, Tecticornia disarticulata* and *Cratystylis subspinescens* mid isolated shrubs over *Maireana tomentosa* subsp. *tomentosa, Maireana pyramidata* and *Maireana triptera* low isolated chenopod shrubs over *Sclerolaena eriacantha, Atriplex codonocarpa* and *Maireana carnosa* low isolated forbs

Species List

Species Name	Cover (%)	Height (m)
Acacia inceana subsp. *conformis*	15	6
Atriplex codonocarpa	0.1	0.1
Cratystylis subspinescens	0.1	1
Eragrostis dielsii	0.1	0.05
Maireana carnosa	0.1	0.1
Maireana glomerifolia	0.1	0.4
Maireana pyramidata	2	0.5
Maireana sedifolia	1	1
Maireana tomentosa subsp. *tomentosa*	5	0.5
Maireana triptera	2	0.2

Species Name	Cover (%)	Height (m)
Ptilotus obovatus	0.1	0.6
Ptilotus sp. *Goldfields* (R. Davis 10796)	0.1	0.2
Sclerolaena eriacantha	0.5	0.1
Tecticornia disarticulata	2	1.5

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
25	5	10

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR28

Photo Number: LGR28



Leonora Gold – LGR29

Site Details:

Described by: Brian Morgan

Date: 2/12/2016

Type: Relevé

MGA Zone: 51 358523 mE 6827958 mN

Environmental Variables:

Landform:

Slope: Level (0-3°)

Soils:

Soil Texture: Medium clay

Soil Colour: Red

Rock Type: Quartzite

Coarse Surface Particles:

Site coverage: 2-10

Size: 6-20,20-60

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle,Native,Rabbit

FLORA AND VEGETATION DATA

Description: *Eremophila platycalyx* subsp. *platycalyx, Acacia incurvaneura* and *Acacia tetragonophylla* low isolated trees over *Sida ectogama* and *Eremophila simulans* subsp. *simulans*, mid isolated shrubs over *Fimbristylis* sp., *Rhodanthe propinqua* and *Euphorbia drummondii* low forbland with Poaceae sp. and *Eragrostis pergracilis* low grassland

General Notes: Recorded when very dry

Species List

Species Name	Cover (%)	Height (m)
Acacia incurvaneura	0.5	3
Acacia tetragonophylla	0.5	2.8
Calandrinia creethiae	0.1	0.1
Eragrostis pergracilis	3	0.1
Eremophila platycalyx subsp. *platycalyx*	1	2.5
Eremophila simulans subsp. *simulans*	0.1	1
Euphorbia drummondii	1	0.05
Fimbristylis sp.	30	0.1

Species Name	Cover (%)	Height (m)
Goodenia occidentalis	0.1	0.1
Myriocephalus pygmaeus	1	0.1
POACEAE sp.	20	0.1
Rhodanthe propinqua	3	0.05
Sida ectogama	0.5	1.2

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
55	0	40

Veg Condition: Degraded

Fire Age: None

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR29

Photo Number: LGR29



Leonora Gold – LGR30

Site Details:

Described by: Sophie Fox

Date: 2/12/2016

Type: Relevé

MGA Zone: 51 361472 mE 6813841 mN

Environmental Variables:

Landform: Hill

Slope: Moderately inclined (5-15°)

Soils:

Soil Texture: Sandy loam

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: >90

Size: 60-200

Outcropping: <2

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: N/A

FLORA AND VEGETATION DATA

Description: *Casuarina pauper, Acacia aneura* and *Acacia caesaneura* low woodland over *Acacia ramulosa* var. *ramulosa, Scaevola spinescens* and *Sida ectogama* mid isolated shrubs over *Ptilotus obovatus, Eremophila oldfieldii* subsp. *angustifolia* and *Maireana triptera* low isolated shrubs over *Sclerolaena eriacantha* and *Sclerolaena densiflora* low isolated forbs

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	2	5
Acacia aneura	4	4
Acacia aptaneura	0.1	1
Acacia caesaneura	2	4
Acacia ramulosa var. *ramulosa*	1	2
Brunonia australis	0.1	0.1
Casuarina pauper	5	5
Eremophila latrobei subsp. *latrobei*	0.1	0.3
Eremophila oldfieldii subsp. *angustifolia*	0.5	0.6
Maireana sedifolia	0.1	1

Species Name	Cover (%)	Height (m)
Maireana tomentosa subsp. *tomentosa*	0.1	0.1
Maireana tomentosa subsp. *tomentosa*	0.1	0.1
Maireana triptera	0.5	0.1
Ptilotus obovatus	4	0.6
Ptilotus sp. *Goldfields* (R. Davis 10796)	0.1	0.2
Scaevola spinescens	0.1	1.2
Sclerolaena densiflora	0.5	0.1
Sclerolaena eriacantha	1	0.1
Sida ectogama	0.1	1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
5	5	10

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR30

Photo Number: LGR30



Leonora Gold – LGR31

Site Details:

Described by: Brian Morgan

Date: 2/12/2016

Type: Relevé

MGA Zone: 51 358557 mE 6827454 mN

Environmental Variables:

Landform:

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Ironstone,Quartzite,Shale

Coarse Surface Particles:

Site coverage: 50-90

Size: 20-60

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Acacia craspedocarpa, Acacia aneura* and *Acacia aptaneura* low woodland over *Acacia ramulosa* var. *ramulosa, Acacia tetragonophylla* and *Acacia aptaneura* tall open shrubland over *Eremophila simulans* subsp. *simulans* and *Sida ectogama* mid isolated shrubs over *Rhodanthe ? charsleyae*, *Cheilanthes sieberi* subsp. *sieberi* and *Aristida obscura* low isolated forbs and grasses

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	25	6.5
Acacia aptaneura	1	5
Acacia aptaneura	6	3.5
Acacia craspedocarpa	2	4
Acacia ramulosa var. *ramulosa*	5	3
Acacia tetragonophylla	3	3
Aristida obscura	1	0.3
Cheilanthes sieberi subsp. *sieberi*	5	0.2
Digitaria ? brownii	0.1	0.5
Duperreya commixta	0.1	1.4

Species Name	Cover (%)	Height (m)
Eragrostis pergracilis	0.1	0.3
Eremophila latrobei subsp. *latrobei*	0.1	0.2
Eremophila metallicorum	0.5	1.1
Eremophila platycalyx subsp. *platycalyx*	0.2	0.5
Eremophila simulans subsp. *simulans*	6	1.7
Goodenia occidentalis	0.1	0.1
POACEAE sp.	0.5	0.1
Podolepis ? kendallii	0.1	0.25
Psydrax rigidula	0.1	0.9
Psydrax suaveolens	0.1	4
Ptilotus obovatus	0.1	0.3
Rhodanthe ? charsleyae	4	0.2
Rhodanthe propinqua	15	0.2
Sida ectogama	0.2	1.5
Spartothamnella teucriiflora	0.1	0.6

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
33	20	45

Veg Condition: Excellent

Fire Age: None

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR31

Photo Number: LGR31



Leonora Gold – LGR32

Site Details:

Described by: Sophie Fox

Date: 2/12/2016

Type: Relevé

MGA Zone: 51 361784 mE 6815297 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 50-90

Size: 2-6,6-20

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: N/A

FLORA AND VEGETATION DATA

Description: *Acacia aneura, Grevillea berryana* and *Acacia incurvaneura* low woodland over *Acacia ramulosa* var. *ramulosa* tall isolated shrubs over *Acacia tetragonophylla* and *Scaevola spinescens* mid isolated shrubs over *Eremophila margarethae, Ptilotus schwartzii* subsp. *schwartzii* and *Sida ectogama* low isolated shrubs

General Notes: Lots of old drill tracks

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	4	4
Acacia incurvaneura	3	4
Acacia ramulosa var. *ramulosa*	2	2.5
Acacia tetragonophylla	1	1.2
Dodonaea rigida	0.1	1
Eremophila margarethae	1.5	1
Grevillea berryana	3	5
Psydrax rigidula	0.1	1

Species Name	Cover (%)	Height (m)
Ptilotus schwartzii var. *schwartzii*	0.5	0.4
Scaevola spinescens	1	1.1
Sida ectogama	0.1	1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
10	3	2

Veg Condition: Good

Fire Age: 5-15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR32

Photo Number: LGR32



Leonora Gold – LGR33

Site Details:

Described by: Brian Morgan

Date: 2/12/2016

Type: Relevé

MGA Zone: 51 358266 mE 6827216 mN

Environmental Variables:

Landform:

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 50-90

Size: 2-6,6-20

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle,Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia aneura, Acacia aptaneura* and *Acacia pteraneura* low woodland over *Acacia craspedocarpa* tall isolated shrubs over *Acacia tetragonophylla*, *Eremophila platycalyx* subsp. *platycalyx* and *Sida ectogama* mid isolated shrubs over *Eremophila metallicorum, Ptilotus obovatus* and *Scaevola spinescens* low sparse shrubland

General Notes: In unit, woodlands exist as open woodlands to scattered trees

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	9	6
Acacia aptaneura	2	5.5
Acacia craspedocarpa	3	2.4
Acacia pteraneura	7	4.4
Acacia tetragonophylla	0.1	1.3
Atriplex ? nummularia	0.5	1.1
Austrostipa elegantissima	0.1	0.5
Eremophila metallicorum	8	0.9

Species Name	Cover (%)	Height (m)
Eremophila platycalyx subsp. *platycalyx*	0.1	1.2
Marsdenia australis	0.1	0.7
Marsdenia australis	1	0.2
Ptilotus obovatus	2	0.4
Ptilotus sp. *Goldfields* (R. Davis 10796)	0.1	0.2
Scaevola spinescens	0.1	0.7
Sclerolaena densiflora	0.1	0.1
Sida ectogama	0.1	1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
75	5	10

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR33

Photo Number: LGR33



Leonora Gold – LGR34

Site Details:

Described by: Sophie Fox

Date: 2/12/2016

Type: Relevé

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 50-90

Size: 2-6,6-20

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle,Goat,Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia aneura, Acacia ramulosa* var. *ramulosa* and *Eremophila oldfieldii* subsp. *angustifolia* low woodland over *Acacia tetragonophylla, Eremophila platycalyx* subsp. *platycalyx* and *Hakea preissii* tall isolated shrubs over *Rhagodia drummondii, Sida ectogama* and *Scaevola spinescens* mid isolated shrubs over *Ptilotus obovatus, Maireana triptera* and *Enchylaena tomentosa* low isolated shrubs

General Notes: Old exploration tracks throughout

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	10	7
Acacia aptaneura	0.5	3
Acacia caesaneura	5	4
Acacia ramulosa var. *ramulosa*	7	6
Acacia tetragonophylla	3	3.5
Austrostipa nitida	0.1	0.1
Duperreya commixta	0.5	
Enchylaena tomentosa	1	1
Eremophila metallicorum	0.1	1.2

Species Name	Cover (%)	Height (m)
Eremophila metallicorum	0.1	2
Eremophila oldfieldii subsp. *angustifolia*	2	6
Eremophila oldfieldii subsp. *angustifolia*	0.1	1.2
Eremophila oldfieldii subsp. *angustifolia*	0.5	1
Eremophila platycalyx subsp. *platycalyx*	1	2.5
Hakea preissii	1	2
Maireana triptera	0.5	0.2
Psydrax rigidula	0.5	1.5
Ptilotus obovatus	3	0.6
Rhagodia drummondii	2	1.2
Rhodanthe sp.	0.1	0.1
Santalum lanceolatum	0.5	3
Santalum spicatum	1	5
Scaevola spinescens	1	1.2
Sclerolaena densiflora	0.5	0.1
Sida ectogama	3	1.1
Solanum cleistogamum	0.1	0.5
Solanum lasiophyllum	0.1	0.5

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
40	25	15

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR34

Photo Number: LGR34



Leonora Gold – LGR35

Site Details:

Described by: Brian Morgan

Date: 3/12/2016

Type: Relevé

MGA Zone: 51 357136 mE 6826939 mN

Environmental Variables:

Landform:

Slope: Moderately inclined (5-15°)

Soils:

Soil Texture: Clay loam

Soil Colour: Orange

Rock Type: Granite,Ironstone

Coarse Surface Particles:

Site coverage: 50-90

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

Outcropping: <2

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle,Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia craspedocarpa, Acacia aptaneura* and *Eremophila oldfieldii* subsp. *angustifolia* low open woodland over *Hakea preissii* mid isolated shrubs over *Ptilotus* sp. Goldfields, *Enneapogon caerulescens* and *Aristida contorta* low isolated forbs and grasses

General Notes: Middle of low broad hill

Species List

Species Name	Cover (%)	Height (m)
Acacia aptaneura	1	4
Acacia craspedocarpa	3	3.5
Aristida contorta	3	0.2
Atriplex codonocarpa	0.1	0.2
Austrostipa sp.	0.1	0.4
Cylindropuntia fulgida var. *mamillata*	0.1	0.3
Dissocarpus paradoxus	0.1	0.15
Dodonaea viscosa subsp. *viscosa*	0.1	0.6

Species Name	Cover (%)	Height (m)
Enchylaena tomentosa	0.1	0.35
Enneapogon caerulescens	2	0.2
Eragrostis kennedyae	0.5	0.4
Eremophila oldfieldii subsp. *angustifolia*	0.5	3.5
Hakea preissii	3	1.4
Maireana tomentosa subsp. *tomentosa*	0.1	0.2
Maireana triptera	1	0.3
Maireana triptera	2	0.5
Ptilotus aervoides	0.1	0.5
Ptilotus obovatus	0.1	0.4
Ptilotus sp. *Goldfields* (R. Davis 10796)	0.5	0.4
Rhagodia ? drummondii	0.1	0.9
Scaevola spinescens	0.1	0.9
Sclerolaena fusiformis	0.1	0.2
Sclerolaena lanicuspis	0.1	0.2
Sida calyxhymenia	0.1	0.5
Solanum lasiophyllum	0.1	0.3

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
50	2	20

Veg Condition: Very Good

Fire Age: None

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR35

Photo Number: LGR35



Leonora Gold – LGR36

Site Details:

Described by: Paul Bolton

Date: 2/12/2016

Type: Relevé

MGA Zone: 51 361717 mE 6814215 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 50-90

Size: 2-6,6-20

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: N/A

FLORA AND VEGETATION DATA

Description: *Acacia aneura, Acacia caesaneura, Eremophila platycalyx* subsp. *platycalyx* low woodland over *Acacia ramulosa* var. *ramulosa*, *Acacia craspedocarpa* and *Acacia tetragonophylla* tall sparse shrubland over *Eremophila margarethae, Ptilotus obovatus* and *Ptilotus schwartzii* low isolated shrubs

General Notes: Old exploration tracks

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	8	5
Acacia aptaneura	0.5	3
Acacia caesaneura	2	5
Acacia craspedocarpa	1	2
Acacia ramulosa var. *ramulosa*	5	2
Acacia tetragonophylla	1	2
Calandrinia sp. *Black angular seeds* (A.A. Mitchell PRP 1661)	0.1	0.1
Eremophila margarethae	2	0.5

Species Name	Cover (%)	Height (m)
Eremophila platycalyx subsp. *platycalyx*	2	3
Eriachne pulchella	0.1	0.1
Lemooria burkittii	0.1	0.1
Marsdenia australis	0.1	0
Podolepis lessonii	0.1	0.1
Ptilotus obovatus	0.1	0.4
Ptilotus schwartzii var. *schwartzii*	0.1	0.2
Solanum lasiophyllum	0.1	0.5
Spartothamnella teucriiflora	0.1	0.6

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
45	5	5

Veg Condition: Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR36

Photo Number: LGR36



Leonora Gold – LGR37

Site Details:

Described by: Brian Morgan

Date: 3/12/2016

Type: Relevé

MGA Zone: 51 358130 mE 6826314 mN

Environmental Variables:

Landform: Slope

Slope: Moderately inclined (5-15°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Shale

Coarse Surface Particles:

Site coverage: >90

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

Outcropping: 10-20

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: Old Mine Workings

Introduced species: N/A

FLORA AND VEGETATION DATA

Description: *Acacia burkittii* tall open shrubland over *Eremophila platycalyx* subsp. *platycalyx, Eremophila forrestii* subsp. *forrestii* and *Senna artemisioides* subsp. *artemisioides* mid isolated shrubs over *Ptilotus obovatus* low isolated shrubs, over *Aristida contorta* low isolated grasses

Species List

Species Name	Cover (%)	Height (m)
Acacia burkittii	1	3
Acacia burkittii	18	3.5
Aristida contorta	6	0.2
Eremophila forrestii subsp. *forrestii*	0.1	1.5
Eremophila metallicorum	0.1	0.4
Eremophila oldfieldii subsp. *angustifolia*	0.1	0.3
Eremophila platycalyx subsp. *platycalyx*	0.1	1.6
Ptilotus obovatus	3	0.4
Rumex vesicarius	0.1	0.3
Scaevola spinescens	0.1	1.4

Species Name	Cover (%)	Height (m)
Senna artemisioides subsp. *artemisioides*	0.5	1.2
Senna artemisioides subsp. *helmsii*	0.1	0.5

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
10	5	10

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR37

Photo Number: LGR37



Leonora Gold – LGR38

Site Details:

Described by: Paul Bolton

Date: 3/12/2016

Type: Relevé

MGA Zone: 51 360312 mE 6817502 mN

Environmental Variables:

Landform: Drainage Line

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Sand

Soil Colour: Brown

Rock Type: Sandstone

Coarse Surface Particles:

Site coverage: 50-90

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

Outcropping: >90

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle,Donkey

FLORA AND VEGETATION DATA

Description: *Acacia aneura, Acacia burkittii* and *Acacia craspedocarpa* low open woodland over G*revillea extorris, Acacia ramulosa* var. *ramulosa* and *Eremophila platycalyx* subsp. *platycalyx* mid isolated shrubs over *Monachather paradoxus* low isolated grasses

General Notes: Exposed bedrock of conglomerate sandstone with shallow layer of alluvial sand and gravel.

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	1	4
Acacia burkittii	5	3
Acacia craspedocarpa	0.1	1
Acacia craspedocarpa	1	3
Acacia ramulosa var. *ramulosa*	1	2
Acacia tetragonophylla	0.5	3
Dodonaea rigida	0.1	0.5
Duperreya commixta	0.1	0

Species Name	Cover (%)	Height (m)
Eremophila alternifolia	0.1	1.2
Eremophila forrestii subsp. *forrestii*	0.1	0.5
Eremophila margarethae	0.1	0.5
Eremophila platycalyx subsp. *platycalyx*	0.5	1
Eriachne pulchella	0.1	0.1
Grevillea extorris	5	2.5
Marsdenia australis	0.1	0
Monachather paradoxus	0.5	0.3
Ptilotus helipteroides	0.1	0.4
Ptilotus roei	0.1	0.05
Rhodanthe sp.	0.1	0.1
Santalum spicatum	0.1	2.2
Senna manicula	0.1	1.2
Solanum lasiophyllum	0.1	0.3
Spartothamnella teucriiflora	0.1	0.6

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
10	5	5

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR38

Photo Number: LGR38



Leonora Gold – LGR39

Site Details:

Described by: Brian Morgan

Date: 4/12/2016

Type: Relevé

MGA Zone: 51 357974 mE 6830351 mN

Environmental Variables:

Landform: Alluvial Plain,Slope

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Quartzite

Coarse Surface Particles:

Site coverage: 20-50

Size: 6-20

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Acacia aneura, Acacia caesaneura* and *Acacia pteraneura* low open woodland over *Acacia ramulosa* var. *ramulosa* tall isolated shrubs over *Eremophila margarethae, Maireana tomentosa* and *Spartothamnella teucriflora* low isolated shrubs over *Eragrostis eriopoda* and *Monachather paradoxus* low isolated grasses

General Notes: Similar to LGR25 and LGR21; *Eremophila simulans* occurs in unit and *Grevillea berryana, Eremophila platycalyx* present in unit

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	2	3.5
Acacia caesaneura	3	6
Acacia pteraneura	6	5.5
Acacia ramulosa var. *ramulosa*	1	2.4
Calandrinia sp.	0.01	0.05
Eragrostis eriopoda	0.1	0.4
Eremophila margarethae	1.5	0.5
Maireana tomentosa	0.1	0.5

Species Name	Cover (%)	Height (m)
Monachather paradoxus	0.1	0.4
Sida sp. *dark green fruits* (S. van Leeuwen 2260)	0.1	0.4
Spartothamnella teucriiflora	0.1	0.4

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
75	5	5

Veg Condition: Excellent

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR39

Photo Number: LGR39



Leonora Gold – LGR40

Site Details:

Described by: Paul Bolton

Date: 3/12/2016

Type: Relevé

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 50-90

Size: 2-6,6-20

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle,Donkey,Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia incurvaneura, Acacia caesaneura* tall open woodland over *Eremophila* spp., *Ptilotus obovatus* low scattered shrubs over herbs and grasses

Species List

Species Name	Cover (%)	Height (m)
Chrysocephalum puteale	0.1	0.5
Acacia incurvaneura		
Eremophila spp.		
Ptilotus obovatus		

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
30	5	5

Veg Condition:	Very Good	Fire Age:	>15
Weeds:	N/A	Fire Notes:	N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR40

Photo Number: LGR40



Leonora Gold – LGR41

Site Details:

Described by: Brian Morgan

Date: 4/12/2016

Type: Relevé

MGA Zone: 51 345906 mE 6798354 mN

Environmental Variables:

Landform: Alluvial Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 50-90

Size: 6-20

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: N/A

FLORA AND VEGETATION DATA

Description: *Acacia aneura, Acacia aptaneura* and *Acacia incurvaneura* low woodland over *Acacia tetragonophylla* and *Acacia incurvaneura* tall isolated shrubs over *Eremophila margarethae, Ptilotus schwartzii* and *Ptilotus obovatus* low isolated shrubs over *Monachather paradoxus* low isolated grasses

General Notes: Lots of regrowth due to past disturbance, condition variable throughout range

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	8	4
Acacia aptaneura	1	6
Acacia incurvaneura	9	5
Acacia incurvaneura	1	2.6
Acacia tetragonophylla	2	2.8
Calocephalus multiflorus	0.1	0.6
Eragrostis eriopoda	0.5	0.4
Eremophila georgei	0.1	1.5

Species Name	Cover (%)	Height (m)
Eremophila latrobei subsp. *latrobei*	0.1	1.3
Eremophila margarethae	5	1
Eremophila platycalyx subsp. *platycalyx*	0.1	0.8
Goodenia occidentalis	0.1	0.1
Marsdenia australis	0.1	1.2
Monachather paradoxus	0.2	0.3
Psydrax suaveolens	0.1	0.7
Ptilotus obovatus	0.1	0.4
Ptilotus schwartzii	0.5	0.3
Santalum acuminatum	0.1	1.7
Scaevola spinescens	0.1	1.5
Sida sp. *dark green fruits* (S. van Leeuwen 2260)	0.1	0.3
Solanum lasiophyllum	0.1	0.3
Spartothamnella teucriiflora	0.1	0.4

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
60	5	10

Veg Condition: Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR41

Photo Number: LGR41



Leonora Gold – LGR42

Site Details:

Described by: Paul Bolton

Date: 3/12/2016

Type: Relevé

MGA Zone: 51 358966 mE 6819342 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Sandy loam

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: >90

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

Outcropping: 2-10

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Donkey

FLORA AND VEGETATION DATA

Description: *Acacia incurvaneura* and *Acacia quadrimarginea* low open woodland over *Acacia tetragonophylla*, *Scaevola spinescens* and *Eremophila* spp. low open shrubland over *Triodia schwartzii* and *Ptilotus obovatus* scattered shrubs

Species List

Species Name	Cover (%)	Height (m)
Cheilanthes sieberi subsp. *sieberi*		
Eremophila metallicorum		

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
16	2	2

Veg Condition:	Very Good	Fire Age:	>15
Weeds:	N/A	Fire Notes:	N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR42

Photo Number: LGR42



Leonora Gold – LGR43

Site Details:

Described by: Brian Morgan

Date: 4/12/2016

Type: Relevé

MGA Zone: 51 345486 mE 6798380 mN

Environmental Variables:

Landform: Drainage Line

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Ironstone,Quartzite

Coarse Surface Particles:

Site coverage: 2-10

Size: 2-6,6-20

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle,Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia caesaneura* and *Acacia* aneura low open forest over *Eremophila glandulifera* and *Eremophila georgei* mid isolated shrubs over *Sida ectogama* and *Eremophila glandulifera* low isolated shrubs over *Eragrostis pergracilis* low grassland

Species List

Species Name	Cover (%)	Height (m)
Abutilon cryptopetalum	0.1	0.2
Acacia aneura	15	6
Acacia aneura	4	5
Acacia caesaneura	20	6.5
Acacia tetragonophylla	1	2.3
Aristida obscura	0.1	0.35
Cheilanthes sieberi subsp. *sieberi*	3	0.3
Dianella revoluta var. *divaricata*	0.1	0.7
Eragrostis pergracilis	40	0.1
Eragrostis sp.	0.1	0.4
Eremophila alternifolia	0.1	0.6
Eremophila georgei	1	1

Species Name	Cover (%)	Height (m)
Eremophila glandulifera	2	0.7
Eremophila glandulifera	0.5	1.1
Eremophila latrobei subsp. *latrobei*	0.1	0.8
Eremophila pterocarpa subsp. *pterocarpa*	0.1	0.6
Gnephosis arachnoidea	1	0.2
Podolepis ? kendallii	0.1	0.3
Podolepis lessonii	0.1	0.2
Psydrax suaveolens	0.1	0.5
Ptilotus gaudichaudii var. *gaudichaudii*	0.1	0.3
Rhodanthe ? charsleyae	0.1	0.2
Rhodanthe propinqua	12	0.2
Sida ectogama	1	0.8
Sida sp. *dark green fruits* (S. van Leeuwen 2260)	0.1	0.4
Solanum lasiophyllum	0.1	0.3
Spartothamnella teucriiflora	0.1	0.5
Thyridolepis multiculmis	0.5	0.45
Thysanotus sp.	0.1	0.2

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
20	20	59

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR43

Photo Number: LGR43



Leonora Gold – LGR44

Site Details:

Described by: Paul Bolton

Date: 3/12/2016

Type: Relevé

MGA Zone: 51 358529 mE 6820222 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Sandy loam

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: >90

Size: 6-20,20-60

Outcropping: <2

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia aneura, Acacia caesaneura* tall open woodland over *Senna artemisioides* subsp. *filifolia*, *Maireana sedifolia* and *Ptilotus obovatus* low open shrubland over chenopods

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura		

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
5	5	5

Veg Condition: Excellent

Weeds: N/A

Fire Age: 5-15

Fire Notes: Dead branches

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR44

Photo Number: LGR44



Leonora Gold – LGR45

Site Details:

Described by: Brian Morgan

Date: 4/12/2016

Type: Relevé

MGA Zone: 51 344415 mE 6799209 mN

Environmental Variables:

Landform: Drainage Line

Slope: Level (0-3°)

Soils:

Soil Texture: Sandy loam

Soil Colour: Red

Rock Type: Ironstone,Quartzite

Coarse Surface Particles:

Site coverage: >90

Size: 2-6,6-20

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle,Rabbit

FLORA AND VEGETATION DATA

Description: Acacia caesaneura, Acacia *incurvaneura* and *Grevillea berryana* low woodland over *Eremophila georgei* mid isolated shrubs over *Eremophila glandulifera*, *Dianella revoluta* and *Spartothamnella teucriflora* low sparse shrubland over *Monachather paradoxus*, *Eragrostis eriopoda* and *Eragrostis pergracilis* low sparse tussock grassland

Species List

Species Name	Cover (%)	Height (m)
Acacia caesaneura	15	5
Acacia incurvaneura	8	5
Calandrinia creethiae	3	0.1
Cheilanthes sieberi subsp. *sieberi*	0.1	0.2
Cynanchum floribundum	0.1	0.8
Dianella revoluta	1	0.8
Eragrostis eriopoda	0.1	0.4
Eragrostis pergracilis	0.1	0.1
Eremophila georgei	2	1.5
Eremophila glandulifera	3	0.6

Species Name	Cover (%)	Height (m)
Eremophila glandulifera	2	0.8
Grevillea berryana	5	4
Monachather paradoxus	5	0.6
Psydrax suaveolens	0.1	4
Ptilotus schwartzii	0.1	0.4
Roebuckiella oncocarpa	0.1	0.3
Sida sp. *Excedentifolia* (J.L. Egan 1925)	0.1	0.5
Spartothamnella teucriiflora	1	0.6

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
75	5	15

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR45

Photo Number: LGR45



Leonora Gold – LGR46

Site Details:

Described by: Paul Bolton

Date: 3/12/2016

Type: Relevé

MGA Zone: 51 358158 mE 6823614 mN

Environmental Variables:

Landform: Escarpment

Slope: Moderately inclined (5-15°)

Soils:

Soil Texture: Sandy loam

Soil Colour: Grey

Rock Type: Ferricrete

Coarse Surface Particles:

Site coverage: >90

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

Outcropping: 10-20

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Donkey

FLORA AND VEGETATION DATA

Description: *Eucalyptus striaticalyx* and *Acacia aneura* low open woodland over *Eremophila scoparia* and *Eremophila glabra* subsp. *glabra* mid isolated shrubs over *Ptilotus obovatus*, *Scaevola spinescens* and *Lepidium platypetalum* low isolated shrubs

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	3	6
Eremophila glabra subsp. *glabra*	0.1	1
Eremophila scoparia	2	1.5
Eucalyptus striaticalyx	3	7
Grevillea acuaria	0.1	1
Gunniopsis propinqua	0.1	0.05
Lepidium platypetalum	0.1	0.5
Maireana trichoptera	0.1	0.01
Maireana triptera	0.1	0.3
Olearia muelleri	0.1	0.5

Species Name	Cover (%)	Height (m)
Petrophile pauciflora	0.1	0.2
Psydrax rigidula	0.1	0.4
Ptilotus helipteroides	0.1	0.05
Ptilotus obovatus	0.1	0.5
Ptilotus sp. *Goldfields* (R. Davis 10796)	0.1	0.1
Scaevola spinescens	0.1	0.6
Sclerolaena eriacantha	0.1	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
10	5	5

Veg Condition: Excellent

Fire Age: 3-5

Weeds: N/A

Fire Notes: Dead branches,Epicormic shoots

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR46

Photo Number: LGR46



Leonora Gold – LGR47

Site Details:

Described by: Brian Morgan

Date: 4/12/2016

Type: Relevé

MGA Zone: 51 344814 mE 6798776 mN

Environmental Variables:

Landform: Alluvial Plain,Drainage Line

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 50-90

Size: 6-20

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Acacia caesaneura* low open forest over *Acacia tetragonophylla* tall isolated shrubs over *Eremophila margarethae, Eremophila georgei* and *Eremophila latrobei* subsp. latrobei low isolated shrubs over *Calandrinia creethiae* low isolated forbs

General Notes:

Species List

Species Name	Cover (%)	Height (m)
Acacia caesaneura	35	6.5
Acacia caesaneura	8	4.5
Acacia tetragonophylla	1.5	2.5
Aristida contorta	0.1	0.2
Calandrinia creethiae	4	0.1
Dianella revoluta	0.1	0.6
Eremophila georgei	0.1	1
Eremophila latrobei subsp. *latrobei*	0.1	1.3

Species Name	Cover (%)	Height (m)
Eremophila margarethae	2	0.45
Eremophila platycalyx	0.1	0.8
Monachather paradoxus	0.1	0.3
Ptilotus obovatus	0.1	0.6
Ptilotus schwartzii	0.1	0.5
Sida sp. *dark green fruits* (S. van Leeuwen 2260)	0.1	0.6
Thyridolepis multiculmis	0.1	0.4

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
45	30	15

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR47

Photo Number: LGR47



Leonora Gold – LGR48

Site Details:

Described by: Paul Bolton

Date: 3/12/2016

Type: Relevé

MGA Zone: 51 358074 mE 6825793 mN

Environmental Variables:

Landform: Drainage Line

Slope: Level (0-3°)

Soils:

Soil Texture: Medium clay

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 20-50

Size: 20-60,60-200

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle,Donkey

FLORA AND VEGETATION DATA

Description: *Acacia craspedocarpa, Acacia aneura* and *Acacia caesaneura* low woodland over *Acacia tetragonophylla, Santalum acuminatum* and *Eremophila platycalyx* subsp. *platycalyx* tall isolated shrubs over *Ptilotus obovatus* low isolated shrubs over *Aristida contorta, Rhodanthe* sp. and *Podolepis ?kendallii* low forbs and grasses

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	10	6
Acacia caesaneura	6	8
Acacia craspedocarpa	6	5
Acacia tetragonophylla	2	4
Amyema miquelii	0.1	2
Aristida contorta	4	0.1
Calandrinia sp.	0.1	0.05
Enneapogon caerulescens	0.1	0.1
Eremophila latrobei subsp. *latrobei*	0.1	1.5
Eremophila margarethae	0.1	0.5

Species Name	Cover (%)	Height (m)
Eremophila platycalyx subsp. *platycalyx*	1	2
Hakea recurva subsp. *recurva*	0.1	1.5
Monachather paradoxus	0.1	0.1
Podolepis ? kendallii	2	0.1
Podolepis lessonii	0.5	0.1
Psydrax rigidula	0.1	1
Ptilotus obovatus	0.5	0.5
Rhodanthe sp.	2	0.1
Santalum spicatum	1	4
Sida ectogama	0.1	1
Solanum lasiophyllum	0.1	0.5
Spartothamnella teucriiflora	0.1	0.5

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
75	5	15

Veg Condition: Very Good

Fire Age: 5-15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR48

Photo Number: LGR48



Leonora Gold – LGR49

Site Details:

Described by: Brian Morgan

Date: 4/12/2016

Type: Relevé

MGA Zone: 51 344524 mE 6798682 mN

Environmental Variables:

Landform: Alluvial Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 20-50

Size: 2-6

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle,Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia aneura* and *Acacia aptaneura* low woodland over *Acacia ramulosa* var. *ramulosa* tall sparse shrubland over *Eremophila margarethae, Eremophila glandulifera* and *Eremophila georgei* low isolated shrubs over *Monachather paradoxus* and *Eragrostis eriopoda* low isolated tussock grasses

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	4	4.5
Acacia pteraneura	12	3.5
Acacia ramulosa var. *ramulosa*	6	2.3
Dianella revoluta	0.1	0.9
Eragrostis eriopoda	0.1	0.4
Eremophila georgei	0.1	0.5
Eremophila glandulifera	0.1	0.8
Eremophila margarethae	1	0.7
Monachather paradoxus	1	0.4
Ptilotus schwartzii	0.1	0.4

Species Name	Cover (%)	Height (m)
Sida sp. *dark green fruits* (S. van Leeuwen 2260)	0.1	0.3

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
8	2	5

Veg Condition: Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR49

Photo Number: LGR49



Leonora Gold – LGR50

Site Details:

Described by: Paul Bolton

Date: 4/12/2016

Type: Relevé

MGA Zone: 51 361716 mE 6814865 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Sandy loam

Soil Colour: Brown

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 20-50

Size: 2-6,6-20

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia aneura* and *Acacia caesaneura* low woodland over *Acacia ramulosa* var. *ramulosa* tall isolated shrubs over *Eremophila margarethae*, *Eremophila georgei* and *Eremophila forrestii* subsp. *forrestii* mid open shrubland over *Eragrostis eriopoda* and *Monachather paradoxus* low isolated tussock grasses

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	10	6
Acacia caesaneura	10	4
Acacia ramulosa var. *ramulosa*	4	2.2
Eragrostis eriopoda	2	0.3
Eremophila forrestii subsp. *forrestii*	10	1
Eremophila georgei	1	1.1
Eremophila margarethae	2	1.2
Grevillea berryana	0.1	6
Monachather paradoxus	1	0.2
Ptilotus drummondii	0.1	1

Species Name	Cover (%)	Height (m)
Senna charlesiana	0.1	1.5
Solanum lasiophyllum	0.1	0.5

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
70	3	3

Veg Condition: Very Good

Fire Age: 5-15

Weeds: N/A

Fire Notes: Dead branches

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR50

Photo Number: LGR50



Leonora Gold – LGR51

Site Details:

Described by: Brian Morgan

Date: 4/12/2016

Type: Relevé

MGA Zone: 51 344193 mE 6799144 mN

Environmental Variables:

Landform: Alluvial Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: >90

Size: 2-6

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Acacia incurvaneura* and *Acacia caesaneura* low woodland over *Acacia ramulosa* var. *ramulosa* tall isolated shrubs over *Eremophila forrestii* subsp. *forrestii*, *Eremophila georgei* and *Eremophila margarethae* mid sparse shrubland over *Monachather paradoxus* low isolated tussock grasses

Species List

Species Name	Cover (%)	Height (m)
Acacia caesaneura	4	5
Acacia incurvaneura	12	6
Acacia incurvaneura	1	5
Acacia ramulosa var. *ramulosa*	5	2.4
Dianella revoluta	0.1	0.4
Eremophila forrestii subsp. *forrestii*	8	1.6
Eremophila georgei	0.1	1.1
Eremophila margarethae	0.1	0.6
Maireana convexa	0.1	1
Monachather paradoxus	4	0.3

Species Name	Cover (%)	Height (m)
Rhagodia drummondii	0.1	1.5

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
10	10	15

Veg Condition: Very Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR51

Photo Number: LGR51



Leonora Gold – LGR52

Site Details:

Described by: Paul Bolton

Date: 4/12/2016

Type: Relevé

MGA Zone: 51 364886 mE 6816212 mN

Environmental Variables:

Landform: Hill

Slope: Level (0-3°)

Soils:

Soil Texture: Sandy loam

Soil Colour: Brown

Rock Type: Basalt

Coarse Surface Particles:

Site coverage: 50-90

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

Outcropping: 10-20

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Rabbit

FLORA AND VEGETATION DATA

Description: *Acacia aneura* low open woodland over *Acacia ramulosa* var. *ramulosa*, *Acacia caesaneura* and *Acacia tetragonophylla* tall sparse shrubland over *Ptilotus obovatus*, *Senna* sp. Meekatharra and *Maireana sedifolia* mid sparse shrubland over *Maireana triptera*, *Eremophila latrobei* subsp. *latrobei* and *Ptilotus schwartzii* subsp. *schwartzii* low isolated shrubs over mixed low isolated forbs and grasses

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	4	5
Acacia caesaneura	1	2
Acacia ramulosa var. *ramulosa*	2	2.2
Acacia tetragonophylla	1	2
Aristida contorta	0.5	0.1
Dodonaea rigida	0.1	1
Enneapogon caerulescens	0.1	0.1
Eremophila latrobei var. *latrobei*	0.1	0.6
Eremophila platycalyx subsp. *platycalyx*	1	1.5
Maireana sedifolia	2	1.1

Species Name	Cover (%)	Height (m)
Maireana triptera	1	0.2
Ptilotus helipteroides	1	0.1
Ptilotus obovatus	5	1.1
Ptilotus schwartzii var. *schwartzii*	0.1	0.5
Ptilotus sp. *Goldfields* (R. Davis 10796)	0.1	0.1
Scaevola spinescens	1	1.5
Sclerolaena eriacantha	0.1	0.1
Senna sp. *Meekatharra* (E. Bailey 1-26)	1	1.2
Solanum lasiophyllum	0.1	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
5	2	3

Veg Condition: Good

Fire Age: 5-15

Weeds: N/A

Fire Notes: Dead branches

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR52

Photo Number: LGR52



Leonora Gold – LGR54

Site Details:

Described by: Brian Morgan

Date: 2/12/2016

Type: Relevé

MGA Zone: 51 358216 mE 6827735 mN

Environmental Variables:

Landform: Alluvial Plain,Floodplain

Slope: Level (0-3°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: >90

Size: 2-6,6-20

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Acacia craspedocarpa, Santalum acuminatum* and *Acacia caesaneura* low isolated trees over *Acacia tetragonophylla* and *Eremophila platycalyx* subsp. *platycalyx* tall isolated shrubs over Poaceae sp. low open grassland

General Notes: Area scrapped for topsoil.

Species List

Species Name	Cover (%)	Height (m)
Acacia caesaneura	3	2.8
Acacia craspedocarpa	3	2.2
Acacia tetragonophylla	1	2.5
Amyema preissii	0.1	3
Eragrostis pergracilis	0.1	0.1
Eremophila platycalyx subsp. *platycalyx*	0.5	2.3
Fimbristylis sp.	1	0.05
POACEAE sp.	15	0.15

Species Name	Cover (%)	Height (m)
Ptilotus obovatus	0.1	0.4
Santalum acuminatum	0.5	3.8

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
80	1	15

Veg Condition: Degraded

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR54

Photo Number: LGR54



Leonora Gold – LGR55

Site Details:

Described by: Brian Morgan

Date: 2/12/2016

Type: Relevé

MGA Zone: 51 358129 mE 6826749 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: N/A

Soil Colour:

Rock Type: N/A

Coarse Surface Particles:

Site coverage:

Size:

Outcropping:

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: N/A

FLORA AND VEGETATION DATA

Description: *Acacia aneura*, *Acacia pteraneura* and *Acacia caesaneura* low open woodland over *Acacia tetragonophylla*, *Scaevola spinescens* and *Eremophila oldfieldii* subsp. *angustifolia* mid isolated shrubs over *Eremophila metallicorum*, *Ptilotus obovatus* and *Sclerolaena densiflora* low isolated shrubs

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	3	3.5
Acacia caesaneura	2	2.6
Acacia pteraneura	2	4.6
Acacia tetragonophylla	1	1.7
Eremophila latrobei subsp. *latrobei*	0.1	0.5
Eremophila metallicorum	2	0.6
Eremophila oldfieldii subsp. *angustifolia*	0.1	1.2
Ptilotus obovatus	0.2	0.4
Scaevola spinescens	1	1.2
Sclerolaena densiflora	0.2	0.2

Species Name	Cover (%)	Height (m)
Sclerolaena diacantha	0.1	0.1
Senna artemisioides subsp. *helmsii*	0.1	0.6

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
N/A	N/A	N/A

Veg Condition:

Fire Age:

Weeds: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR55

Photo Number: LGR55



Leonora Gold – LGR56

Site Details:

Described by: Brian Morgan

Date: 3/12/2016

Type: Relevé

MGA Zone: 51 357026 mE 6626474 mN

Environmental Variables:

Landform: Drainage Line

Slope: Level (0-3°)

Soils:

Soil Texture: Medium clay

Soil Colour: Orange

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: <2

Size: 2-6,6-20

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Acacia craspedocarpa, Acacia caesaneura* and *Acacia tetragonophylla* low open forest over *Sida* sp. dark green fruits, *Eremophila metallicorum* and *Maireana georgei* low isolated shrubs over *Eragrostis kennedyae*, *Enneapogon caerulescens* and *Aristida contorta* low open tussock grassland

General Notes: Similar to LGR23, differs in cover of weeds and use by cattle

Species List

Species Name	Cover (%)	Height (m)
Acacia caesaneura	37	6
Acacia craspedocarpa	10	5
Acacia tetragonophylla	1.5	2.8
Aristida contorta	0.2	0.1
Calotis multicaulis	0.1	0.2
Centipeda minima	0.2	0.3
Cylindropuntia fulgida var. *mamillata*	0.1	0.4
Enchylaena tomentosa	0.1	0.7

Species Name	Cover (%)	Height (m)
Enneapogon caerulescens	2	0.3
Eragrostis kennedyae	25	0.4
Eremophila metallicorum	0.1	0.9
Eremophila platycalyx subsp. *platycalyx*	0.1	0.7
Maireana georgei	0.1	0.8
Psydrax rigidula	0.1	1.8
Ptilotus obovatus var. *obovatus*	1	0.4
Ptilotus roei	0.1	0.1
Rhodanthe ? charsleyae	1	0.4
Sida sp. *dark green fruits* (S. van Leeuwen 2260)	0.5	1
Sisymbrium irio	6	0.6
Vittadinia sulcata	0.1	0.3

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
20	20	60

Veg Condition: Good

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR56

Photo Number: LGR56



Leonora Gold – LGR57

Site Details:

Described by: Brian Morgan

Date: 3/12/2016

Type: Relevé

MGA Zone: 51 356831 mE 6826907 mN

Environmental Variables:

Landform: Slope

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Clay loam

Soil Colour: Orange

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: >90

Size: 2-6,6-20

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Cattle,Sheep

FLORA AND VEGETATION DATA

Description: *Acacia craspedocarpa, Acacia aneura* and *Acacia caesaneura* low woodland over *Sida ectogama* and *Acacia tetragonophylla* mid isolated shrubs over *Eremophila oldfieldii* subsp. *angustifolia*, *Ptilotus obovatus* and *Scaevola spinescens* low isolated shrubs over *Aristida contorta* and *Enneapogon caerulescens* low isolated grasses

General Notes: Was originally mapping note, but changed

Species List

Species Name	Cover (%)	Height (m)
Acacia aneura	5	3.5
Acacia caesaneura	2	4
Acacia craspedocarpa	5	4
Acacia pteraneura	1	3.5
Acacia tetragonophylla	0.5	1.2
Aristida contorta	1	0.2
Cynodon prostratus	0.1	0.2
Enneapogon caerulescens	2	0.2

Species Name	Cover (%)	Height (m)
Eremophila oldfieldii subsp. *angustifolia*	0.1	0.9
Eriachne pulchella	0.01	0.05
Hakea preissii	0.3	2.2
Maireana georgei	0.1	0.4
Maireana tomentosa subsp. *tomentosa*	0.1	0.25
Ptilotus obovatus	0.25	0.5
Ptilotus roei	2.5	0.1
Scaevola spinescens	0.25	0.8
Sclerolaena densiflora	0.1	0.15
Sclerolaena densiflora	0.1	0.1
Sida ectogama	0.1	1.1
Sida sp. *dark green fruits* (S. van Leeuwen 2260)	0.1	0.5

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
20	2	18

Veg Condition: Excellent

Fire Age: >15

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR57

Photo Number: LGR57



Leonora Gold – LGR58

Site Details:

Described by: Brian Morgan

Date: 3/12/2016

Type: Relevé

MGA Zone: 51 357160 mE 6827720 mN

Environmental Variables:

Landform:

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Clay loam

Soil Colour:

Rock Type: Granite,Ironstone

Coarse Surface Particles:

Site coverage:

Size: N/A

Outcropping: 0

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: N/A

Introduced species: Rabbit

FLORA AND VEGETATION DATA

Description: *Eremophila platycalyx* subsp. *platycalyx* mid isolated shrubs over *Ptilotus obovatus* and *Maireana carnosa* low isolated shrubs over *Enneapogon caerulescens* and *Aristida contorta* low open grassland

Species List

Species Name	Cover (%)	Height (m)
Aristida contorta	3	0.3
Atriplex codonocarpa	0.1	0.2
Enneapogon caerulescens	12	0.3
Eragrostis dielsii	2	0.05
Eremophila platycalyx	1	1.9
Maireana carnosa	1	0.1
Maireana georgei	0.1	0.3
Maireana triptera	0.1	0.3
Cylindropuntia fulgida var. *mamillata**.	0.1	0.4
Ptilotus obovatus	2.5	0.4
Ptilotus roei	0.1	0.1

Species Name	Cover (%)	Height (m)
Ptilotus sp. *Goldfields* (R. Davis 10796)	0.1	0.3
Rhodanthe ? charsleyae	0.1	0.3
Sclerolaena lanicuspis	0.1	0.2
Solanum lasiophyllum	0.1	0.3

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
N/A	N/A	N/A

Veg Condition: Degraded

Fire Age: None

Weeds: N/A

Fire Notes: N/A

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR58

Photo Number: LGR58



Leonora Gold – LGR101

Site Details:

Described by: Megan Stone & Sophie Fox

Date: 10/05/2017

Type: Relevé

MGA Zone: 51 0363653 mE 6816998 mN

Environmental Variables:

Landform: Floodplain

Slope: Level (0-3°)

Soils:

Soil Texture: Cracking Clay

Soil Colour: Orange

Rock Type: Basalt, Quartzite

Coarse Surface Particles:

Site coverage: 2-10%

Size: 2-60 mm

Outcropping: 0%

FLORA AND VEGETATION DATA

Description: *Maireana pyramidata* and *Tecticornia disarticulata* low shrubland over *Sclerolaena densiflora* isolated dwarf chenopod shrubs with Poaceae sp. low sparse tussock grassland

Species List

Species Name	Height (m)	Cover (%)
Acacia tetragonophylla	1.2	0.1
Aristida contorta	0.1	0.1
Atriplex codonocarpa	0.1	0.1
Cynodon prostratus	0.05	0.1
Dactyloctenium radulans	0.05	0.1
Duperreya commixta	1	0.1
Enneapogon caerulescens var. *caerulescens*	0.1	0.1
Eragrostis dielsii	0.05	0.1
Maireana pyramidata	1	5
Eremophila oldfieldii subsp. *angustifolia*	1.6	1
Santalum acuminatum	3	0.1
Scaevola spinescens	1.2	1
Sclerolaena cuneata	0.1	0.1
Sclerolaena densiflora	0.2	0.1
Tecticornia disarticulata	1	5

Species Name	Height (m)	Cover (%)
Streptoglossa liatroides	0.05	0.1
Enteropogon ramosus	0.5	0.1
Ertagrostis caroli	0.2	0.1
Eragrostis eriopoda	0.3	1
Poaceae sp.	0.1	1.5
Lawrencia densiflora	0.05	0.1
Minuria cunninghamii	1	0.1
Pittosporum angustifolium	1.2	0.1
Acacia ? incurvaneura	3.5	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
76	0.1	20

Veg Condition: Excellent

Fire Age: Unknown (no evidence)

Weeds: none

Fire Notes:

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR101

Photo Number: LGR101



Leonora Gold – LGR102

Site Details:

Described by: Megan Stone & Sophie Fox

Date: 10/05/2017

Type: Relevé

MGA Zone: 51 0363520 mE 6816721 mN

Environmental Variables:

Landform: Plain

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Medium clay

Soil Colour: Orange

Rock Type: Basalt, Calcrete, Quartzite

Coarse Surface Particles:

Site coverage: 2-10%

Size: 2-200 mm

Outcropping: 0%

Impacts:

Waterlogging:

Inundation:

Flooding:

Erosion:

Human disturbance: Tracks

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Acacia inceana* subsp. *conformis* low open woodland over *Maireana sedifolia*, *Maireana pyramidata* and *Tecticornia disarticulata* mid to low shrubland over *Sclerolaena densiflora*, *Sclerolaena diacantha* and *Eriochiton sclerolaenoides* open dwarf chenopod shrubland with *Enneapogon caerulescens* and *Eragrostis dielsii* low sparse tussock grassland

Species List

Species Name	Height (m)	Cover (%)
Acacia inceana subsp. *conformis*	4	8
Aristida contorta	0.1	0.1
Enchylaena tomentosa	0.2	0.1
Enneapogon caerulescens	0.1	2
Eremophila scoparia	2	0.1
Euphorbia drummondii	0.05	0.1
Maireana pyramidata	1	2
Maireana sedifolia	1.5	10
Maireana tomentosa	0.3	0.1
Sclerolaena densiflora	0.2	1

Species Name	Height (m)	Cover (%)
Sclerolaena diacantha	0.1	0.1
Solanum lasiophyllum	0.1	0.1
Tecticornia disarticulata	1.5	10
Eragrostis dielsii	0.1	2
Chenopodium curvispicatum	0.5	0.1
Eriochiton sclerolaenoides	0.1	0.5

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
50	20	35

Veg Condition: Excellent

Fire Age: Unknown (no evidence)

Weeds: none

Fire Notes:

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR102

Photo Number: LGR102



Leonora Gold – LGR103

Site Details:

Described by: Megan Stone & Sophie Fox

Date: 10/05/2017

Type: Relevé

MGA Zone: 51 0363655 mE 6816601 mN

Environmental Variables:

Landform: Floodplain

Slope: Level (0-3°)

Soils:

Soil Texture: Cracking clay

Soil Colour: Orange

Rock Type: Basalt

Coarse Surface Particles:

Site coverage: <2%

Size: 2-20 mm

Outcropping: 0%

Impacts:

Waterlogging: Prone to flooding

Inundation:

Flooding:

Erosion:

Human disturbance: Tracks

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Maireana pyramidata* and *Tecticornia disarticulata* mid to low isolated chenopod shrubs

Species List

Species Name	Height (m)	Cover (%)
Maireana pyramidata	0.5	0.1
Tecticornia disarticulata	0.5	0.1
Enteropogon ramosus	0.2	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
98	0	1

Veg Condition:	Excellent	Fire Age:	Unknown (no evidence)
Weeds:	none	Fire Notes:	

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR103

Photo Number: LGR103



Leonora Gold – LGR104

Site Details:

Described by: Megan Stone & Sophie Fox

Date: 10/05/2017

Type: Relevé

MGA Zone: 51 0363247 mE 6816903 mN

Environmental Variables:

Landform: Floodplain

Slope: Level (0-3°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Orange

Rock Type: Basalt, Quartzite

Coarse Surface Particles:

Site coverage: 2-10%

Size: 2-20 mm

Outcropping: 0%

Impacts:

Waterlogging: Prone to flooding

Inundation:

Flooding:

Erosion:

Human disturbance: Grazing, feral trampling

Introduced species: cattle

FLORA AND VEGETATION DATA

Description: *Hakea preissii* low open woodland over *Cratystylis subspinesens* and *Maireana pyramidata* mid to low open shrubland over *Tecticornia disarticulata* low open chenopod shrubland

Species List

Species Name	Height (m)	Cover (%)
Acacia tetragonophylla	1.5	0.1
Aristida contorta	0.1	0.1
Atriplex codonocarpa	0.1	0.1
Cratystylis subspinescens	1.5	20
Duperreya commixta	1	0.1
Exocarpos aphyllus	3.5	0.1
Hakea preissii	3.5	2
Maireana pyramidata	1	15
Scaevola spinescens	1.5	0.1
Solanum lasiophyllum	0.2	0.1
Tecticornia disarticulata	0.6	15

Species Name	Height (m)	Cover (%)
Enteropogon ramosus	0.2	0.1
Eremophila youngii subsp. *youngii*	1	0.5
Sida calyxhymenia	0.1	1.1
Pittosporum angustifolium	2	01
Brachyscome ciliaris	0.1	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
35	0.1	65

Veg Condition: Excellent

Fire Age: >15 years

Weeds: none

Fire Notes: Dead branches

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR104

Photo Number: LGR104



Leonora Gold – LGR105

Site Details:

Described by: Megan Stone & Sophie Fox

Date: 11/05/2017

Type: Relevé

MGA Zone: 51 364385 mE 6812239 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Medium clay

Soil Colour: Red

Rock Type: Basalt, Quartzite

Coarse Surface Particles:

Site coverage: 20-50%

Size: 2-200 mm

Outcropping: 0%

Impacts:

Waterlogging: Prone to flooding

Inundation:

Flooding:

Erosion:

Human disturbance: Grazing, feral scats, feral trampling

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Maireana pyramidata* and *Tecticornia disarticulata* low chenopod shrubland over *Sclerolaena cuneata* isolated dwarf chenopod shrubs with *Aristida contorta*, *Enteropogon ramosus* and *Sporobolus actinocladus* isolated tussock grasses

Species List

Species Name	Height (m)	Cover (%)
Aristida contorta	0.1	1
Atriplex codonocarpa	0.05	0.1
Enneapogon caerulescens	0.1	0.1
Euphorbia drummondii	0.05	0.1
Maireana pyramidata	0.7	20
Sclerolaena cuneata	0.1	0.1
Solanum lasiophyllum	0.2	0.1
Tecticornia disarticulata	0.5	15
Enteropogon ramosus	0.2	0.5
Sporobolus actinocladus	0.1	0.5

Species Name	Height (m)	Cover (%)
Sida intricata	0.1	0.1
Maireana villosa	0.2	0.5
Enneapogon polyphyllus	0.2	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
25	0.1	35

Veg Condition: Excellent

Fire Age: Unknown (no evidence)

Weeds: none

Fire Notes:

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR105

Photo Number: LGR105



Leonora Gold – LGR106

Site Details:

Described by: Megan Stone & Sophie Fox

Date: 11/05/2017

Type: Relevé

MGA Zone: 51 364221 mE 6812448 mN

Environmental Variables:

Landform: Hill

Slope: Steep (15-45°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Basalt, Quartzite

Coarse Surface Particles:

Site coverage: 50-90%

Size: 2-200 mm

Outcropping: 0%

Impacts:

Waterlogging: Never

Inundation:

Flooding:

Erosion:

Human disturbance:

Introduced species:

FLORA AND VEGETATION DATA

Description: *Acacia ? resinimarginea* and *Acacia ramulosa* var. *ramulosa* low open woodland over *Eremophila forrestii* subsp. *forrestii* and *Maireana sedifolia* low open shrubland over *Aristida contorta* low open tussock grassland

Species List

Species Name	Height (m)	Cover (%)
Acacia sp.	2.5	0.1
Acacia ramulosa var. *ramulosa*	3	5
Acacia tetragonophylla	1.2	0.1
Aristida contorta	0.1	12
Cymbopogon ambiguus	0.5	0.1
Euphorbia drummondii	0.05	0.1
Maireana sedifolia	1.2	2
Prostanthera campbellii	1.4	0.1
Ptilotus aervoides	0.05	0.1
Ptilotus helipteroides	0.1	0.1

Species Name	Height (m)	Cover (%)
Ptilotus schwartzii	0.3	0.1
Scaevola spinescens	1.2	1
Senna artemisioides subsp. *filifolia*	0.5	0.1
Solanum lasiophyllum	0.3	0.1
Eremophila forrestii subsp. forrestii	1	15
Acacia ? resinimarginea	3	6
Senna cardiosperma	1.2	0.2
Chrysocephalum puteale	0.1	0.5
Maireana triptera	0.5	0.1
Zygophyllum ? compressum	0.1	0.1
Eremophila georgei	0.2	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
15	5	60

Veg Condition: Excellent

Fire Age: Unknown (no evidence)

Weeds: none

Fire Notes:

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR106

Photo Number: LGR106



Leonora Gold – LGR107

Site Details:

Described by: Megan Stone & Sophie Fox

Date: 11/05/2017

Type: Relevé

MGA Zone: 51 0365008 mE 6812561 mN

Environmental Variables:

Landform: Plain

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Clay loam

Soil Colour: Red

Rock Type: Basalt, Granite. Quartzite

Coarse Surface Particles:

Site coverage: 50-90%

Size: 2-600 mm

Outcropping: 0%

Impacts:

Waterlogging: never

Inundation:

Flooding:

Erosion:

Human disturbance:

Introduced species:

FLORA AND VEGETATION DATA

Description: *Acacia incurvaneura* low open woodland over *Eremophila latrobei*, *Solanum lasiophyllum* and *Ptilotus obovatus* low sparse shrubland over *Enneapogon caerulescens* low grassland over *Sclerolaena diacantha* isolated dwarf chenopod shrubs

Species List

Species Name	Height (m)	Cover (%)
Acacia incurvaneura	5	20
Aristida contorta	0.1	0.1
Digitaria brownii	0.5	0.1
Enneapogon caerulescens	0.1	50
Eremophila latrobei subsp. *latrobei*	1	2
Euphorbia drummondii	0.05	0.1
Maireana pyramidata	1	0.1
Maireana triptera	0.2	0.5
Portulaca oleracea	0.05	0.1
Ptilotus aervoides	0.05	0.1

Species Name	Height (m)	Cover (%)
Ptilotus helipteroides	0.1	0.1
Ptilotus obovatus	0.5	0.5
Sclerolaena diacantha	0.1	0.1
Solanum lasiophyllum	0.4	1
Sida calyxhymenia	0.2	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
20	5	70

Veg Condition: Excellent

Fire Age: > 15 years

Weeds: none

Fire Notes: Dead branches

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR107

Photo Number: LGR107



Leonora Gold – LGR108

Site Details:

Described by: Megan Stone & Sophie Fox

Date: 11/05/2017

Type: Relevé

MGA Zone: 51 0364909 mE 6812779 mN

Environmental Variables:

Landform: Drainage line

Slope: Level (0-3°)

Soils:

Soil Texture: Sandy loam

Soil Colour: Red

Rock Type: Basalt, granite, quartzite

Coarse Surface Particles:

Site coverage: 20-50%

Size: 2-60 mm

Outcropping: 0%

Impacts:

Waterlogging: Prone to flooding

Inundation:

Flooding:

Erosion:

Human disturbance: Grazing, feral trampling

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Acacia incurvaneura* and *Acacia caesaneura* low open woodland over mixed *Eremophila* and *Senna* species open shrubland over *Cymbopogon ambiguus*, *Enteropogon ramosus* and *Enneapogon caerulescens* grassland

Species List

Species Name	Height (m)	Cover (%)
Abutilon cryptopetalum	0.5	0.1
Acacia caesaneura	6	6
Acacia incurvaneura	6	8
Acacia tetragonophylla	1	0.1
Aristida contorta	0.1	4
Cynodon prostratus	0.05	0.1
Cymbopogon ambiguus	0.5	0.5
Digitaria brownii	0.2	2
Duperreya commixta	1	0.1
Enneapogon caerulescens	0.1	3

Species Name	Height (m)	Cover (%)
Eremophila forrestii	0.5	0.1
Eremophila longifolia	2	0.1
Eremophila oppositifolia	1.6	0.1
Euphorbia drummondii	0.05	0.1
Hibiscus burtonii	0.5	0.1
Nicotiana occidentalis	0.5	0.1
Paspalidium rarum	0.1	0.1
Podolepis capillaris	0.1	0.1
Ptilotus obovatus	0.2	0.1
Scaevola spinescens	1.6	1
Senna artemisioides subsp. *artemisioides*	1.5	0.1
Senna artemisioides subsp. *filifolia*	1	0.1
Solanum cleistogamum	0.2	0.1
Solanum lasiophyllum	0.2	0.1
Spartothamnella teucriiflora	1	0.1
Eremophila youngii subsp. *youngii*	4	1
Enteropogon ramosus	0.3	0.1
Eremophila serrulata	1	0.1
Brachyscome ciliaris	0.2	0.1
Glycine canescens	0.5	0.1
Eremophila oldfieldii subsp. *angustifolia*	1	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
20	5	50

Veg Condition: Excellent

Fire Age: > 15 years

Weeds: none

Fire Notes: Dead branches

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR108

Photo Number: LGR108



Leonora Gold – LGR109

Site Details:

Described by: Megan Stone & Sophie Fox

Date: 11/05/2017

Type: Relevé

MGA Zone: 51 0364675 mE 6813054 mN

Environmental Variables:

Landform: Plain

Slope: moderately inclined (5-15°)

Soils:

Soil Texture: Silty loam

Soil Colour: Red

Rock Type: Basalt, Ironstone

Coarse Surface Particles:

Site coverage: 20-50%

Size: 2-200 mm

Outcropping: 0%

Impacts:

Waterlogging: Never

Inundation:

Flooding:

Erosion:

Human disturbance: Feral trampling, tracks

Introduced species: Cattle, rabbit

FLORA AND VEGETATION DATA

Description: *Acacia sp.* tall low open woodland over *Maireana sedifolia* and *Eremophila scoparia* mid open shrubland over *Sclerolaena diacantha* sparse dwarf chenopod shrubland

Species List

Species Name	Height (m)	Cover (%)
Acacia tetragonophylla	0.2	0.1
Atriplex codonocarpa	0.1	0.1
Dissocarpus paradoxus	0.1	0.1
Enneapogon caerulescens	0.1	0.1
Eremophila oppositifolia	2	0.5
Eremophila scoparia	1.2	6
Euphorbia drummondii	0.05	0.1
Maireana sedifolia	1	6
Maireana triptera	0.2	0.1
Paspalidium sp.	0.1	0.1
Ptilotus obovatus	0.2	0.1

Species Name	Height (m)	Cover (%)
Scaevola spinescens	1	0.1
Sclerolaena cuneata	0.1	0.1
Sclerolaena diacantha	0.2	2
Senna artemisioides subsp. *filifolia*	0.5	0.1
Senna stowardii	1	0.1
Solanum cleistogamum	0.1	0.1
Solanum lasiophyllum	0.2	0.1
Vittadinia sulcata	0.3	0.1
Acacia sp.	6	10
Maireana villosa	0.2	1
Zygophyllum ? compressum	0.1	0.1
Sida intricata	1	0.1
Eriochiton sclerolaenoides	0.1	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
10	2	20

Veg Condition: Excellent

Fire Age: > 15 years

Weeds: none

Fire Notes: Dead branches

SITE PHOTOGRAPH

Project: Leonora Gold

Site: LGR109

Photo Number: LGR109



Leonora Gold – LGR110

Site Details:

Described by: Megan Stone & Sophie Fox

Date: 11/05/2017

Type: Relevé

MGA Zone: 51 0364451 mE 6813632 mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Red

Rock Type: Basalt, Quartzite

Coarse Surface Particles:

Site coverage: 20-50%

Size: 2-60 mm

Outcropping: 0%

Impacts:

Waterlogging: Never

Inundation:

Flooding:

Erosion:

Human disturbance: Tracks

Introduced species: Cattle

FLORA AND VEGETATION DATA

Description: *Hakea preissii* low open woodland over *Cratystylis subspinesens* and *Maireana pyramidata* low sparse shrubland over *Sclerolaena cuneata* and *Sclerolaena diacantha* isolated dwarf chenopod shrubs

Species List

Species Name	Height (m)	Cover (%)
Atriplex codonocarpa	0.1	0.1
Cynodon prostratus	0.05	0.1
Cratystylis subspinescens	1.5	5
Enneapogon caerulescens	0.1	1
Eragrostis dielsii	0.05	0.1
Eremophila platycalyx	2	0.1
Eremophila scoparia	1	0.1
Euphorbia drummondii	0.05	0.1
Frankenia setosa	0.1	0.1
Hakea preissii	2	2
Maireana glomerifolia	0.2	0.1
Maireana pyramidata	1	5
Maireana triptera	0.2	0.5

Species Name	Height (m)	Cover (%)
Sclerolaena cuneata	0.2	0.1
Sclerolaena diacantha	0.2	0.1
Solanum lasiophyllum	0.2	0.1
Tecticornia disarticulata	0.1	0.5
Maireana villosa	0.5	0.1
Enteropogon ramosus	0.2	0.1
Brachyscome ciliaris	0.1	0.1
Surreya diandra	0.2	0.1

Ground Cover (percent)

Bare soil	Litter	Perennial ground cover
25	1	20

Veg Condition: Excellent

Fire Age: > 15 years

Weeds: none

Fire Notes: Dead branches

SITE PHOTOGRAPH

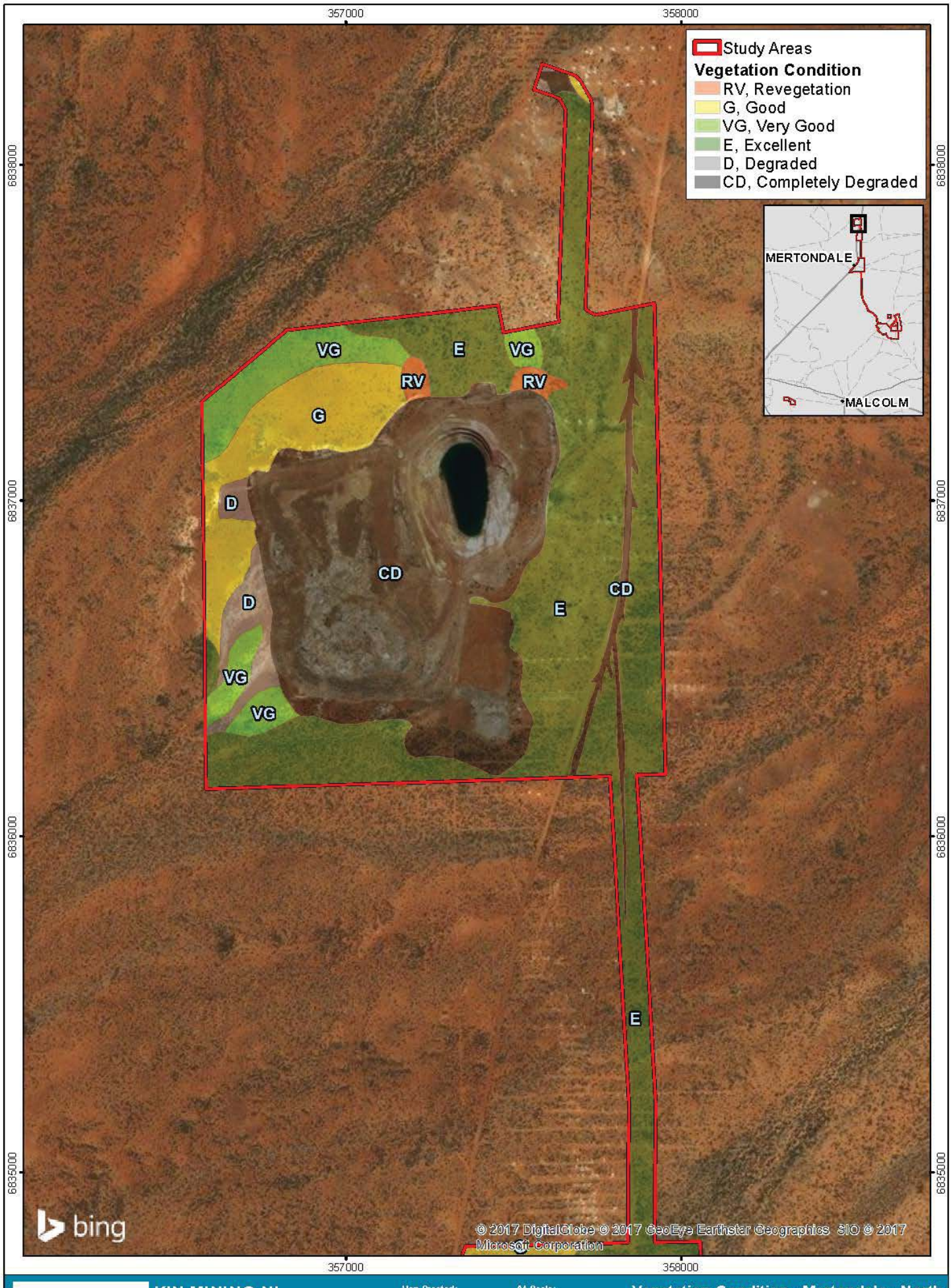
Project: Leonora Gold

Site: LGR110

Photo Number: LGR110



Appendix E Vegetation Condition of the Study Area



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LEONORA GOLD PROJECT

Map Created: 8/06/2017 cthatcher

Coordinate System: GDA 1994 MGA Zone 51

A4 Scale: 1:14,000

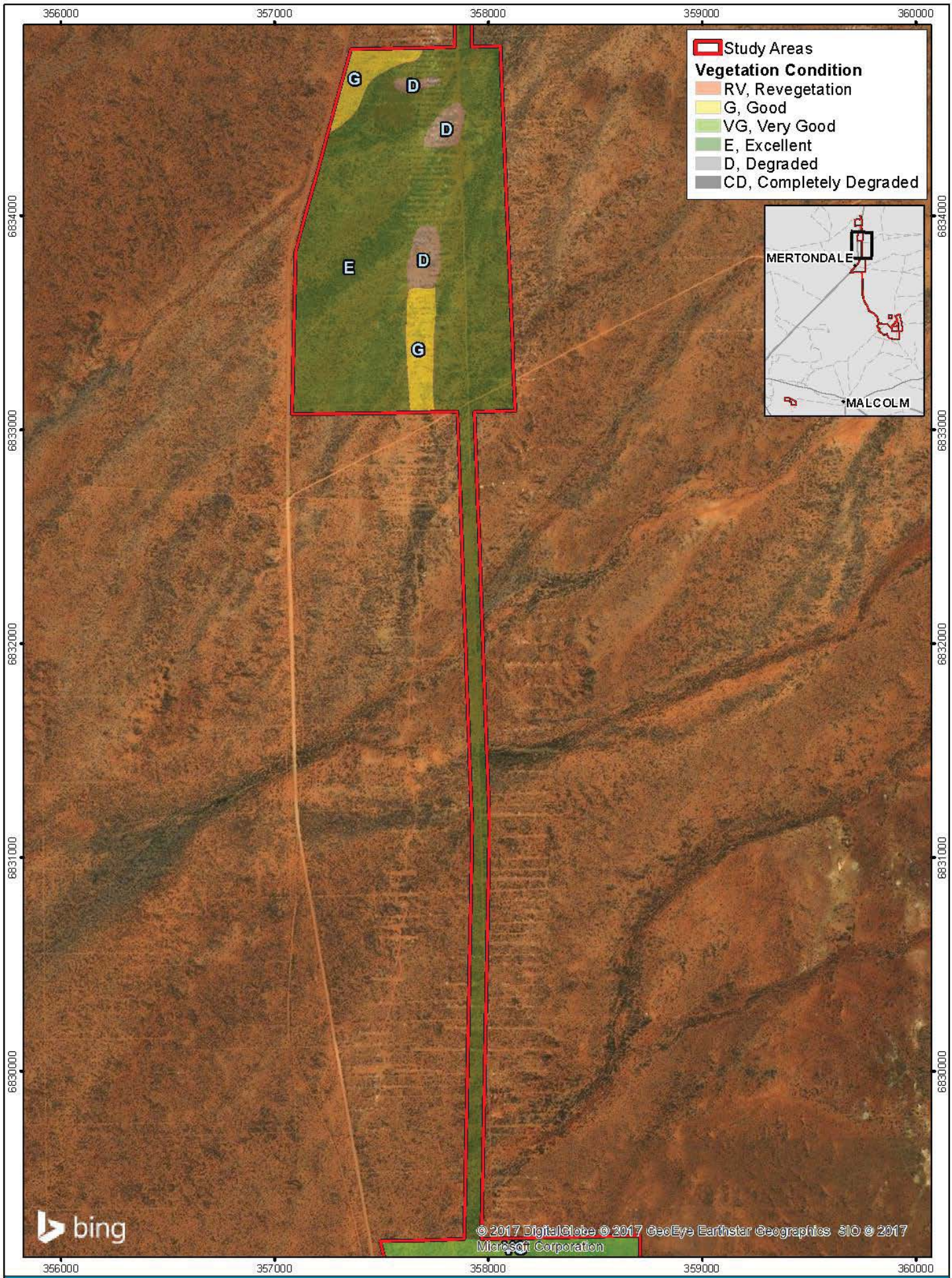
File Name: LEON_FS_VegCond_v2

Vegetation Condition - Mertondale - North

0 250 500 m

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LEONORA GOLD PROJECT

Map Created: 8/06/2017 cthatcher

Coordinate System: GDA 1994 MGA Zone 51

A4 Scale: 1:22,000

File Name: LEON_FS_VegCond_v2

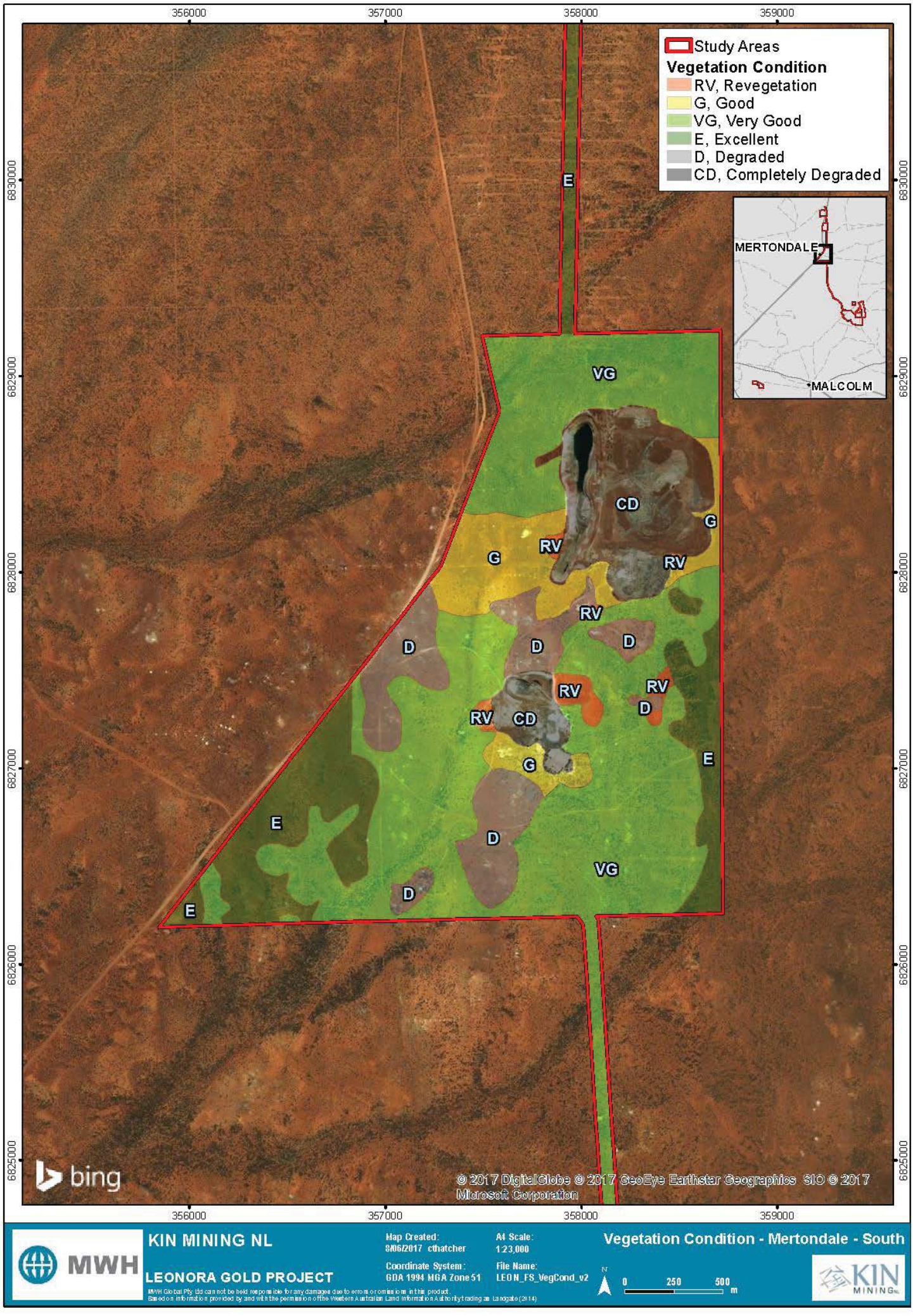
Vegetation Condition - Mertondale - Central

N

0 250 500 m

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LEONORA GOLD PROJECT

Map Created: 8/06/2017 cthatcher

Coordinate System: GDA 1994 MGA Zone 51

A4 Scale: 1:23,000

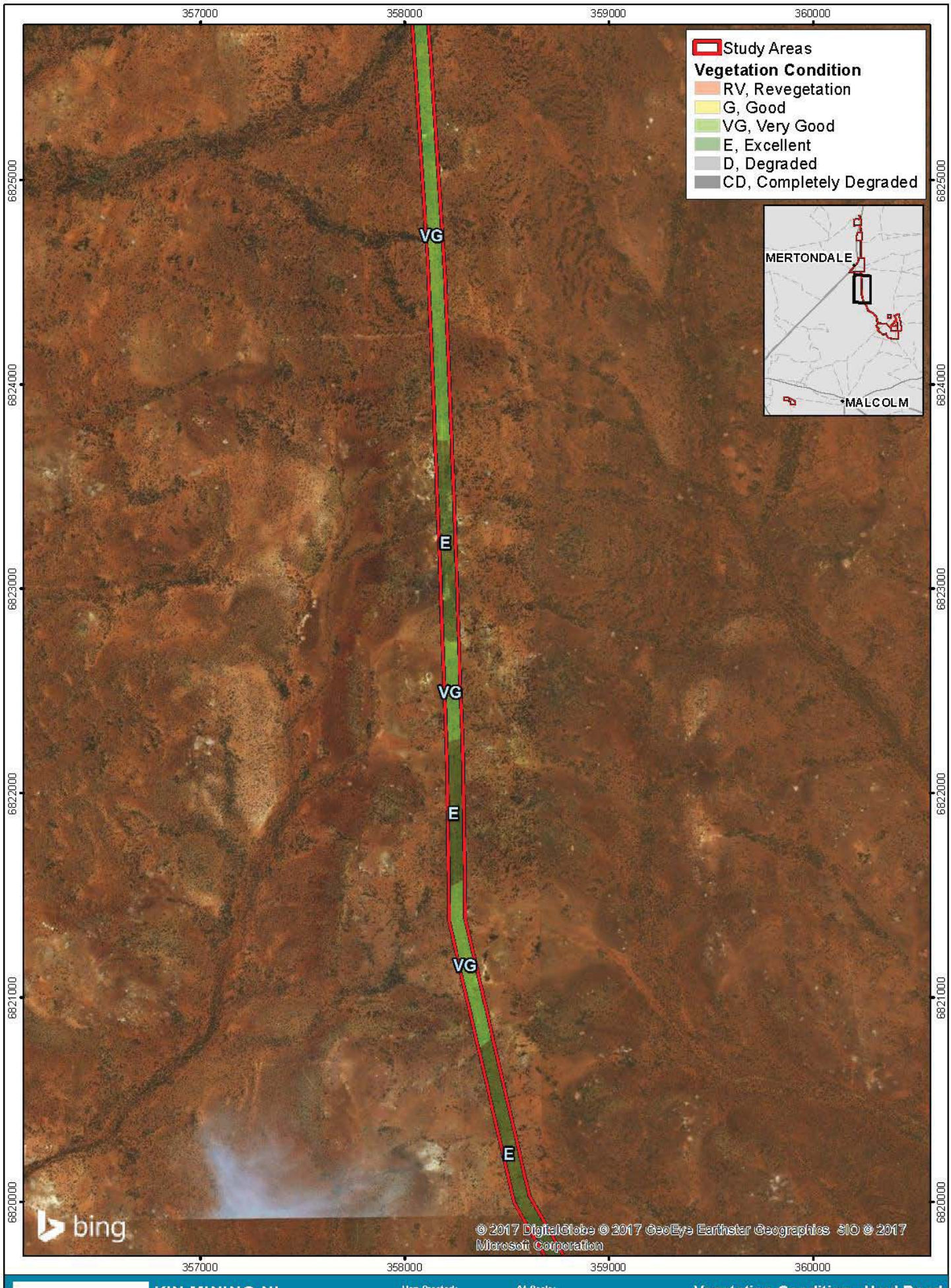
File Name: LEON_FS_VegCond_v2

Vegetation Condition - Mertondale - South

0 250 500 m

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LEONORA GOLD PROJECT

Map Created: 8/06/2017 cthatcher

Coordinate System: GDA 1994 MGA Zone 51

A4 Scale: 1:23,000

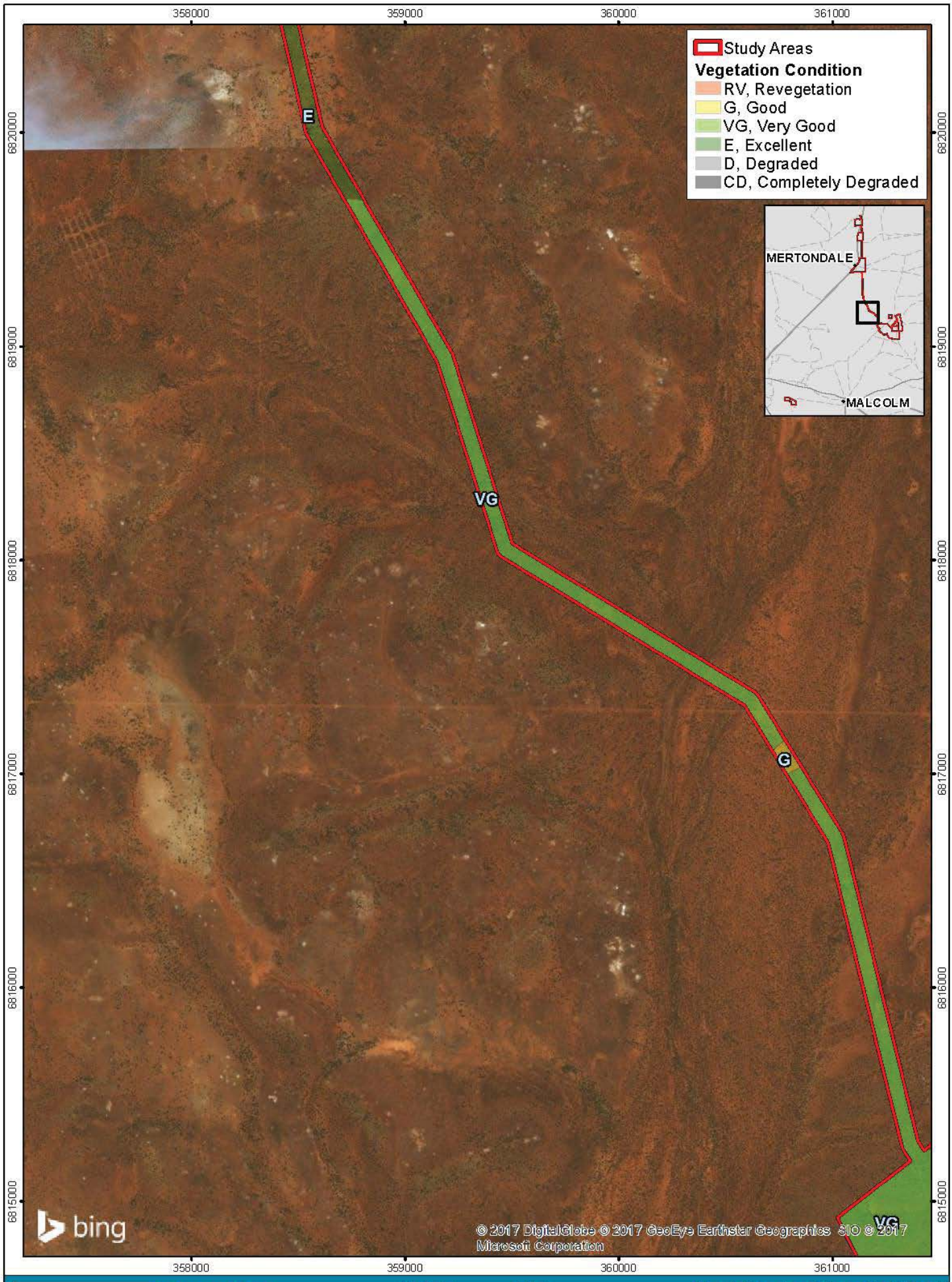
File Name: LEON_FS_VegCond_v2

0 250 500 m

Vegetation Condition - Haul Road

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Coordinate System: GDA 1994 MGA Zone 51

A4 Scale: 1:22,000

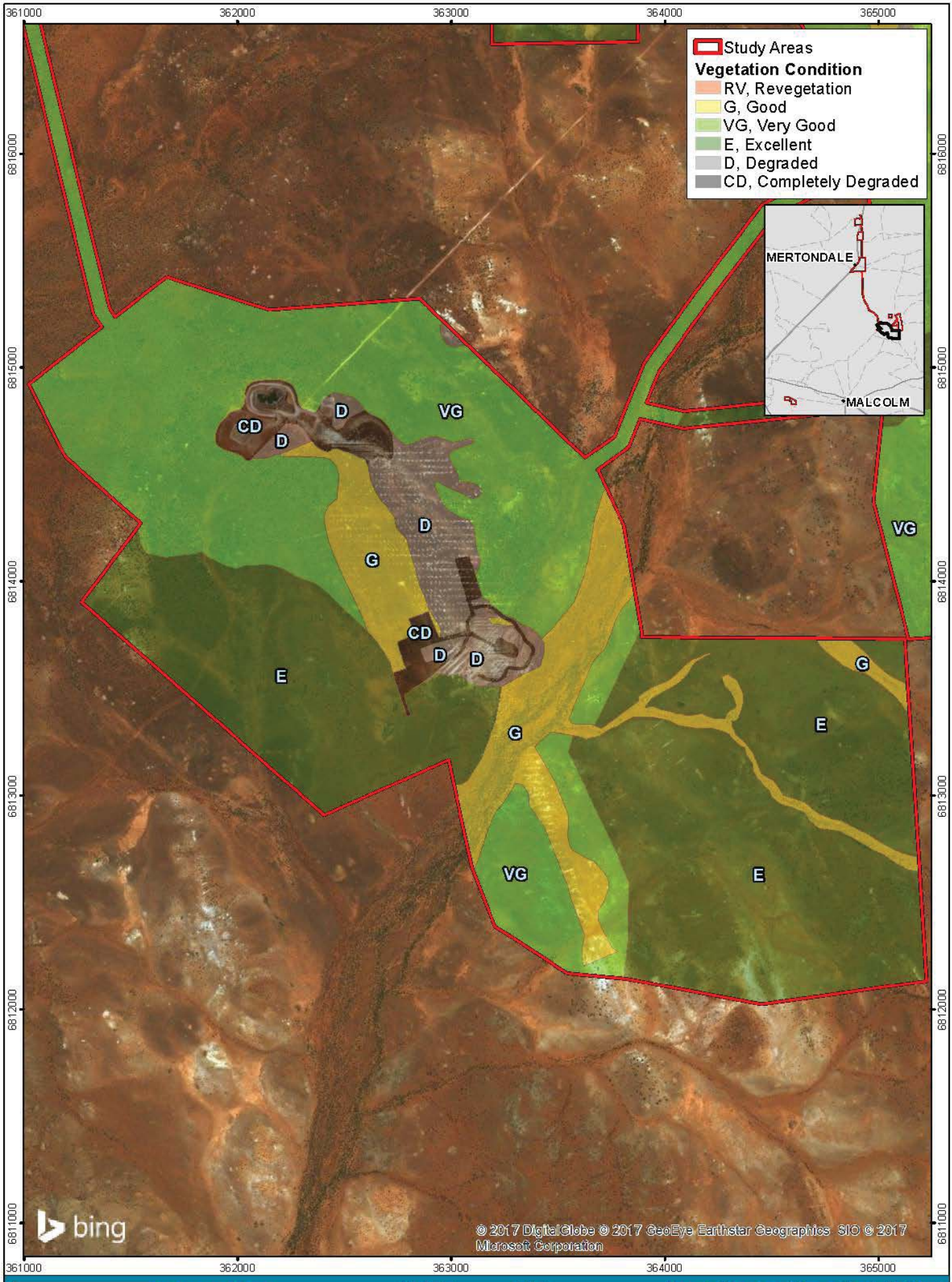
File Name: LEON_FS_VegCond_v2

0 250 500 m

Vegetation Condition - Haul Road

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LEONORA GOLD PROJECT

Map Created: 8/06/2017 cthatcher

Coordinate System: GDA 1994 MGA Zone 51

A4 Scale: 1:22,000

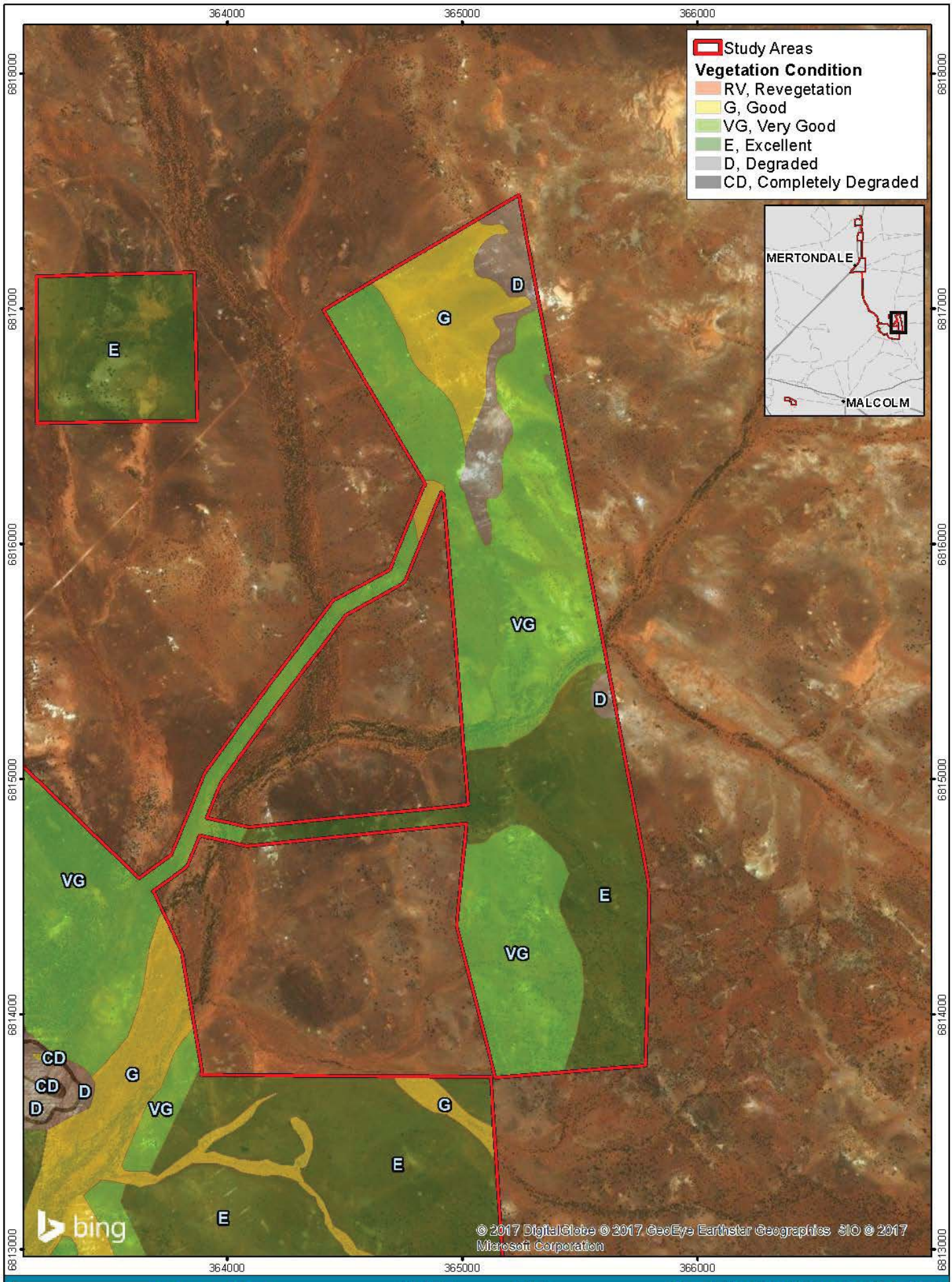
File Name: LEON_FS_VegCond_v2

0 250 500 m

Vegetation Condition - Cardinia West

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LEONORA GOLD PROJECT

Map Created: 8/06/2017 cthatcher

Coordinate System: GDA 1994 MGA Zone 51

A4 Scale: 1:20,000

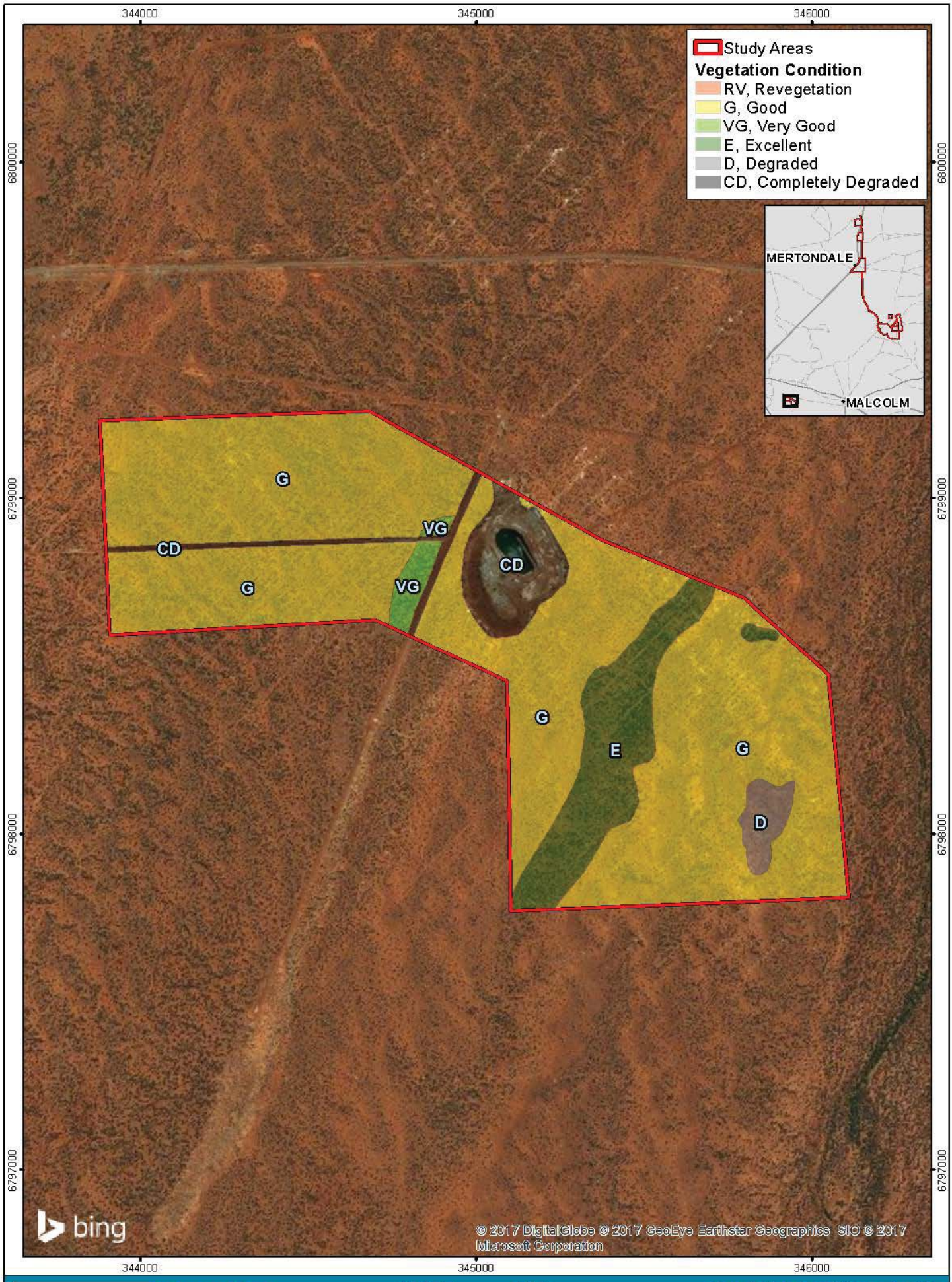
File Name: LEON_FS_VegCond_v2

Vegetation Condition - Cardinia East

0 250 500 m

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LEONORA GOLD PROJECT

Map Created: 8/06/2017 cthatcher

Coordinate System: GDA 1994 MGA Zone 51

A4 Scale: 1:14,000

File Name: LEON_FS_VegCond_v2

Vegetation Condition - Raeside

0 250 500 m

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Appendix F Vegetation Units of the Study Area



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LEONORA GOLD PROJECT

Map Created: 8/06/2017 cthatcher

A4 Scale: 1:14,000

Coordinate System: GDA 1994 MGA Zone 51

File Name: LEON_FS_VegUnits

Vegetation Units - Mertondale - North

N

0 250 500 m

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LEONORA GOLD PROJECT

Map Created: 8/06/2017 cthatcher

A4 Scale: 1:22,000

Coordinate System: GDA 1994 MGA Zone 51

File Name: LEON_FS_VegUnits

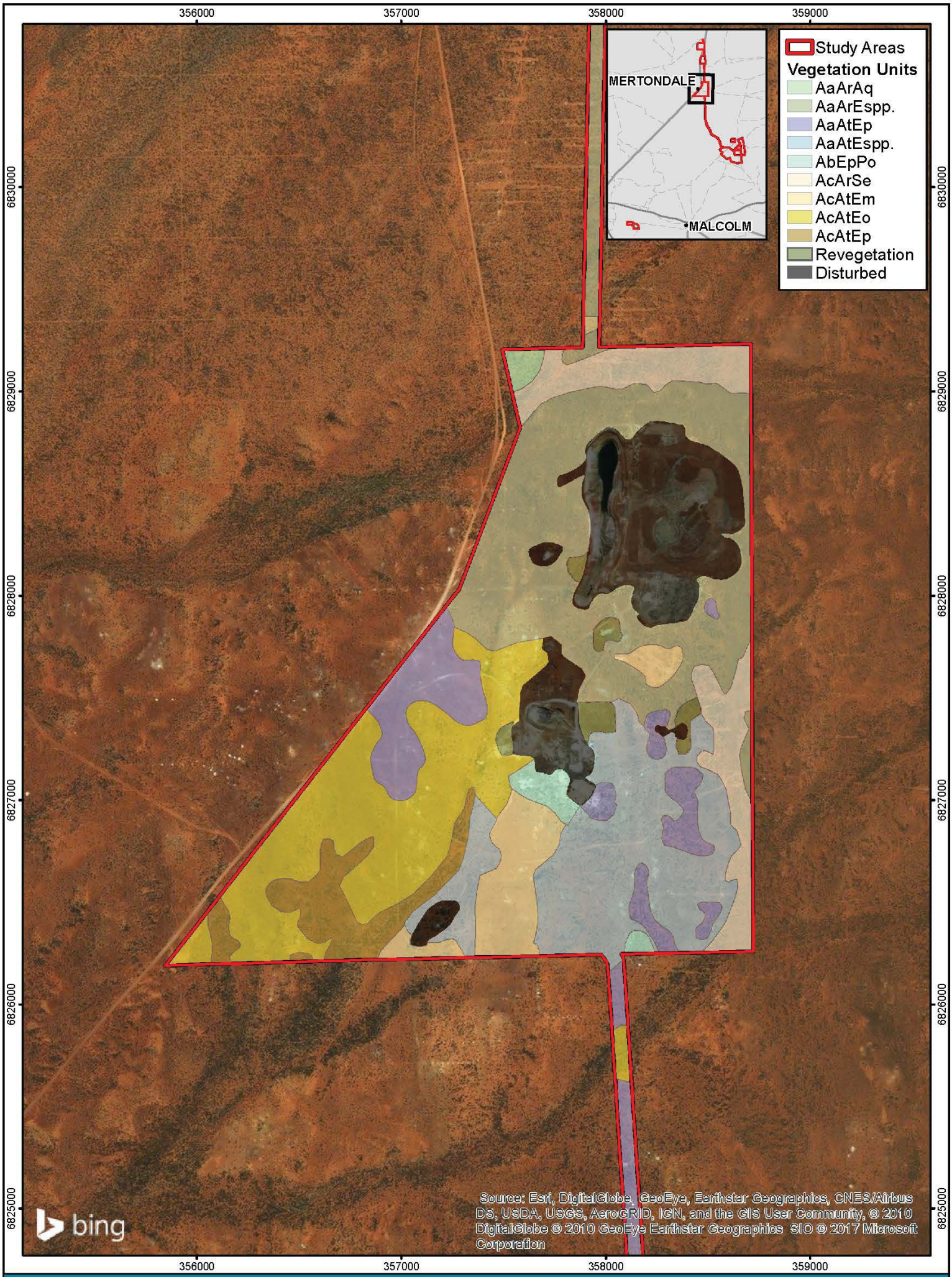
Vegetation Units - Mertondale - Central

N

0 250 500 m

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LEONORA GOLD PROJECT

Map Created: 8/06/2017 cthatcher

A4 Scale: 1:23,000

Coordinate System: GDA 1994 MGA Zone 51

File Name: LEON_FS_VegUnits

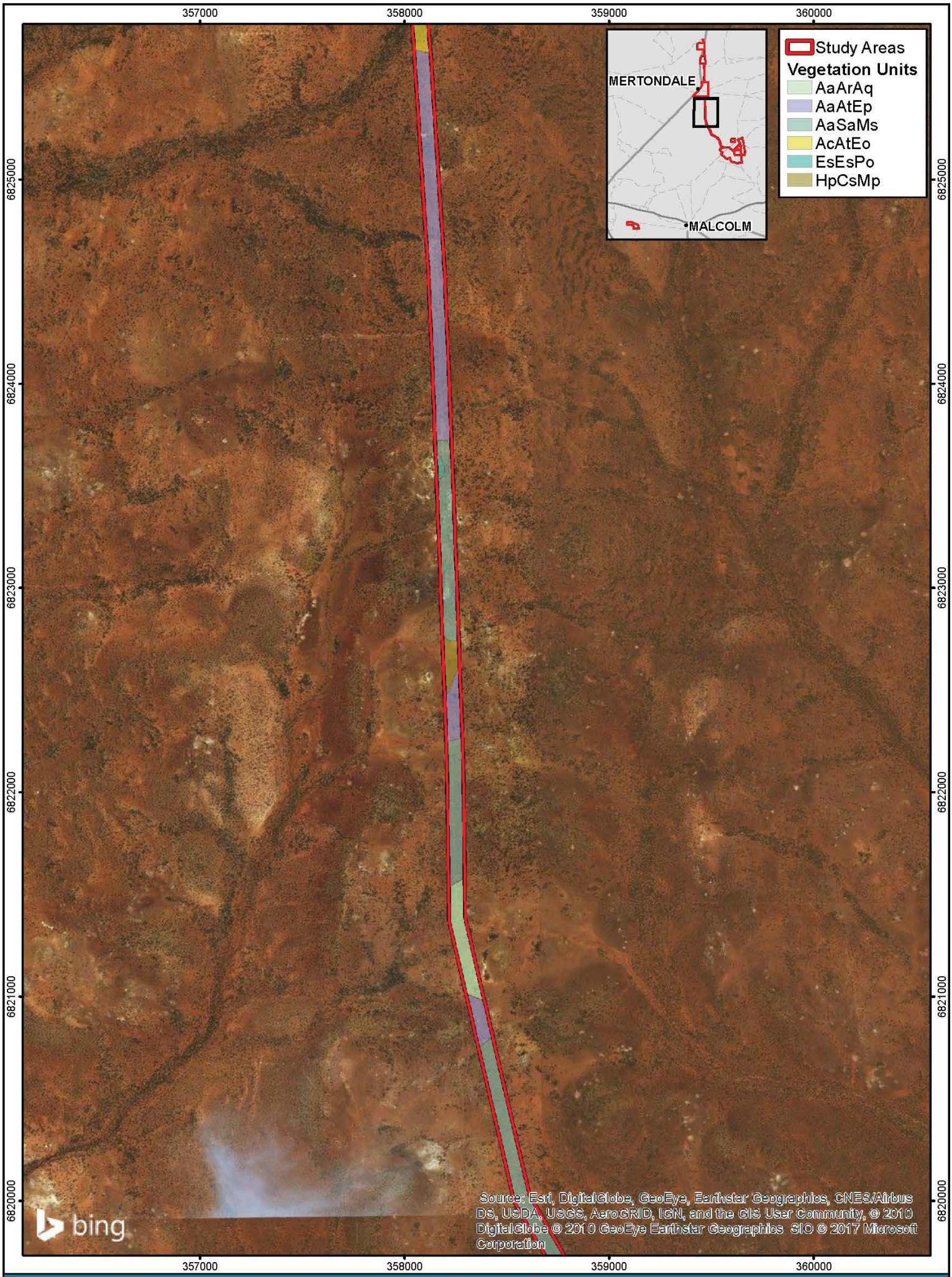
Vegetation Units - Mertondale - South

N

0 250 500 m

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LEONORA GOLD PROJECT

Map Created: 8/06/2017 cthatcher

A4 Scale: 1:23,000

Coordinate System: GDA 1994 MGA Zone 51

File Name: LEON_FS_VegUnits

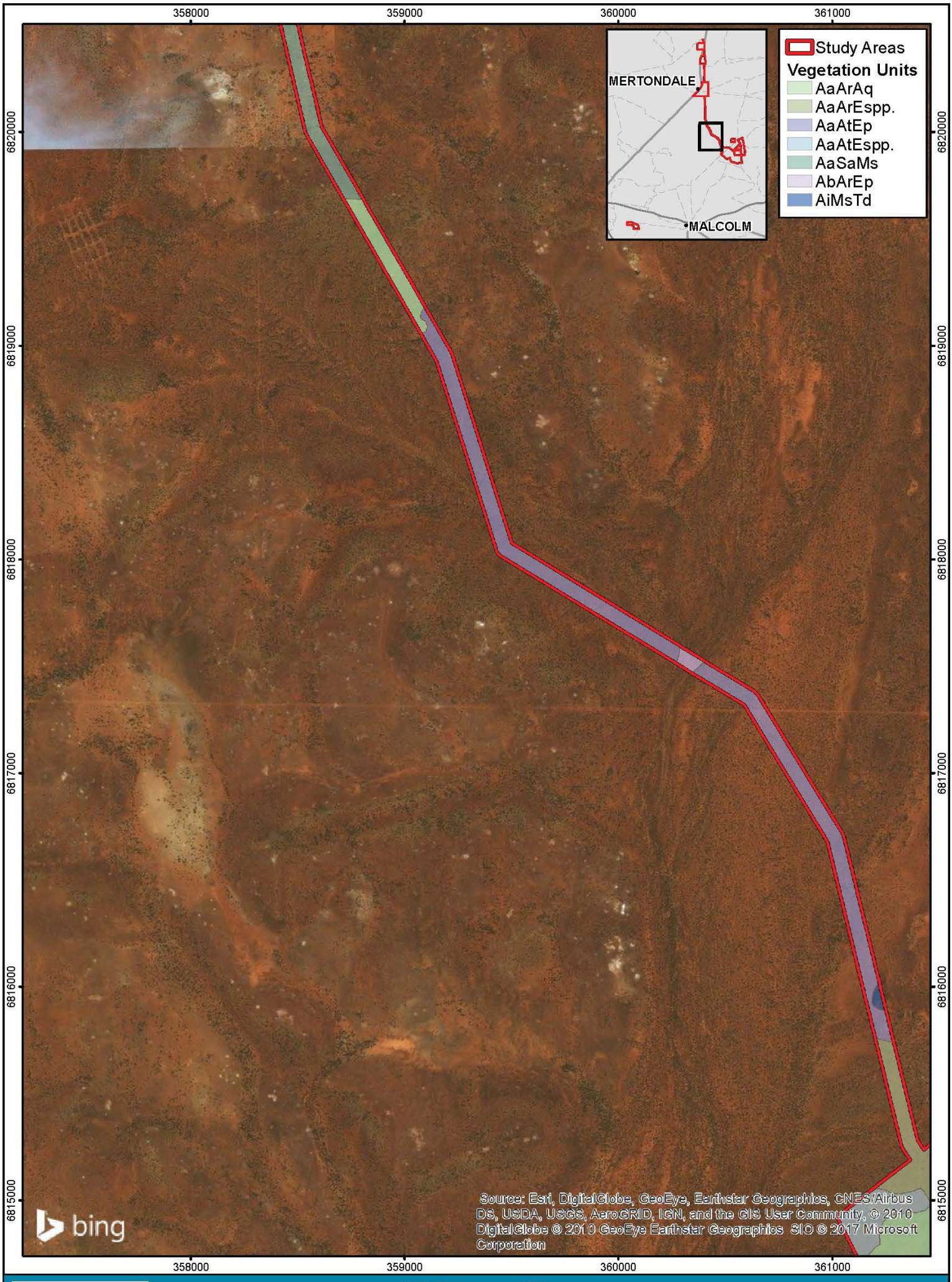
N

0 250 500 m

Vegetation Units - Haul Road

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LEONORA GOLD PROJECT

Map Created: 8/06/2017 cthatcher

A4 Scale: 1:22,000

Coordinate System: GDA 1994 MGA Zone 51

File Name: LEON_FS_VegUnits

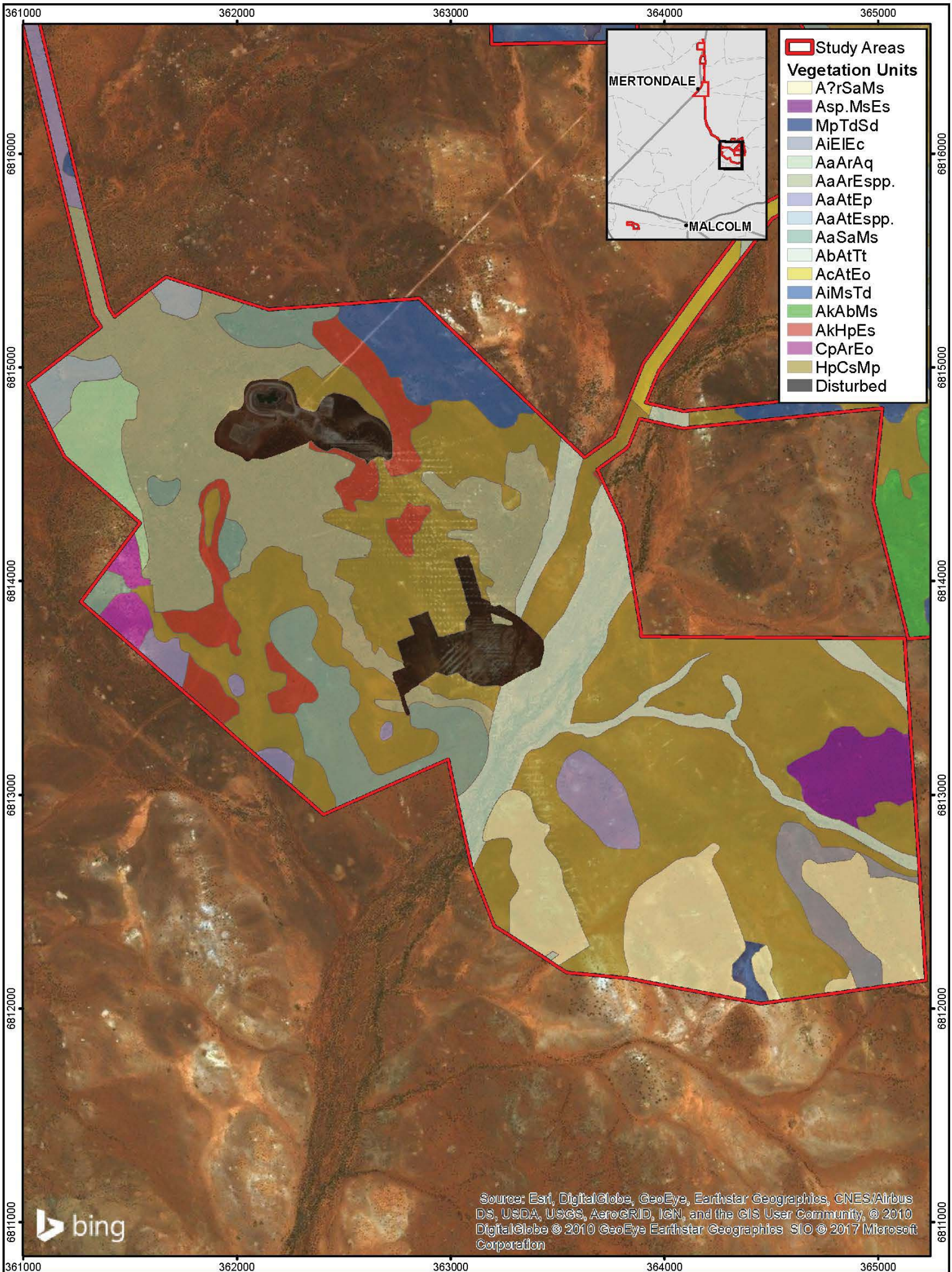
N

0 250 500 m

Vegetation Units - Haul Road

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LEONORA GOLD PROJECT

Map Created: 8/06/2017 cthatcher

A4 Scale: 1:22,000

Coordinate System: GDA 1994 MGA Zone 51

File Name: LEON_FS_VegUnits

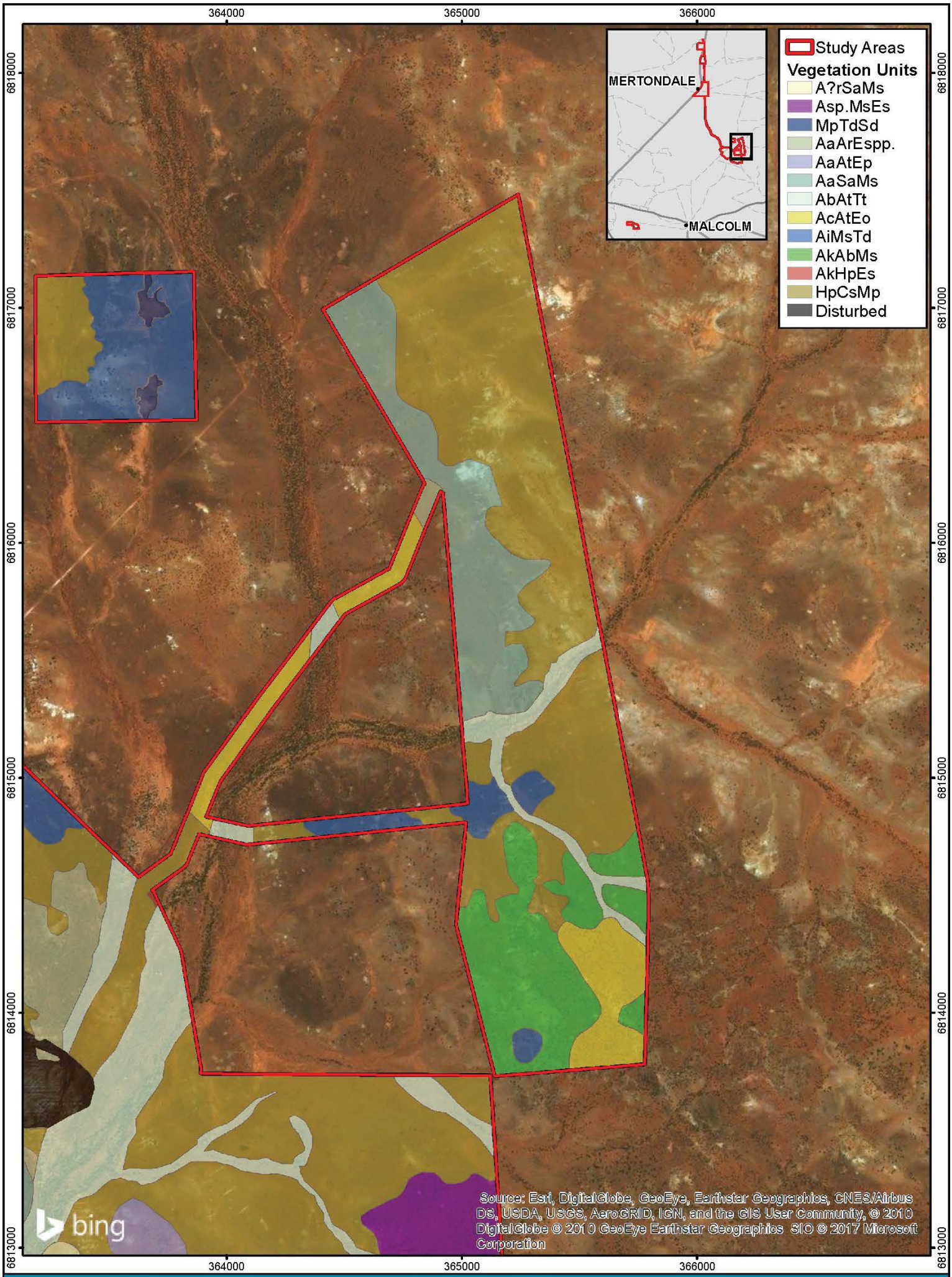
Vegetation Units - Cardinia West

N

0 250 500 m

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LEONORA GOLD PROJECT

Map Created: 8/06/2017 cthatcher

A4 Scale: 1:20,000

Coordinate System: GDA 1994 MGA Zone 51

File Name: LEON_FS_VegUnits

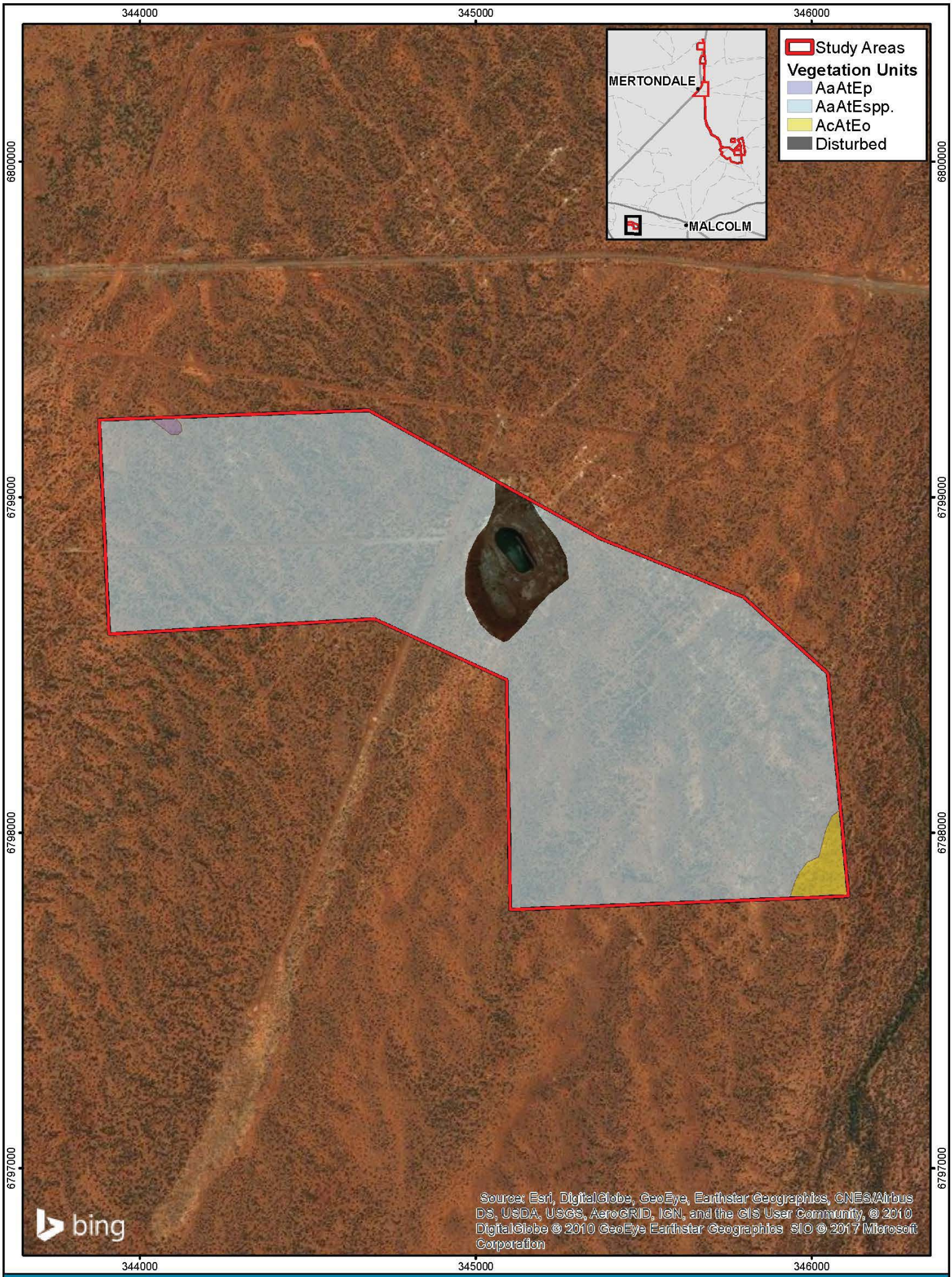
Vegetation Units - Cardinia East

N

0 250 500 m

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LEONORA GOLD PROJECT

Map Created: 8/06/2017 cthatcher

A4 Scale: 1:14,000

Coordinate System: GDA 1994 MGA Zone 51

File Name: LEON_FS_VegUnits

Vegetation Units - Raeside

N

0 250 500 m

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Appendix G Inventory of Vascular Flora Recorded

Family	Species
Aizoaceae	**Carpobrotus aequilaterus*
	Gunniopsis propinqua
Amaranthaceae	*Alternanthera nodiflora*
	Ptilotus aervoides
	Ptilotus drummondii
	Ptilotus gaudichaudii subsp. *gaudichaudii*
	Ptilotus helipteroides
	Ptilotus obovatus var. *obovatus*
	Ptilotus roei
	Ptilotus schwartzii var. *schwartzii*
	Ptilotus sp.
	Ptilotus sp. Goldfields (R.Davis 10796)
	Surreya diandra
Apocynaceae	*Cynanchum floribundum*
	Marsdenia australis
Asteraceae	*Brachyscome ciliaris*
	Calocephalus multiflorus
	Calotis hispidula
	Calotis multicaulis
	Centipeda minima
	Centipeda thespidioides
	Cephalipterum drummondii
	Chrysocephalum puteale
	Chthonocephalus pseudevax
	Cratystylis subspinescens
	Gnephosis arachnoidea
	Lemooria burkittii
	Minuria cunninghamii
	Myriocephalus pygmaeus
	Olearia muelleri
	Podolepis ? kendallii
	Podolepis lessonii
	Rhodanthe ? charsleyae
	Rhodanthe maryonii
	Rhodanthe propinqua
	Rhodanthe sp.
	Roebuckiella oncocarpa

Family	Species
	Senecio magnificus
	Streptoglossa liatroides
	Vittadinia sp.
	Vittadinia sulcata
	Waitzia acuminata subsp. *acuminata*
Brassicaceae	**Sisymbrium erysimoides*
	**Sisymbrium irio*
	Lepidium oxytrichum
	Lepidium platypetalum
	Stenopetalum anfractum
Cactaceae	**Cylindropuntia fulgida* var. *mamillata*
Campanulaceae	*Wahlenbergia queenslandica*
	Wahlenbergia tumidifructa
Casuarinaceae	*Casuarina pauper*
Chenopodiaceae	? *Enchylaena tomentosa*
	Atriplex ? *nummularia*
	Atriplex codonocarpa
	Atriplex nummularia subsp. *spathulata*
	Atriplex quinii
	Atriplex sp.
	Atriplex vesicaria
	Chenopodium curvispicatum
	Dissocarpus paradoxus
	Dysphania saxatilis
	Einadia nutans subsp. *eremaea*
	Enchylaena tomentosa
	Eriochiton sclerolaenoides
	Maireana ? *platycarpa*
	Maireana ? *tomentosa*
	Maireana carnosa
	Maireana convexa
	Maireana georgei
	Maireana glomerifolia
	Maireana pyramidata
	Maireana sedifolia
	Maireana tomentosa subsp. *tomentosa*
	Maireana trichoptera
	Maireana triptera
	Maireana villosa

Family	Species
	Rhagodia ? drummondii
	Rhagodia drummondii
	Salsola australis
	Sclerolaena cuneata
	Sclerolaena densiflora
	Sclerolaena diacantha
	Sclerolaena eriacantha
	Sclerolaena fusiformis
	Sclerolaena lanicuspis
	Sclerolaena sp.
	Tecticornia disarticulata
	Tecticornia indica
	Tecticornia pergranulata subsp. *pergranulata*
	Tecticornia pruinosa
Convolvulaceae	**Cuscuta planiflora*
	Duperreya ? commixta
	Duperreya commixta
Crassulaceae	*Crassula colorata* var. *acuminata*
Cyperaceae	*Fimbristylis* sp.
Euphorbiaceae	*Euphorbia drummondii*
Fabaceae	*Acacia ? caesaneura*
	Acacia ? incurvaneura
	Acacia sp. nov. aff. *resinimarginea*
	Acacia aneura
	Acacia aptaneura
	Acacia burkittii
	Acacia caesaneura
	Acacia coolgardiensis
	Acacia craspedocarpa
	Acacia inceana subsp. *conformis*
	Acacia incurvaneura
	Acacia kalgoorliensis
	Acacia kempeana
	Acacia macraneura
	Acacia oswaldii
	Acacia ? oswaldii
	Acacia pteraneura
	Acacia quadrimarginea
	Acacia ramulosa var. *linophylla*

Family	Species
	Acacia ramulosa var. *ramulosa*
	Acacia sclerosperma
	Acacia sibirica
	Acacia sp.
	Acacia tetragonophylla
	Acacia victoriae
	Glycine canescens
	Senna artemisioides subsp. *artemisioides*
	Senna artemisioides subsp. *filifolia*
	Senna artemisioides subsp. *helmsii*
	Senna artemisioides subsp. *helmsii x oligophylla*
	Senna artemisioides subsp. *x artemisioides*
	Senna cardiosperma
	Senna charlesiana
	Senna manicula
	Senna sp. Meekatharra (E. Bailey 1-26)
	Senna stowardii
Frankeniaceae	*Frankenia setosa*
Goodeniaceae	*Brunonia australis*
	Goodenia havilandii
	Goodenia occidentalis
	Scaevola densifolia
	Scaevola spinescens
	Velleia glabrata
Hemerocallidaceae	*Dianella revoluta* var. *divaricata*
Juncaceae	*Juncus aridicola*
Lamiaceae	*Spartothamnella teucriiflora*
Loranthaceae	*Amyema fitzgeraldii*
	Amyema miquelii
	Amyema preissii
	Lysiana murrayi
Malvaceae	**Malvastrum americanum*
	Abutilon cryptopetalum
	Abutilon oxycarpum subsp. Prostrate (A.A. Mitchell PRP 1266)
	Abutilon sp.
	Brachychiton gregorii
	Hibiscus burtonii
	Lawrencia densiflora
	Sida calyxhymenia

Family	Species
	Sida ectogama
	Sida intricata
	Sida sp.
	Sida sp. dark green fruits (S. van Leeuwen 2260)
	Sida sp. Excedentifolia (J.L. Egan 1925)
Marsileaceae	*Marsilea drummondii*
Myrtaceae	*Baeckea* sp. Melita Station (H. Pringle 2738)
	Eucalyptus ? striaticalyx
	Eucalyptus striaticalyx
Pittosporaceae	*Pittosporum angustifolium*
Plantaginaceae	*Plantago debilis*
Poaceae	*Aristida contorta*
	Aristida holathera
	Aristida obscura
	Austrostipa ? nitida
	Austrostipa elegantissima
	Austrostipa nitida
	Austrostipa sp.
	Cynodon prostratus
	Digitaria ? brownii
	Enneapogon caerulescens
	Enneapogon polyphyllus
	Enteropogon ramosus
	Eragrostis caroli
	Eragrostis dielsii
	Eragrostis eriopoda
	Eragrostis kennedyae
	Eragrostis lacunaria
	Eragrostis pergracilis
	Eragrostis sp.
	Eriachne ? helmsii
	Eriachne flaccida
	Eriachne helmsii
	Eriachne pulchella subsp. *pulchella*
	Monachather paradoxus
	Poaceae sp.
	Poaceae sp.
	Sporobolus actinocladus
	Themeda triandra

Family	Species
	Thyridolepis multiculmis
	Triodia basedowii
Polygonaceae	**Rumex hypogaeus*
	**Rumex vesicarius*
Portulacaceae	*Calandrinia ? translucens*
	Calandrinia creethiae
	Calandrinia eremaea
	Calandrinia porifera
	Calandrinia ptychosperma
	Calandrinia sp.
	Calandrinia sp. Black angular seeds (A.A. Mitchell PRP 1661)
	Calandrinia translucens
	Calandrinia eremaea
Primulaceae	*Lysimachia arvensis*
Proteaceae	*Grevillea acuaria*
	Grevillea berryana
	Grevillea extorris
	Hakea lorea subsp. *lorea*
	Hakea preissii
	Hakea recurva subsp. *arida*
	Hakea recurva subsp. *recurva*
Pteridaceae	*Cheilanthes sieberi* subsp. *sieberi*
Rubiaceae	*Psydrax rigidula*
	Psydrax suaveolens
Santalaceae	*Exocarpos aphyllus*
	Santalum ? lanceolatum
	Santalum acuminatum
	Santalum lanceolatum
	Santalum spicatum
Sapindaceae	*Alectryon oleifolius* subsp. *oleifolius*
	Dodonaea lobulata
	Dodonaea rigida
	Dodonaea viscosa subsp. *mucronata*
Scrophulariaceae	*Eremophila ? georgei*
	Eremophila alternifolia
	Eremophila exilifolia
	Eremophila forrestii subsp. *forrestii*
	Eremophila georgei
	Eremophila gilesii subsp. *variabilis*

Family	Species
	Eremophila glabra subsp. *glabra*
	Eremophila glandulifera
	Eremophila homoplastica
	Eremophila latrobei subsp. latrobei
	Eremophila longifolia
	Eremophila mackinlayi subsp. *spathulata*
	Eremophila margarethae
	Eremophila metallicorum
	Eremophila oldfieldii subsp. *angustifolia*
	Eremophila pantonii
	Eremophila platycalyx subsp. *platycalyx*
	Eremophila pterocarpa subsp. *pterocarpa*
	Eremophila scoparia
	Eremophila serrulata
	Eremophila simulans subsp. *simulans*
	Eremophila sp.
	Eremophila sp.
	Eremophila sp.
	Eremophila youngii subsp. *youngii*
	Eremophila longifolia
Solanaceae	*Nicotiana rosulata* subsp. *rosulata*
	Solanum cleistogamum
	Solanum lasiophyllum
Zygophyllaceae	*Zygophyllum ? compressum*
	Zygophyllum eichleri

Appendix H Flora of Conservation Significance identified from the Desktop Study

Species	Conservation Code			Habitat[1]	Nearest locality (km)	Likelihood of occurrence: Reason of likelihood
	EPBC Act	WC Act	DPaW			
Acacia websteri	–	–	P1	Red sand, clay or loam. Low-lying areas, flats.	19	**Very Likely:** The Study Area contains suitable habitat for this species, and is close to its known distribution
Eremophila arachnoides subsp. *tenera*	–	–	P1	Red sandy loam or calcrete platforms, with Acacia shrubland or Casuarina woodland	150	**Unlikely:** The Study Area lies outside its known distribution.
Eremophila eversa	–	–	P1	Red sandy loam, mulga shrubland, know only from Yerilla Station.	55	**Unlikely:** The Study Area lies outside its known distribution, this species is very restricted, and only known to occur on Yerilla Station.
Lechenaultia aphylla	–	–	P1	Red sand. Slopes, drainage areas.	120	**Unlikely:** The Study Area lies outside its known distribution.
Micromyrtus chrysodema	–	–	P1	Red sands. Sandplains.	85	**Unlikely:** The Study Area is unlikely to contain suitable habitat and lies outside its known distribution.
Persoonia leucopogon	–	–	P1	Yellow sand, sandy clay.	115	**Unlikely:** The Study Area is unlikely to contain suitable habitat and lies outside its known distribution.
Philotheca tubiflora	–	–	P1	Rocky rises, hills, outcrops.	70	**Possible**: The Study Area is just outside the known distribution but contains suitable habitat
Ptilotus tetrandrus	–	–	P1	Loamy sand.	37	**Likely**: The Study Area lies close to the known location, and may contain suitable habitat
Stenanthemum patens	–	–	P1	Rocky hillside.	30	**Likely**: The Study Area lies close to the known location, and may contain suitable habitat
Vittadinia cervicularis var. *oldfieldii*	–	–	P1	Alluvium.	100	**Unlikely:** The Study Area is unlikely to contain suitable habitat and lies outside its known distribution.
Eremophila mirabilis	–	–	P2	Clay sand, stony clayey loam. Granite country.	40	**Likely**: The Study Area lies close to the known location, and may contain suitable habitat
Thryptomene eremaea	–	–	P2	Red or yellow sand. Sandplains.	50	**Unlikely:** The Study Area is unlikely to contain suitable habitat

Species	Conservation Code			Habitat[1]	Nearest locality (km)	Likelihood of occurrence: Reason of likelihood
	EPBC Act	WC Act	DPaW			
Angianthus prostratus	–	–	P3	Red clay or loamy soils, saline depressions.	13	**Very Likely:** The Study Area contains suitable habitat for this species, and lies within its known distribution
Calytrix praecipua	–	–	P3	Skeletal sandy soils over granite or laterite. Breakaways, outcrops	13	**Very Likely:** The Study Area contains suitable habitat for this species, and lies within its known distribution
Calytrix verruculosa	–	–	P3	Sandy clay.	370	**Unlikely:** The Study Area lies outside its known distribution.
Cratystylis centralis	–	–	P3	Red sandy loam with ironstone gravel. Flat plains, breakaway country.	17	**Very Likely:** The Study Area contains suitable habitat for this species, and lies within its known distribution
Eremophila annosocaulis	–	–	P3	Brown loam, rocky soil. *Acacia* spp. over *Eremophila* spp. shrublands.	45	**Likely**: The Study Area lies close to the known location, and contains suitable habitat
Eremophila shonae subsp. *diffusa*	–	–	P3	Stony yellow or red sandy soils.	60	**Unlikely:** The Study Area lies outside its known distribution.
Eremophila simulans subsp. megacalyx	–	–	P3	Sandy loam, sand.	21	**Possible**: The Study Area is inside the known distribution but may not contain suitable habitat
Goodenia lyrata	–	–	P3	Red sandy loam. Near claypan.	60	**Possible**: The Study Area is just outside the known distribution but contains suitable habitat
Grevillea obliquistigma subsp. *cullenii*	–	–	P3	Red sand.	105	**Unlikely:** The Study Area lies outside its known distribution.
Gunniopsis propinqua	–	–	P3	Stony sandy loam. Lateritic outcrops, winter-wet sites.	30	**Confirmed:** this species was recorded within the Study Area during this field survey
Hybanthus floribundus subsp. *chloroxanthus*	–	–	P3	Dark red-brown soil, never sandy, rich in oxide, laterite. Rocky areas, creek banks, along drainage lines.	17	**Possible**: The Study Area lies inside the known distribution but may not contain suitable habitat
Micromyrtus serrulata	–	–	P3	Brownish sandy and clayey soils over granite.	25	**Possible**: The Study Area lies inside the known distribution but may not contain suitable habitat
Philotheca coateana	–	–	P3	Red sand.	85	**Unlikely:** The Study Area is unlikely to contain suitable habitat and lies outside its known distribution.

Species	Conservation Code			Habitat[1]	Nearest locality (km)	Likelihood of occurrence: Reason of likelihood
	EPBC Act	WC Act	DPaW			
Phyllanthus baeckeoides	–	–	P3	Red lateritic & sandy clay soils. Granite outcrops.	59	**Unlikely:** The Study Area is unlikely to contain suitable habitat and lies outside its known distribution.
Sauropus sp. Woolgorong (M. Officer s.n. 10/08/94)	–	–	P3	Red sand. Plains.	130	**Unlikely:** The Study Area lies outside its known distribution.
Thryptomene nealensis	–	–	P3	Lateritic breakaways.	130	**Unlikely:** The Study Area lies outside its known distribution.
Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362)	–	–	P3	Red loam, crest, upper slope, ridge, breakaway, ironstone, outcropping.	85	**Possible**: The Study Area is just outside the known distribution but contains suitable habitat
Triglochin protuberans	–	–	P3	Winter-wet sites, claypans, near salt lakes, margins of pools.	15	**Likely**: The Study Area lies close to the known location, and contains suitable habitat
Eremophila pungens	–	–	P4	Sandy loam, clayey sand over laterite. Plains, ridges, breakaways.	115	**Possible**: The Study Area is outside the known distribution but contains suitable habitat
Eucalyptus jutsonii subsp. *jutsonii*	–	–	P4	Red to pale orange deep sands. Undulating areas and on dunes.	50	**Unlikely:** The Study Area is unlikely to contain suitable habitat and lies outside its known distribution.
Grevillea inconspicua	–	–	P4	Loam, gravel. Along drainage lines on rocky outcrops, creeklines.	30	**Likely**: The Study Area lies close to the known location, and contains suitable habitat
Hemigenia exilis	–	–	P4	Laterite. Breakaways, slopes.	18	**Likely**: The Study Area lies close to the known location, and contains suitable habitat

Appendix I Fauna habitats within the Study Area



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LEONORA GOLD PROJECT

Map Created: 14/07/2017 cthatcher

Coordinate System: GDA 1994 MGA Zone 51

A4 Scale: 1:14,000

File Name: LEON_FS_Habitat_v2

Fauna Habitat - Mertondale - North

N

0 250 500 m

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A4 Scale: 1:22,000

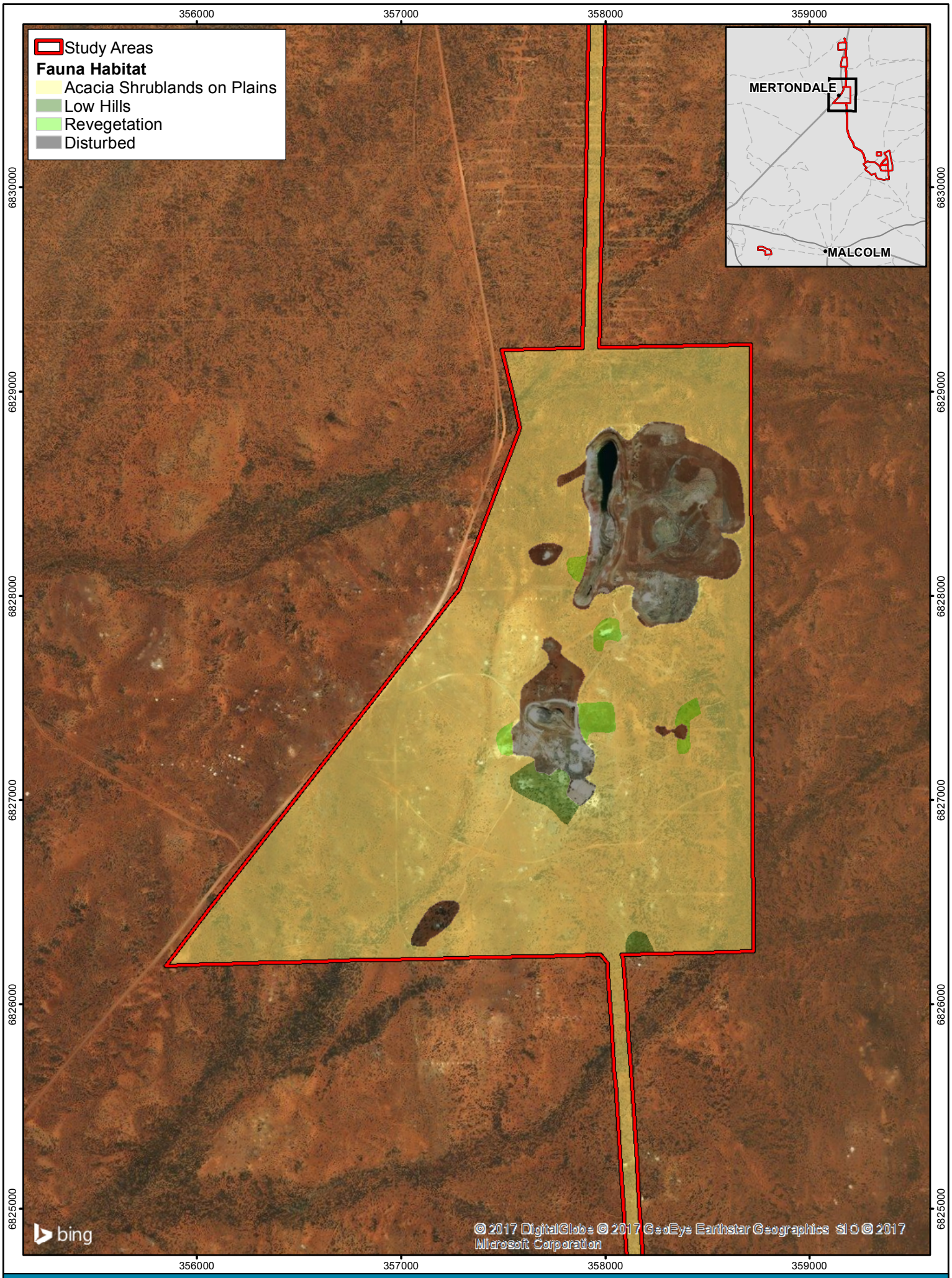
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N

0 250 500 m

Fauna Habitat - Mertondale - Central

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Coordinate System: GDA 1994 MGA Zone 51

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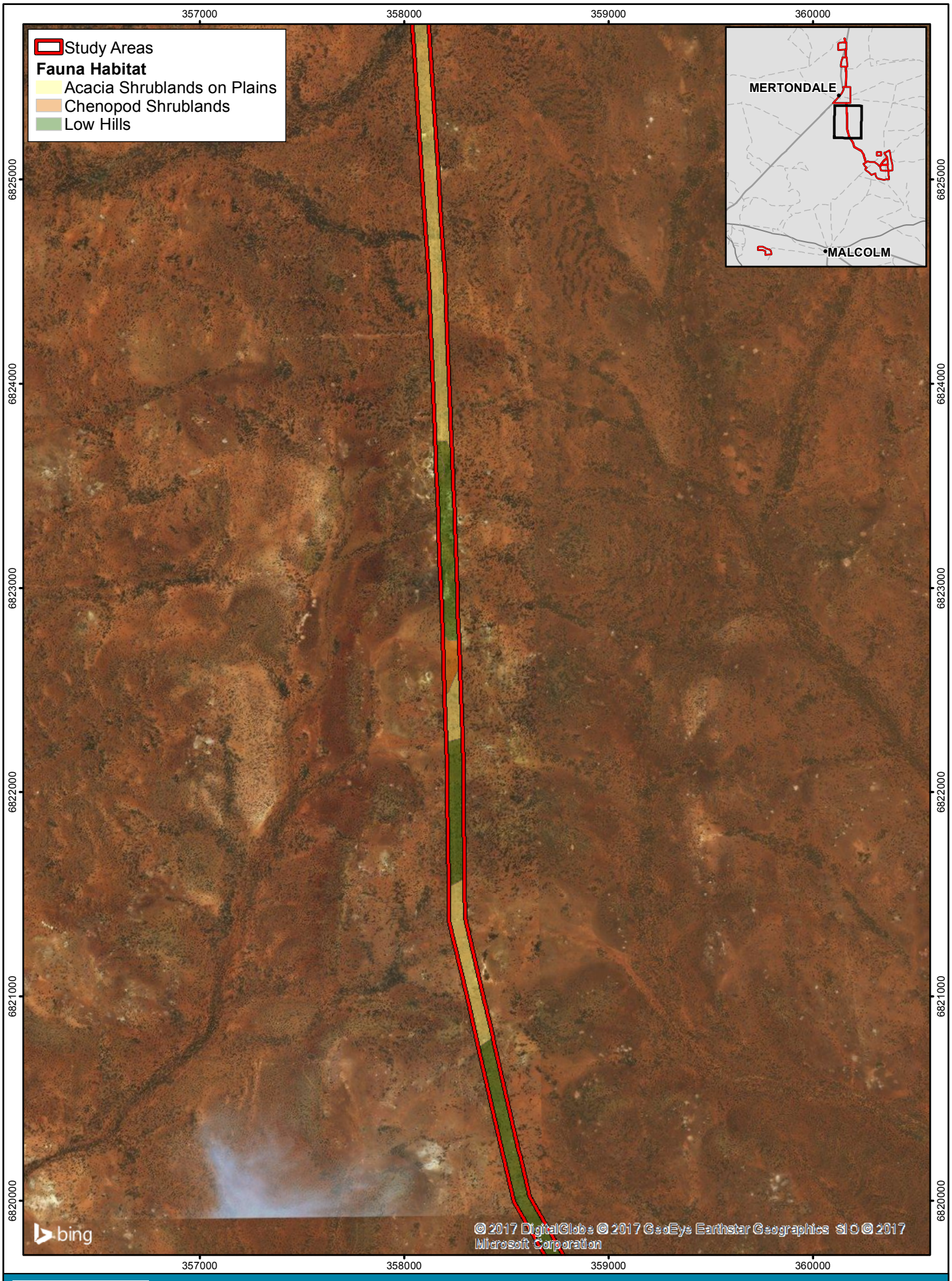
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Fauna Habitat - Mertondale - South

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LEONORA GOLD PROJECT

Map Created: 14/07/2017 cthatcher

A4 Scale: 1:23,000

Coordinate System: GDA 1994 MGA Zone 51

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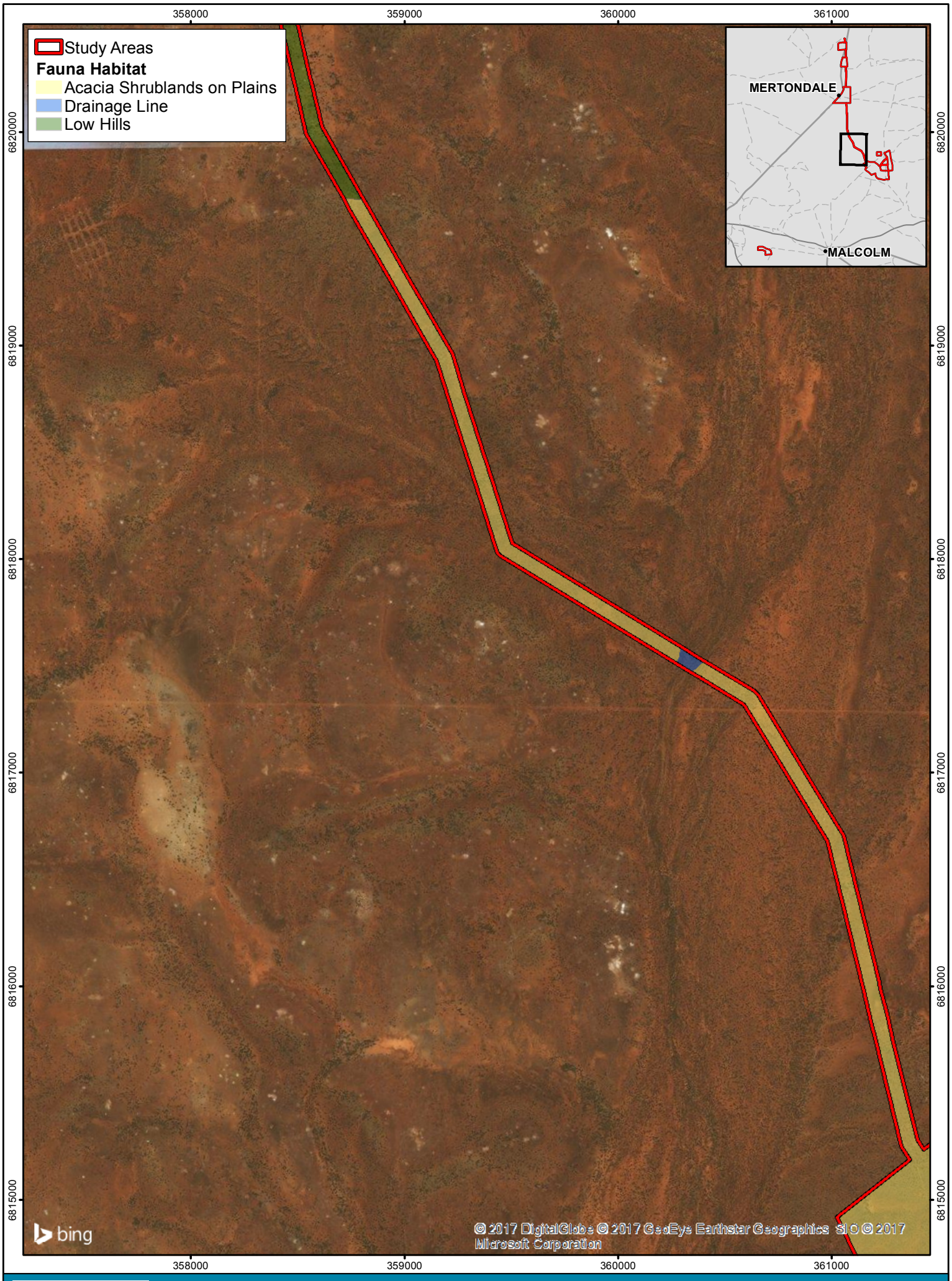
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0 250 500 m

Fauna Habitat - Haul Road

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Map Created: 14/07/2017 cthatcher

Coordinate System: GDA 1994 MGA Zone 51

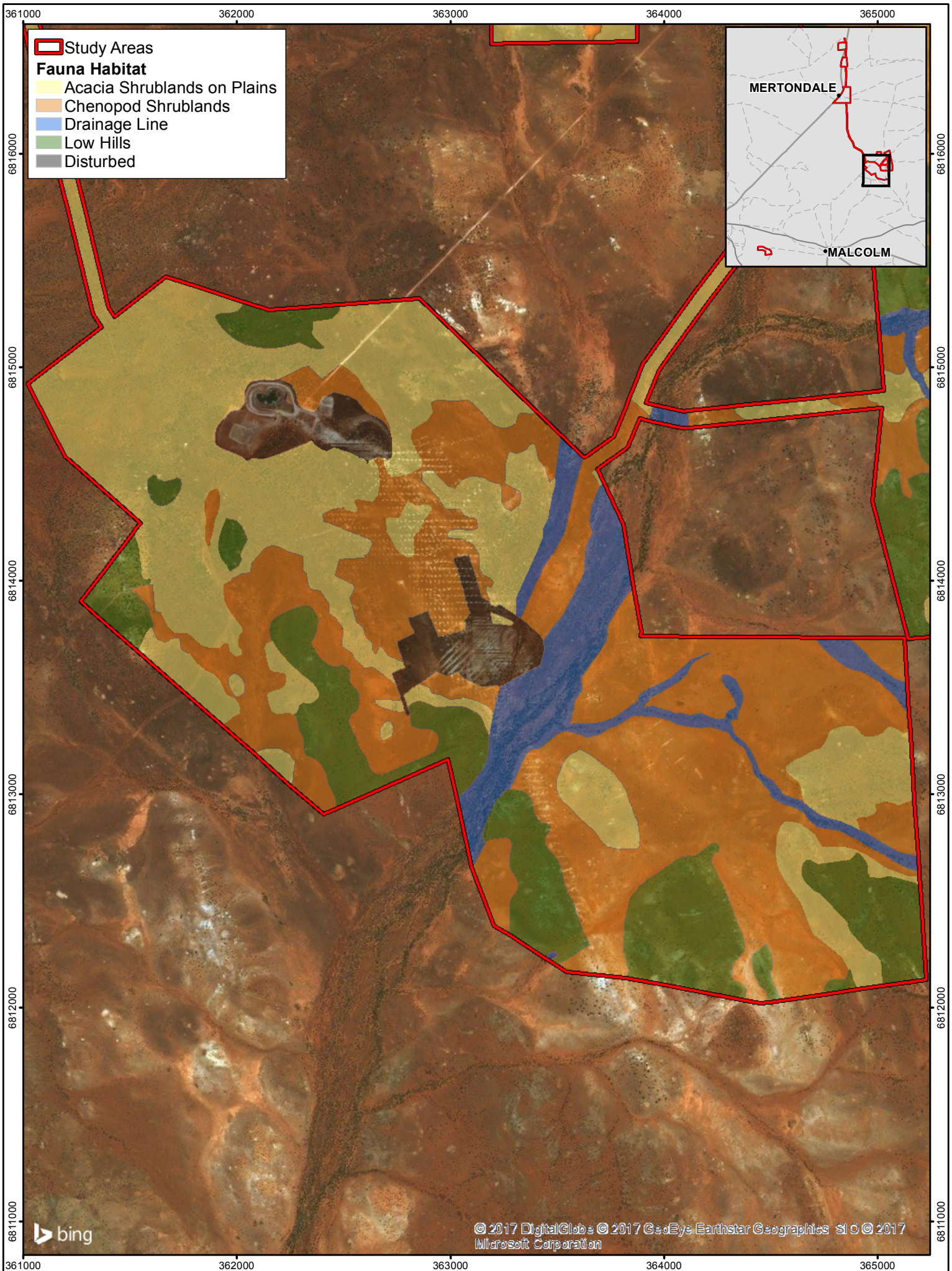
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File Name: LEON_FS_Habitat_v2

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0 250 500 m

Fauna Habitat - Haul Road



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A4 Scale: 1:22,000

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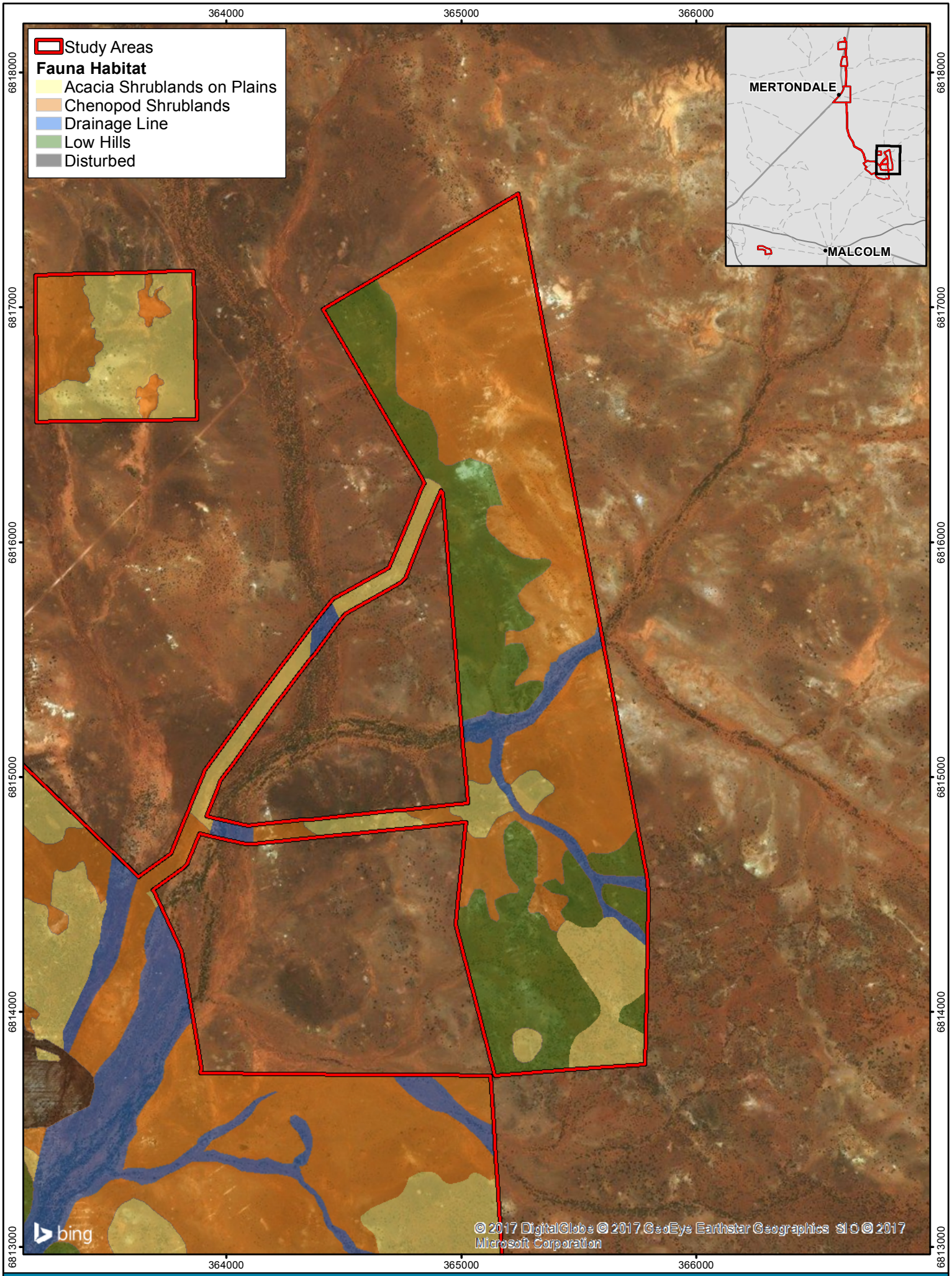
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0 250 500 m

Fauna Habitat - Cardinia West

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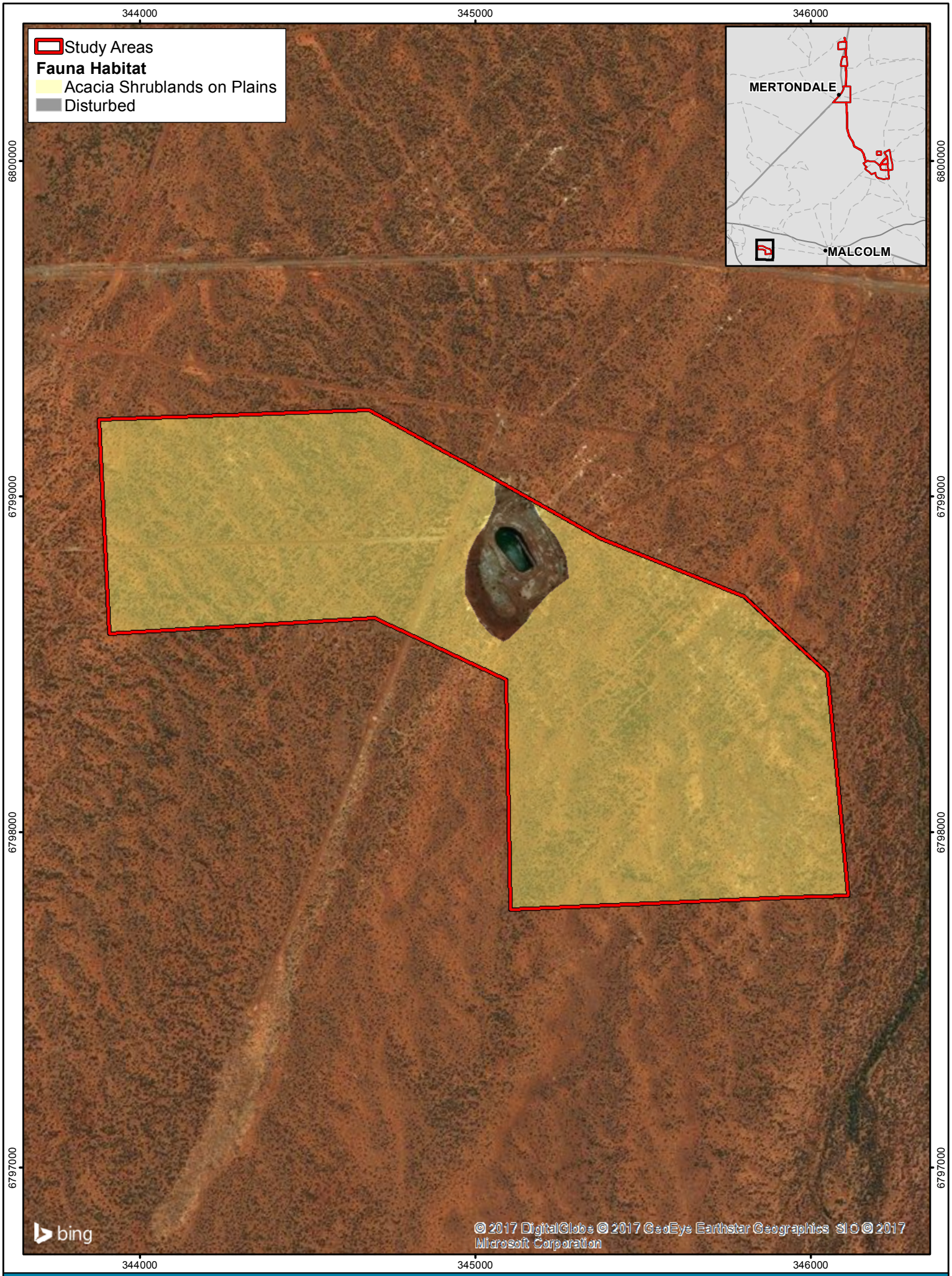
File Name: LEON_FS_Habitat_v2

N

0 250 500 m

Fauna Habitat - Cardinia East

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LEONORA GOLD PROJECT

Map Created: 14/07/2017 cthatcher

Coordinate System: GDA 1994 MGA Zone 51

A4 Scale: 1:14,000

File Name: LEON_FS_Habitat_v2

Fauna Habitat - Raeside

N

0 250 500 m

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APPENDIX D

Stantec – Flora, Vegetation and Fauna Report, Proposed Mertondale Haul Road and Pipeline Deviation and Cardinia Access Road 2018d



LEONORA GOLD PROJECT - PROPOSED MERTONDALE HAUL ROAD AND PIPELINE DEVIATION AND CARDINIA ACCESS ROAD: FLORA, VEGETATION AND FAUNA REPORT

PREPARED FOR **KIN MINING NL**

11 September 2018

Stantec

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QUALITY STATEMENT

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Alice Bott	.....	24/04/2018
REVIEWED BY		
Paul Bolton	.....	24/04/2018
APPROVED FOR ISSUE BY		
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REVISION SCHEDULE

Rev No.	Date	Description	Signature or Typed Name (documentation on file)			
			Prepared by	Checked by	Reviewed by	Approved by
v.1.0	24/04/18	Draft report for client comment.	CH	PB	AB	SO
v. 1.1.	11/09/18	Final report	CH	SO	-	SO

Executive Summary

Kin Mining NL (Kin) plans to develop the Leonora Gold Project (LGP), located between seven and 40 kilometres (km) east of the town of Leonora, in the Murchison bioregion. The LGP comprises three historically mined areas (Mertondale, Cardinia and Raeside), a proposed haul road that links the three mining areas, a processing plant and Tailings Storage Facility (TSF). Stantec Australia Pty Ltd (Stantec) has been appointed by Kin to complete a Reconnaissance (Level 1) flora, vegetation and fauna assessment of two areas, collectively termed, the Study Area:

- the proposed realignment of Miscellaneous Licence L37/226 along the Mertondale Haul Road (the Mertondale Haul Road and Pipeline Deviation Survey Area); and
- Miscellaneous Licence L37/106 for the Cardinia Access Road (the Cardinia Access Road Survey Area).

Stantec completed a flora, vegetation and fauna survey that encompassed the majority of the project area and information and date from the previous assessment was used to supplement the findings of the field survey of the Study Area. The overarching objectives for the assessment were to undertake a Reconnaissance (Level 1) Flora, Vegetation and Fauna survey and assess the Study Area against the ten Clearing Principles listed under Schedule 5 of the *Environmental Protection Act 1986*. The specific objectives of the assessment were to:

- conduct a field survey to identify, describe and map fauna habitats and vegetation types and their condition within the Study Area;
- conduct targeted searches for flora, fauna and vegetation communities of conservation significance;
- develop a list of flora and fauna species recorded as occurring within the Study Area, including introduced fauna and weed species;
- assess the survey findings in a local and regional context by comparing them with available data from other localities within the bioregion; and
- assess potential impacts of the LGP against the ten Native Vegetation Clearing Principles.

The objectives were addressed by way of a desktop survey and a field survey to ground-truth desktop results. The field survey took place from the 14th to the 18th of March 2018 and involved sampling of a total of 14 relevés and 14 detailed mapping notes, in addition to opportunistic collections and vegetation mapping. The Mertondale Haul Road Survey Area was traversed on foot and the Cardinia Access Road Survey Area was traversed on foot and by vehicle.

The vegetation condition of the Study Area ranged from 'Degraded' to 'Excellent'. The majority of the habitat adjacent to the existing access track in the Cardinia Access Road Survey Area and the entire Mertondale Haul Road area had been marginally altered from its natural state and was in a 'Very Good' ecological condition.

Three vegetation types were identified in the Mertondale Haul Road Survey area and 11 vegetation types were identified in the Cardinia Access Road Survey Area. The vegetation recorded broadly comprised mixed Mulga shrublands over mixed shrubs dominated by *Eremophila* species, *Ptilotus obovatus* and *Senna* species; also with large areas dominated by chenopod shrublands of *Cratystylis subspinescens, Maireana pyramidata, Maireana sedifolia* and *Maireana triptera*. No vegetation units are considered analogous to any Threatened or Priority Ecological Communities, and none are considered regionally significant.

A total of 120 flora taxa (including subspecies and variants) from 26 families and 61 genera were recorded within the Study Area. The most represented families included Chenopodiaceae (23 taxa), Poaceae (20 taxa), Fabaceae (17 taxa) and Scrophulariaceae (11 taxa), equating to approximately 60% of the recorded taxa. The floral diversity recorded from the Study Area is consistent with the expected diversity of the Mulga shrublands of the Murchison region; given the level of survey effort for the reconnaissance field survey.

No Threatened Flora species and 35 Priority Flora species were recorded from the desktop study with five considered as 'Very Likely' and seven as 'Likely' to occur within the Study Area, however these were not recorded during the field survey.

Four borad fauna habitats were identified within the Study Area; Acacia Shrubland on Plains, Chenopod Shrublands, Wetlands and Drainage Lines. All habitats were widespread and of limited singificance to fauna with the exception of wetland habitat. This comprised a small area within the Cardinia Access Road area, and was considered of 'moderate' significance to SRE fuana owing to it's limited extent and likelihood to be seasonally inundated.

Sixty four vertebrate fauna species were recorded from the vicinity of the Study Area during the previous survey conducted by Stantec in 2018 and the current survey. No fauna of conservation significance were recorded, however the desktop assessment identified one species as Likely to occur (Peregrine Falcon; S7) and three species as Possible to occur (Grey Falcon; S3, Fork-tailed Swift; Mi/S5, Mallee Fowl; Vu/S3). While the Peregrine Falcon may fly over the Study Area, the species is considered unlikely to depend upon it due to the lack of suitable breeding habitat.

Assuming that the entire Study Area will be subjected to some form of clearing or disturbance associated with the LGP, the proposed vegetation clearing may be at variance to Principles (b) and (f), and is unlikely to be at variance with the remnaining eight Principles. A 0.59 ha area of hydrophilic vegetation associated with vegetation unit PaAtEp was recorded within the Cardinia Access Road. This is likely to be seasonally inundated and may provide suitable habitat to wetland species including SREs. If clearing of this vegetation unit is avoided, proposed clearing will not be at variance.

Kin Mining NL

Leonora Gold Project - Proposed Mertondale Haul Road and pipeline deviation and Cardinia Access Road: Flora, Vegetation and Fauna Report

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APPENDICES

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1. Introduction

1.1 Project Background

Kin Mining NL (Kin) plans to develop the Leonora Gold Project (LGP) which is located between seven and 40 kilometres (km) east of the town of Leonora. The LGP comprises three historically mined areas (Mertondale, Cardinia and Raeside), a proposed haul road that links the three mining areas, a processing plant and Tailings Storage Facility (TSF). Previously, Stantec completed a flora, vegetation and fauna survey that encompassed the majority of the project area (Stantec (2018)). Subsequent to this survey, Kin appointed Stantec Australia Pty Ltd (Stantec) to complete a Reconnaissance Survey (formerly referred to as a Level 1 Flora Survey) and a Level 1 Fauna Survey (this Survey) of two additional areas (**Figure 1-1**):

- the proposed realignment of Miscellaneous Licence L37/226 along the Mertondale Haul Road (the Mertondale Haul Road and Pipeline Deviation Survey Area) (52 hectares (ha)); and
- Miscellaneous Licence L37/106 for the Cardinia Access Road (the Cardinia Access Road Survey Area) (215.44ha).

Collectively, these two survey areas are referred to as the Study Area in this report.

1.2 Report Scope and Objectives

The overarching objective was to complete a Reconnaissance Survey (formerly referred to as a Level 1 Flora Survey) and a Level 1 Fauna Survey of the Study Area. Additionally, vegetation units and habitats have been aligned with those previously described within the existing Stantec (2018) report, where appropriate. The scope of work was to:

- conduct a field survey to identify, describe and map fauna habitats and vegetation types and their condition within the Study Area;
- conduct targeted searches for flora, fauna and vegetation communities of conservation significance;
- develop a list of flora and fauna species recorded as occurring within the Study Area, including introduced fauna and weed species;
- assess the survey findings in a local and regional context by comparing them with available data from other localities within the bioregion; and
- assess potential impacts of the LGP in relation to the Study Area against the ten Native Vegetation Clearing Principles.

The flora, vegetation and fauna survey was undertaken in accordance with the following relevant regulatory guidelines:

- EPA Factor Guideline (EPA 2016f), Environmental Factor Guideline: Flora and Vegetation;
- EPA Factor Guideline (EPA 2016a), Environmental Factor Guideline: Terrestrial Fauna;
- EPA Technical Guide (DPaW 2016e), Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment;
- EPA Technical Guide (EPA 2016d), Technical Guidance – Terrestrial Fauna Surveys; and
- EPA Technical Guide (EPA 2016c), Technical Guidance – Sampling methods for terrestrial vertebrate fauna.

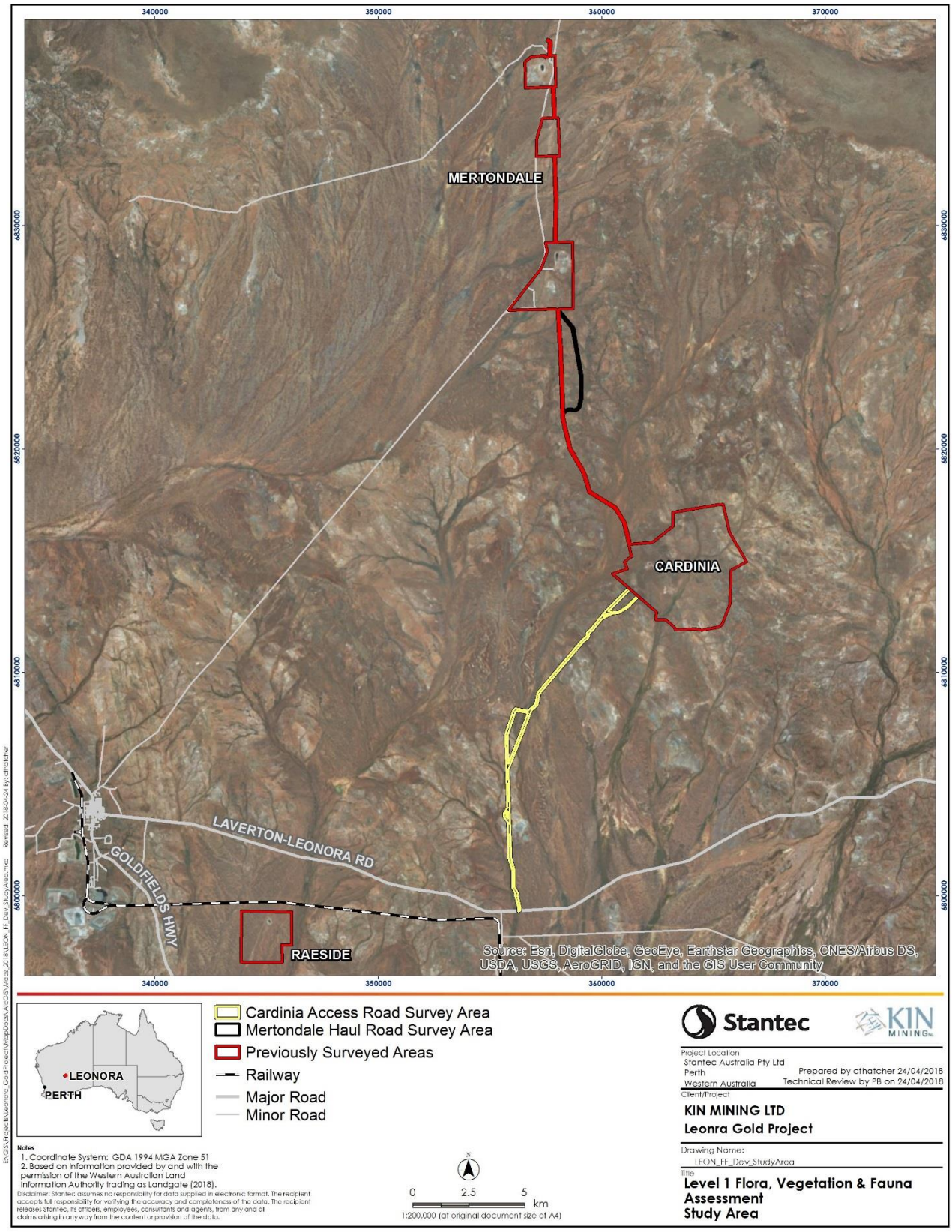


Figure 1-1: Study Area

2. Existing Environment

2.1 Biogeography

The Study Area is located within the Murchison biogeographic region (bioregion), as defined by the Interim Biogeographic Regionalisation for Australia (IBRA) classification system (Thackway and Cresswell 1995).

The Murchison bioregion comprises the northern part of the Yilgarn Craton and includes two major subregions, the Eastern Murchison (MUR01) and the Western Murchison (MUR02). The LGP is located within the Southern Eremaean Province, in the Eastern Murchison (MUR01) subregion, which is characterised by its internal drainage, areas of red sandplains, salt lake systems associated with an occluded Palaeodrainage system, broad plains of red-brown soils and breakaway complexes (Desmond *et al.* 2001). Vegetation is dominated by low Mulga woodlands (*Acacia aneura* complex) on plains, and thick woodland with *Tecticornia* in the Palaeodrainage, with some local areas of spinifex grassland, shrublands and mosaic units related to the underlying geology (Pringle *et al.* 1994). The bioregion is rich and diverse in both its flora and fauna although most species are wide-ranging and usually occur in adjoining regions (McKenzie *et al.* 2003).

2.2 Land Systems

An assessment of land systems provides an indication of the occurrence and distribution of fauna habitats and vegetation within and surrounding the Study Area (Curry *et al.* 1994). Land systems across the Murchison have been mapped by the Natural Resources Assessment Group of the former Department of Agriculture (now Department of Primary Industries and Regional Development, DPIRD) and provide a comprehensive description of biophysical resources within the area (Curry *et al.* 1994). There are seven land systems present within the Study Area (**Table 2-1** and **Figure 2-1**). The Cardinia Access Road Survey Area traverses six land systems. The Mertondale Haul Road Survey Area, however, coincides primarily with the Violet System (97%), with only a small proportion of the linear route traversing the Nubev System.

Table 2-1: Land systems mapped over the Study Area

Land system	Description	Portion of Study Area			
		Mertondale Haul Road Survey Area		Cardinia Access Road Survey Area	
		ha	%	ha	%
Felix System	Gently undulating plains with quartz mantles, supporting acacia-eremophila shrublands locally with wanderrie grasses.	-	-	33.11	15
Gundockerta System	Extensive, gently undulating calcareous stony plains supporting bluebush shrublands.	-	-	17.35	8
Hootanui System	Breakaways, hills and ridges with saline gravelly and stony lower plains supporting scattered halophytic low shrublands.	-	-	21.09	10
Leonora System	Low greenstone hills and stony plains supporting mixed chenopod shrublands.	-	-	<0.001	<1
Nubev System	Gently undulating stony plains, minor limonitic low rises and drainage floors supporting mulga and halophytic shrublands.	1.64	3	65.39	30
Tiger System	Gravelly hardpan plains and sandy banks with mulga shrublands and wanderrie grasses.	-	-	78.51	36

Land system	Description	Portion of Study Area			
		Mertondale Haul Road Survey Area		Cardinia Access Road Survey Area	
		ha	%	ha	%
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.	50.36	97	-	-
Total		**52**	**100**	**215.44**	**100**

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

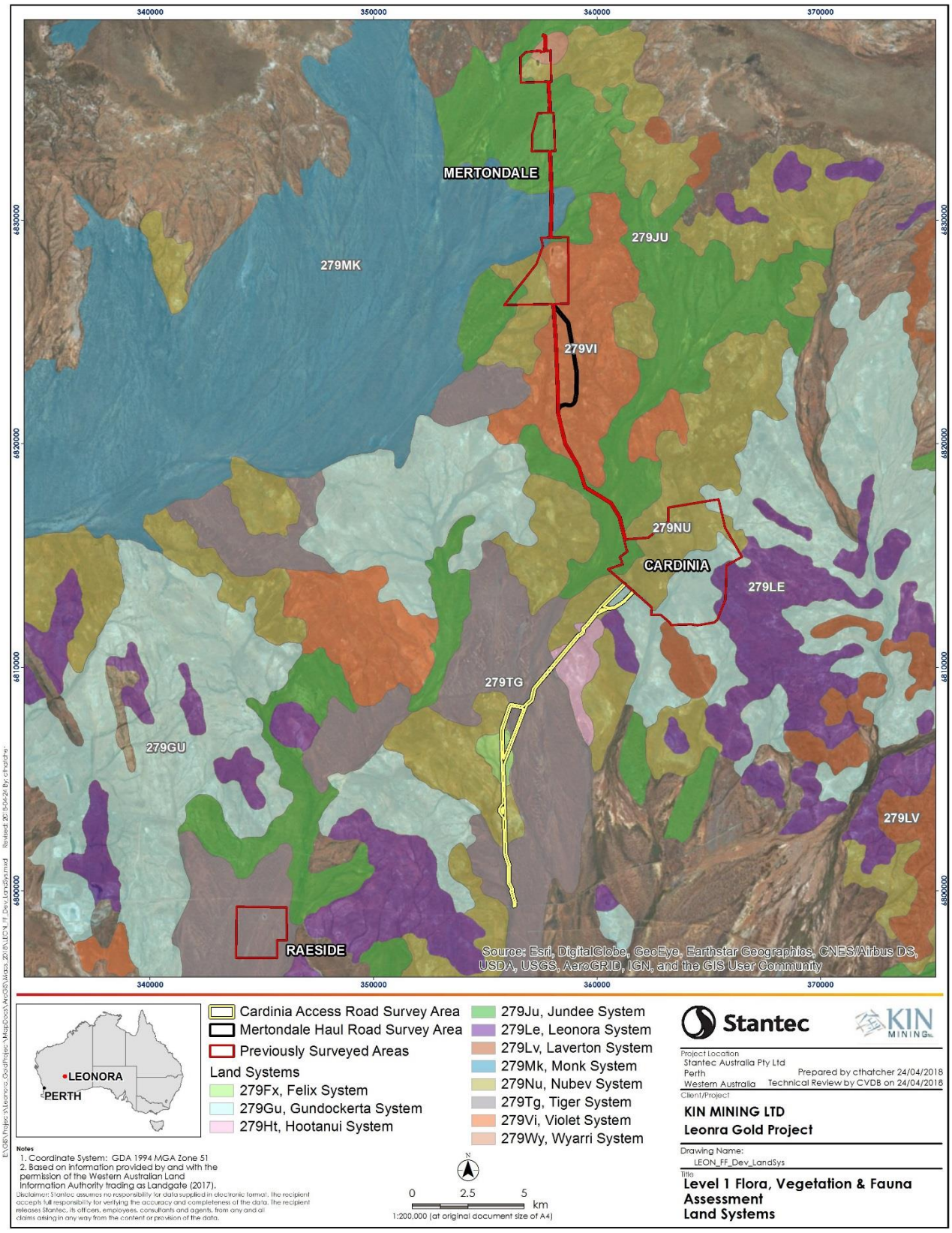


Figure 2-1: Land systems of the Study Area

2.3 Pre-European Vegetation

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

The Study Area occurs within the Laverton Botanical District of the Eremaean Province (Beard 1990a). The Laverton Botanical District corresponds broadly to the Murchison region which was mapped by Beard (1976) at a 1:1,000,000 scale. Three vegetation associations mapped by Beard (1976), and reinterpreted by Shepherd *et al.* (2002), intersect the Study Area (**Table 2-2**, **Table 2-3** and **Figure 2-2**). The Mertondale Haul Road Study Area traverses a single vegetation association, Laverton 18, whereas the Cardinia Access Road Survey Area traverses Laverton 18, Laverton 28 and Laverton 39.

Table 2-2: Pre-European vegetation associations of Study Area

Vegetation association	Description	Portion of Study Area			
		Mertondale Haul Road Survey Area		Cardinia Access Road Survey Area	
		ha	%	ha	%
Laverton_18	Shrublands, Mulga scrub	52	-	101.62	47
Laverton_28	Low woodland; mulga (*Acacia aneura*)	-	-	49.35	23
Laverton_39	Open low woodland; mulga	-	-	64.47	30
	Total	**52**	**100**	**215.44**	**100**

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

The current extent remaining of the vegetation associations are more than 99% across three regional scales (State, bioregion and subregion), and above 97% at the Local Government Authority (LGA) scale (**Table 2-3**) (Government of Western Australia 2015). The current extent remaining is well above the advised threshold for biodiversity conservation of 30% remaining (EPA 2000).

Table 2-3: Pre-European extent of vegetation associations remaining

Code	Scale	Pre-European extent (ha)	Current extent (ha)	Current extent remaining (%)	Current extent protected (%)
Laverton_18	State	2,353,515	2,342,968	99.55	0.45
	Bioregion	2,349,889	2,339,342	99.55	0.45
	Subregion	2,349,889	2,339,342	99.55	0.45
	LGA	1,216,599	1,216,599	99.72	0
Laverton_28	State	133,739.72	131,531.31	98.35	0
	Bioregion	133,739.72	131,531.31	98.35	0
	Subregion	133,739.72	131,531.31	98.35	0
	LGA	126,344.70	124,136.29	98.25	0
Laverton_39	State	155,416	151,580	97.53	2.5
	Bioregion	155,416	151,580	97.53	2.5
	Subregion	155,416	151,580	97.53	2.5
	LGA	141,819	138,361	97.56	0

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

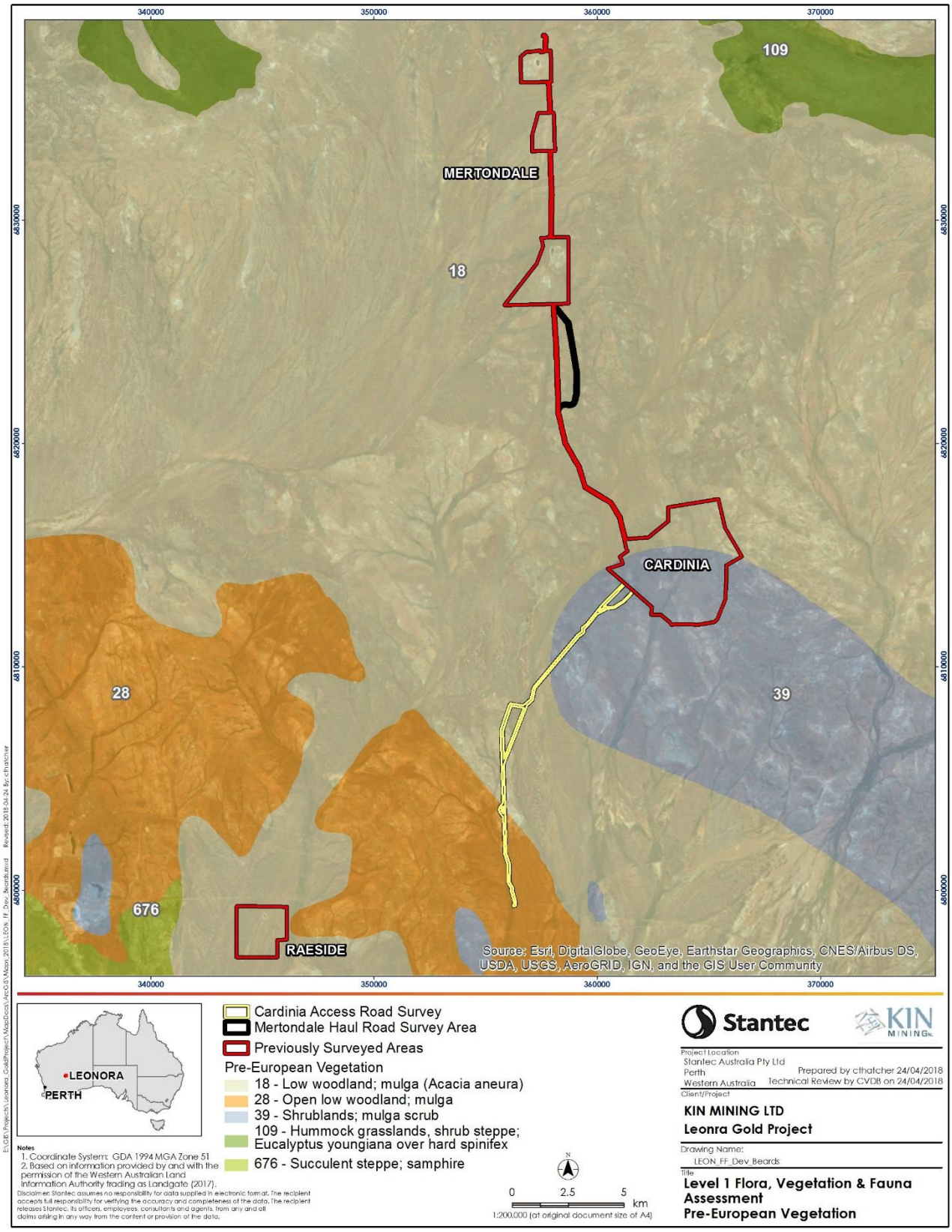


Figure 2-2: Pre-European vegetation associations of the Study Area

2.4 Land Use

The vast majority of the Eastern Murchison subregion is used for grazing of native pasture. The remainder comprises Unallocated Crown Land, and a small amount (1.4%), is allocated to conservation (Cowan 2001). The land is also used for mining, particularly gold and nickel, however most mining leases fall under the pastoral lands act and remain stocked (Cowan 2001). The proposed Mertondale Haul Road traverses the Mertondale and Clover Downs pastoral leases and the Cardinia Access Road traverses the Minara pastoral lease (**Figure 2-3**).

The Study Area is not located within or immediately adjacent to a National Park or conservation reserve. The operations within the Study Area are highly unlikely to impact on any National Parks or conservation reserves. The nearest national parks and conservation reserves are:

- Ex-Goongarrie Pastoral Lease (former leasehold proposed for conservation) – 100 km south;
- Ex-Credo Pastoral Lease (former leasehold proposed for conservation) – 120 km south west;
- Ex-Bulga downs Pastoral Lease (former leasehold proposed for conservation) – 126 km west;
- Wanjarri Nature Reserve (Class A) – 150 km north west;
- De La Poer Range Nature Reserve (Class C) – 160 km north-east;
- Ex-Mt Elvire Pastoral Lease (former leasehold proposed for conservation) – 170 km south-west
- Ex-cashmere downs Pastoral Lease (former leasehold proposed for conservation) – 190 km west;
- Ex-Lake Mason Pastoral Lease (former leasehold proposed for conservation) – 195 km north-west
- Yeo Lake Nature Reserve (Class A) – 250 km north-east; and
- Plumridge Lakes Nature Reserve (Class A) – 300 km south-east.

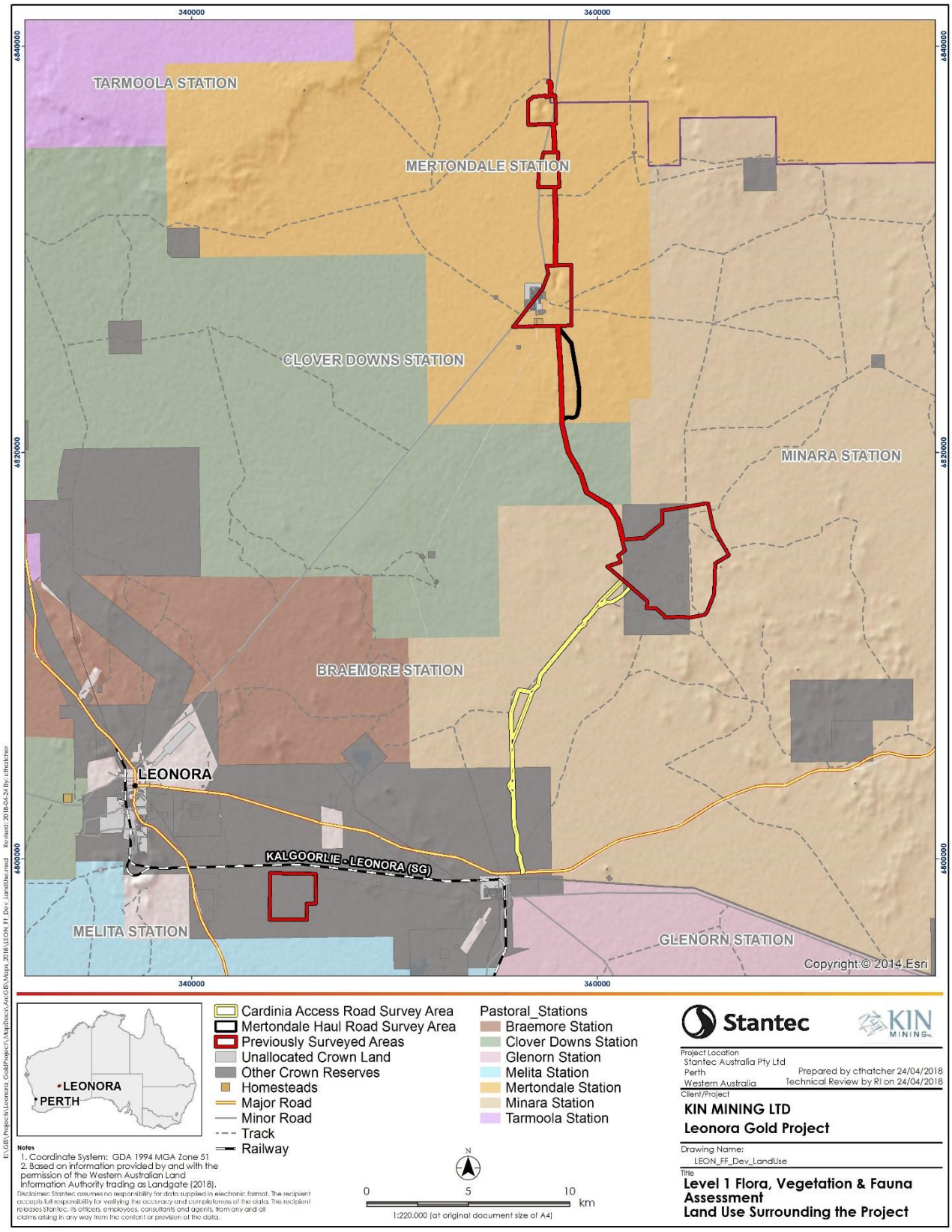


Figure 2-3: Land Use associated with the Study Area

2.5 Climate

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

Leonora Aero (station number 012241) is the nearest Bureau of Meteorology (BoM) weather station to the LGP with the most complete long-term climatic data (BoM 2018). The mean historical annual rainfall recorded between 2007 and February 2018 is 276.84 mm, with the majority received between January and March each year (**Figure 2-4**). The hottest maximum temperatures occur between November and March, with the coolest minimum temperatures occurring between May and August.

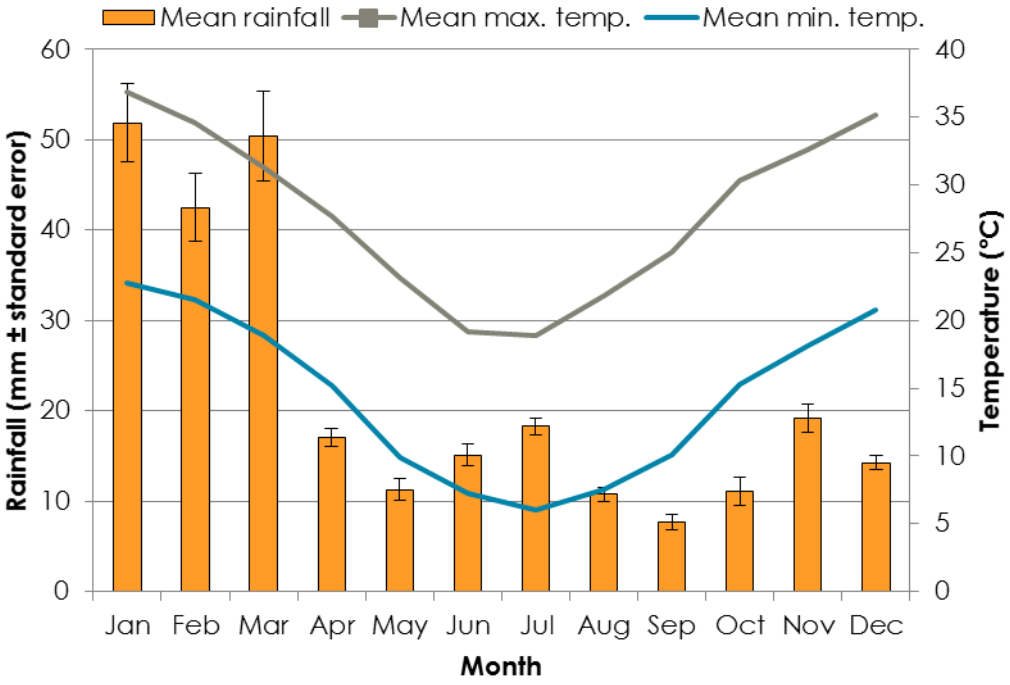


Figure 2-4: Long-term climate data recorded at the Leonora Aero Weather Station (station number 012241)

3. Desktop Study

A desktop study, comprising database searches and a literature review, was undertaken prior to the field survey. The purpose of the desktop study was to identify flora, vegetation and terrestrial fauna potentially occurring in the Study Area, in particular, species of conservation significance. Conservation significance and conservation rankings used under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Wildlife Conservation Act 1950* (WC Act), as well as the Department of Parks and Wildlife's (Parks and Wildlife) Priority list, are defined in **Appendix A**.

3.1 Database Searches

Database searches were undertaken to generate a list of vascular flora and vertebrate fauna previously recorded within, and within the vicinity of, the Study Area. The searches focussed on species of conservation significance and introduced species. Six database searches were conducted around a central coordinate within the Study Area (51J 357273 E, 6812438 S). The distance of each search buffer around the central co-ordinate was adjusted to the most appropriate distance for each database (**Table 3-1**).

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

Custodian	Database	Taxonomic Group	Reference	Buffer (km)
DoEE	Protected Matters	Flora and Fauna	DoEE (2016)	80
Parks and Wildlife (now DBCA)	NatureMap	Flora and Fauna	DPaW (2016a)	40
Parks and Wildlife (now DBCA)	Threatened and Priority Ecological Communities	Flora and Fauna	DPaW (2016b)	40
Parks and Wildlife (now DBCA)	Threatened and Priority Flora	Flora	DPaW (2016d)	40
Parks and Wildlife (now DBCA)	Threatened and Priority Fauna	Fauna	DPaW (2016e)	100
Birdlife Australia	Birdlife Bird data	Fauna	Birdlife Australia (2016)	80

3.2 Literature Review

The literature review considered six previous reports of relevance to the Study Area, comprising four flora and vegetation reports (**Table 3-2**) and two fauna reports (**Table 3-3**). Additionally, the following regional documents were also considered as part of this assessment:

- Biological survey of the eastern Goldfields of Western Australia Part 5: vertebrate fauna (Dell and How 1988).
- Biological survey of the eastern Goldfields of Western Australia Part 7: vertebrate fauna (Dell and How 1988).

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

Reference	Study Details	Proximity to Study Area	Vegetation Units	Flora Recorded	Vegetation Condition	Species and communities of conservation significance
Stantec (2018)	Location: Leonora Gold Project Study Type: Level 1 Flora, Vegetation and Fauna Assessment Survey Date: November and December 2016; May 2017 and August 2017 (targeted survey).	Overlaps with Study Area	23 vegetation units broadly comprised of mixed Mulga shrublands over mixed shrubs dominated by *Eremophila* species, *Ptilotus obovatus*, *Scaevola spinescens* and *Rhagodia* species, also with large areas dominated by *Cratystylis subspinescens, Maireana pyramidata* and *Maireana sedifolia*.	• 257 taxa • 37 families • 103 genera	Vegetation condition ranged from 'Excellent' to 'Completely Degraded'. Disturbances included historical and recent mining and drilling activities, in addition to grazing from introduced herbivores.	• *Gunniopsis propinqua* (P3) • *Acacia* sp. Marshall Pool [G. Cockerton 3024])
Outback Ecology (2009a)	Location: Leonora Gold Project Study Type: Level 1 Flora and Vegetation Survey Survey Date: February 2009	Coincident with Study Area	11 Vegetation units including: • Mertondale Drainage areas – Acacia shrublands: ○ *Acacia minyura* Tall Shrubland over *Eremophila platycalyx* subsp. *platycalyx* and *A. ramulosa* var. *ramulosa* Open Shrubland over *Ptilotus obovatus* var. *obovatus* Low Shrubland ○ *Eucalyptus striaticalyx* Low Open Woodland over *Acacia minyura* Tall ○ Shrubland over *Eremophila scoparia, Ptilotus obovatus,*	• 98 taxa • 30 families • 50 genera	Vegetation condition ranged from 'Excellent' to 'Degraded' condition. Disturbances included grazing, tracks, exploration and historic mining.	None

Reference	Study Details	Proximity to Study Area	Vegetation Units	Flora Recorded	Vegetation Condition	Species and communities of conservation significance
			Maireana triptera Low Shrubland; ○ *Acacia coolgardiensis* subsp. *effusa, A. ramulosa* var. *ramulosa, A. aneura* var. major, *A. quadrimarginea* Tall Open Scrub over *Eremophila platycalyx* subsp. platycalyx Tall Shrubland over *E. simulans* subsp. *simulans, E. exilifolia* Open Shrubland over *Ptilotus obovatus* var. *obovatus* Low Shrubland • *Maireana* Shrublands: ○ Acacia or *Eremophila* shrubland over *Maireana;* ○ *Acacia coolgardiensis* subsp. effusa Low Open Forest over *A. burkitii, A. tetragonophylla* Tall ○ Open Scrub *Maireana pyramidata, Eremophila forrestii* subsp. *forrestii, Ptilotus obovatus* var. *obovatus, Atriplex nummularia* subsp. *spathulata* Low Open Shrubland; ○ *Eremophila oppositifollia* subsp. *augustifolia, E. platycalyx* subsp. *platycalyx*			

Reference	Study Details	Proximity to Study Area	Vegetation Units	Flora Recorded	Vegetation Condition	Species and communities of conservation significance
			and *E. longifolia* tall Open Shrubland over *Cratystylis subspinescens, Maireana glomerifolia, Eremophila scoparia* Low ○ *Maireana sedifolia, Ptilotus obovatus* var. *obovatus, Hakea preisii* Low Open Shrubland • Creekline vegetation: ○ *Acacia aneura* var. *major, A. aneura* var. *aneura* Low Woodland over *A. craspedocarpa* Tall Open *Shrubland over A. ramulosa var. ramulosa* Tall Shrubland over Mixed Scattered Low Shrubs and *Grasses;* ○ *Acacia aneura* var. *major, A. aneura* var. *aneura* Low Open Forest over *A. craspedocarpa* Tall Open Shrubland over *A. ramulosa* var. *ramulosa T*all Shrubland over Mixed Scattered Low Shrubs and Grasses. ○ *Acacia aneura* var. major Low Woodland over *A. burkittii, Eremophila platycalyx* subsp. *platycalyx*			

Reference	Study Details	Proximity to Study Area	Vegetation Units	Flora Recorded	Vegetation Condition	Species and communities of conservation significance
			Tall Shrubland over *Grevillea extorris, A. ramulosa* var. *ramulosa* Open Heath over *Senna artemisioides* subsp. *filifolia* Scattered Low Shrubs. • Rocky Hilltop vegetation: ○ *Acacia burkittii* Tall Open Scrub over *Senna artemisioides* subsp. *filifolia, Ptilotus obovatus* var. *obovatus* Low Shrubland.			
Outback Ecology (2009b)	Location: Leonora Gold Project Study Type: Level 1 Flora and Vegetation Survey Survey Date: April 2008	Coincident with Study Area	Four vegetation units including: • Mertondale Drainage areas • *Maireana* Shrubland • Creekline vegetation • Rocky Hilltop vegetation	• 81 taxa • 26 families • 34 genera	Vegetation condition ranged from /'Excellent' to 'Degraded' condition. Disturbances included grazing, tracks, exploration and historic mining.	None

Reference	Study Details	Proximity to Study Area	Vegetation Units	Flora Recorded	Vegetation Condition	Species and communities of conservation significance
Mattiske Consulting (2002)	Location: Cardinia and Proposed Haul Road Study Type: Flora and Vegetation Survey Survey Date: October 2002	Coincident with Study Area: focus on Cardinia mine area	Four vegetation units: • Open Scrub of *Acacia aneura* – *Acacia minyura* on the flats and plains • Low Open Forest to Low Open Woodland of *Acacia aneura* on the drainage lines • Open Scrub of *Acacia* species on the ridges and breakaways • Low Open Scrub to Low Shrubland of *Maireana triptera* on the saline depressions	• 55 taxa • 28 families • 37 genera	Disturbance from grazing and vehicle tracks in vicinity of proposed pit	None
GHD (2007)	Location: Borrow pits within 30 km of Leonora Study Type: Level 1 Flora and Fauna survey Survey Date: April 2007	5 km west and 30 km south of Study Area	Three vegetation units: • Low Woodland (Mulga) • Open Low Woodland (Mulga) • Open Mulga Shrubland	• 64 taxa • 23 families	'Excellent' to 'Completely Degraded'	None

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

Reference	Study details	Proximity to Study Area	Broad habitats	Fauna assemblage recorded	Species of conservation significance	Notes
Stantec (2018)	Location: Leonora Gold Project Study Type: Level 1 Flora, Vegetation and Fauna Assessment Survey Date: November and December 2016; May 2017 and August 2017 (targeted survey).	Coincident with Study Area	Four broad fauna habitat types including: • *Acacia* Shrublands on plains; • Drainage Lines; • Low Hills; and • Chenopod Shrublands.	65 vertebrate taxa: • Nine mammals • Six introduced mammals • 48 birds • Eight reptiles	None.	None

Reference	Study details	Proximity to Study Area	Broad habitats	Fauna assemblage recorded	Species of conservation significance	Notes
Outback Ecology (2009c)	Location: Leonora Gold Project Study Type: Level 1 Vertebrate Fauna and Level 2 (trapping) SRE invertebrate fauna survey SRE component involved 8 sampling sites. Methods at each site included: • dry-pitfall trapping (5 traps over 7 nights) • targeted searching (2hrs) • leaf litter collection (5 samples) • soil sieving (5 samples); and • ultraviolet spotlighting (1 hr) Survey Date: September 2008	Coincident with Study Area	Six broad fauna habitats including: • Stony Plains • Loamy surfaced plains • Low rises supporting Mulga • Saline alluvial plains • Wash plains and drainage lines • Breakaways	58 vertebrate taxa: o two native mammals o Four introduced mammals o 46 birds o Five reptiles 10 taxa from SRE groups: o Three mygalomorph spiders o One scorpion o Four pseudoscorpion o Two Molluscs	No Vertebrate Fauna No known SRE invertebrate fauna. Four potential SRE invertebrate fauna: o *Idiommata* sp. (drainage line) o Pseudoscorpion: *Austrohorus* sp. (wash plains) o *Beierolpium* 'sp. 8/3' (stony plains) o Terrestrial mollusc: *Succinea* sp. (stony plain)	Habitats present were considered to have low potential to support SRE species
GHD (2007)	Location: Main Roads Western Australia (borrow pits within 30 km of Leonora) Study Type: Level 1 Flora and Fauna Survey Survey Date: April 2007	5 km west and 30 km south of Study Area	Mulga woodlands and shrublands	30 taxa: o Two native mammal o Three introduced mammal o 22 bird o Three reptile	None	None

Reference	Study details	Proximity to Study Area	Broad habitats	Fauna assemblage recorded	Species of conservation significance	Notes
Ninox Wildlife Consulting (2011)	Location: Proposed Rail Siding near Menzies Study Type: Level 1 fauna survey Survey Date: September 2011	97 km south of Study Area	Two broad fauna habitats: • Shrublands • Woodlands	One native mammal Two introduced mammal 18 bird Two reptile	None	None

3.3 Desktop Results

This section details the results of the database searches and literature review. Included are lists of flora and fauna taxa of conservation significance that have the propensity to occur within the Study Area. The likelihood of occurrence of each taxa are assessed according to the ranking described in the section below (**section 3.3.1**).

3.3.1 Likelihood of Occurrence for Flora and Fauna

The likelihood of occurrence of each species of conservation significance in the Study Area was assessed and ranked. The rankings were assigned using the following definitions:

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

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

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

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

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

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

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

3.3.2 Flora

Thirty five flora taxa of conservation significance were identified from the database searches (**Table 3-4**). None of the conservation significant flora species are listed as Threatened under the WC Act, or listed under the EPBC Act. Of the thirty five priority flora species listed, ten are listed as Priority 1, two are listed as Priority 2, 18 are listed as Priority 3 and three are listed as Priority 4 (**Table 3-4**). Based on an assessment of the likelihood of occurrence of these taxa within the Study Area (**Appendix G**), five taxa are listed as 'Very likely' to occur and seven taxa are listed as 'Likely' to occur.

Table 3-4: Flora species of conservation significance identified during the desktop assessment

Species	Source[1]	Parks and Wildlife Priority Status
Acacia websteri	DPaW, NatureMap	P1
Eremophila arachnoides subsp. *tenera*	DPaW	P1
Eremophila eversa	DPaW	P1
Lechenaultia aphylla	DPaW	P1

Species	Source[1]	Parks and Wildlife Priority Status
Micromyrtus chrysodema	DPaW	P1
Persoonia leucopogon	DPaW	P1
Philotheca tubiflora	DPaW	P1
Ptilotus tetrandrus	DPaW, NatureMap	P1
Stenanthemum patens	DPaW	P1
Vittadinia cervicularis var. *oldfieldii*	DPaW	P1
Eremophila mirabilis	DPaW	P2
Thryptomene eremaea	DPaW	P2
Angianthus prostratus	DPaW, NatureMap	P3
Calytrix praecipua	DPaW, NatureMap	P3
Calytrix verruculosa	DPaW	P3
Cratystylis centralis	DPaW, NatureMap	P3
Eremophila annosocaulis	DPaW	P3
Eremophila shonae subsp. *diffusa*	DPaW	P3
Eremophila simulans subsp. *megacalyx*	DPaW, NatureMap	P3
Goodenia lyrata	DPaW	P3
Grevillea obliquistigma subsp. cullenii	DPaW	P3
Gunniopsis propinqua	DPaW	P3
Hybanthus floribundus subsp. chloroxanthus	DPaW, NatureMap	P3
Micromyrtus serrulata	DPaW	P3
Philotheca coateana	DPaW	P3
Phyllanthus baeckeoides	DPaW	P3
Sauropus sp. Woolgorong (M. Officer s.n. 10/08/94)	DPaW	P3
Thryptomene nealensis	DPaW	P3
Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362)	DPaW	P3
Triglochin protuberans	DPaW, NatureMap	P3
Eremophila pungens	DPaW	P4
Eucalypts jutsonii subsp. jutsonii	DPaW	P4
Grevillea inconspicua	DPaW	P4

[1] DPaW, now DBCA (Department of Biodiversity, Conservation and Attractions)

3.3.2.1 Introduced Flora

Eight introduced taxa were identified in the previously surveyed areas surrounding the Study Area (**Table 3-5**). Of these, one is considered to be an environmentally significant weed. **Cylindropuntia fulgida* var. *mamillata* is classed as a Declared Pest (DP) under Section 22 of the *Biosecurity and Agriculture Management Act 2007* (BAM Act). **Cylindropuntia fulgida* var. *mamillata*, along with all *Cylindropuntia* spp., is also classified as a Weed of National Significance (WoNS). The introduced taxa listed in **Table 3-5** are considered to be likely to occur within the Study Area, particularly in habitat that has undergone disturbance.

Table 3-5: Introduced flora recorded within the previously surveyed areas of the Project

Species	Common Name	Status
**Carpobrotus aequilaterus*	Angular Pigface	-
**Cuscuta planiflora*	Small Seeded Dodder	-
**Cylindropuntia fulgida* var. *mamillata*	Coral Cactus	WoNS, DP
**Malvastrum americanum*	Spiked Malvastrum	-
**Rumex hypogaeus*	Doublegee	-
**Rumex vesicarius*	Ruby Dock	-
**Sisymbrium erysimoides*	Smooth Mustard	-
**Sisymbrium irio*	London Rocket	-

3.3.3 Vegetation

No Threatened Ecological Communities (TEC's) were identified from the Department of Biodiversity Conservation and Attractions (DBCA) (formerly Department of Parks and Wildlife (DPaW)) Threatened and Priority Ecological Community database or the Department of Environment and Energy's (DoEE) Protected Matters Database Search (DoEE 2016) as occurring within or near to the Study Area.

One Priority Ecological Community (PEC) was identified as occurring within 10 km of the Study Area, however, the PEC community identified by the database search refers to assemblages of subterranean invertebrate fauna, which are not part of the scope for this assessment, and are therefore not discussed within this report (**Table 3-6**).

Table 3-6: Priority Ecological Communities identified by the desktop assessment

Community Name	Description	Conservation Status	Distance from Study Area (direction)
Melita Calcrete	Melita calcrete groundwater assemblage	P1	Approx. 6.07 km (West)

3.3.4 Fauna

The desktop study identified a total of 300 species of vertebrate fauna that have been recorded and/or have the potential to occur within the Study Area (**Appendix B**). This total comprises 29 native mammals, 12 introduced mammals, 164 native birds, three introduced birds, 83 reptile and nine amphibian species. Many of these species are considered unlikely to occur in the Study Area, as these records have been collated from a large area, numerous reports, and encompass a wide variety of habitats, many of which do not occur within the Study Area. Furthermore, some small, common, ground-dwelling reptile and mammal species tend to be patchily distributed, meaning that even where suitable habitat is present they may not occur, and many species of bird can occur as regular migrants, occasional visitors or vagrants.

Of the 300 species of vertebrate fauna identified during the desktop study, 24 species are listed as being of conservation significance, comprising four mammals and 18 bird species (**Table 3-7**). In addition, two invertebrate species of conservation significance were identified, the fairy shrimps *Branchinella apophysata* and *Branchinella simplex* (**Table 3-7**).

Table 3-7: Fauna species of conservation significance identified during the desktop assessment

Conservation Status		Common Name	Species Name
EPBC Act	WC Act		
En; Mi	S5	Red Knot	*Calidris canutus*
En	S1	Night Parrot	*Pezoporus occidentalis*
	S2	Carnaby's Cockatoo	*Calyptorhynchus latirostris*
	S2	Numbat	*Myrmecobius fasciatus*
Vu	S3	Malleefowl	*Leipoa ocellata*
		Bilby	*Macrotis lagotis*
	P4	Princess Parrot	*Polytelis alexandrae*
Mi	S5	Fork-tailed Swift	*Apus pacificus*
		Grey Wagtail	*Motacilla cinerea*
		Yellow Wagtail	*Motacilla flava*
		Oriental Plover	*Charadrius veredus*
		Sharp-tailed Sandpiper	*Calidris acuminata*
		Red-necked Stint	*Calidris ruficollis*
		Glossy Ibis	*Plegadis falcinellus*
		Pacific Golden Plover	*Pluvialis fulva*
		Wood Sandpiper	*Tringa glareola*
		Common Greenshank	*Tringa nebularia*
-	S3	Grey Falcon	*Falco hypoleucos*
	S3	Banded Hare-wallaby	*Lagostrophus fasciatus fasciatus*
	S7	Peregrine Falcon	*Falco peregrinus*
	P1	a fairy shrimp	*Branchinella apophysata*
	P1	a fairy shrimp	*Branchinella simplex*
	P4	Long-tailed Dunnart	*Sminthopsis longicaudata*
	P4	Hooded Plover	*Thinornis cucullatus*

4. Methodology and Approach

4.1 Survey Timing and Weather

The optimal timing for surveying flora and fauna in the Eremaean Province (where the Study Area is located) is 6 to 8 weeks following the season which normally contributes the most rainfall (EPA 2016b, e). For the Murchison bioregion, the season of highest rainfall is summer. The field survey took place from the 14th to the 18th of March 2018. Since the first significant rainfall event of the season took place on the 19th of February 2018, the field survey took place at least two weeks prior to the perceived optimal period for field surveys. However, since the rainfall during the two months preceding the field survey was above the yearly average (**Figure 4-1**), the timing was considered suitable for a reconnaissance survey.

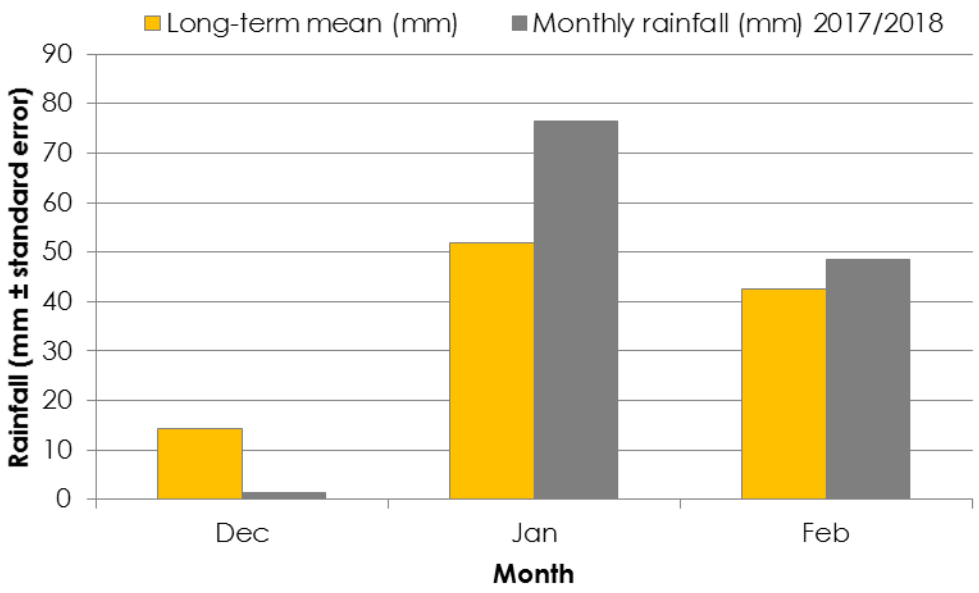


Figure 4-1: Rainfall recorded at the Leonora Aero weather station (station number 012241) three months prior to the field survey (BoM 2019)

4.2 Survey Team and Licencing

The field survey was undertaken by experienced botanists/ecologists Crystal Heydenrych and Laura True. All plant collections were made under flora collecting permits SL012176 pursuant to the WC Act Section 23C and Section 23F.

4.3 Flora and Vegetation Assessment

Best practice suggests that a survey width of 500 to 1,000 metres (m) should be surveyed for environmental impact assessment. However, as the local and regional context for the LGP is well known, a survey width of 50 to 100 m was considered sufficient.

Relevés (unbounded floristic sampling sites) were sampled to characterise vegetation types and condition, and ensure appropriate representation of the flora and vegetation present. A total of 14 relevés and 14 detailed mapping notes were sampled within the Study Area, comprising four relevés and seven mapping notes within the Mertondale Haul Road Survey Area and 10 relevés and seven mapping notes within the Cardinia Access Road Survey Area (**Figure 4-2**, **Appendix E**). Indicative site locations were identified prior to commencement of the field survey using aerial photography, topographic maps and existing vegetation

maps, to ensure that all broad vegetation types and landforms within the Study Area would be sampled. At each relevé the following information was recorded:

- GPS Location (recorded in GDA94 UTM 50J);
- a colour photograph of the vegetation;
- habitat type;
- vegetation condition (Trudgen 1988);
- vegetation description;
- dominant species present;
- average percentage cover of leaf litter;
- average percentage cover of bare ground; and
- disturbance details including fire history (time since last fire), physical disturbance, including evidence of erosion, grazing and weed invasion.

An inventory of flora within the Study Area was developed by recording vascular flora taxa encountered at each of the 14 relevés and opportunistically between sites within the Study Area. Flora taxa not identified in the field were collected and pressed for identification at the Western Australian Herbarium (WAH). Identifications were carried out by Crystal Heydenrych and Sharnya Thomson. The nomenclature and taxonomy of all vascular flora taxa in this report follows that of the WAH. All taxa were checked against FloraBase to ensure their currency and validity (WAH 2018).

Broad vegetation mapping was conducted in the field, with vegetation boundaries delineated over aerial photography, and later refined based on field survey data. Vegetation condition was assessed based on the (Trudgen 1988) vegetation condition scale (**Appendix B**). The vegetation types were described based on the floristic data recorded from the relevés and visual observations while traversing the Study Area. The vegetation classifications were delineated and described based on the National Vegetation Information System (NVIS) to hierarchical level V (ESCAVI 2003). Hierarchical level V requires the dominant growth form, cover, height and dominant species (three for each stratum) for each of the three traditional strata (i.e. upper, mid and ground to a maximum of nine taxa) to be detailed, where present.

Prior to the field survey, flora of conservation significance with potential to occur within the Study Area were identified from the desktop study (**Table 3-4**). Field personnel familiarised themselves with photographs, descriptions of these taxa, and the habitat in which they might occur, and actively searched for them while traversing the Study Area. Any flora taxa of conservation significance, or species that showed similarities to such species were recorded and detailed.

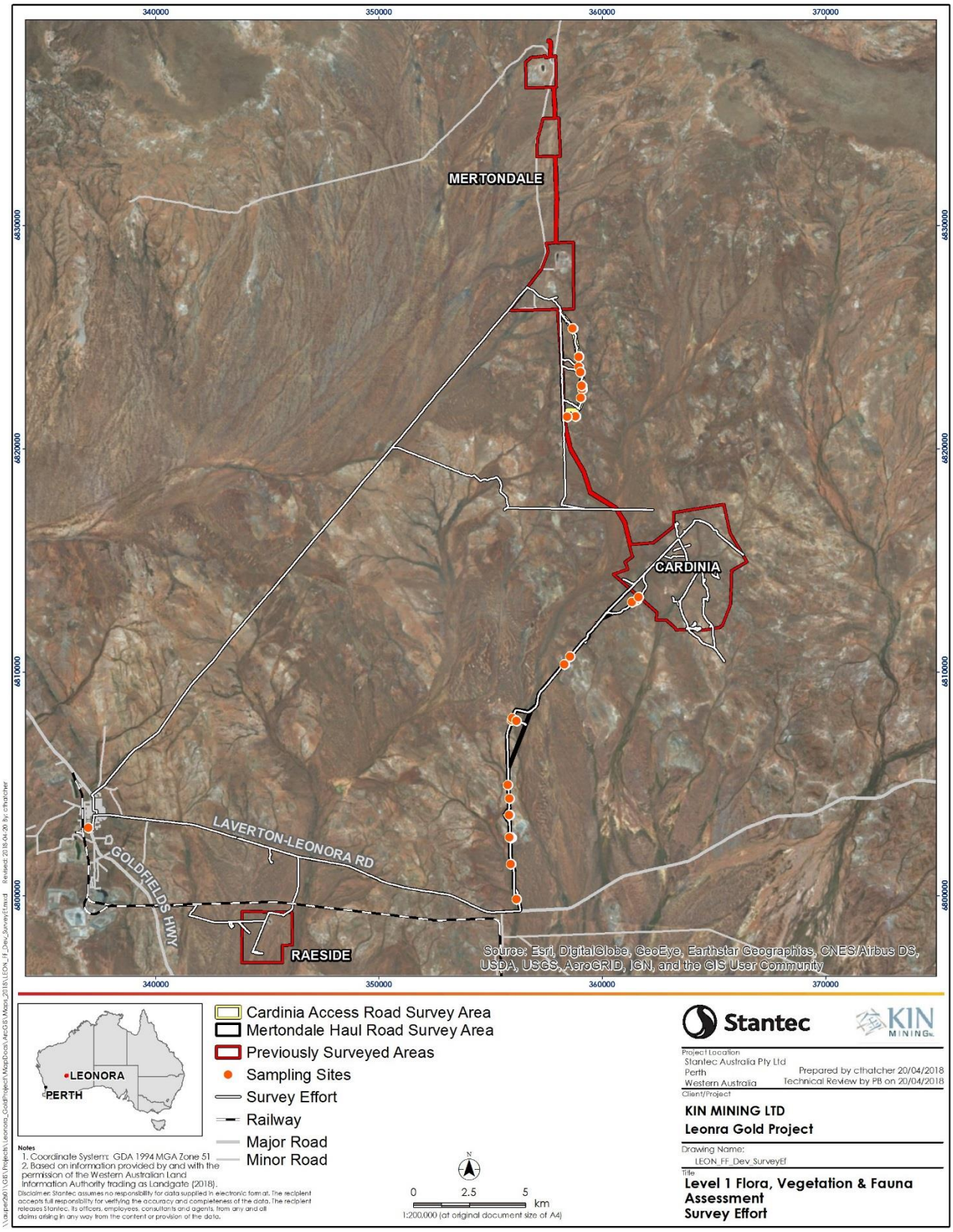


Figure 4-2: Survey effort across the Study Area

4.4 Terrestrial Fauna Assessment

Fauna habitat assessments were undertaken at 14 locations throughout the Study Area concurrent with the flora relevés **(Figure 4-2**). At each location, the following key habitat parameters were recorded:

- description of broad vegetation community;
- hollow bearing trees and dead stag trees (average size and abundance);
- rocky outcrops (average rock size and extent);
- coarse woody debris, i.e. logs and fallen timber (abundance and size);
- substrate (description of composition, presence of algal crust and % cover of leaf litter);
- wetland habitats and water courses including drainage lines, billabongs, floodplains, etc.; and
- any nest, roosts or other evidence of breeding habitat present.

Searches were conducted across all habitats types to identify possible fauna taxa of conservation significance and to develop a fauna species list for the Study Area. Additional field survey effort focused on habitat likely to support fauna of conservation significance, such as dense shrublands and thickets potentially supporting Malleefowl. Potential wetlands or temporary water bodies with the capacity to support waterbirds or migratory waders were also targeted. Searching methods included:

- hand-searching for cryptic species, for example by overturning logs and stones;
- searching beneath the bark of dead trees;
- investigating crevices; and
- searching for burrows, tracks, diggings, scats, and other signs of fauna.

In addition, aural surveys for avifauna were also undertaken. All vertebrate fauna seen or heard, or whose presence was inferred from secondary evidence was documented.

The nomenclature and taxonomy of mammals, birds, reptiles and amphibians within this report follow the Checklist of the Vertebrates of Western Australia (WAM 2017). Relevant texts, from which information on habitat preferences and general patterns of distribution are available, were also considered for:

- mammals (van Dyck *et al.* 2013, Woinarski *et al.* 2014);
- birds (Johnstone and Storr 1998b, 2004, Morcombe 2003, Pizzey and Knight 2007)
- reptiles (Cogger 2014, Storr *et al.* 1999, 2002, Wilson and Swan 2013); and
- amphibians (Cogger 2014, Tyler and Doughty 2009).

4.5 Limitations of the Assessment

There are a number of possible limitations and constraints that can reduce the adequacy of vegetation, flora and fauna surveys (EPA 2016b, d). These are discussed with respect to the survey of the Study Area (**Table 4-1**).

Table 4-1: Potential limitations and contraints of the field survey

Factor	Constraint	Comments
Competency and experience of consultants	No constraint	The field personal have appropriate qualifications and experience for undertaking reconnaissance-level flora and fauna surveys of this nature within the Murchison region. The survey was conducted by Crystal Heydenrych and Laura True who were able to build on existing knowledge of the area through the previous report for the LGP before undertaking the field survey.
Scope	No constraint	This report has satisfied the scope and objectives of the assessment, as detailed in **Section 1.2**. Flora,

Factor	Constraint	Comments
		vegetation and fauna were surveyed using standardised and well-established techniques. Relevant databases and previous studies surrounding the Study Area were reviewed.
Proportion of species identified	No constraint	Previous flora and vegetation surveys of the LGP were conducted over two separate surveys, which were undertaken during the optimal survey timing for the region (report ref here). In addition, the previous surveys covered an area that was characterised by greater diversity of habitats and larger total area in general. A total of 257 flora taxa were recorded in the previous survey. The current survey of the Study Area was undertaken early in the season, and as such only 120 species in total were recorded. Given the relatively low level of diversity in habitat types, the floristic richness from the current survey is considered comparable to other surveys in the area. Most taxonomic groups expected within the survey area were represented. However, some species which may be expected to be present post-rainfall, such as Asteraceae and annual grasses, may be considered slightly under-represented and it is possible that additional species may occur following optimal seasonal conditions. Further to this, five flora taxa could not be identified to genus level and ten could not be identified to species or infraspecific level due to a lack of flowering and/or fruiting material The survey aimed to contribute to the overall fauna species list for the LGP. This survey brought the total number of fauna to 64 vertebrate fauna species encountered and identified. Although a comprehensive fauna inventory is not a vital component for this level of survey (Level 1).
Information sources (e.g. historic or recent)	No	The Study Area is located in a relatively well-surveyed region with data available from previous surveys and records from database searches. Six previous studies were available for review during the assessment, including the previous assessment of the Study Area conducted by (Stantec 2018). Two regional documents were also considered as part of this assessment (Dell and How 1988).
Proportion of task achieved, and further work which might be needed	No	Planned survey works were conducted and completed as per the scope. A single field day was spent surveying the Mertondale haul Road Survey Area and two days were spent surveying the Cardinia Access Road Survey Area. The Study Area was adequately surveyed to compile a representative species list and to describe and map habitats present.
Timing / weather / season / cycle	No	The field survey took place at least two weeks prior to the optimal period for flora and vegetation

Factor	Constraint	Comments
		assessments. As a result, some of the plant taxa encountered in the field were senescent and could not be identified to either genus or species level, as further outlined in **Section 5.2.1.**
Disturbances	No	The majority of the Study Area was considered to be in a 'Very Good' condition, with disturbances primarily being from grazing and trampling by feral fauna (cattle and camels), the establishment of introduced flora species, and the clearing of vegetation. The Cardinia Access Road Survey Area is proposed to align with an existing access track and as a result, vegetation in this area has been marginally altered from its natural state.
Intensity	No	The entire length of the Mertondale Haul Road Survey Area was traversed on foot over a single day (**Figure 4-2**). The Cardinia Access Road Survey Area was traversed by vehicle and foot over a period of two field days. This level of on-ground survey effort is appropriate for a Level 1 flora, vegetation and fauna assessment, given the nature of the proposed development and the level of disturbance of the Study Area.
Completeness	No	The survey was conducted at 14 relevés and 14 mapping note sites chosen to ensure adequate representative coverage of the Study Area.
Resources	No	Resources were adequate to carry out the survey and the survey participants were competent in identification of species present. WAH specimens, taxonomic guides, Parks and Wildlife database searches and the *FloraBase* database were all used to prepare for the survey and used for the confirmation of any flora species where identification was uncertain.
Remoteness / access	No	All survey sites were easily accessible by vehicle or on foot.
Availability of contextual information	No	The data available for the Western Murchison subregion was adequate for the level of survey work undertaken during this assessment. Relevant information was also gleaned from IBRA (Thackway and Cresswell 1995), the vegetation mapping completed by Beard (1975), and land systems mapping (Curry *et al.* 1994)for the area. Further to this, additional contextual information was gleaned from previous surveys conducted in the greater Study Area by (Stantec 2018).

5. Results

5.1 Vegetation

This section describes the vegetation units, ecological condition and conservation significance of vegetation present within the Study Area. Maps showing the distribution of the identified vegetation units

and vegetation condition categories are also represented. Raw quadrat and relevé data is represented in **Appendix E**.

5.1.1 Vegetation Units

A total of 15 vegetation types were recorded across the Study Area, including three vegetation types along the Mertondale Haul Road Survey Area and 11 vegetation types along the Cardinia Access Road Survey Area (**Table 5-1**, **Figure 5-1** and **Figure 5-2**). The vegetation recorded broadly comprised mixed Mulga shrublands over mixed shrubs dominated by *Eremophila* species, *Ptilotus obovatus* and *Senna* species; also with large areas dominated by *Cratystylis subspinescens, Maireana pyramidata*, *Maireana sedifolia* and *Maireana triptera*. Of the 15 mapped vegetation types, eight of these were present in the previously surveyed areas of the LGP (Stantec 2018). Accuracy in vegetation mapping was at times difficult to achieve due to the presence of a mosaic of vegetation across micro-scales, and the absence of distinct boundaries between vegetation types that could easily be detected on aerial imagery or in the field.

The AaAtEp vegetation type was prevalent in the Mertondale Haul Road Survey Area, covering approximately 91% (**Figure 5-1**). This unit was broadly made up of Mulga upper strata, with *Eremophila platycalyx* subsp. *platycalyx* dominant in the mid-stratum, as well as other associated shrubs.

Over 40% of the Cardinia Access Road Survey Area was comprised of the HpCsMp vegetation type (**Figure 5-4**), which is characterised by an upper stratum of *Hakea preissii* over a mid-layer of *Cratystylis subspinescens* and *Maireana pyramidata* over a low chenopod shrubland.

Table 5-1: Vegetation units recorded within the Study Area

Code	Description	Relevés	Portion of Study				Photograph
			Mertondale Haul Road Survey Area		Cardinia Access Road Study Area		
			ha	%	ha	%	
AaEpp	*Acacia aneura* woodland over *Eremophila platycalyx* subsp. *platycalyx* isolated shrubs	LD04	1.14	2.18	-	-	

Code	Description	Relevés	Portion of Study				Photograph
			Mertondale Haul Road Survey Area		Cardinia Access Road Study Area		
			ha	%	ha	%	
AaAtEp[1]	*Acacia aneura, Acacia aptaneura* and *Acacia caesaneura* low open woodland over *Eremophila platycalyx* subsp. *platycalyx, Acacia ramulosa* subsp. *ramulosa* and *Acacia tetragonophylla* tall to mid isolated shrubs over *Ptilotus obovatus, Eremophila metallicorum* and *Eremophila margarethae* low isolated shrubs, over mixed low grasses.	LDM05	47.10	90.58	-	-	
AcAtEo[1]	*Acacia craspedocarpa, Acacia aneura* and *Acacia caesaneura* low woodland over *Acacia tetragonophylla, Scaevola spinescens* and *Eremophila oldfieldii* subsp. *angustifolia* mid isolated shrubs over *Ptilotus obovatus* and *Maireana tomentosa* subsp. *tomentosa* low isolated shrubs, over *Ptilotus* sp. Goldfields (R. Davis 10796), *Enneapogon caerulescens* and *Aristida contorta* low isolated forbs and grasses	LD1	3.76	7.23	-	-	

Code	Description	Relevés	Portion of Study				Photograph
			Mertondale Haul Road Survey Area		Cardinia Access Road Study Area		
			ha	%	ha	%	
CpArEo[1]	*Casuarina pauper, Acacia caesaneura* and *Acacia aneura* low woodland over *Acacia ramulosa* var. *ramulosa* and *Acacia tetragonophylla* tall isolated shrubs over *Eremophila oldfieldii* subsp. *angustifolia* mid isolated shrubs over *Maireana triptera, Sclerolaena eriacantha* and *Sclerolaena densiflora* low isolated forbs	-	-	-	0.08	0.04	

Code	Description	Relevés	Portion of Study				Photograph
			Mertondale Haul Road Survey Area		Cardinia Access Road Study Area		
			ha	%	ha	%	
HpCsMp[1]	*Hakea preissii* low isolated trees over *Cratystylis subspinescens* and *Maireana pyramidata* mid open shrubland over *Tecticornia pruinosa, Tecticornia disarticulata* and *Tecticornia pergranulata* subsp. *pergranulata* low open chenopod shrubland over *Enneapogon caerulescens* low isolated grasses	LHR01 LHRM04 LHR02 LHR10	-	-	90.83	42.16	
AbAtTt[1]	*Acacia burkittii* and *Acacia aptaneura* low open woodland over *Acacia tetragonophylla* and *Acacia burkittii* mid sparse shrubland over *Themeda triandra, Eriachne flaccida* and *Enteropogon ramosus* low tussock grasses on sandy drainage line	-	-	-	0.74	0.34	

Code	Description	Relevés	Portion of Study				Photograph
			Mertondale Haul Road Survey Area		Cardinia Access Road Study Area		
			ha	%	ha	%	
AkHpEs[1]	*Acacia kalgoorliensis, Acacia oswaldii* and *Hakea preissii* low open woodland over *Eremophila scoparia, Senna stowardii* and *Acacia craspedocarpa* mid isolated shrubs over *Ptilotus obovatus, Maireana triptera and Cratystylis subspinescens low isolated shrubs* over *Sclerolaena eriacantha, Sclerolaena densiflora* and *Ptilotus sp.* Goldfields (R. Davis 10796) low isolated forbs on rocky plains		-	-	0.82	0.38	
AaArEspp.[1]	*Acacia aneura, Acacia incurvaneura* and *Acacia caesaneura* low open forest over *Acacia ramulosa* var. *ramulosa* tall isolated shrubs over *Eremophila* spp. mid isolated shrubs over low isolated mixed shrubs, herbs and grasses.	-	-	-	62.79	29.15	

Code	Description	Relevés	Portion of Study				Photograph
			Mertondale Haul Road Survey Area		Cardinia Access Road Study Area		
			ha	%	ha	%	
Asp.MsEs[1]	*Acacia* sp. tall isolated trees over *Senna artemisoides* var *filifolia, Eremophila scoparia, Maireana sedifolia* mid sparse shrubland over *Tecticornia ? disarticulata* chenopod shrubland	LHR04	-		10.14	4.71	
AcAaSpp.M	*Acacia craspedocarpa*, *Acacia ayersiana*, *Acacia aneura* to tall isolated shrubs over *Senna* sp. Meekatharra (E. Bailey 1-26) mid sparse shrubland over *Maireana triptera* and *Sclerolaena* sp. chenopod shrubland	LHRM05 LHRM08	-	-	28.00	13.00	

Code	Description	Relevés	Portion of Study				Photograph
			Mertondale Haul Road Survey Area		Cardinia Access Road Study Area		
			ha	%	ha	%	
AaAcEms	*Acacia aneura* tall open shrubland over *Acacia craspedocarpa* mid open shrubland over *Ptilotus obovatus* var. *obovatus, Eremophila mackinlayi* subsp. *spathulata* low sparse shrubland over *Fimbristylis dichotoma, Cheilanthes sieberi* and introduced forbs	LHR08	-	-	10.13	4.70	
PaAtEp	*Pittosporum angustifolium* isolated trees over *Santalum spicatum, Acacia tetragonophylla* mid isolated trees over *Eleocharis pallens* sedgeland over *Marsilea sp.*	LHR09	-	-	0.59	0.28	

Code	Description	Relevés	Portion of Study				Photograph
			Mertondale Haul Road Survey Area		Cardinia Access Road Study Area		
			ha	%	ha	%	
AaAaEspp.	*Acacia ? aneura* mid isolated trees over low *Acacia ? aneura, Eremophila youngii* subsp. *youngii* mid sparse shrubland over *Eremophila hygrophana* low isolated shrubs over mixed grassland.	-	-	-	2.84	1.32	

Code	Description	Relevés	Portion of Study				Photograph
			Mertondale Haul Road Survey Area		Cardinia Access Road Study Area		
			ha	%	ha	%	
A?dArrEspp.	*Acacia ? duriscula, Acacia ? aneura* isolated trees over *Acacia ramulosa* var. *ramulosa* mid isolated shrubs over *Eremophila margarethae, Ptilotus obovatus* var. *obovatus* low openshrubland.	LHR07	-	-	8.48	3.93	

Key: 1 denotes vegetation units identified in the Study Area that have also been identified in areas previously surveyed by (Stantec 2018).

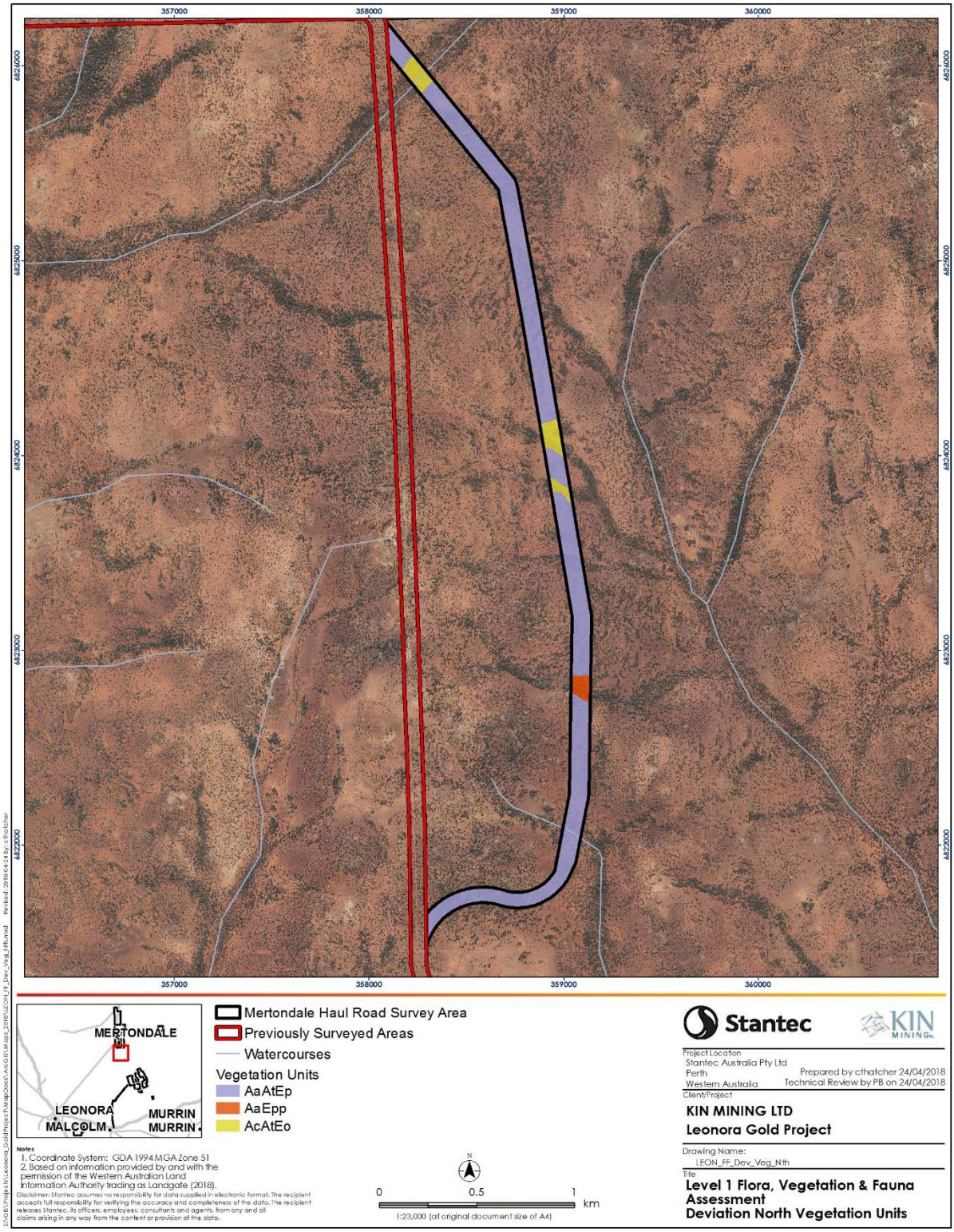


Figure 5-1: Vegetation Units - Mertondale Haul Road Survey Area

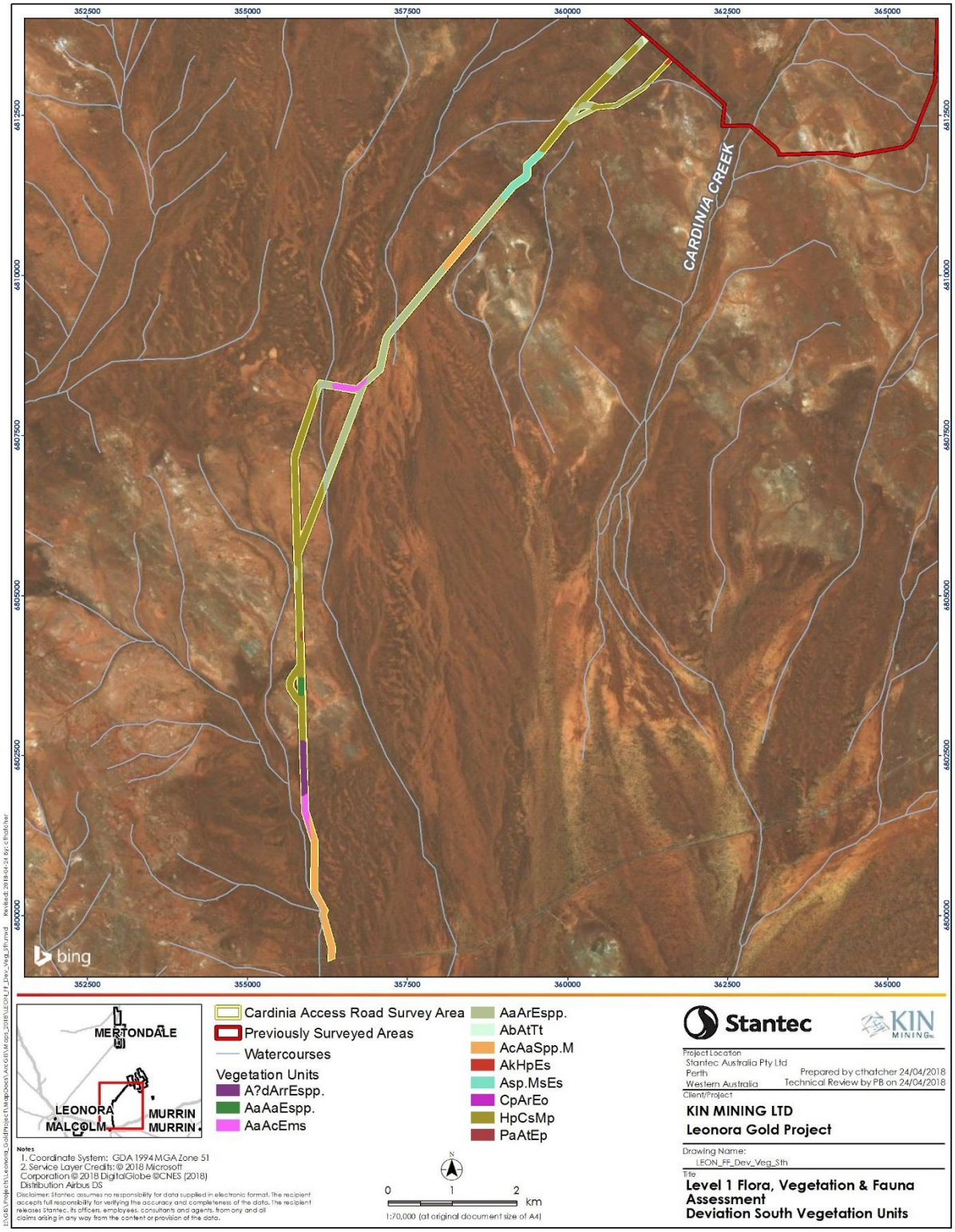


Figure 5-2: Vegetation units - Cardinia Access Road Survey Area

5.1.2 Vegetation Condition

The vegetation condition of the Study Area ranged from 'Degraded' to 'Excellent' (Trudgen 1988) (**Table 5-2**, **Figure 5-3** and **Figure 5-4**). Some of the disturbance factors identified during the field survey included grazing and trampling by feral fauna (cattle and camels), the establishment of introduced flora species, and most notably; the clearing of vegetation for existing access roads.

Due to relatively negligible impacts from human activity along the Mertondale Haul Road Survey Area, the vegetation was in an 'Excellent' condition (**Figure 5-1**). The majority of the habitat adjacent to the existing access track in the Cardinia Access Road Survey Area had been marginally altered from its natural state and was in a 'Very Good' ecological condition (**Figure 5-4**). Areas that had been subjected to considerable edge effects from vehicle disturbance were in a 'Good' condition, whereas areas that had been previously cleared or significantly altered were in a 'Degraded' condition.

Table 5-2: Vegetation Condition

Condition rating	Mertondale Haul Road Survey Area		Cardinia Access Road Survey Area		Total	
	ha	%	ha	%	ha	%
Excellent	-	-	2.43	1.13	2.43	0.91
Very Good	52	100	194.98	90.50	246.98	92.35
Good	-	-	14.97	6.95	14.97	5.60
Degraded	-	-	3.07	1.43	3.07	1.15
Completely Degraded	-	-	-	-	-	-
Total	**52**	**100**	**215.44**	**100**	**267.45**	**100**

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

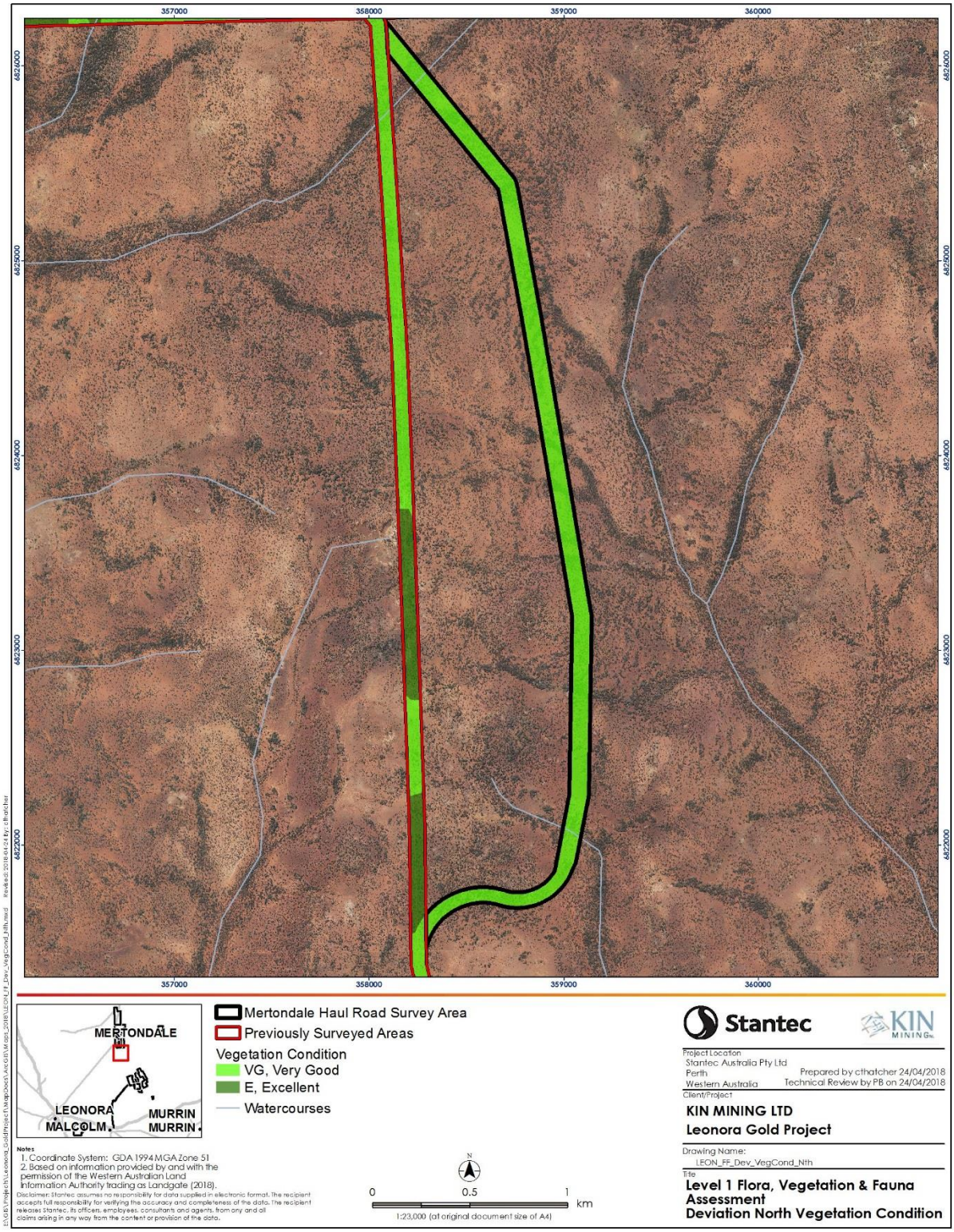


Figure 5-3: Vegetation Condition – Mertondale Haul Road Survey Area

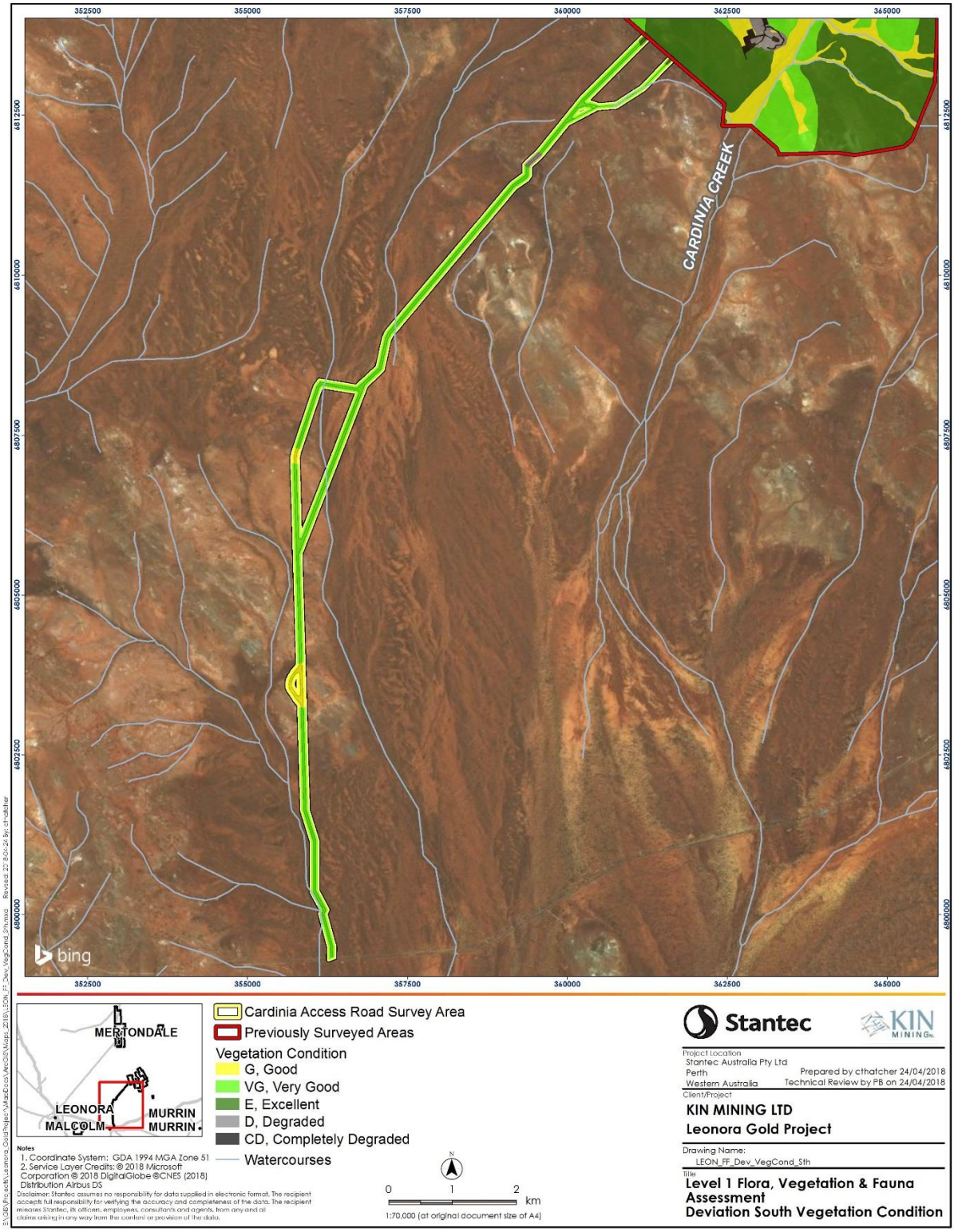


Figure 5-4: Vegetation Condition - Cardinia Access Road Survey Area

5.1.3 Vegetation of Conservation Significance

None of the vegetation units within the Study Area are analogous to any TECs under the EPBC Act, or listed by the DBCA, which qualify for special protection. There were no PECs directly related to terrestrial vegetation recorded within the Study Area. The vegetation units described from the Study Area are not considered to represent any PECs known to occur in the Murchison bioregion.

The EPA (EPA 2004) advises that vegetation may be considered to be of significance for a range of reasons, other than a listing as a TEC or a PEC, including:

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

Further to this, there were no vegetation units recorded from within the Study Area that would be considered to be of regional significance.

5.2 Flora

5.2.1 Flora Composition

A total of 120 flora taxa were recorded from the Study Area (**Appendix F**). Of the 120 vascular flora recorded in the Study Area, 108 were recorded from the 14 relevés and 12 vascular flora species were recorded opportunistically from the Study Area. The recorded flora comprised two introduced taxa and 118 native taxa (including naturalised species). The most represented families included Chenopodiaceae (23 taxa), Poaceae (20 taxa), Fabaceae (17 taxa) and Scrophulariaceae (11 taxa), equating to approximately 60% of the recorded taxa. Further to this, the dominant plant genera were *Eremophila* (11 taxa), *Acacia* (11 taxa), *Maireana* (9 taxa) and *Ptilotus* (7 taxa), comprising approximately 32% of the recorded taxa, as represented in **Figure 5-5**.

Five of the 120 recorded flora taxa could not be identified to genus level and ten could not be identified to species or infraspecific level due to a lack of flowering and/or fruiting material. Owing to the timing of the field survey, at least two weeks prior to the perceived optimal period for field surveys in the Eremaean Province, many of the plant taxa encountered were senescent.

Of the 11 Acacia taxa recorded in the Study Area, five are part of the Western Australia Mulga Flora Group (*Acacia aneura* F.Muell. ex Benth. and its close relatives) (Maslin and Reid 2012). The Mulga association was predominant in the mid to upper shrub strata of the majority of the vegetation types described in **Section 5.2.2**. These shrublands typically consist of a tall shrub layer of *Acacia aneura* and it's close relatives over undershrubs (typically *Senna* spp. and/or *Eremophila* spp.), sparse perennial and annual grasses and a ground layer of ephemeral herbs, which may be closed in a favourable season (Beard 1990b). The floral diversity recorded from the Study Area is consistent with the expected diversity of the Mulga shrublands of the Murchison region; given the level of survey effort for the reconnaissance field survey.

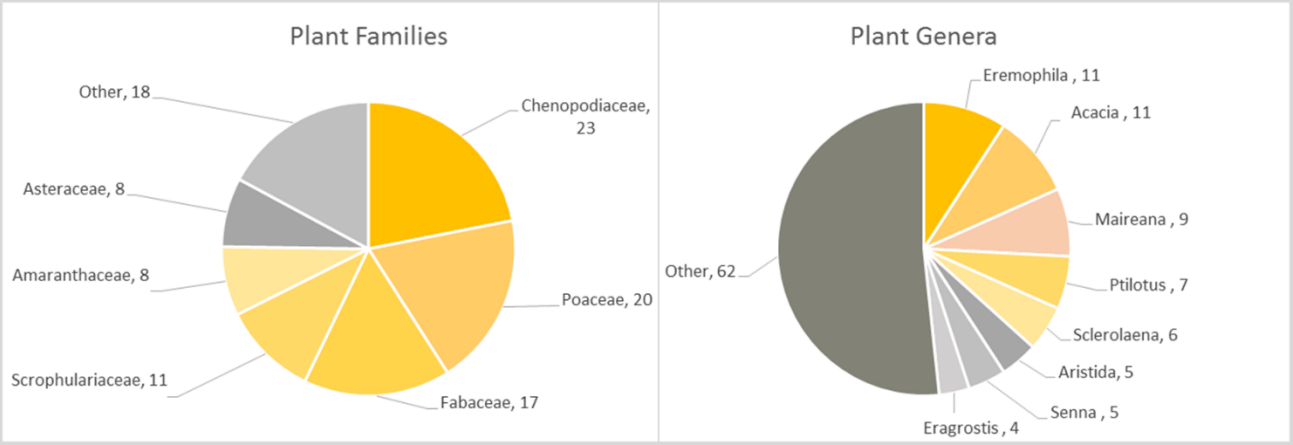


Figure 5-5: Flora composition of plant families and genera from the Study Area

5.2.2 Flora of Conservation Significance

No State listed or Commonwealth listed Threatened flora were recorded within the Study Area. Depiste thorough searches of potential habitat, the five conservation significant species listed as 'Very Likely' to occur and the seven conservation significant species listed as 'Likely' to occur were not recorded during the survey (**Appendix F** and **Appendix G**). Further to this, of the senescent flora taxa that could not be identified to genus, species or infraspecies level, none were regarded to have the propensity to occur in the Study Area.

The priority listed flora taxon, *Gunniopsis propinqua* (P3), which was identified in the previously surveyed area of the LGP (Stantec 2018) in two of the vegetation units described in **Section 5.1.1** was not recorded during the current survey.. Although this taxon was not identified during the field survey of the Study Area, this does not necessarily preclude it from occurring. The flowering time for this taxon is between August and September and it can be inconspicuous due to its small size. Due to the disturbed nature of the Cardinia Access Road Survey Area, it is unlikely to occur. However, it could possibly occur in the AcAtEo vegetation unit of the Mertondale Haul Road Study Area.

5.2.3 Flora of Other Significance

The EPA (2004) advises that flora species, subspecies, varieties, hybrids and ecotypes may be considered significant for reasons other than listing as a Threatened or Priority Flora taxa, and may include the following:

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

Based on these parameters, no flora of other significance was identified within the Study Area. However, the putative hybrid, *Acacia* sp. Marshall Pool (G. Cockerton 3024), has been identified extensively in areas previously surveyed within the LGP. Suitable habitat for this taxon is not present within the Study Area and it is unlikely to occur.

5.2.4 Introduced Flora

Two introduced flora taxa were identified in the Study Area (**Table 5-3**). These species do not represent significant environmental weeds (i.e. WoNS, and Declared Plants listed under Section 22 of the BAM Act). None of the introduced flora recorded in the previously surveyed areas of the LGP (**Table 3-5**) were identified in the Study Area, however, this does not preclude their likelihood of occurrence or spread.

Table 5-3: Introduced flora recorded in the Study Area

Species	Common Name	Vegetation Unit/Habitat
**Lysimachia arvensis*	Pimpernel	AaAcEms (**Section 5.1.1**)
**Solanum nigrum*	Black Berry Nightshade	PaAtEp (**Section 5.1.1**)

5.3 Fauna

5.3.1 Fauna Habitats

Broad fauna habitats were identified and delineated from fauna habitat assessments conducted across the Study Area (**Table 5-4**, **Appendix H**). Four broad fauna habitat types were identified within the Study Area;

- Acacia Shrublands on Plains;
- Chenopod Shrublands;
- Wetlands; and
- Drainage Lines.

These habitats differed in the composition of substrate (i.e. rock, sand or alluvial based), as well as vegetation density and structure. Soil types across the vast majority of the Study Area comprised of red to orange clayey sand with ironstone/quartzite gravel. Based on aerial imagery of the area, rocky outcrops in the form of breakaways are likely to be common outside the Study Area, approximately 12-16 km to the northeast and northwest of the pipeline deviation.

The habitat types in the Study Area were assessed on their extents and levels of significance according to the following criteria:

- **Distribution:** those habitats widespread and common within the surrounding regions were categorised as widespread; otherwise they were categorised as limited. All habitat types with the exception of Wetlands were considered widespread; and
- **Significance:** those habitats considered important to species of conservation significance or distinct fauna assemblages are deemed significant; otherwise they were categorised as limited significance. All habitats with the exception of Wetlands were considered to be of limited significance.
- **SRE potential:** habitats were categorised as having a high, medium or low potential to support SRE invertebrate fauna, based on the presence of microhabitats, whether the habitat was restricted or widespread in the landscape, and whether the habitat formed isolates or was well connected in the landscape. All habitats within the Study Area were considered to have low potential to support SRE species with the exception of Wetland habitat, which was considered to have a moderate potential to support SRE species.

Table 5-4: Fauna habitats recorded within the Study Area

Habitat Type	Mertondale Haul Road Survey Area		Cardinia Access Road Survey Area		Study Area		Vegetation Units	Disturbance and Condition	Value to Fauna	Reference Photograph
	Ha	%	Ha	%	Ha	%				
Acacia Shrublands on Plains • Widespread • Limited Significance • Low SRE potential	52	100.00	123.20	57.19	175.28	65.59	AaArEspp., AcAaSpp.M, AkHpEs, Asp.MsEs, AaAaEssp., AaAcEms, A?dArrEspp., AaEpp, AaAtEp, AcAtEo, CpArEo AaArAq.	Very Good to Degraded: Clearing, feral grazing, and tracks	The Acacia Shrublands on Plain habitat occurred throughout the Study Area, covering the entire Mertondale Haul Road area and areas within the Cardina Access Road. Dominant vegetation varied within this habitat from low open Mulga with limited understorey through to lower shrubs of Acacia spp. over vegetation including Eremophila spp., Ptilotus spp., Senna spp., Maireana spp. and tussock grasses. These changes in vegetation are mapped and described in greater detail in **Section 5.1.1**. Broadly, this habitat offered similar habitat qualities to fauna across much of its range however there were some variation in topography and substrate. The Mertondale Haul Road comprised stony plains which broadly aligned with the Violet Land System and the Cardina access road corridor largely comprised gravelly hardpan plains and sandy banks associated with the Tiger system (**Section 5.1.1**). Soils broadly comprised red/brown sandy clays and sandy loams often with occasional scattered ironstone or quartz stony fragments. Leaf litter and woody debris tended to be rare to moderately common. The vegetation was suitable for supporting small birds, reptiles and mammals and has high foraging potential for nectivorous birds when in flower. The substrate was suitable for burrowing and fossorial species. This habitat is unlikely to support high species diversity, is largely composed of generalist species and is unlikely to support fauna species of conservation significance.	
Drainage Line • Widespread • Limited Significance • Low SRE potential	0	0	0.74	0.34	0.74	0.28	AbAtTt	Excellent: Feral grazing	Drainage Line occurred in the Cardinia Access Road area in association with the main drainage feature that drains south through the Study Area from the northeast. This habitat differed from the surrounding habitats due to the high density of vegetation, generally comprised of Mulga and a mixture of smaller shrubs. The substrate which was comprised of red/orange sandy clay loam and alluvial sand and stones. Leaf litter was generally higher in this habitat than in the adjacent habitats as a result of the higher density of vegetation. After periods of rainfall, this habitat would likely support a higher density of annual flora species which would be attractive for native and non-native grazing species. Although this habitat is likely to support a higher abundance and diversity of species than other habitats in the region, this habitat is unlikely to be important for fauna species of conservation significance.	

Habitat Type	Mertondale Haul Road Survey Area		Cardinia Access Road Survey Area		Study Area		Vegetation Units	Disturbance and Condition	Value to Fauna	Reference Photograph
	Ha	%	Ha	%	Ha	%				
Chenopod Shrubland • Widespread • Limited Significance • Low SRE potential	0	0	90.83	42.16	90.83	90.83	HpCsMp	Good to Very Good: Clearing, tracks	Chenopod Shrubland habitat occurred along substantial areas of the Cardina Access Road in association with low lying areas often with saline influences. Chenopods in these areas comprised species from genera such as Tecticornia spp., Mariana spp., Sclerolaena spp. and *Cratystylis subspinescens*. Upper and mid story vegetation tended to be sparse, often dominant with *Hakea preissii*. Soils comprised clayey sand and leaf litter and woody debris were rare owing to the lack of mid and upper storey vegetation. This habitat broadly occurred in association with the Nubev, Felix and Gundockerta Land Systems (**Section 5.1.1**). It is unlikely that the habitat will support fauna species of conservation significance.	
Wetland • Limited extent • Significance • Moderate SRE potential	0	0	0.59	0.28	0.59	0.59	PaAtEp	Very Good Weeds	Wetland habitat occurred in a small area of the Cardinia Access Road corridor. The area contains wetland plant species, indicating it is likely to be seasonally inundated with water more often than other areas, however was dry at the time of the survey. The habitat consists of a mid-upper storey of isolated *Pittosporum angustifolium*, *Santalum spicatum* and *Acacia tetragonophylla* trees over sedgeland and Marsilea spp.. The substrate comprised a heavy orange clay largely covered by perennial vegetation, with rare presence of leaf litter. This habitat was affected by weeds, however was otherwise in excellent condition. Wetland habitat was not common throughout the area, and would potentially provide suitable habitat for amphibians and migratory wetland birds when inundated. The dense lower storey would provide shelter to a variety of reptiles and mammals. SRE invertebrate species tend to have restricted distributions which are often aligned with mesic habitats, isolated habitats or both (Harvey 2002). Although the Wetland habitat is small in size, it is considered to have 'Moderate' potential to support SRE species as the habitat fulfils the criteria of being mesic (temporarily contains water) and isolated from other similar habitats in the landscape. Avoidance is recommended.	

5.3.2 Fauna Assemblages

The previous survey completed by Stantec (2018) compiled a thorough list of fauna which occurred within in the vicinity of the LGP. This Survey aimed to contribute to this list with any additional fauna which had not been previously recorded. The only new species recorded during this Survey which had not been previously recorded for the LGP was the Camel (*Camelus dromedarius*). This brings the total list of vertebrate fauna recorded for the LGP to 64 (**Table 5-5**). This comprised, nine mammals (two native), 47 birds and eight reptile species. Seven introduced vertebrate fauna species have been recorded for the LGP comprising; Camel (*Camelus dromedarius*), European Cattle (*Bos taurus*), Donkey (*Equus asinus*), Horse (*Equus caballus*), Dog (*Canis familiaris*), Cat (*Felis catus*) and Rabbit (*Oryctolagus cuniculus*). No fauna of conservation significance were recorded.

Table 5-5: Vertebrate fauna species recorded during the field survey

Family and Species Name	Common Name	Conservation Status	
		EPBC Act	In WA
Mammals			
Felis catus	Cat	-	-
Canis familiaris	Dog	-	-
Equus asinus	Donkey	-	-
Macropus robustus	Euro	-	-
Bos taurus	European Cattle	-	-
Equus caballus	Horse	-	-
Oryctolagus cuniculus	Rabbit	-	-
Macropus rufus	Red Kangaroo	-	-
Camelus dromedarius	Camel	-	-
Birds			
Acanthiza apicalis	Inland Thornbill	-	-
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	-	-
Acanthiza robustirostris	Slaty-backed Thornbill	-	-
Acanthiza uropygialis	Chestnut-rumped Thornbill	-	-
Accipiter cirrocephalus	Collared Sparrowhawk	-	-
Accipiter fasciatus	Brown Goshawk	-	-
Aphelocephala leucopsis	Southern Whiteface	-	-
Aquila audax	Wedge-tailed Eagle	-	-
Artamus cinereus	Black-faced Woodswallow	-	-
Artamus minor	Little Woodswallow	-	-
Cheramoeca leucosternus	White-backed Swallow	-	-
Cinclosoma clarum	Western Chestnut Quail-thrush	-	-
Colluricincla harmonica	Grey Shrike-thrush	-	-
Coracina novaehollandiae	Black-faced Cuckoo-shrike	-	-
Corvus bennetti	Little Crow	-	-
Corvus orru	Torresian Crow	-	-
Cracticus nigrogularis	Pied Butcherbird	-	-
Cracticus tibicen	Australian Magpie	-	-
Daphoenositta chrysoptera	Varied Sittella	-	-
Dicaeum hirundinaceum	Mistletoebird	-	-
Dromaius novaehollandiae	Emu	-	-
Eurostopodus argus	Spotted Nightjar	-	-

Family and Species Name	Common Name	Conservation Status	
		EPBC Act	In WA
Gavicalis virescens	Singing Honeyeater	-	-
Geopelia cuneata	Diamond Dove	-	-
Grallina cyanoleuca	Magpie-lark	-	-
Hirundo neoxena	Welcome Swallow	-	-
Malurus lamberti	Variegated Fairy-wren	-	-
Malurus leucopterus	White-winged Fairy-wren	-	-
Malurus splendens	Splendid Fairy-wren	-	-
Manorina flavigula	Yellow-throated Minor	-	-
Melanodryas cucullata	Hooded Robin	-	-
Melopsittacus undulatus	Budgerigar	-	-
Neophema bourkii	Bourke's Parrot	-	-
Ocyphaps lophotes	Crested Pigeon	-	-
Oreoica gutturalis	Crested Bellbird	-	-
Pachycephala rufiventris	Rufous Whistler	-	-
Petroica goodenovii	Red-capped Robin	-	-
Phaps chalcoptera	Common Bronzwing	-	-
Platycercuc zonarius	Australian Ringneck	-	-
Platycercus varius	Mulga Parrot	-	-
Pomatostomus superciliosus	White-browed Babbler	-	-
Pterochelidon nigricans	Tree Martin	-	-
Ptilonorhynchus maculatus guttatus	Western Bowerbird	-	-
Pyrrholaemus brunneus	Redthroat	-	-
Rhipidura leucophrys	Willie Wagtail	-	-
Strepera versicolour	Grey Currawong	-	-
Taeniopygia guttata	Zebra Finch	-	-
Reptiles			
Ctenotus leonhardii		-	-
Diporiphora amphiboluroides		-	-
Egernia depressa	Southern Pygmy Spiny-tailed Skink	-	-
Gehyra vareigata		-	-
Heteronotia binoei	Bynoe's Gecko	-	-
Strophurus wellingtonae		-	-
Varanus caudolineatus		-	-
Varanus panoptes	Yellow-spotted Monitor	-	-

5.3.3 Fauna of Conservation Significance

Of the 300 species of vertebrate fauna identified during the desktop study, 24 species are listed as being of conservation significance, comprising, four mammals and 18 bird species (**Table 3-7**). In addition, two invertebrate species of conservation significance were identified, the fairy shrimps *Branchinella apophysata* and *Branchinella simplex* (**Table 3-7**). Of the 24 species recorded from the desktop study:

- Eight species are listed as Threatened under the EPBC Act and/or WC Act (**Table 3-7**). Legislation has been developed at national (EPBC Act) and state (WC Act) levels to protect species of fauna that have been formally recognised as rare, threatened with extinction or having high conservation value (**Appendix A**);
- five are recognised by DBCA as Priority fauna. DBCA recognises several species that are not listed under the WC Act or the EPBC Act but for which there is some conservation concern, and has produced a supplementary list of Priority fauna (**Appendix A**);
- one species is listed as recognised by state (WC Act) to be in need of special protection (**Appendix A**); and
- 11 species are listed as Migratory under the EPBC Act and Schedule 5 under the WC Act. Many species of migratory bird are listed under the EPBC Act, the WC Act and international agreements (**Appendix A**).

Some of the species referred to above, listed as Threatened, Migratory and/or Priority fauna, may be included in multiple groups.

Of the conservation listed species identified from the desktop study, 10 are waterbirds that rely on aquatic environments that do not occur within the Study Area. These species are therefore deemed Unlikely to occur. This includes the following Migratory or Priority listed species from the families Anatidae, Ardeidae, Charadriidae, Glareolidae, Motacillidae and Scolopacidae:

- Red Knot (*Calidris canutus*);
- Yellow Wagtail (*Motacilla flava*);
- Oriental Plover (*Charadrius veredus*);
- Sharp-tailed Sandpiper (*Calidris acuminata*);
- Red-necked Stint (*Calidris ruficollis*);
- Glossy Ibis (*Plegadis falcinellus*);
- Pacific Golden Plover (*Pluvialis fulva*);
- Wood Sandpiper (*Tringa glareola*);
- Common Greenshank (*Tringa nebularia*); and
- Hooded Plover (*Thinornis cucullatus*).

Three mammal species were identified from the desktop study from historical records, but are now considered extinct from the Murchison bioregion; the Numbat (*Myrmecobius fasciatus*), Banded Hare-wallaby (*Lagostrophus fasciatus fasciatus*) and the Bilby (*Macrotis lagotis*) (Woinarski *et al.* 2014). In addition, fairy-shrimps *Branchinella apophysata* and *Branchinella simplex* are confined solely to salt lakes of the region, as such these species are Unlikely to occur within the Study Area. Each of these species is no longer assessed in this report.

The likelihood for each of the remaining species of conservation significance occurring in the Study Area was assessed and ranked (**Table 5-6**). The rankings were assigned definitions described in **Section 3.3.1**. One fauna species of conservation significance was considered Likely to occur, three species were considered Possible to occur and the remaining 18 were assessed as Unlikely to occur (**Table 5-6**).

Table 5-6: Likelihood of occurance for fauna of conservation significance

Common Name (Scientific Name)	Conservation status		Broad Habitat Type	Likelihood of Occurrence Reason for Likelihood
	EPBC Act	In WA		
Mammals				
Long-tailed Dunnart (Sminthopsis longicaudata)	-	P4	Rocky, hilly areas, breakaways, occasionally open areas with a stony, rocky mantle (van Dyck and Strahan 2008).	**Unlikely** There have been recent records in the region with the closest record from approximately 25km southeast of the Study Area in 2011 (DPaW 2016c). However, suitable habitat for the species does not occur within the Study Area.
Birds				
Night Parrot (Pezoporus occidentalis)	En	S1	Known to inhabit treeless or sparsely wooded long unburnt spinifex hummock plains often interspersed with chenopods (Pyke and Ehrlich 2014).	**Unlikely** Species only identified by DoEE (2016) because 'species habitat may occur within area'. Species unknown from the Murchison region and suitable habitat not present within Study Area.
Carnaby's Cockatoo (Calyptorhynchus latirostris)	En	S2	Proteaceous scrubs and heaths and adjacent eucalypt woodlands and forests (Johnstone and Storr 1998a).	**Unlikely** The Study Area is well outside the natural distribution of the species. These records returned from the DPaW (2016c) database are likely to be a projection error and are erroneous.
Princess Parrot (Polytelis alexandrae)	Vu	P4	Spinifex with eucalypts and acacias, and succulents around salt lakes (often far from fresh water) (Pizzey and Knight 2007).	**Unlikely** Historical record from Laverton (unknown year) (DPaW 2016c). Species identified by DoEE (2016) because 'species habitat may occur within area'. Species sparsely distributed in Murchison region and suitable habitat is not present within Study Area.
Malleefowl (Leipoa ocellata)	Vu	S3	Mainly scrubs and thickets of mallee, boree and bowgada, but	**Possible** Species has been recorded within 25 km east of the Study Area in 2011 and within 30 km

Common Name (Scientific Name)	Conservation status		Broad Habitat Type	Likelihood of Occurrence Reason for Likelihood
	EPBC Act	In WA		
			also other litter forming shrublands (Johnstone and Storr 1998b).	south of the Study Area in 2009 (DPaW 2016c). The species is only thought to be scattered throughout the region (Benshemesh 2007) with the majority of records occurring further to the south (DoEE 2016). The species tends to occur in dense shrublands and low woodlands which may provide leaf litter suitable for use in the construction of nesting mounds (DoEE 2016). If the species does occur, it is likely to be at low densities. Habitat within the Study Area was marginal for the species and no evidence of nesting mounds were discovered during the survey, however given the recent records in relatively close proximity, it is possible that the species occurs.
Fork-tailed Swift (Apus pacificus)	Mi	S5	Aerial species, which forages high above the tree canopy and rarely lower (Johnstone and Storr 1998b).	**Possible** No records were found in the DPaW or Birdlife database searches. Species identified by DoEE (2016) because 'species habitat may occur within area'. The species is a migratory aerial species not common within the Murchison (Johnstone and Storr 1998b). The species may infrequently overfly the Study Area without utilising any particular habitats present.
Grey Wagtail (Motacilla cinerea)	Mi	S5	Grey Wagtails are listed as rare vagrants to the Australian continent from the North.	**Unlikely** Species identified by DoEE (2016) because 'species habitat may occur within area'. Species sparsely distributed in Murchison region and suitable habitat not present within Study Area.

Common Name (Scientific Name)	Conservation status		Broad Habitat Type	Likelihood of Occurrence Reason for Likelihood
	EPBC Act	In WA		
Grey Falcon (Falco hypoleucos)	-	S3	Lightly treed inland plains, gibber deserts, sandridges, pastoral lands, timbered watercourses (Pizzey and Knight 2007).	**Possible** Species identified from one record 30 km east of the Study Area in 1996 (DPaW 2016c). Species is not common in the Murchison region. The species may infrequently overfly the Study Area without utilising any particular habitats present.
Peregrine Falcon (Falco peregrinus)	-	S7	The species occurs along coastal cliffs, rivers and ranges as well as wooded watercourses and lakes nesting on cliffs, granite outcrops, quarries (Johnstone and Storr 1998b).	**Likely** Species recorded just outside the northern boundary of the Study Area during a fauna survey in 2009 (DPaW 2016a). Additionally, there are a number of other records from the region. The species may fly-over the Study Area infrequently while dispersing or during foraging but is unlikely to breed due to a lack of suitable habitat.

6. Assessment against the Native Vegetation Clearing Principles

Assessment against the ten Clearing Principles listed under Schedule 5 of the EP Act was based on a precautionary approach that assumed all habitats within the Study Area may be exposed to clearing. The proposed LGP disturbance footprint is still being finalised following resource identification and project design.

6.1 Principle (a) Native vegetation should not be cleared if it comprises a high level of biological diversity

A total of 120 flora taxa (including subspecies and variants) were recorded from 15 vegetation units within the Study Area. The floral diversity and composition recorded from the Study Area is consistent with the Murchison bioregion, the landforms, the season of field survey, and the level of sampling intensity. Native vegetation of the Study Area was comprised broadly of open Mulga shrublands and open *Acacia* shrublands and is considered to contain a low level of biological diversity. The Study Area occurs within the Laverton 18, Laverton 28 and Laverton 39 Botanical Districts of the Eremaean Province (Beard 1990a). All three of these are widespread and well represented within the Murchison bioregion (Government of Western Australia 2015). None of the vegetation units described within the Study Area represent any known TEC's or PEC's.

No Threatened flora species were recorded within the Study Area, and none are expected to occur based on the results of the desktop assessment and the field survey. The database search identified 35 Priority flora taxa listed by the DBCA (**Section 3.3**).

A total of 65 vertebrate fauna species were recorded from four broad fauna habitats within the Study Area. The faunal habitats and assemblage recorded from the Study Area are consistent with the Murchison bioregion, the landforms present, the season of the field survey, and the level of sampling intensity. The habitats identified within the Study Area are common, widespread and considered to be of limited significance. The fauna assemblage expected to occur within these habitats, consists of largely generalist species that are widely distributed throughout the region.

The proposed clearing is **not** at variance with this principle.

6.2 Principle (b) Native vegetation should not be cleared if it comprises the whole, or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia

The majority of habitat types recorded within the Study Area are typical of the Murchison bioregion and are well represented within the bioregion. These habitats do not form significant areas of habitat for native fauna. This is with the excpetion of the 'Wetland' fauna habitat within the Cardina Access Road. This habitat comprised a small area of hydrophilic vegetation that was considered likely to seasonally inundate and be of limited extent in the area. This habitat has a moderate capability of supporting SREs and may serve as habitat for migratory wetland birds when inundated. If clearing this habiata is avoided, the project is unlikely to be at variance with this principle.

Although habitats recorded may be suitable for fauna of conservation significance, none of the species identified from the desktop study are reliant on the habitats present nor do they form a significant proportion of the suitable habitat for these species within the region. Species considered likely to occur comprise the

Peregrine Falcon. The Peregrine Falcon may overfly the Study Area only as there is no breeding habitat (large Eucalypts or cliffs).

Aside form wetland habitat, the clearing of native vegetation within the Study Area will not significantly impact habitat for fauna of conservation significance, or significant habitat for fauna more broadly, and the impacts to significant fauna are expected to be minimal.

The proposed clearing is **may** be at variance with this principle.

6.3 Principle (c) Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora

No Threatened flora listed under the WC Act 1950, or listed under the EPBC Act 1999, have previously been recorded within the Study Area, nor were any recorded during the field survey. No species listed as Threatened flora taxa are Likely to occur within the Study Area.

The proposed clearing is **not** at variance with this principle.

6.4 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

No Threatened Ecological Communities listed by the DBCA, or Threatened under the EPBC Act 1999 were recorded during the field survey, nor are any likely to occur. No TECs, relevant to terrestrial environments, were identified as occurring within 40 km of the Study Area. Additionally, no PECs were recorded from the Study Area.

The proposed clearing is **not** at variance with this principle.

6.5 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.

The LGP may require the clearing of native vegetation consistent with Beard's vegetation association of Shrublands, Mulga scrub (Laverton_18), Low woodland; mulga (Acacia aneura) (Laverton_28 and Low woodland; mulga, *Acacia aneura* (Laverton_39). All three associations are well represented in Western Australia (DPaW 2014), with greater than 99% (Laverton_18) 98% (Laverton_28) and 97% (Laverton_39) of their pre-European extent remaining within both the Murchison bioregion and the Eastern Murchison subregion (Government of Western Australia 2015). If it is assumed that the entire Study Area will be cleared or indirectly impacted, the current extent of the vegetation association will not fall below the 30% threshold where species loss increases exponentially as determined by (EPA 2000).

The proposed clearing is **not** at variance with this principle.

6.6 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.

Drainage Line habitat is present within the Study Area, however, it did not contain vegetation communities or species that are confined to watercourses or wetlands, or are groundwater dependent. The drainage

lines within the Study Area are not considered regionally prominent and are not listed within the *Directory of Important Wetlands in Australia* (DoE 2015) or listed as an Environmentally Sensitive Area (ESA) under the EP Act. The nearest ESA or Important wetland is Lake Ballard, 65 km south of the Study Area. Drainage lines within the Study Area may be related to hydrological regimes of this area. If the natural hydrological regimes should be maintained during and following vegetation clearing to avoid variance with this principle.

The Cardinia Access Road Survey Area traverses a small inward-draining depression that supports wetland habitat. It is unclear as to whether this wetland area is of natural origin or if it has formed as a consequence of human-induced activities. This wetland does, however, support hydrophilic vegetation (sedges) and is likely to provide suitable habitat for wetland-dependant fauna. To avoid variance with this principle, the wetland area associated with the vegetation unit, PaAtEp, should be avoided.

The proposed clearing **may** be at variance with this principle.

6.7 Principle (g) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation

The terrain of the Study Area is relatively level aside from some low hills, with no permanent surface water features. The soil substrate is firm, with areas of continuous gravel maintaining structure. Any clearing of native vegetation is unlikely to increase soil erosion or nutrient export within the landscape due to the already low density of vegetation and firm soil structure. The Study Area is not within a salinity risk area and the site would not be expected to be vulnerable to salinity even following proposed clearing.

The proposed clearing is **not** at variance with this principle.

6.8 Principle (h) Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area

There are no National Parks within 300 km of the Study Area. The nearest Nature Reserve, Wanjarri Nature Reserve (Class A), is located 150 km north-west of the Study Area, and the nearest DBCA-managed land is Ex-Goongarrie Pastoral Lease, currently UCL but managed by DBCA for conservation purposes is approximately 100 km south of the Study Area. The Study Area does not overlap with any National Parks or any conservation areas. The nearest ESA, Lake Ballard is approximately 65 km south west of the Study Area, and is also a Nationally Important Wetland (DIWA). Two other ESAs and DIWAs, Lake Marmion and Lake Barlee, are located 70 km south west, and 153 km west south west, of the Study Area respectively. Minor drainage lines within the Study Area may be broadly related to hydrological regimes of this area.

Based on aerial imagery, drainage from the project area appears to flow southwards into the Raeside Palaeoriver and then onto Lake Raeside to the south-east of Leonora. Given topographical relief of the area, any flows from this point should be in a southeast direction along the Raeside Palaeoriver, away from the ESAs or DIWAs of Lake Ballard, Lake Marmion and Lake Barlee. Although impacts to the hydrological regimes of the area should be minimised where possible during construction, impacts to ESAs or DIWAs are unlikely.

The proposed clearing is **unlikely to be** at variance with this principle.

6.9 Principle (i) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water

No permanent surface water features were observed in the, Study Area, however drainage lines are present. Clearing and/or construction should not impact on drainage or surface water quality, provided sediments are controlled during construction and operation by implementing standard management procedures.

Currently, no information is available on the extent and quality of the groundwater and whether the LGP will require any groundwater drawdown and release into the natural environment, however, significant impacts are considered unlikely.

The proposed clearing is **not** at variance with this principle.

6.10 Principle (j) Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence of flooding

The incidence of flooding in the Study Area is not anticipated to be exacerbated by clearing of the vegetation due to the fact that the Study Area occurs on free draining soils and is relatively flat in terrain. The minor drainage lines that flow through the Study Area would not carry a high volume of surface water during standard rainfall events. The implementation of standard surface water management strategies during construction and operations would mitigate any likelihood of flooding. A surface modelling assessment will be undertaken for future approvals associated with the LGP so that appropriate mitigation strategies can be implemented during construction of the LGP.

The proposed clearing is **not** at variance with this principle.

7. Conclusions

Vegetation condition ranged from 'Degraded' to 'Excellent'. All vegetation within the Mertondale Haul Road and the majorioty of vegetation within the Cardinia Access road was only marginally altered and in 'Very Good' condition. Disturbances included clearing, tracks and evidence of non-native fauna including rabbits and camels.

Three vegetation types were identified in the Mertondale Haul Road Survey area and 11 vegetation types were identified in the Cardinia Access Road Survey Area. The vegetation recorded broadly comprised mixed Mulga shrublands over mixed shrubs dominated by *Eremophila* species, *Ptilotus obovatus* and *Senna* species; also with large areas dominated by chenopod shrublands of *Cratystylis subspinescens, Maireana pyramidata, Maireana sedifolia* and *Maireana triptera*. No vegetation units are considered analogous to any TECs or PECs, and none are considered regionally significant.

A total of 120 flora taxa (including subspecies and variants) from 26 families and 61 genera were recorded within the Study Area. The most represented families included Chenopodiaceae (23 taxa), Poaceae (20 taxa), Fabaceae (17 taxa) and Scrophulariaceae (11 taxa), equating to approximately 60% of the recorded taxa. The floral diversity recorded from the Study Area is consistent with the expected diversity of the Mulga shrublands of the Murchison region; given the level of survey effort for the reconnaissance field survey.

No Threatened Flora species and 35 Priority Flora species were recorded from the desktop study. Five conservation significant species were considered as 'Very Likely' and seven as 'Likely' to occur. These were targeted during the survey however none were recorded.

Four borad fauna habitats were identified within the Study Area; Acacia Shrubland on Plains, Chenopod Shrublands, Wetlands and Drainage Lines. All habitats were widespread and of limited singificance to fauna with the exception of wetland habitat. This comprised a 0.59 ha area of hydrophilic vegetation within the Cardinia Access Road area, which may provide habitat for migratory wetland bird species and was considered of 'moderate' significance to SRE fauna owing to it's limited extent and likelihood to be seasonally inundated.

The previous survey completed by Stantec compiled a thorough list of fauna which occurred within in the vicinity of the LGP, comprising 64 species when including observations during the current survey. No fauna of conservation significance were recorded, however the desktop assessment identified one species as Likely to occur (Peregrine Falcon; S7) and three species as Possible to occur (Grey Falcon; S3, Fork-tailed Swift; Mi/S5, Mallee Fowl; Vu/S3). While the Peregrine Falcon may fly over the Study Area, the species is considered unlikely to depend upon it due to the lack of suitable breeding habitat.

It is not yet clear to what extent of native vegetation clearing will be required for the Project. Assessment against the ten Clearing Principles was based on a precautionary approach that assumed all habitats within the Study Area may be exposed to clearing. Based on this assumption, the proposed Project is not at variance to principles (a), (c), (d), (e), (g), (h), (i) and (j). However, clearing may be at variance with (b): Native vegetation should not be cleared if it comprises the whole, or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia, and (f): Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland. To avoid variance with these principle, the wetland depression associated with PaAtEp, should be avoided. This wetland may have formed due to unnatural causes, however, is likely to be seasonally inundated and as such has a moderate chance of supporting SREs and potentially provides habitat for migratory wetland birds.

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Appendices



Appendix A Codes and Terms used to describe Species of Conservation Significance

Flora and fauna may be accorded legislative protection by being listed under the Environment Protection and Biodiversity Conservation Act 1999 (Cwlth) (EPBC Act) and/or the Wildlife Conservation Act 1950 (WA) (WC Act), or by being listed on the WA Department of Environment and Conservation's Priority Species List. This Appendix presents a summary of the different rankings and listings used to describe conservation status. Some categories, such as 'extinct', 'extinct in the wild' and 'conservation dependent' (EPBC Act) are not presented here, as the table includes only the information needed to fully understand the codes presented in the preceding report. Refer to the relevant legislation for a full description of all codes in use, as well as their associated criteria.

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

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

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

Priorities assigned under the DBCA Priority Taxa List		
Priority 1	**P1**	Taxa with few, poorly known populations on threatened lands. These are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened taxa
Priority 2	**P2**	Taxa with few, poorly known populations on conservation lands. These are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened taxa
Priority 3	**P3**	Taxa with several, poorly known populations, some on conservation lands. These are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened taxa
Priority 4	**P4**	Taxa in need of monitoring. These are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands
Priority 5	**P5**	Taxa in need of monitoring. These are not considered threatened but are subject to a specific conservation programme, the cessation of which would result in the species becoming threatened within five years

Appendix B Vertebrate Fauna Identified from the Desktop Assessment

Code	Source
a.	This Survey and (Stantec 2018)
b.	DPaW (now DBCA) Threatened Fauna Database
c.	DPaW (now DBCA) NatureMap Database
d.	Birdlife Australia Database
e.	DoEE Protected Matters Search
f.	Outback Ecology (2009) Leonora Gold Project Terrestrial Fauna Assessment
g.	GHD (2007) Main Roads Western Australia
h.	Dell & How (1988) Part 5: Biological survey of the eastern Goldfields
i.	Dell & How (1992) Part 7: Biological survey of the eastern Goldfields
j.	Ninox (2011) Level 1 Vertebrate Fauna Assessment of a Proposed Rail Siding Near Menzies

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Mammalia													
Tachyglossidae													
Tachyglossus aculeatus	Short-beaked Echidna					x				x	x		x
Dasyuridae													
Antechinomys laniger	Kultarr					x						x	
Ningaui ridei	Wongai Ningaui					x					x	x	
Sminthopsis crassicaudata	Fat-tailed Dunnart					x					x	x	
Sminthopsis dolichura	Little long-tailed Dunnart					x					x	x	
Sminthopsis hirtipes	Hairy-footed Dunnart											x	
Sminthopsis longicaudata	Long-tailed Dunnart		P4		x	x							
Sminthopsis macroura	Stripe-faced Dunnart					x						x	
Sminthopsis ooldea	Ooldea Dunnart											x	
Myrmecobiidae													

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Myrmecobius fasciatus	Numbat	En	S2		x								
Thylacomyidae													
Macrotis lagotis	Bilby	Vu	S3		x								
Macropodidae													
Lagostrophus fasciatus fasciatus	Banded Hare-wallaby		S3		x								
Macropus fuliginosus	Western Grey Kangaroo										x		
Osphranter robustus	Euro			x		x			x		x	x	
Osphranter rufus	Red Kangaroo			x		x			x		x	x	
Muridae													
Mus musculus	*House Mouse					x		x			x	x	
Notomys alexis	Spinifex Hopping-mouse					x					x	x	
Notomys mitchellii	Mitchell's Hopping-mouse										x		
Pseudomys bolami	Bolam's Mouse										x		

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Pseudomys hermannsburgensis	Sandy Inland Mouse					x					x	x	
Leporidae													
Oryctolagus cuniculus	*Rabbit			x		x		x	x	x	x	x	x
Emballonuridae													
Taphozous hilli	Hill's Sheathtail-bat					x							
Molossidae													
Austronomus australis	White-striped Freetail-bat					x					x		
Ozimops kitcheneri	South-western Free-tailed Bat										x		
Vespertilionidae													
Chalinolobus gouldii	Gould's Wattled Bat					x					x	x	
Nyctophilus geoffroyi	Lesser Long-eared Bat					x					x	x	
Scotorepens balstoni	Inland Broad-nosed Bat					x					x		
Scotorepens greyii	Little Broad-nosed Bat											x	

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Vespadelus baverstocki	Inland Forest Bat					x					x		
Vespadelus finlaysoni	Finlayson's Cave Bat					x							
Vespadelus regulus	Southern Forest Bat											x	
Canidae													
Canis lupus	*Dog			x					x		x		
Vulpes vulpes	*Red Fox							x			x		
Felidae													
Felis catus	*Cat			x		x		x			x	x	
Equidae													
Equus asinus	*Donkey			x				x	x				
Equus caballus	*Horse			x									
Suidae													
Sus scrofa	*Pig					x							

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Camelidae													
Camelus dromedarius	*Camel			x				x			x		
Bovidae													
Bos taurus	*European Cattle			x						x		x	x
Capra hircus	*Goat							x	x		x	x	
Ovis aries	*Sheep										x	x	
Birds													
Dromaiidae													
Dromaius novaehollandiae	Emu			x		x	x		x		x	x	
Anatidae													
Anas gracilis	Grey Teal					x	x				x	x	
Anas rhynchotis	Australasian Shoveler						x						
Anas superciliosa	Pacific Black Duck					x	x				x		

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Aythya australis	Hardhead					x	x						
Biziura lobata	Musk Duck					x	x						
Chenonetta jubata	Australian Wood Duck					x	x				x	x	
Cygnus atratus	Black Swan					x	x						
Malacorhynchus membranaceus	Pink-eared Duck						x						
Tadorna tadornoides	Australian Shelduck					x	x				x	x	
Megapodiidae													
Leipoa ocellata	Malleefowl	Vu	S3		x	x		x			x		
Phasianidae													
Coturnix pectoralis	Stubble Quail										x		
Podicipedidae													
Podiceps cristatus	Great Crested Grebe					x	x						
Poliocephalus poliocephalus	Hoary-headed Grebe					x	x					x	

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Tachybaptus novaehollandiae	Australasian Grebe					x	x						
Threskiornithidae													
Platalea flavipes	Yellow-billed Spoonbill					x	x						
Plegadis falcinellus	Glossy Ibis	Mi	S5		x		x						
Threskiornis molucca	Australian White Ibis						x						
Threskiornis spinicollis	Straw-necked Ibis					x	x						
Ardeidae													
Ardea modesta	Eastern Great Egret				x	x	x	x					
Ardea novaehollandiae	White-faced Heron					x	x				x	x	
Ardea pacifica	White-necked Heron					x	x				x	x	
Pelecanidae													
Pelecanus conspicillatus	Australian Pelican					x	x						
Phalacrocoracidae													

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Phalacrocorax carbo	Great Cormorant					x	x						
Phalacrocorax melanoleucos	Little Pied Cormorant					x	x						
Phalacrocorax sulcirostris	Little Black Cormorant					x	x						
Anhingidae													
Anhinga novaehollandiae	Australiasian Darter					x	x						
Accipiter cirrocephalus	Collared Sparrowhawk			x		x	x		x		x	x	
Accipiter fasciatus	Brown Goshawk			x		x	x				x	x	
Aquila audax	Wedge-tailed Eagle			x		x	x		x		x	x	
Circus approximans	Swamp Harrier					x	x						
Circus assimilis	Spotted Harrier					x					x		
Elanus axillaris	Black-shouldered Kite					x	x						
Haliastur sphenurus	Whistling Kite					x	x		x			x	
Hieraaetus morphnoides	Little Eagle						x				x	x	

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Milvus migrans	Black Kite					x	x						
Otididae													
Ardeotis australis	Australian Bustard					x					x		
Rallidae													
Fulica atra	Eurasian Coot					x	x						
Tribonyx ventralis	Black-tailed Native-hen					x	x				x		
Turnicidae													
Turnix velox	Little Button-quail					x					x	x	
Burhinidae													
Burhinus grallarius	Bush Stone-curlew					x	x						
Recurvirostridae													
Cladorhynchus leucocephalus	Banded Stilt						x				x		
Himantopus himantopus	Black-winged Stilt					x	x						

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Recurvirostra novaehollandiae	Red-necked Avocet					x	x				x		
Charadriidae													
Charadrius melanops	Black-fronted Dotterel					x	x				x		
Charadrius ruficapillus	Red-capped Plover					x	x				x		
Charadrius veredus	Oriental Plover	Mi	S5					x					
Erythrogonys cinctus	Red-kneed Dotterel					x	x						
Peltohyas australis	Inland Dotterel						x						
Pluvialis fulva	Pacific Golden Plover	Mi	S5		x								
Thinornis cucullatus	Hooded Plover		P4			x	x	x					
Vanellus tricolor	Banded Lapwing					x	x				x	x	
Scolopacidae													
Calidris acuminata	Sharp-tailed Sandpiper	Mi	S5		x								
Calidris canutus	Red Knot	En; Mi	S5		x								

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Calidris ruficollis	Red-necked Stint	Mi	S5		x								
Tringa glareola	Wood Sandpaper	Mi	S5		x		x						
Tringa hypoleucos	Common Sandpiper	Mi	S5			x	x						
Tringa nebularia	Common Greenshank	Mi	S5		x	x	x	x					
Laridae													
Larus novaehollandiae	Silver Gull					x	x						
Sterna hybrida	Whiskered Tern					x					x		
Sterna nilotica	Gull-billed Tern	Mi	S5				x						
Columbidae													
Columba livia	*Domestic Pigeon					x							
Geopelia cuneata	Diamond Dove			x		x	x				x		
Ocyphaps lophotes	Crested Pigeon			x		x	x		x		x	x	
Phaps chalcoptera	Common Bronzewing			x		x	x		x		x	x	

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Streptopelia chinensis	*Spotted Turtle-Dove						x						
Streptopelia senegalensis	*Laughing Turtle-Dove					x	x						
Cuculidae													
Cacomantis pallidus	Pallid Cuckoo					x	x				x	x	
Chrysococcyx basalis	Horsfield's Bronze Cuckoo					x	x			x	x	x	x
Chrysococcyx osculans	Black-eared Cuckoo						x				x		
Tytonidae													
Tyto alba	Barn Owl					x							
Strigidae													
Ninox boobook	Boobook Owl						x				x		
Podargidae													
Podargus strigoides	Tawny Frogmouth					x	x				x	x	
Caprimulgidae													

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Eurostopodus argus	Spotted Nightjar			x		x	x		x		x	x	
Aegothelidae													
Aegotheles cristatus	Australian Owlet-nightjar					x	x		x		x	x	
Apodidae													
Apus pacificus	Fork-tailed Swift	Mi	S5					x					
Alcedinidae													
Todiramphus pyrrhopygius	Red-backed Kingfisher					x	x		x		x	x	
Todiramphus sanctus	Sacred Kingfisher					x	x						
Meropidae													
Merops ornatus	Rainbow Bee-eater				x	x	x	x			x		
Falconidae													
Falco berigora	Brown Falcon					x	x		x		x	x	
Falco cenchroides	Australian Kestrel					x	x				x	x	

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Falco hypoleucos	Grey Falcon		S3		x	x							
Falco longipennis	Australian Hobby					x	x				x	x	
Falco peregrinus	Peregrine Falcon		S7		x	x	x					x	
Cacatuidae													
Cacatua roseicapilla	Galah					x	x		x		x	x	
Nymphicus hollandicus	Cockatiel					x	x				x	x	
Psittacidae													
Melopsittacus undulatus	Budgerigar			x		x	x				x	x	
Neophema bourkii	Bourke's Parrot			x		x	x				x	x	
Neophema splendida	Scarlet-chested Parrot										x		
Pezoporus occidentalis	Night Parrot	En	S1					x					
Platycercus varius	Mulga Parrot			x		x	x				x	x	
Platycercus zonarius	Australian Ringneck			x		x	x		x		x	x	

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Polytelis alexandrae	Princess Parrot	Vu	P4		x			x					
Ptilonorhynchidae													
Ptilonorhynchus maculatus guttatus	Western Bowerbird			x		x	x				x	x	
Climacteridae													
Climacteris affinis	White-browed Treecreeper					x					x	x	
Maluridae													
Malurus lamberti	Variegated Fairy-wren			x		x	x		x				
Malurus leucopterus	White-winged Fairy-wren			x		x	x		x		x	x	
Malurus pulcherrimus	Blue-breasted Fairy-wren										x		
Malurus splendens	Splendid Fairy-wren			x		x	x		x	x	x		x
Meliphagidae													
Acanthagenys rufogularis	Spiny-cheeked Honeyeater					x	x		x	x	x	x	x
Anthochaera carunculata	Red Wattlebird					x	x				x		

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Certhionyx variegatus	Pied Honeyeater					x	x		x		x	x	
Epthianura albifrons	White-fronted Chat					x	x				x		
Epthianura aurifrons	Orange Chat					x	x				x	x	
Epthianura tricolor	Crimson Chat					x	x				x	x	
Gavicalis virescens	Singing Honeyeater			x			x		x	x	x	x	x
Lichenostomus leucotis	White-eared Honeyeater										x		
Lichmera indistincta	Brown Honeyeater					x	x		x	x	x		x
Manorina flavigula	Yellow-throated Miner			x		x	x		x		x	x	
Melithreptus brevirostris	Brown-headed Honeyeater										x		
Ptilotula ornatus	Yellow-plumed Honeyeater						x				x		
Ptilotula penicillatus	White-plumed Honeyeater						x						
Ptilotula plumulus	Grey-fronted Honeyeater						x				x		
Purnella albifrons	White-fronted Honeyeater					x	x		x		x	x	

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Sugomel niger	Black Honeyeater						x				x		
Pardalotidae													
Pardalotus rubricatus	Red-browed Pardalote					x							
Pardalotus striatus	Striated Pardalote					x	x				x	x	
Acanthizidae													
Acanthiza apicalis	Inland Thornbill			x		x	x		x	x	x	x	x
Acanthiza chrysorrhoa	Yellow-rumped Thornbill			x		x	x		x		x	x	
Acanthiza iredalei	Slender-billed Thornbill										x		
Acanthiza robustirostris	Slaty-backed Thornbill			x		x	x		x		x		
Acanthiza uropygialis	Chestnut-rumped Thornbill			x		x	x		x	x	x	x	x
Aphelocephala leucopsis	Southern Whiteface			x		x	x		x		x		
Calamanthus campestris	Rufous Fieldwren											x	
Gerygone fusca	Western Gerygone						x		x			x	

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Pyrrholaemus brunneus	Redthroat			x		x	x				x		
Smicrornis brevirostris	Weebill					x	x				x	x	
Pomatostomidae													
Pomatostomus superciliosus	White-browed Babbler			x		x	x		x		x	x	
Psophodidae													
Cinclosoma clarum	Western Chestnut Quail-thrush			x		x	x				x		
Cinclosoma marginatum	Western Quail-thrush						x						
Psophodes occidentalis	Western Wedgebill					x	x						
Artamidae													
Artamus cinereus	Black-faced Woodswallow			x		x	x		x		x	x	
Artamus minor	Little Woodswallow			x		x							
Artamus personatus	Masked Woodswallow					x	x				x	x	
Artamus superciliosus	White-browed Woodswallow										x		

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Cracticidae													
Cracticus nigrogularis	Pied Butcherbird			x		x	x		x	x	x	x	x
Cracticus tibicen	Australian Magpie			x		x	x		x	x	x	x	x
Cracticus torquatus	Grey Butcherbird					x	x		x		x	x	
Strepera versicolor	Grey Currawong			x		x	x				x		
Campephagidae													
Coracina maxima	Ground Cuckoo-shrike					x	x				x	x	
Coracina novaehollandiae	Black-faced Cuckoo-shrike			x		x	x		x	x	x	x	x
Lalage tricolor	White-winged Triller					x	x				x		
Neosittidae													
Daphoenositta chrysoptera	Varied Sittella			x			x				x		
Oreoicidae													
Oreoica gutturalis	Crested Bellbird			x		x	x		x	x	x	x	x

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Pachycephalidae													
Colluricincla harmonica	Grey Shrike-thrush			x		x	x		x	x	x		x
Pachycephala pectoralis	Golden Whistler					x	x						
Pachycephala rufiventris	Rufous Whistler			x		x	x		x	x	x	x	x
Rhipiduridae													
Rhipidura albiscapa	Grey Fantail						x			x	x		x
Rhipidura leucophrys	Willie Wagtail			x		x	x		x	x	x	x	x
Monarchidae													
Grallina cyanoleuca	Magpie-lark			x		x	x		x		x	x	
Corvidae													
Corvus bennetti	Little Crow			x		x	x		x		x	x	
Corvus coronoides	Australian Raven					x	x						
Corvus orru	Torresian Crow			x		x	x		x	x	x	x	x

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Petroicidae													
Melanodryas cucullata	Hooded Robin			x			x		x		x	x	
Microeca fascinans	Jacky Winter					x	x				x		
Petroica goodenovii	Red-capped Robin			x		x	x				x	x	
Hirundinidae													
Cheramoeca leucosternus	White-backed Swallow			x		x	x		x		x		
Hirundo neoxena	Welcome Swallow			x		x	x		x	x	x		x
Petrochelidon ariel	Fairy Martin						x				x		
Petrochelidon nigricans	Tree Martin			x		x	x		x		x	x	
Locustellidae													
Megalurus cruralis	Brown Songlark					x	x				x	x	
Megalurus mathewsi	Rufous Songlark					x	x			x	x		x
Dicaeidae													

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Dicaeum hirundinaceum	Mistletoebird			x		x	x		x		x	x	
Estrildidae													
Taeniopygia guttata	Zebra Finch			x		x	x				x	x	
Motacillidae													
Anthus australis	Australian Pipit					x	x		x		x	x	
Motacilla cinerea	Grey Wagtail	Mi	S5					x					
Motacilla flava	Yellow Wagtail	Mi	S5					x					
Reptiles													
Cheluidae													
Chelodina steindachneri	Flat-shelled Turtle											x	
Carphodactylidae													
Nephrurus laevissimus											x		
Nephrurus vertebralis						x					x	x	

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Nephrurus wheeleri						x							
Underwoodisaurus milii	Southern Barking Gecko					x					x		
Diplodactylidae													
Diplodactylus conspicillatus	Variable Fat-tailed Gecko					x					x	x	
Diplodactylus granariensis						x					x		
Diplodactylus pulcher						x					x	x	
Lucasium maini											x		
Lucasium squarrosum						x					x	x	
Rhynchoedura ornata	Western Beaked Gecko					x					x	x	
Strophurus assimilis	Goldfields Spiny-tailed Gecko					x					x		
Strophurus ciliaris											x		
Strophurus elderi												x	
Strophurus strophurus											x		

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Strophurus wellingtonae				x		x							
Gekkonidae													
Gehyra purpurascens											x	x	
Gehyra variegata				x		x			x		x	x	
Heteronotia binoei	Bynoe's Gecko			x		x			x		x	x	
Pygopodidae													
Aprasia picturata						x							
Delma butleri												x	
Delma nasuta											x		
Lialis burtonis											x	x	
Pygopus nigriceps						x					x	x	
Agamidae													
Ctenophorus caudicinctus	Ring-tailed Dragon										x	x	

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Ctenophorus cristatus	Bicycle Dragon										x		
Ctenophorus fordi	Mallee Sand Dragon										x	x	
Ctenophorus isolepis	Military Dragon					x						x	
Ctenophorus nuchalis	Central Netted Dragon					x					x	x	
Ctenophorus reticulatus	Western Netted Dragon					x					x	x	
Ctenophorus salinarum	Salt Pan Dragon										x	x	
Ctenophorus scutulatus						x				x	x		x
Diporiphora amphiboluroides				x									
Moloch horridus	Thorny Devil										x	x	
Pogona minor						x					x	x	
Tympanocryptis pseudopsephos	Goldfields Pebble-mimic dragons					x					x		
Scincidae													
Cryptoblepharus australis						x							

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Cryptoblepharus buchananii						x					x		
Cryptoblepharus plagiocephalus											x		
Ctenotus atlas											x	x	
Ctenotus brooksi											x		
Ctenotus calurus											x		
Ctenotus grandis												x	
Ctenotus greeri											x		
Ctenotus helenae											x	x	
Ctenotus leonhardii				x		x					x	x	
Ctenotus pantherinus	Leopard Ctenotus					x					x		
Ctenotus quattuordecimlineatus											x	x	
Ctenotus schomburgkii											x	x	
Ctenotus severus						x					x		

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Ctenotus uber						x					x		
Cyclodomorphus branchialis			S3								x		
Egernia depressa	Southern Pygmy Spiny-tailed Skink			x		x					x	x	
Egernia formosa											x	x	
Eremiascincus richardsonii	Broad-banded Sand Swimmer					x					x		
Lerista desertorum						x			x		x	x	
Lerista macropisthopus											x		
Lerista picturata											x		
Lerista timida						x					x	x	
Liopholis inornata						x					x	x	
Liopholis striata	Night Skink										x	x	
Menetia greyii						x					x	x	
Morethia butleri						x					x	x	

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Tiliqua occipitalis	Western Bluetongue										x		
Varanidae													
Varanus caudolineatus				x		x					x	x	
Varanus eremius	Pygmy Desert Monitor											x	
Varanus giganteus	Perentie										x	x	
Varanus gouldii	Sand Monitor					x			x		x	x	
Varanus panoptes	Yellow-spotted Monitor			x		x					x	x	
Varanus tristis	Racehorse Monitor										x	x	
Typhlopidae													
Anilios hamatus											x	x	
Anilios waitii											x	x	
Pythonidae													
Antaresia stimsoni	Stimson's Python					x							

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Elapidae													
Brachyurophis fasciolatus											x		
Brachyurophis semifasciatus												x	
Demansia psammophis	Yellow-faced Whipsnake										x		
Parasuta monachus						x					x		
Pseudechis australis	Mulga Snake					x							
Pseudechis butleri	Spotted Mulga Snake					x							
Pseudonaja mengdeni	Western Brown Snake					x					x	x	
Pseudonaja modesta	Ringed Brown Snake					x					x	x	
Simoselaps bertholdi	Jan's Banded Snake										x		
Suta fasciata	Rosen's Snake					x					x		
Amphibians													
Hylidae													

Species	Common Name	Conservation Status		a	b	c	d	e	f	g	h	i	j
		EPBC Act	WA Status										
Cyclorana maini	Sheep Frog					x						x	
Cyclorana platycephala	Western Water-holding Frog					x							
Litoria rubella	Little Red Tree Frog					x							
Limnodynastidae													
Neobatrachus kunapalari	Kunapalari Frog					x						x	
Neobatrachus sutor	Shoemaker Frog					x					x		
Neobatrachus wilsmorei	Plonking Frog										x	x	
Notaden nichollsi	Desert Spadefoot					x							
Platyplectrum spenceri	Centralian Burrowing Frog										x	x	
Myobatrachidae													
Pseudophryne occidentalis	Western Toadlet					x					x		

Appendix C Vegetation Condition Scale (Trudgen 1988)

Code	Description
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
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 or shrubs.

Appendix D Vegetation Structure Scale

NVIS Vegetation Structural Classifications (ESCAVI 2003).

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

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

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

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

Appendix E Flora Relevés

Leonora Gold – Kin Mining – LD01

Site Details:

Described by: Crystal Heydenrych

Date: 16/03/2018

Type: Relevé

MGA Zone: 50 358265mE 6825906mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Red

Rock Type: Basalt, Ironstone

Coarse Surface Particles:

Site coverage: 10-20

Size: 6-20, 2-6

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Flooding:

Erosion: N/A

Human disturbance: Grazing, Tracks

Introduced species: Camel

FLORA AND VEGETATION DATA

Description: *Acacia aneura* tall sparse woodland over *Acacia aneura, Santalum spicatum* mid to tall isolated trees over isolated trees over *Eremophila exilifolia* low shrubs over mixed grasses

Species List

Species Name	Height (m)	Cover (%)
Acacia incurvaneura	4	2
Eremophila exilifolia	0.8	0.1
Acacia? duriscula	4.5	5
Acacia craspedocarpa	2.5	2
Sida ectogama	1.2	0.5
Solanum lasiophyllum	0.3	0.2
Acacia aneura	1.4	0.5
Eremophila mackinlayi subsp. *spathulata*	1.5	0.5
Aristida holathera	0.2	0.1
Austrostipa elegantissima	0.3	0.1

Species Name	Height (m)	Cover (%)
Ptilotus schwartzii	0.2	0.13
Acacia aneura	3	1
Teucrium teucriiflorum		

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
5	65	3	28

Veg Condition: Good

Fire Age: Unknown (no evidence)

Weeds:

Fire Notes: N/A

SITE PHOTOGRAPH



Leonora Gold – Kin Mining – LD02

Site Details:

Described by: Crystal Heydenrych

Date: 16/03/2018

Type: Relevé

MGA Zone: 50 358967mE 6824144mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Red

Rock Type: Ironstone, Quartzite

Coarse Surface Particles:

Site coverage: 2-10

Size: 6-20, 2-6

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Inundation:

Flooding:

Erosion: N/A

Human disturbance: Grazing, Feral trampling, Tracks

Introduced species: Camel

FLORA AND VEGETATION DATA

Description: *Acacia aneura, Acacia? duriscula* tall dense shrubland over *Acacia tetragonophylla, Eremophila platycalyx subsp. platycalyx* tall isolated shrubs over *Eremophila exilifolia* mid isolated shrubs over chenopod low sparse shrubland

Species List

Species Name	Height (m)	Cover (%)
Acacia aneura	5	5
Acacia aneura	5.5	5
Eremophila platycalyx subsp. platycalyx	1	1
Eremophila exilifolia	0.5	0.1
Solanum lasiophyllum	0.4	0.1
Acacia tetragonophylla	1.5	0.1
Sida ectogama	0.6	0.1
Ptilotus obovatus	0.3	0.1
Maireana ? georgei		
Maireana triptera	0.25	0.1

Species Name	Height (m)	Cover (%)
Ptilotus sp.	0.5	0.1
Enneapogon polyphyllus	0.2	0.1
Ptilotus schwartzii	0.4	0.1
Aristida contorta	0.15	0.1
Abutilon forby	0.15	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
3	37	20	40

Veg Condition: Very Good

Fire Age: Unknown (no evidence)

Weeds:

Fire Notes: N/A

SITE PHOTOGRAPH



Leonora Gold – Kin Mining – LD04

Site Details:

Described by: Crystal Heydenrych

Date: 16/03/2018

Type: Relevé

MGA Zone: 50 359114mE 6822676mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Red

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 50-90

Size: 2-6

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Inundation:

Flooding:

Erosion: N/A

Human disturbance: Feral trampling, Feral scats

Introduced species: Camel, rabbit

FLORA AND VEGETATION DATA

Description: *Acacia aneura, Acacia ? duriscula* mid isolated trees over *Ptilotus obovatus Maireana* low sparse shrubland

Species List

Species Name	Height (m)	Cover (%)
Acacia aneura	2	0.1
Eremophila scoparia	0.8	0.1
Solanum lasiophyllum	0.3	0.1
Maireana triptera	0.15	0.1
Aristida contorta	0.25	0.1
Senna artemisioides	1	0.1
Enneapogon polyphyllus	0.2	71
Ptilotus obovatus var. obovatus	0.35	0.1
Maireana ? georgei	0.15	0.1
Sclerolaena sp.	0.2	0.1
Maireana pyramidata	0.2	0.1

Species Name	Height (m)	Cover (%)
Atriplex nummularia	0.15	0.1
Maireana glomerifolia	0.4	0.1
Ptilotus sp.	0.2	0.1
Ptilotus aervoides	0.15	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
2	75	1	22

Veg Condition: Very Good

Fire Age: Unknown (no evidence)

Weeds:

Fire Notes: N/A

SITE PHOTOGRAPH



Leonora Gold – Kin Mining – LHR01

Site Details:

Described by: Crystal Heydenrych

Date: 15/03/2018

Type: Relevé

MGA Zone: 51 361549mE 6813246mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Red

Rock Type: Laterite

Coarse Surface Particles:

Site coverage: 2-10

Size: 2-6, 6-20

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Inundation:

Flooding:

Erosion: N/A

Human disturbance: Grazing, Tracks

Introduced species: Camel

FLORA AND VEGETATION DATA

Description: *Maireana pyramidata* and *Cratystylis subspinescens* mid chenopod shrubland over isolated *Solanum lasiophyllum* low shrubs over low chenopod shrubland over sparse grassland

Species List

Species Name	Height (m)	Cover (%)
Solanum lasiophyllum	0.2	0.1
Cratystylis subspinescens	0.8	5
Maireana pyramidata	0.3	8
Enteropogon ramosus	0.25	0.1
Aristida contorta	0.15	0.1
Enneapogon caerulescens	0.15	0.1
Euphorbia drummondii prostrate	0	0.1
Ptilotus obovatus var. obovatus	0.25	0.1
Maireana tomentosa	0.15	0.1
Sclerolaena diacantha	0.15	0.1
Enneapogon polyphyllus	0.15	0.1

Species Name	Height (m)	Cover (%)
Sida ectogama	0.2	0.1
Maireana triptera	0.15	3
Brachyscome ciliaris	0.15	0.1
Sida sp.	0.2	0.1
Portulaca oleracea	0.05	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	60	1	39

Veg Condition: Very Good

Fire Age: Unknown (no evidence)

Weeds:

Fire Notes: N/A

SITE PHOTOGRAPH



Leonora Gold – Kin Mining – LHR02

Site Details:

Described by: Crystal Heydenrych

Date: 15/03/2018

Type: Relevé

MGA Zone: 50 361355mE 6813138mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Sandy loam

Soil Colour: Red

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 2-10

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

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Inundation:

Flooding:

Erosion: N/A

Human disturbance: Grazing

Introduced species: Camel

FLORA AND VEGETATION DATA

Description: *Acacia caesaneura* isolated trees over *Senna sp. Meekatharra* (E. Bailey 1-26) low shrubland over *Cratystylis subspinescens* isolated shrubs over chenopod shrubland

Species List

Species Name	Height (m)	Cover (%)
Solanum lasiophyllum	0.3	0.1
Acacia caesaneura	3	0.1
Senna sp. Meekatharra (E. Bailey 1-26)	0.5	0.1
Ptilotus obovatus var. obovatus	0.3	0.1
Enneapogon polyphyllus	0.3	0.1
Maireana tomentose	0.4	0.1
Enneapogon caerulescens	0.015	0.1
Maireana pyramidata	0.3	0.1
Eremophila latrobei subsp. latrobei	0.6	0.1
Sida ectogama	0.2	0.1
Enteropogon ramosus	0.4	0.1

Species Name	Height (m)	Cover (%)
Aristida contorta	0.2	0.1
Portulaca oleracea	0	0.1
Abutilon oxycarpum var. prostrate (A.A. Mitchell PRP 1266)	0.02	0.1
Eremophila mackinlayi subsp. spathulata	0.03	0.1
Euphorbia drummondii prostrate	0.01	0.1
? Sclerolaena sp.	0.2	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
3	65	2	30

Veg Condition: Very Good

Fire Age: Unknown (no evidence)

Weeds:

Fire Notes: N/A

SITE PHOTOGRAPH



Leonora Gold – Kin Mining – LHR03

Site Details:

Described by: Crystal Heydenrych

Date: 15/03/2018

Type: Relevé

MGA Zone: 50 355913mE 6807896mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Sandy loam

Soil Colour: Red

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 2-10

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

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Inundation:

Flooding:

Erosion: N/A

Human disturbance: Grazing, Tracks

Introduced species: Camel

FLORA AND VEGETATION DATA

Description: *Acacia aneura* small and *Acacia ? duriscula* mid to tall shrubland over *Eremophila platycalyx subsp. platycalyx* isolated trees over *Ptilotus obovatus subsp. obovatus* and *Senna artemisioides subsp. X artemisioides* low sparse shrubland over *Aristida contorta* grassland

Species List

Species Name	Height (m)	Cover (%)
Acacia? duriscula	3.5	0.1
Acacia craspedocarpa	0.5	5
Sida ectogama	0.4	0.1
Eremophila exilifolia	0.5	0.1
? Portulaca sp.	0.001	0.1
Eremophila platycalyx subsp. platycalyx	1.2	0.1
Acacia tetragonophylla	0.5	0.1
Tribulus astrocarpus	0.01	0.1
Erodium sp.	0.001	0.1
Ptilotus obovatus var. obovatus	0.3	0.1

Species Name	Height (m)	Cover (%)
Acacia ramulosa var. ramulosa	1.8	1
Aristida contorta	0.2	0.1
Santalum spicatum	1.5	0.1
Euphorbia drummondii prostrate	0.01	0.1
Enneapogon caerulescens	0.25	0.1
Ptilotus roei	0.01	0.1
Digitaria brownii	0.35	0.1
Goodenia havilandii	0.01	0.1
Eremophila mackinlayi subsp. spathulata	1	0.2

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
10	55	2	33

Veg Condition: Very Good

Fire Age: Unknown (no evidence)

Weeds:

Fire Notes: N/A

SITE PHOTOGRAPH



Leonora Gold – Kin Mining – LHR04

Site Details:

Described by: Crystal Heydenrych

Date: 15/03/2018

Type: Relevé

MGA Zone: 51 359255mE 6811386mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Red

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 50-90

Size: 2-6

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Inundation:

Flooding:

Erosion: N/A

Human disturbance: Grazing

Introduced species: Camel

FLORA AND VEGETATION DATA

Description: *Acacia sp.* tall isolated trees over *Senna artemisoides var filifolia, Eremophila scoparia, Maireana sedifolia* mid sparse shrubland over *Tecticornia ? disarticulata* chenopod shrubland

Species List

Species Name	Height (m)	Cover (%)
Acacia sp.	4	3
Maireana sedifolia	0.8	1
Cratystylis microphylla	0.8	0.1
Enteropogon ramosus	0.3	0.1
Maireana ? villosa	0.2	2
Solanum lasiophyllum	0.3	0.1
Eremophila platycalyx subsp. platycalyx	0.8	1
Maireana triptera	0.2	0.1
Sclerolaena densiflora	0.2	0.1
Enneapogon caerulescens	0.2	0.1

Species Name	Height (m)	Cover (%)
Sclerolaena sp.	0.015	0.1
? Sclerolaena sp.	0.15	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	75	1	24

Veg Condition: Very Good

Fire Age: Unknown (no evidence)

Weeds:

Fire Notes: N/A

SITE PHOTOGRAPH



Leonora Gold – Kin Mining – LHR05

Site Details:

Described by: Crystal Heydenrych

Date: 17/03/2018

Type: Relevé

MGA Zone: 51 355866mE 6803619mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Medium clay

Soil Colour: Red

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 10-20

Size: 6-20, 2-6

Outcropping: N/A

Impacts:

Waterlogging: Yes – temporary

Inundation:

Flooding:

Erosion: N/A

Human disturbance: Grazing, Feral trampling, Feral scats, Weeds, Tracks

Introduced species: Camel, rabbit

FLORA AND VEGETATION DATA

Description: *Acacia ? aneura* mid isolated trees over low *Acacia ? aneura* trees, *Eremophila youngii subsp. youngii* mid sparse shrubland over *Eremophila hygrophana* low isolated shrubs over mixed grassland

Species List

Species Name	Height (m)	Cover (%)
Eremophila youngii	1	1
Acacia aneura	5	0.1
Ptilotus nobilis	0.15	0.1
Ptilotus divaricatus	0.15	0.1
Eriachne flaccida	0.2	0.1
Solanum lasiophyllum	0.25	0.1
Alternanthera nodiflora	0.15	0.1
Ptilotus sp.	0.1	0.1
Abutilon cryptopetalum	0.4	0.1
Indet. sp.	0.015	0.1
Dactyloctenium radulans	0.15	0.1

Species Name	Height (m)	Cover (%)
Eremophila mackinlayi subsp. spathulata	0.35	0.1
Nicotiana rosulata subsp. rosulata	0.15	0.1
Dysphania melanocarpa	0.15	0.1
Enteropogon ramosus	0.35	0.1
Ptilotus obovatus var. obovatus	0.35	0.1
Eremophila longifolia	1.2	0.1
Acacia tetragonophylla	2	0.1
Cratystylis subspinescens	0.5	0.1
Enchylaena tomentosa	0.2	0.1
Cyperus iria	0.2	0.1
Eriachne flaccida	0.3	0.1
Sonchus sp.	0.15	0.1
Eragrostis leptocarpa	0.3	0.1
Geraniaceae sp.	0.15	0.1
Iseilema eremaeum	0.15	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
2	50	1	47

Veg Condition: Degraded

Fire Age: Unknown (no evidence)

Weeds:

Fire Notes: N/A

SITE PHOTOGRAPH



Leonora Gold – Kin Mining – LHR06

Site Details:

Described by: Crystal Heydenrych

Date: 17/03/2018

Type: Relevé

MGA Zone: 51 355653mE 6803600mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Clayey sand

Soil Colour: Red

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 2-6

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

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Inundation:

Flooding:

Erosion: N/A

Human disturbance: Tracks, Feral scats

Introduced species: Camel

FLORA AND VEGETATION DATA

Description: *Hakea preissii, Eremophila youngii subsp. youngii* isolated shrubs over *Cratystylus subspinescens* low isolated shrubs over mixed chenopod shrubland

Species List

Species Name	Height (m)	Cover (%)
Eremophila youngii subsp. youngii	2	0.1
Hakea preissii	1.5	0.1
Cratystylis subspinescens	0.5	0.1
? Sclerolaena sp.	0.2	0.1
Atriplex nummularia	0.15	0.1
Sclerolaena cuneata	0.15	0.1
Sclerolaena sp.	0.2	0.1
Maireana triptera	0.25	0.1
Maireana pyramidata	0.35	0.1
Podilepis kendallii	0.05	0.1
Enteropogon ramosus	0.3	0.1

Species Name	Height (m)	Cover (%)
Solanum lasiophyllum	0.25	0.1
Enneapogon polyphyllus	0.3	0.1
Cymbopogon excavatus	0.35	0.1
Ptilotus obovatus	0.3	0.1
Boerhavia coccinea	0.3	0.1
Aristida contorta	0.25	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	60	1	39

Veg Condition: Good

Fire Age: Unknown (no evidence)

Weeds:

Fire Notes: N/A

SITE PHOTOGRAPH



Leonora Gold – Kin Mining – LHR07

Site Details:

Described by: Crystal Heydenrych

Date: 17/03/2018

Type: Relevé

MGA Zone: 51 355924mE 6802599mN

Environmental Variables:

Landform: Plain

Slope: Level (0-3°)

Soils:

Soil Texture: Sandy loam

Soil Colour: Red

Rock Type: Ironstone, Quartzite

Coarse Surface Particles:

Site coverage: 2-10

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

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Inundation:

Flooding:

Erosion: N/A

Human disturbance: Feral scats

Introduced species: Camel

FLORA AND VEGETATION DATA

Description: *Acacia ? duriscula, Acacia ? aneura* isolated trees over *Acacia ramulosa var. ramulosa* mid isolated shrubs over *Eremophila margarethae, Ptilotus obovatus subsp. obovatus* low shrubland

Species List

Species Name	Height (m)	Cover (%)
Erem ? Georgei	0.4	0.1
Eremophila mackinlayi spathulata	1	0.1
Acacia ramulosa var. ramulosa	1.3	0.1
Acacia aneura	5	2
Acacia striated	3	0.1
Solanum lasiophyllum	0.5	0.1
Monochather paradoxa	0.5	0.1
Maireana planifolia	0.5	0.1
Maireana triptera	0.3	0.1
Maireana ? georgei	0.2	0.1

Species Name	Height (m)	Cover (%)
Eremophila platycalyx subsp. platycalyx	1.7	0.1
Maireana tomentose	0.2	0.1
Acacia aneura	4	0.1
Sida ectogama	0.4	0.1
Enneapogon polyphyllus	0.35	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	65	2	33

Veg Condition: Very Good

Fire Age: Unknown (no evidence)

Weeds:

Fire Notes: N/A

SITE PHOTOGRAPH



Leonora Gold – Kin Mining – LHR08

Site Details:

Described by: Crystal Heydenrych

Date: 17/03/2018

Type: Relevé

MGA Zone: 51 355918mE 6801415mN

Environmental Variables:

Landform: Floodplain

Slope: Level (0-3°)

Soils:

Soil Texture: Medium clay

Soil Colour: Red

Rock Type: Ironstone, Quartzite

Coarse Surface Particles:

Site coverage: N/A

Size: N/A

Outcropping: N/A

Impacts:

Waterlogging: Yes – Semi-permanent

Inundation:

Flooding:

Erosion: N/A

Human disturbance: Weeds, Tracks, Feral trampling, Feral scats

Introduced species: Camel

FLORA AND VEGETATION DATA

Description: *Acacia aneura* tall open shrubland over *Acacia craspedocarpa* (hybrid) mid open shrubland over *Ptilotus obovatus subsp. obovatus, Eremophila mackinlayi subsp. spathulata* low sparse shrubland over *Fimbristylis dichotoma, Cheilanthes sieberi* and introduced forbs

Species List

Species Name	Height (m)	Cover (%)
Acacia aneura	5	4
Cheilanthes sieberi	0.1	1
Podolepis kendallii	0.15	0.1
Eremophila mackinlayi subsp. spathulata	1	0.1
Euphorbia drummondii prostrate	0.005	0.1
Santalum lanceolatum	4	0.1
Acacia craspedocarpa (hybrid)	0.8	0.1
Brachyscome ciliaris	0.15	0.1

Species Name	Height (m)	Cover (%)
Ptilotus obovatus var. obovatus	0.45	0.1
Acacia tetragonophylla	1.5	0.1
Solanum lasiophyllum	0.35	0.1
Nicotiana rosulata subsp. rosulata	0.2	0.1
Geraniaceae sp.	0.3	0.1
Convolvulus clementii	0	0.1
Glycine canescens	0	0.1
Portulaca oleracea	0.05	0.1
Eragrostis leptocarpa	0.3	0.1
Lysimachia arvensis	0.05	0.1
Enchylaena tomentosa	0.4	0.1
Dactyloctenium radulans	0.2	0.1
Phyllanthus erwinii	0.1	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	35	5	60

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

SITE PHOTOGRAPH



Leonora Gold – Kin Mining – LHR09

Site Details:

Described by: Crystal Heydenrych

Date: 17/03/2018

Type: Relevé

MGA Zone: 51 355872mE 6804355mN

Environmental Variables:

Landform: Wetland

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Heavy clay

Soil Colour: Orange

Rock Type: N/A

Coarse Surface Particles:

Site coverage: N/A

Size: N/A

Outcropping: N/A

Impacts:

Waterlogging: Yes – Semi-pernanent

Inundation:

Flooding:

Erosion: N/A

Human disturbance: Weeds

Introduced species: N/A

FLORA AND VEGETATION DATA

Description: *Pittosporum angustifolium* isolated trees over *Santalum spicatum, Acacia tetragonophylla* mid isolated trees over *Eleocharis pallens* sedgeland over *Marsilea sp.*

Species List

Species Name	Height (m)	Cover (%)
Pittosporum angustifolium	8	1
Eleocharis pallens	0.4	60
Acacia tetragonophylla	2	0.1
Santalum spicatum	3	0.1
Hakea preissii	1.3	0.1
Marsilea sp	0.5	20
Cyperus iria	0.3	0.1
Cratystylis subspinescens	1	0.1
Scaevola spinescens	1	0.1
Eriachne flaccida	0.4	0.1
Alternanthera nodiflora	0.5	0.1

Species Name	Height (m)	Cover (%)
Vittadinia sulcata	0.1	0.1
Eragrostis eriopoda	0.3	0.1
Juncus aridicola	0.5	0.1
Exocarpos aphyllus	2	0.1
Solanum nigrum	0.25	0.1
Sonchus sp	0.05	0.1
Rhagodia drummondii	0.1	0.1
Ptilotus divaricatus	0.3	0.1
Enteropogon ramosus	0.35	0.1
Isolepis congrua	0.05	0.1
Hakea preissii	0.8	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
0	20	1	79

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

SITE PHOTOGRAPH



Leonora Gold – Kin Mining – LHR10

Site Details:

Described by: Crystal Heydenrych

Date: 17/03/2018

Type: Relevé

MGA Zone: 51 360316mE 6812835mN

Environmental Variables:

Landform: Hill

Slope: Gently inclined (3-5°)

Soils:

Soil Texture: Sandy loam

Soil Colour: Red

Rock Type: Ironstone

Coarse Surface Particles:

Site coverage: 50-90

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

Outcropping: N/A

Impacts:

Waterlogging: No - Never

Inundation:

Flooding:

Erosion: N/A

Human disturbance: Grazing, Feral scats

Introduced species: Camel

FLORA AND VEGETATION DATA

Description: *Acacia ? aneura*, *Acacia aneura* low to mid isolated sparse trees over *Acacia ramulosa var. ramulosa* over *Ptilotus obovatus subsp. obovatus* open shrubland

Species List

Species Name	Height (m)	Cover (%)
Solanum lasiophyllum	0.3	0.1
Acacia aneura	3.5	1
Ptilotus obovatus	0.5	8
Sclerolaena sp.	0.4	0.1
Scaevola spinescens	1	0.1
Maireana triptera	0.2	0.1
Acacia aneura	3	0.1
Acacia ? doreta	0.8	0.1
Ptilotus sp	0.4	0.1
Enneapogon caerulescens	0.3	0.1

Species Name	Height (m)	Cover (%)
Aristida contorta	0.2	0.1
Eremophila exilifolia	1	0.1
Ptilotus nobilis	0.05	0.1
Acacia yellow	2	0.1
Ptilotus schwartzii	0.3	0.1
Eremophila mackinlayi subsp. spathulata	0.5	0.1
Eremophila latrobei subsp. latrobei	0.8	0.1
Sida ectogama	0.5	0.1
Alyogyne pinoniana	0.5	0.1

Ground Cover (percent)

Rock	Bare soil	Litter	Perennial ground cover
5	55	2	38

Veg Condition: Very Good

Fire Age: Unknown (no evidence)

Weeds:

Fire Notes: N/A

SITE PHOTOGRAPH



Appendix F Inventory of Vascular Flora Recorded

Family	Species
	Alternanthera nodiflora
	Ptilotus divaricatus
	Ptilotus helipteroides
	Ptilotus nobilis
	Ptilotus obovatus var. obovatus
	Ptilotus roei
	Ptilotus schwartzii
Amaranthaceae	*Ptilotus sp.*
	? Sonchus
	Asteraceae sp.
	Brachyscome ciliaris
	Cratystylis microphylla
	Cratystylis subspinescens
	Podolepis kendallii
Asteraceae	*Vittadinia sulcata*
Casuarinaceae	*Casuarina pauper*
	? Sclerolaena sp.
	Atriplex nummularia
	Atriplex quinii
	Atriplex sp.
	Dysphania melanocarpa
	Enchylaena tomentosa
	Maireana ? georgei
	Maireana ? villosa
	Maireana convexa
	Maireana glomerifolia
	Maireana planifolia
	Maireana pyramidata
	Maireana sedifolia
	Maireana tomentosa
	Maireana triptera
	Rhagodia drummondii
	Salsola australis
	Sclerolaena cuneata
	Sclerolaena densiflora
	Sclerolaena diacantha
	Sclerolaena drummondii
	Sclerolaena sp.
Chenopodiaceae	*Tecticornia ? disarticulata*
	Convolvulus clementii
Convolvulaceae	*Duperreya commixta*
	Cyperus iria
Cyperaceae	*Isolepis congrua*
Euphorbiaceae	*Euphorbia drummondii*

Family	Species
	Acacia ? doreta
	Acacia aneura
	Acacia ayersiana
	Acacia burkittii
	Acacia caesaneura
	Acacia craspedocarpa (hybrid)
	Acacia incurvaneura
	Acacia ramulosa var. ramulosa
	Acacia sp.
	Acacia tetragonophylla
	Acacia? duriscula
	Senna artemisioides
	Senna artemisioides subsp. filifolia
	Senna artemisioides subsp. X sturtii
	Senna sp. Meekatharra (E. Bailey 1-26)
	Senna stowardii
Fabaceae	*Glycine canescens*
	Erodium sp.
Geraniaceae	*Geraniaceae sp.*
	Scaveola spinescens
Goodeniaceae	*Goodenia triodiophila*
Juncaceae	*Juncus aridicola*
Lamiaceae	*Teucrium teucriiflorum*
	Abutilon cryptopetalum
	Abutilon oxycarpum var. prostrate (A.A. Mitchell PRP 1266)
	Hibiscus sp. Gardneri (A.L. Payne PRP 1435)
	Sida ectogama
	Sida sp.
Malvaceae	*Sida calyxhymenia*
Marsileaceae	*Marsilea sp.*
Nyctaginaceae	*Boerhavia coccinea*
Phyllanthaceae	*Phyllanthus erwinii*
Pittosporaceae	*Pittosporum angustifolium*
	Aristida contorta
	Aristida holothera
	Austrostipa elegantissima
	Austrostipa trichophylla
	Cymbopogon obtectus
	Dactyloctenium radulans
	Digitaria brownii
	Eleocharis pallens
	Enneapogon avenaceus
	Enneapogon caerulescens
Poaceae	*Enneapogon polyphyllus*

Family	Species
	Enteropogon ramosus
	Eragrostis dielsii
	Eragrostis eriopoda
	Eragrostis leptocarpa
	Eragrostis setifolia
	Eriachne flaccida
	Iseilema eremaeum
	Monochather paradoxus
	Poaceae sp.
Portulacaceae	*Portulaca oleracea*
Primulaceae	**Lysimachia arvensis*
Proteaceae	*Hakea preissii*
Pteridaceae	*Cheilanthes sieberi*
	Exocarpos aphyllus
	Santalum lanceolatum
Santalaceae	*Santalum spicatum*
	Eremophila exilifolia
	Eremophila latrobei subsp. latrobei
	Eremophila longifolia
	Eremophila mackinlayi subsp. spathulata
	Eremophila margarethae
	Eremophila oldfieldii subsp. angustifolia
	Eremophila oppositifolia subsp. angustifolia
	Eremophila platycalyx subsp. platycalyx
	Eremophila scoparia
	Eremophila serrulata
Scrophulariaceae	*Eremophila youngii subsp. youngii*
	Nicotiana rosulata subsp. rosulata
	Solanum lasiophyllum
Solanaceae	*Solanum nigrum*
Zygophyllaceae	*Tribulus astrocarpus*

Appendix G Flora of Conservation Significance identified from the Desktop Study

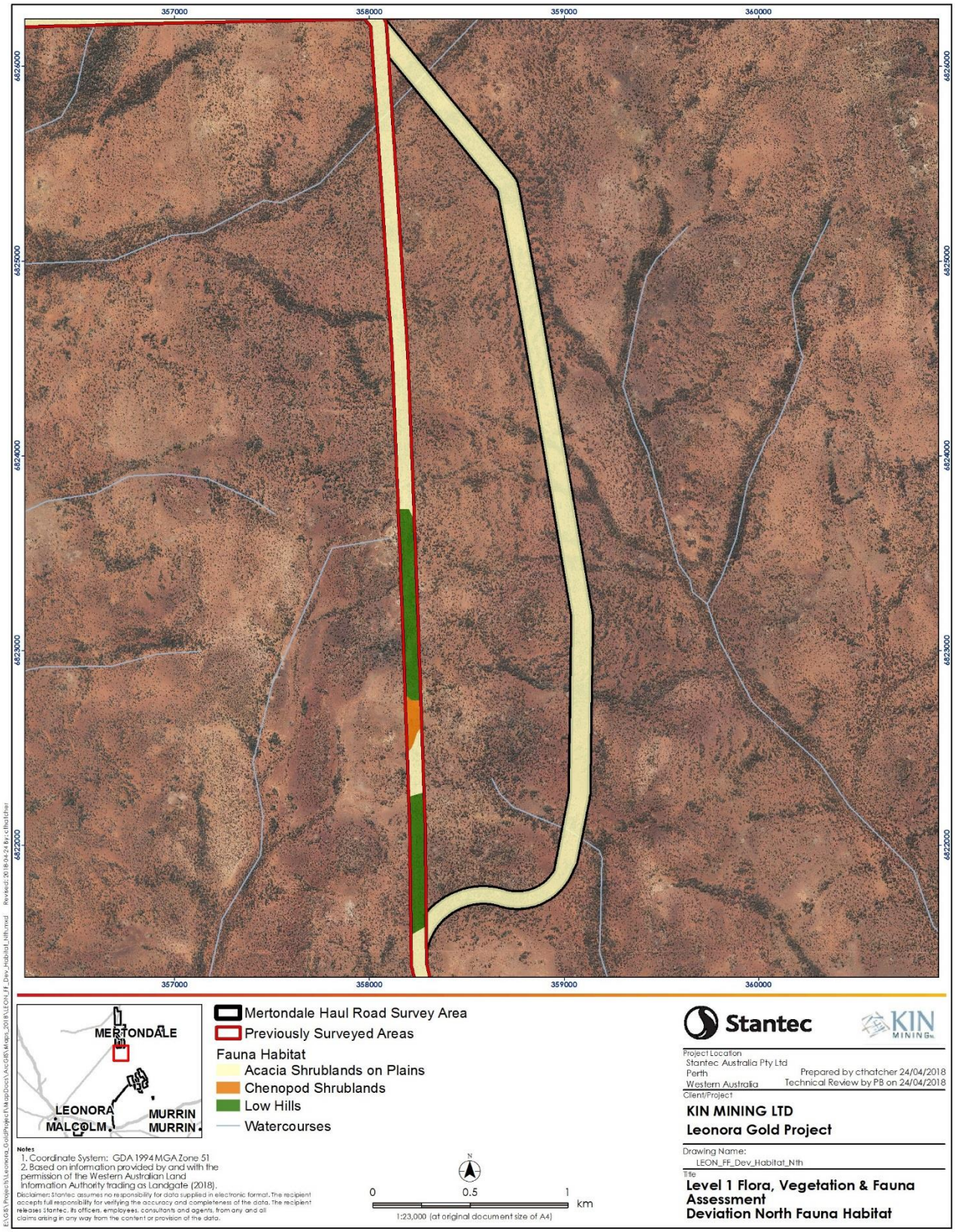
Species	Conservation Code			Habitat[1]	Nearest locality (km)	Likelihood of occurrence: Reason of likelihood
	EPBC Act	WC Act	DPaW (now DBCA)			
Acacia websteri	–	–	P1	Red sand, clay or loam. Low-lying areas, flats.	19	Very Likely: The Study Area contains suitable habitat for this species, and is close to its known distribution
Eremophila arachnoides subsp. *tenera*	–	–	P1	Red sandy loam or calcrete platforms, with Acacia shrubland or Casuarina woodland	150	Unlikely: The Study Area lies outside its known distribution.
Eremophila eversa	–	–	P1	Red sandy loam, mulga shrubland, know only from Yerilla Station.	55	Unlikely: The Study Area lies outside its known distribution, this species is very restricted, and only known to occur on Yerilla Station.
Lechenaultia aphylla	–	–	P1	Red sand. Slopes, drainage areas.	120	Unlikely: The Study Area lies outside its known distribution.
Micromyrtus chrysodema	–	–	P1	Red sands. Sandplains.	85	Unlikely: The Study Area is unlikely to contain suitable habitat and lies outside its known distribution.
Persoonia leucopogon	–	–	P1	Yellow sand, sandy clay.	115	Unlikely: The Study Area is unlikely to contain suitable habitat and lies outside its known distribution.
Philotheca tubiflora	–	–	P1	Rocky rises, hills, outcrops.	70	Possible: The Study Area is just outside the known distribution but contains suitable habitat
Ptilotus tetrandrus	–	–	P1	Loamy sand.	37	Likely: The Study Area lies close to the known location, and may contain suitable habitat
Stenanthemum patens	–	–	P1	Rocky hillside.	30	Likely: The Study Area lies close to the known location, and may contain suitable habitat
Vittadinia cervicularis var. *oldfieldii*	–	–	P1	Alluvium.	100	Unlikely: The Study Area is unlikely to contain suitable habitat and lies outside its known distribution.
Eremophila mirabilis	–	–	P2	Clay sand, stony clayey loam. Granite country.	40	Likely: The Study Area lies close to the known location, and may contain suitable habitat
Thryptomene eremaea	–	–	P2	Red or yellow sand. Sandplains.	50	Unlikely: The Study Area is unlikely to contain suitable habitat

Species	Conservation Code			Habitat[1]	Nearest locality (km)	Likelihood of occurrence: Reason of likelihood
	EPBC Act	WC Act	DPaW (now DBCA)			
Angianthus prostratus	–	–	P3	Red clay or loamy soils, saline depressions.	13	Very Likely: The Study Area contains suitable habitat for this species, and lies within its known distribution
Calytrix praecipua	–	–	P3	Skeletal sandy soils over granite or laterite. Breakaways, outcrops	13	Very Likely: The Study Area contains suitable habitat for this species, and lies within its known distribution
Calytrix verruculosa	–	–	P3	Sandy clay.	370	Unlikely: The Study Area lies outside its known distribution.
Cratystylis centralis	–	–	P3	Red sandy loam with ironstone gravel. Flat plains, breakaway country.	17	Very Likely: The Study Area contains suitable habitat for this species, and lies within its known distribution
Eremophila annosocaulis	–	–	P3	Brown loam, rocky soil. *Acacia* spp. over *Eremophila* spp. shrublands.	45	Likely: The Study Area lies close to the known location, and contains suitable habitat
Eremophila shonae subsp. *diffusa*	–	–	P3	Stony yellow or red sandy soils.	60	Unlikely: The Study Area lies outside its known distribution.
Eremophila simulans subsp. megacalyx	–	–	P3	Sandy loam, sand.	21	Possible: The Study Area is inside the known distribution but may not contain suitable habitat
Goodenia lyrata	–	–	P3	Red sandy loam. Near claypan.	60	Possible: The Study Area is just outside the known distribution but contains suitable habitat
Grevillea obliquistigma subsp. *cullenii*	–	–	P3	Red sand.	105	Unlikely: The Study Area lies outside its known distribution.
Gunniopsis propinqua	–	–	P3	Stony sandy loam. Lateritic outcrops, winter-wet sites.	30	Very Likely: This species was identified in the previously surveyed area of the Project outside of the current Study Area.
Hybanthus floribundus subsp. *chloroxanthus*	–	–	P3	Dark red-brown soil, never sandy, rich in oxide, laterite. Rocky areas, creek banks, along drainage lines.	17	Possible: The Study Area lies inside the known distribution but may not contain suitable habitat

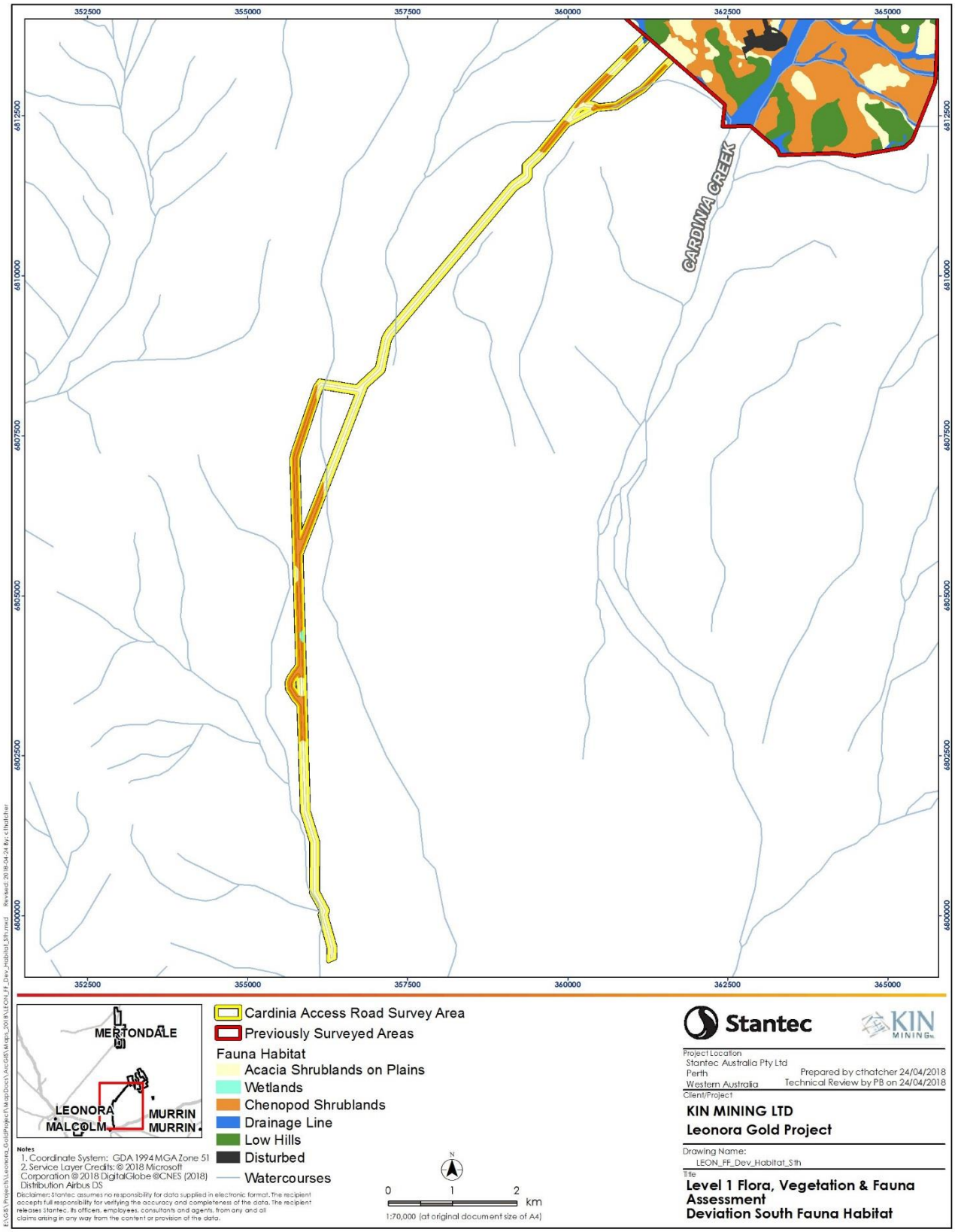
Species	Conservation Code			Habitat[1]	Nearest locality (km)	Likelihood of occurrence: Reason of likelihood
	EPBC Act	WC Act	DPaW (now DBCA)			
Micromyrtus serrulata	–	–	P3	Brownish sandy and clayey soils over granite.	25	Possible: The Study Area lies inside the known distribution but may not contain suitable habitat
Philotheca coateana	–	–	P3	Red sand.	85	Unlikely: The Study Area is unlikely to contain suitable habitat and lies outside its known distribution.
Phyllanthus baeckeoides	–	–	P3	Red lateritic & sandy clay soils. Granite outcrops.	59	Unlikely: The Study Area is unlikely to contain suitable habitat and lies outside its known distribution.
Sauropus sp. Woolgorong (M. Officer s.n. 10/08/94)	–	–	P3	Red sand. Plains.	130	Unlikely: The Study Area lies outside its known distribution.
Thryptomene nealensis	–	–	P3	Lateritic breakaways.	130	Unlikely: The Study Area lies outside its known distribution.
Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362)	–	–	P3	Red loam, crest, upper slope, ridge, breakaway, ironstone, outcropping.	85	Possible: The Study Area is just outside the known distribution but contains suitable habitat
Triglochin protuberans	–	–	P3	Winter-wet sites, claypans, near salt lakes, margins of pools.	15	Likely: The Study Area lies close to the known location, and contains suitable habitat
Eremophila pungens	–	–	P4	Sandy loam, clayey sand over laterite. Plains, ridges, breakaways.	115	Possible: The Study Area is outside the known distribution but contains suitable habitat
Eucalyptus jutsonii subsp. *jutsonii*	–	–	P4	Red to pale orange deep sands. Undulating areas and on dunes.	50	Unlikely: The Study Area is unlikely to contain suitable habitat and lies outside its known distribution.
Grevillea inconspicua	–	–	P4	Loam, gravel. Along drainage lines on rocky outcrops, creeklines.	30	Likely: The Study Area lies close to the known location, and contains suitable habitat
Hemigenia exilis	–	–	P4	Laterite. Breakaways, slopes.	18	Likely: The Study Area lies close to the known location, and contains suitable habitat

Appendix H Fauna Habitats within the Study Area

H.1 Mertondale Haul Road



H.2 Cardinia Access Road



Perth
41 Bishop Street,
JOLIMONT, WA 6014
Tel +61 (08) 9388 8799

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APPENDIX E

Phoenix Environmental Services – Terrestrial Fauna Survey, Leonora Gold Project 2019

PHOENIX
ENVIRONMENTAL SCIENCES

Terrestrial fauna survey for the Leonora Gold Project

Prepared for Kin Mining Ltd

September 2019

Final Report



Terrestrial fauna survey for the Leonora Gold Project

Prepared for Kin Mining Ltd

Final Report

Authors: John Scanlon

Reviewer: Jarrad Clark

Date: 16 September 2019

Submitted to: Anthea Pate

Version history			
Name	**Task**	**Version**	**Date**
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Project code: 1249-LGP-KM-VER

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EXECUTIVE SUMMARY

Kin Mining Ltd is in the process of seeking approval to develop the Leonora Gold Project, comprising a series of adjoining tenements located 25 km east of Leonora and is approximately 13,924 ha (or 139 km^2) in area. Phoenix Environmental Sciences Pty Ltd was commissioned by Kin Mining to undertake a Level 1 terrestrial fauna survey for the LGP.

A Level 1 survey was undertaken 1-4 April 2019. A total of 33 sites were completed (habitat assessment, active searches and timed bird surveys and bat echolocation recordings) in order to characterise the vertebrate fauna assemblage and detect Threatened and Priority species.

The desktop review identified 274 terrestrial vertebrates as potentially occurring, comprising 30 significant terrestrial vertebrate fauna species (23 birds and seven mammals) and two Priority invertebrate taxa.

The field survey identified a total of 65 species (two amphibians, 12 reptiles, 38 birds and 14 mammals), including one extant significant species, Long-tailed Dunnart (P4). Based on the habitats present and historical records in the vicinity of the study area an additional seven significant species are considered to have the potential to occur.

The potential for the study area to support SREs is constrained to significant outcrops, which are few and not proposed to be impacted.

The study area has relatively low relief and rounded hills with few prominent outcrops, which is typical for the East Murchison region. Less typically, it has no desert sandplains or salt lakes, and only small areas of hummock grassland within shrubland or open woodland habitats.

Habitat mapping based on recent vegetation mapping by MWH (2017) and Western Botanical (2019) as well as topography, aerial imagery and field observations during the fauna survey has identified eight broad habitats. These are dominated by Mulga woodland on plains (44%), Shrubland on plains (24%) and *Acacia* shrubland on stony hills (12%). Small but distinctive areas (less than 2% each) of outcropping and breakaway and vegetated gilgai/claypans also occur.

The majority of significant species identified in the desktop study are considered unlikely to occur or may be present only occasionally during wide-ranging foraging (e.g. Peregrine Falcon, Grey Falcon) or dispersal (e.g. Malleefowl), and would not depend on any particular resources or features of the study area.

Significant (but not critical) habitat occurs for three species of conservation significant vertebrates known or likely to be resident:

- potential breeding habitat of Grey Falcon (VU) and Peregrine Falcon (OS) in Mulga woodland on plain (e.g. areas of *Acacia papyrocarpa* woodland with crow nests)
- additional highly suitable breeding habitat for Peregrine Falcon in Cleared areas (specifically, artificial cliffs of old mine pits in Mertondale area)
- overhangs and crevices in outcropping and breakaway habitat inferred to be occupied by Long-tailed Dunnart (P4), and also provide refugia, hunting perches, dens etc. for a range of ecologically significant (but not conservation listed) vertebrates including Wedge-tailed Eagle, Dingo, Euro, Short-beaked Echidna, and formerly for (regionally extinct) Stick-nest Rat (VU).

Calcrete hardpan is present close to the soil surface of hills and plains in much of the study area, associated with burrow complexes of an extinct subspecies of Burrowing Bettong (Boodie). These historic warrens provide important habitat for various species of extant fauna but are not associated with any conservation listed species.

1 INTRODUCTION

Kin Mining Ltd (Kin Mining) is in the process of seeking approval to develop the Leonora Gold Project (LGP), comprising a series of adjoining tenements located 25 km east of Leonora and is approximately 13,924 ha (or 139 km^2) in area (Figure 1-1).

Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Kin Mining to undertake a Level 1 terrestrial fauna survey for the LGP.

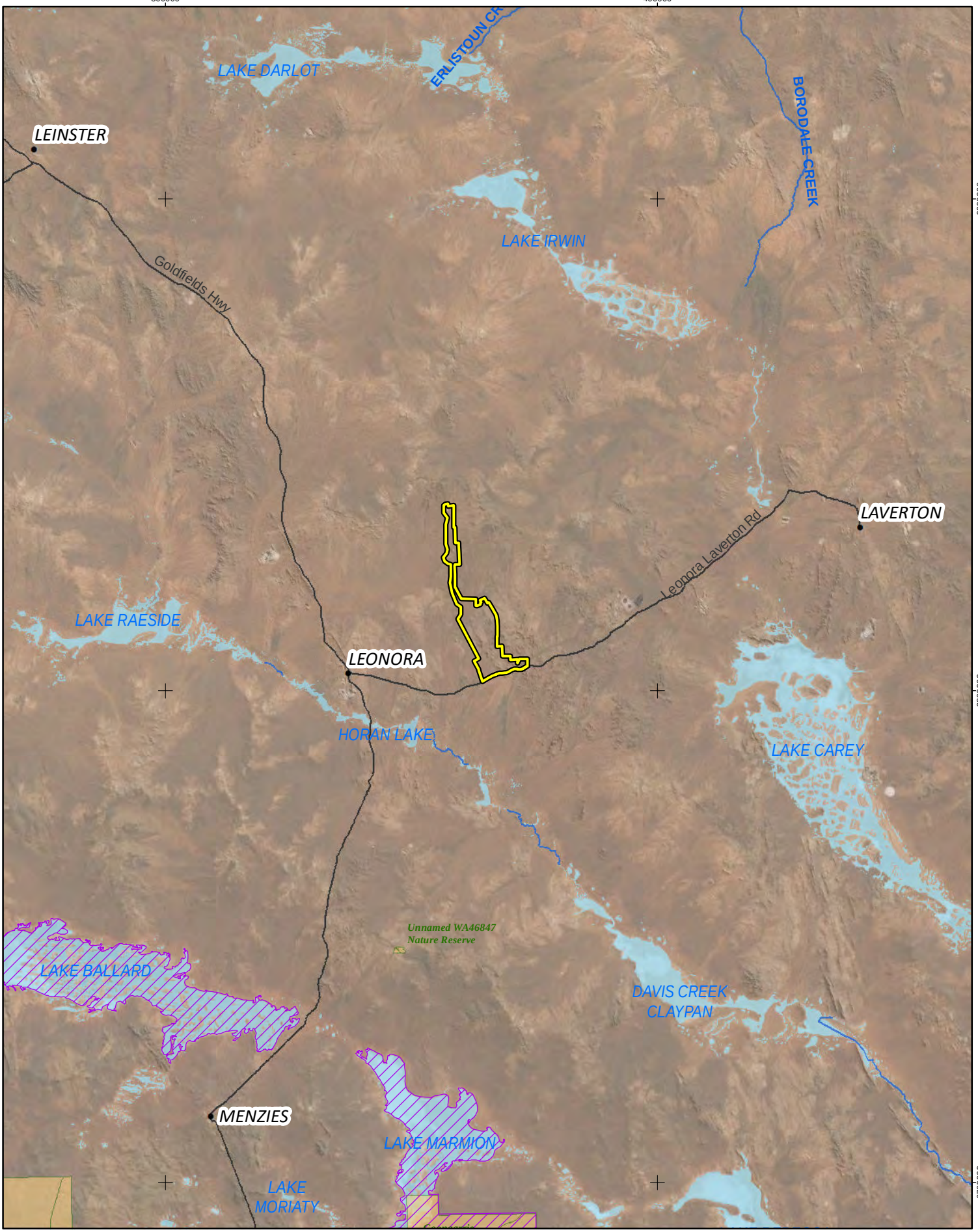
1.1 SCOPE OF WORK

The scope of works was as follows:

- update desktop review conducted as part of previous surveys to include new findings (e.g. new listings of significant taxa, name changes etc.) and changes to taxa in databases
- conduct Level 1 vertebrate fauna survey that includes –
    - general species inventory through
        - timed avifauna surveys
        - active diurnal and nocturnal foraging
        - echolocation recording for bats
    - targeted searches for significant species such as Malleefowl and Night Parrot, if required
    - fauna habitat mapping for –
        - significant species
        - general fauna habitat, based on the vegetation spatial dataset (Western Botanical 2019)
- prepare a terrestrial fauna technical report, including short-range endemic (SRE) desktop assessment, to document the survey findings
- prepare maps showing significant species records and fauna habitats in the study area.

1.2 STUDY AREA

The study area is a single contiguous area covering a total of 13,924 ha (Figure 1-1).





Kin Mining
Terrestrial Fauna Survey for the Leonora Gold Project

Project No	1249
Date	15-Aug-19
Drawn by	AL
Map author	JS

0 10 20 40
Kilometres

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- Study area
- Road
- Environmentally Sensitive Area (ESA)
- Conservation Reserve (CAPAD)

Figure 1–1

Project location and study area

PHOENIX ENVIRONMENTAL SCIENCES

2 LEGISLATIVE CONTEXT

The protection of flora and fauna in Western Australia (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 the Environment and Energy (DoEE). Under the EPBC Act, actions that have, or are likely to have, a significant impact on a Matter of National Environmental Significance (NES), require approval from the Australian Government Minister for the Environment through a formal referral process. The EPBC Act provides for the listing of Threatened native fauna as matters of NES.

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.

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).

2.2 STATE

2.2.1 Threatened and Priority species

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

In WA, the BC Act provides for the listing of Threatened fauna species in the following categories:

- critically endangered (CR) – species facing an extremely high risk of extinction in the wild in the immediate future[2]
- endangered (EN) – species facing a very high risk of extinction in the wild in the near future[2]
- vulnerable (VU)– species facing a high risk of extinction in the wild in the medium-term future[2].

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

- species of special conservation interest – 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
- cetaceans
- species subject to international agreement
- the category of species otherwise in need of special protection.

The Department of Biodiversity Conservation and Attractions (DBCA) administers the BC Act and maintains a non-statutory list of Priority fauna. Priority species are still considered to be of conservation significance – that is they may be rare or 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 Threatened Ecological Community and its listing is otherwise in accordance with the ministerial guidelines.

2.2.3 Other significant fauna

Under the Environmental Protection Authority's (EPA) environmental factor guideline (EPA 2016c), terrestrial fauna may be considered significant for a range of reasons other than listing as a Threatened or Priority species. EPA (2016c) identifies the following attributes that may constitute significant fauna:

- species with restricted distribution
- 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.

2.2.4 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; Ponder & Colgan 2002). Short-

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

range endemism in terrestrial invertebrates is believed to have evolved through two primary processes (Harvey 2002), relictual short-range endemism – where drying climate has forced range contraction into small pockets with remaining moist conditions (e.g. south-facing rock faces or slopes of mountains or gullies) – and habitat specialist SREs that may have 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.

There can be uncertainty in categorising a specimen as 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 (Western Australian Museum 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.

The EPA's environmental factor guideline for Terrestrial Fauna (EPA 2016c) 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. The likelihood of SRE occurrence therefore needs to be considered early in the environmental scoping stage of any proposal (EPA 2016h).

3 EXISTING ENVIRONMENT

3.1 INTERIM BIOGEOGRAPHIC REGIONALISATION OF AUSTRALIA

The Interim Biogeographic Regionalisation of Australia (IBRA) defines 'bioregions' as large land areas characterised by broad, landscape-scale natural features and environmental processes that influence the functions of entire ecosystems (DoE 2012; Thackway & Cresswell 1995b). They categorise the large-scale geophysical patterns that occur across the Australian continent that are linked to fauna and flora assemblages and processes at the ecosystem scale (Thackway & Cresswell 1995a).

The study area is situated within the Eastern Murchison subregion (MUR01) of the Murchison bioregion (Figure 3-1). The Eastern Murchison subregion is characterised by Cowan (2001) as:

- Extensive areas of elevated red desert sandplains with minimal dune development with internal drainage
- Salt lake systems associated with the occluded Palaeodrainage system
- Broad plains of red-brown soils and breakaway complexes as well as red sandplains
- Vegetation dominated by Mulga woodlands often rich in ephemerals; hummock grasslands, saltbush shrublands and Halosarcia shrublands
- Arid climate, with mainly winter rainfall (200 mm).

Rare features within the subregion include calcrete aquifers in the northern part of the subregion known to support a wide range of subterranean fauna and the Lake Barlee salt lake (~153 km west of the study area) which acts a refuge site for Migratory shorebirds following intermittent inundation (Cowan 2001).





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Map author	JS

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Study area

IBRA region, subregion

Murchison, Eastern Murchison

Great Victoria Desert, Shield

Figure 3–1

Study area in relation to IBRA bioregions and subregions

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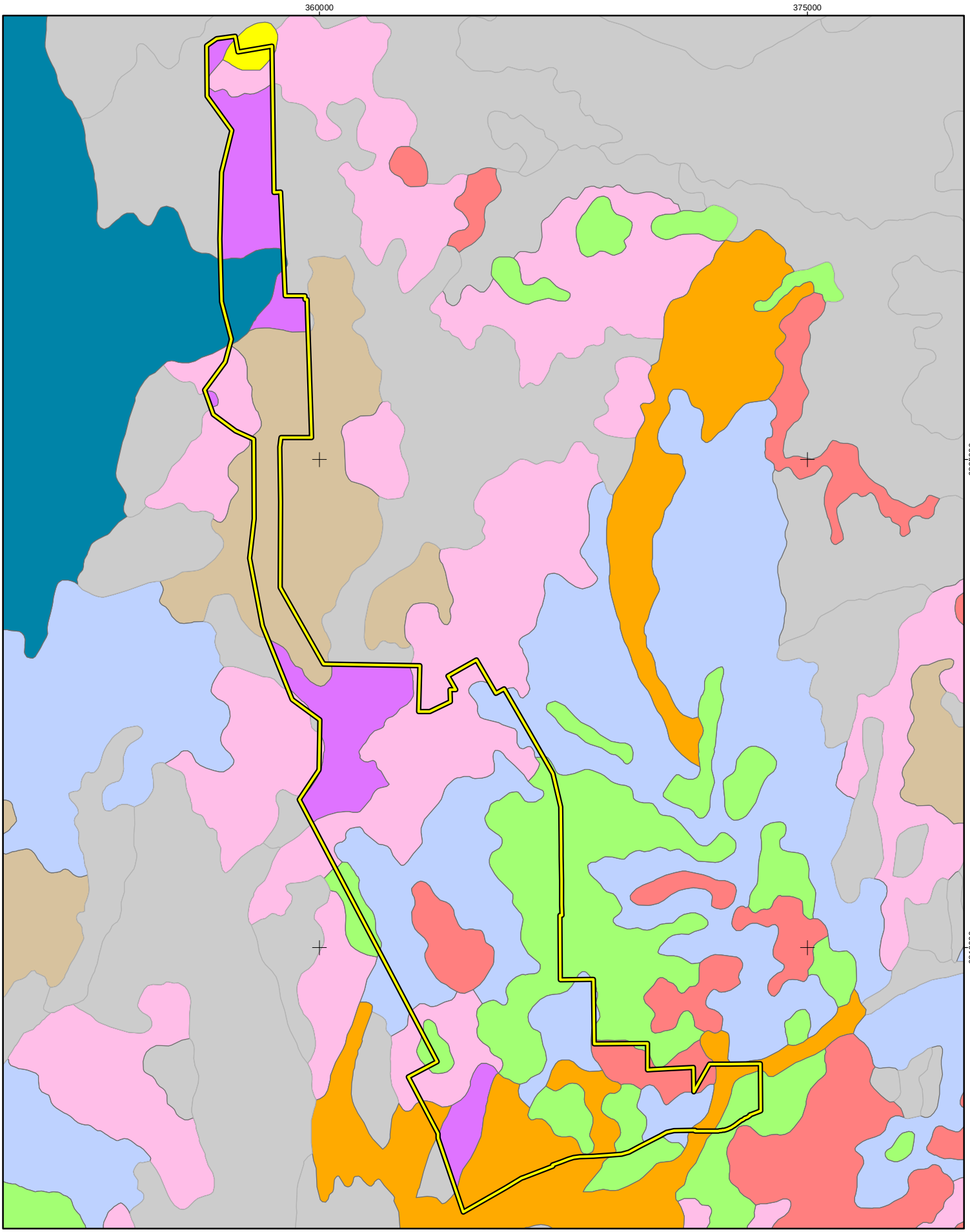
3.2 LAND SYSTEMS

The study area intersects nine land systems mapped by the Department of Agriculture and Food (DAFWA) (Table 3-1; Figure 3-2). No single system predominates, with substantial areas of Gundockerta, Jundee, Leonora, and Nubev land systems occupying similarly large areas (>15%). The remaining five land systems combined occupy 27% of the study area.

Table 3-1 Extent of each land system in the study area

Land system	Description	Area (ha)	% of study area
Gundockerta System	Extensive, gently undulating calcareous stony plains supporting bluebush shrublands.	3,004.52	21.58%
Jundee System	Hardpan plains with variable gravelly mantles and minor sandy banks supporting weakly groved Mulga shrublands.	2,470.82	17.74%
Laverton System	Greenstone hills and ridges with *Acacia* shrublands.	803.86	5.77%
Leonora System	Low greenstone hills and stony plains supporting mixed chenopod shrublands.	2,230.62	16.02%
Monitor System	Distributary alluvial fans and wash plains supporting Mulga - chenopod shrublands.	1,171.5	8.41%
Monk System	Hardpan plains with occasional sandy banks supporting Mulga tall shrublands and wanderrie grasses.	363.34	2.61%
Nubev System	Gently undulating stony plains, minor limonitic low rises and drainage floors supporting Mulga and halophytic shrublands.	2,499.04	17.95%
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.	1,295.5	9.30%
Wyarri System	Granite domes, hills and tor fields with gritty-surfaced fringing plains supporting Mulga and granite wattle shrublands.	85.06	0.61%
Total		**13,924.26**	**100%**

In the Soil_landscapeSystemsDAFWA_019_1 shapefile (DAFWA 2014), part of the study area was identified as Mindura LS, which is not mentioned the relevant documentation (Pringle *et al.* 1994). Mindura LS is only described from the Murchison region, in a different report (Hennig *et al.* 1994). In a new edition of the dataset (SoilLandscapeMapping_RangelandsDPIRD_063, Department of Primary Industries and Regional Development 2019) the same area is correctly identified as Monitor LS.





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Study area

Land System

- Gundockerta System
- Laverton System
- Leonora System
- Monitor System
- Monk System
- Nubev System
- Violet System
- Wyarri System
- Other Land Systems

Figure 3–2

Land systems of the study area

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3.3 CLIMATE AND WEATHER

The climate of the East Murchison subregion is described as arid with winter rainfall (Cowan 2001). The nearest Bureau of Meteorology (BoM) weather station with comprehensive data collection and recent historic climate data is Laverton Aero (no. 012305, Latitude: 28.61°S Longitude: 122.42°E), approximately 80 km east-northeast of the study area. Laverton Aero records the highest mean maximum monthly temperature (35.5°C) in January and the lowest in June (18.4°C). The lowest minimum mean monthly temperature occurs in July (5.9°C) and the highest in January (21.5°C) (BoM 2019) (Figure 3-3). Average annual rainfall is 302.8 mm with February, January and March recording the highest monthly averages historically (61.1, 48.8 and 42.6 mm, respectively). Tropical rain-bearing depressions moving southwards from north-western WA waters can sometimes cause heavy rainfall events during the summer months (BoM 2019) (Figure 3-3).

Daily mean temperatures preceding the surveys from April 2018 to March 2019 fluctuated above and below the long-term annual averages (Figure 3-3). Mean minimum and maximum temperatures recorded were close to annual averages, with the exception of April 2018 and in the lead-up to and during the survey; January-March 2019 recorded maximum temperatures that were 3–5 degrees higher than average for those months.

Rainfall in the 12 months preceding the survey was highly variable when compared to the long-term averages (Figure 3-3). Far above average rainfall was recorded for the months of November and December, but with almost none recorded in January and February, and was well below average in March immediately preceding the survey.

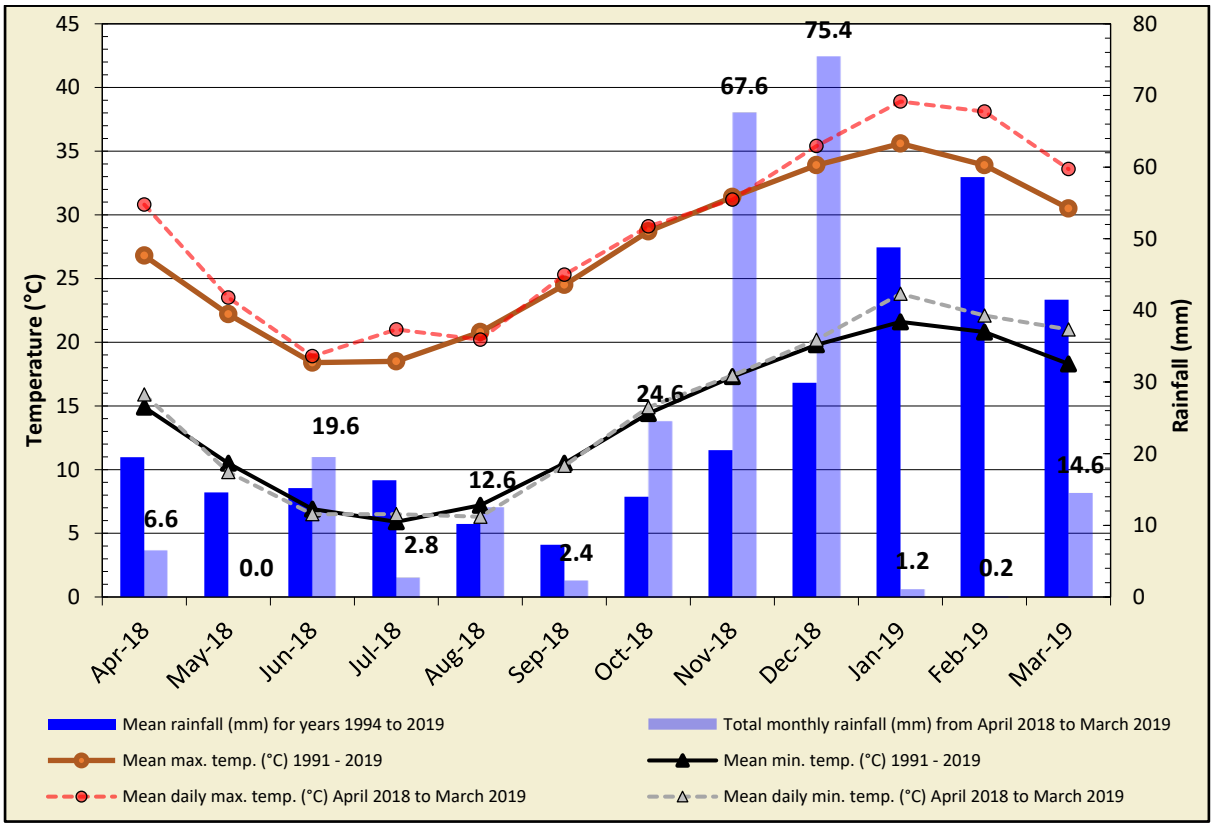


Figure 3-3 **Annual climate and weather data for Laverton Aero (no. 012305) and mean monthly data for the 12 months preceding the field surveys (BoM 2019).**

3.4 LAND USE

The dominant land use within the Eastern Murchison subregion is pastoral land with native pasture grazing, which occurs over approximately 85.47% of the subregion, followed by Crown Reserves (11.34%) (Cowan 2001). Land occupancy for mineral exploration and mining activities, particularly nickel and gold, are considerable within the subregion; however, most occur on pastoral lands where grazing occurs (Cowan 2001).

3.5 CONSERVATION RESERVES AND ENVIRONMENTALLY SENSITIVE AREAS

The study area is not situated within any conservation reserves or Environmentally Sensitive Areas (ESA's) (Figure 1-1). The nearest conservation reserve, an unnamed nature reserve, is located approximately 52 km south-southwest of the study area, followed by Goongarie National Park, approximately 95 km south of the study area (Figure 1-1). The nearest ESA is located approximately 70 km south-southwest of the study area and occurs within a large portion of the Goongarie National Park; however, it is not known what criteria this site meets as an ESA (Figure 1-1).

4 METHODS

The biological survey was conducted in accordance with relevant survey guidelines and guidance, including:

- EPA *Statement of Environmental Principles, Factors and Objectives* (EPA 2016d)
- EPA *Environmental Factor Guideline: Terrestrial fauna* (EPA 2016b)
- EPA *Technical Guidance: Terrestrial fauna surveys* (EPA 2016f)
- EPA *Technical Guidance: Sampling methods for terrestrial vertebrate fauna* (EPA 2016e).

4.1 DESKTOP REVIEW

4.1.1 Database searches and literature review

Database searches and a literature review were undertaken to identify the significant fauna values that may occur within the study area. Desktop review methods entailed:

- a review of existing environmental information relevant to the biological values of the study area including
    - base environmental datasets to define the physical characteristics of the study area
    - searches of relevant biological databases (Table 4-1)
- review of the most recent vegetation mapping for the project (Western Botanical 2019)
- assessment of 'likelihood of occurrence' of Threatened and Priority species.

Table 4-1 Database searches conducted for the desktop review

Database	Target group/s	Search coordinates and extent
Protected Matters Search Tool (DoEE 2019a)	EPBC Act Threatened flora and fauna	Approximate centre point of study area (-28.7538°, 121.5611°) with 40 km buffer
DBCA Threatened and Priority Fauna Database (DBCA 2019b)	Threatened and Priority fauna	As above
DBCA/WAM NatureMap Database (DBCA 2019a)	Fauna	As above.
Atlas of Living Australia area search (ALA 2019)	Fauna	As above.
WA Museum Arachnid and Myriapod Database (WAM 2019)	Arachnid and Myriapod SREs	100km^2 search area encompassing the study area between -28.49°, 121.43° (northwest corner) and -28.99°, 121.81° (southeast corner)
WA Museum Mollusca Database (WAM 2019)	Mollusc SREs	As above

Table 4-2 Survey reports and datasets incorporated in the desktop review

Report author	Survey type	Project
Phoenix Environmental Sciences (2019)	Flora, vegetation and fauna surveys	Murrin Murrin Nickel Cobalt Project
Western Botanical (2019)	Flora, vegetation and fauna surveys	Leonora Gold Project (same area as this study)
Stantec Australia (2018b)	Flora, vegetation and fauna surveys	Leonora Gold Project (Mertondale haul road and pipeline deviation, Cardinia access road)
Stantec Australia (2018a)	Flora, vegetation and fauna surveys and habitat mapping	Leonora Gold Project (Cardinia, Raeside)
MWH Australia (2017)	Flora, vegetation and fauna surveys	Leonora Gold Project (Mertondale, Cardinia and Raeside)
Ecosmart Ecology (2012)	Level 2 fauna survey	Murrin Murrin Nickel Cobalt Project

4.2 FIELD SURVEY

4.2.1 Fauna and fauna habitat

Field work for the terrestrial fauna survey was conducted over four consecutive days from 1–4 April 2019.

Survey methods for terrestrial vertebrate fauna included standardised Level 1 fauna survey sites. A total of 31 Level 1 sites were surveyed within the study area (;). Survey methods for terrestrial vertebrates comprised the following:

- habitat assessment (for details see section 4.2.1.1)
- active searches (see 4.2.1.2)
- avifauna surveys (see 4.2.1.3)
- bat echolocation recordings (see 4.2.1.4).

4.2.1.1 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 conservation significant terrestrial fauna species were identified based on known habitats of such species within the Murchison bioregion.

Survey 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 examples of distinct habitats within the broader habitat associations of the survey area, with a focus on habitat potentially suitable for species of conservation significance identified in the desktop review. Habitat descriptions and characteristics were recorded at all 31 Level 1 survey sites (; Appendix 1).

4.2.1.2 Active searches

Active searches were undertaken at each of the Level 1 survey sites (Figure 4-2; Table 4-3) and primarily targeted diurnal herpetofauna and mammals from direct sightings and secondary evidence. Searches were conducted by the zoologist and field assistant and focused primarily on conservation significant species identified in the desktop review as potentially occurring within the study area including Malleefowl. Opportunistic searches were also conducted at two sites with disturbed/modified habitat (Figure 4-2; Table 4-3).

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, investigating infrastructure ruins or disused building materials such as tin piles, and identifying any secondary evidence including tracks, diggings, scats, fur or sloughs (shed skins), predation or feeding sites, and fauna constructed structures such as pebble mounds or nests. A minimum of one-person hour was spent active searching at each site for a total of 32.5 hours over the duration of the field survey ().

4.2.1.3 Avifauna surveys and recordings

Twenty-minute avifauna surveys were undertaken at each of the Level 1 survey sites (Figure 4-2; Table 4-3). 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; each site was surveyed once, except for the three 'BAT' sites which were each visited twice. Surveys consisted of bird recordings from visual sightings and call recognition. A total of approximately 11.6 person hours (700 min) of avifauna census was undertaken during the field survey (Table 4-3).

Additional avifauna observations were also recorded at opportunistically while other field work was being completed, including observations made during travel and active searches.

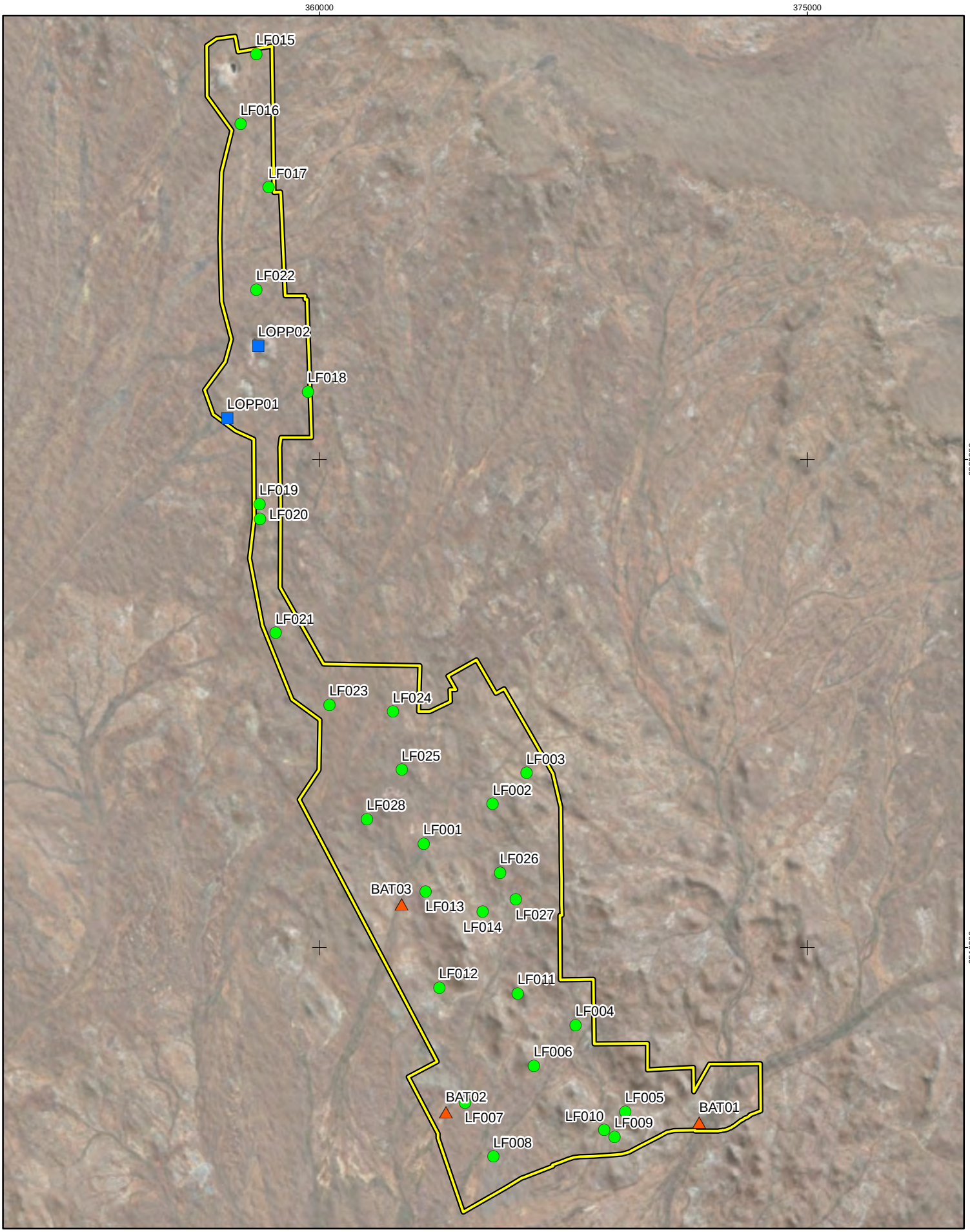
4.2.1.4 Bat echolocation recordings

SongMeter SM2 recording devices were used to record bat echolocation calls at three Level 1 sites during the field survey (BAT01-03; Figure 4-2; Table 4-3). Recording devices were deployed at each site for one night of recording for approximately 12 continuous hours per night (sunset-sunrise). Devices were aimed at a 45° angle to the ground. Recording sites were 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.

Table 4-3 Terrestrial fauna survey site locations and survey effort

Site	Site type	Latitude	Longitude	Vertebrate fauna		
				Active searches (hr)	Avifauna (min)	SongMeter (night)
LF001	Level 1 Fauna site	-28.8017	121.5982	1	20	
LF002	Level 1 Fauna site	-28.7909	121.6202	1	20	
LF003	Level 1 Fauna site	-28.7823	121.6308	1	20	
LF004	Level 1 Fauna site	-28.8524	121.6454	1	20	

Site	Site type	Latitude	Longitude	Vertebrate fauna		
				Active searches (hr)	Avifauna (min)	SongMeter (night)
LF005	Level 1 Fauna site	-28.8766	121.6608	1	20	
LF006	Level 1 Fauna site	-28.8635	121.6321	1	20	
LF007	Level 1 Fauna site	-28.8736	121.6103	1	20	
LF008	Level 1 Fauna site	-28.8886	121.6191	1	20	
LF009	Level 1 Fauna site	-28.8835	121.6573	1	20	
LF010	Level 1 Fauna site	-28.8816	121.6541	1	20	
LF011	Level 1 Fauna site	-28.8434	121.6273	1	20	
LF012	Level 1 Fauna site	-28.8417	121.6026	1	20	
LF013	Level 1 Fauna site	-28.8149	121.5987	1	20	
LF014	Level 1 Fauna site	-28.8208	121.6166	1	20	
LF015	Level 1 Fauna site	-28.582	121.5486	1	20	
LF016	Level 1 Fauna site	-28.6015	121.5433	1	20	
LF017	Level 1 Fauna site	-28.6191	121.5519	1	20	
LF018	Level 1 Fauna site	-28.6759	121.5635	1	20	
LF019	Level 1 Fauna site	-28.7068	121.5478	1	20	
LF020	Level 1 Fauna site	-28.7111	121.5479	1	20	
LF021	Level 1 Fauna site	-28.7427	121.5524	1	20	
LF022	Level 1 Fauna site	-28.6475	121.5476	1	20	
LF023	Level 1 Fauna site	-28.7628	121.5691	1	20	
LF024	Level 1 Fauna site	-28.7649	121.5892	1	20	
LF025	Level 1 Fauna site	-28.7811	121.5917	1	20	
LF026	Level 1 Fauna site	-28.8099	121.6223	1	20	
LF027	Level 1 Fauna site	-28.8174	121.627	1	20	
LF028	Level 1 Fauna site	-28.7947	121.5805	1	20	
BAT01	Level 1 Fauna site + Ultrasonic recording	-28.8798	121.684	1	40	1
BAT02	Level 1 Fauna site + Ultrasonic recording	-28.8762	121.6042	1	40	1
BAT03	Level 1 Fauna site + Ultrasonic recording	-28.8183	121.5911	1	40	1
LOPP01	Opportunistic site	-28.683	121.538	1	20	
LOPP02	Opportunistic site	-28.663	121.5481	0.5		
Total				**32.5**	**700**	**3**





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Study area

Survey site

- Level 1 fauna site
- Level 1 fauna site and Audio recording
- Opportunisitc site

Figure 4–1

Terrestrial fauna survey sites

PHOENIX ENVIRONMENTAL SCIENCES

4.3 COMPARISON OF METHODS AGAINST APPLICABLE GUIDELINES

An assessment of the applied survey methods against numerous State and/or Federal government guidelines determined that the methods applied adhered to all applicable guidelines (Table 4-4).

Table 4-4 Assessment of survey methods against applicable guidelines

Guideline	Jurisdiction	Adherence	Comment
Technical Guidance: Sampling methods for terrestrial vertebrate fauna (EPA 2016g)	State of Western Australia	Yes – Level 1 survey	Level 2 methods inappropriate for all significant species potentially occurring.
Environmental Factor Guideline: Terrestrial fauna. (EPA 2016c)	State of Western Australia	Yes – Level 1 survey	Level 2 methods inappropriate for all significant species potentially occurring.
Technical Guidance: Sampling of short range endemic invertebrate fauna (EPA 2016h)	State of Western Australia	Yes – reconnaissance survey	No sampling required as survey indicated no habitat for SREs present.
Interim guideline for preliminary surveys of Night Parrot (Pezoporus occidentalis) in Western Australia (DPaW 2017)	State of Western Australia	Yes – reconnaissance survey	No sampling required as habitat assessment indicated no habitat present.
National manual for the Malleefowl monitoring system. Standards, protocols and monitoring procedures (Natural Heritage Trust 2007)	Australia – not legislated	Yes – reconnaissance survey	No targeted surveys required as Level 1 assessment and habitat assessment indicated species unlikely to occur.

4.4 ANALYSIS

4.4.1 Habitat classification

Mapped vegetation unit polygons (MWH Australia 2017; Western Botanical 2019) were assigned to fauna habitat types and aggregated taking into account:

- vegetation description and structure
- field observations made during the fauna survey, particularly substrate
- topography (outcrop/breakaway, stony hills, plains, drainage lines, and claypans/gilgai)
- inspection of aerial images

4.4.2 Likelihood of occurrence assessment

The potential occurrence in the study area of any significant fauna identified in the database searches was assessed prior and following the field survey. The assessment was based on the following information

- habitat preference (soils, landforms, elevation and vegetation associations) and habitats presence and condition in the study area
- known biology
- distance (km) of database records from the study area.

The assessment assigned each taxon to one of four ratings:

1. recorded – species recorded within the study area by current or previous surveys
2. likely – study area within known range of species; suitable or optimal habitat occurring within the study area and/or with current and/or previous records in the vicinity of the study area
3. possible – within known range of species; suitable habitat present within study area, though not optimal; no records in the vicinity of the study area
4. unlikely – outside of the species current known range; no records in the vicinity of the study area and/or no suitable habitat present within the study area. Also includes species considered locally or regionally Extinct in relation to eh study area due to historic declines.

4.5 SURVEY PERSONNEL

The personnel involved in the survey are presented (Table 4-5).

Table 4-5 Project team

Name	Qualifications	Role/s
Mr Jarrad Clark	BSc. (Env. Mgmt)	Project management and report review
Dr John Scanlon	PhD (Zoology)	Field survey, data analysis, report writing
Ms Gemma Grigg (Senior Field Technician, Kin Mining)	BSc.	Field survey assistant, opportunistic sighting records
Ms Anna Leung	BSc. (Environmental Science) Honours	Spatial data analysis and mapping

5 RESULTS

5.1 DESKTOP REVIEW

5.1.1 Terrestrial vertebrate fauna

Records for 274 terrestrial vertebrate fauna species were identified as potentially occurring within the study area in the desktop review. These comprised seven frogs, 55 reptiles, 174 birds (including two naturalised species) and 38 mammals (including 12 introduced) (Appendix 2).

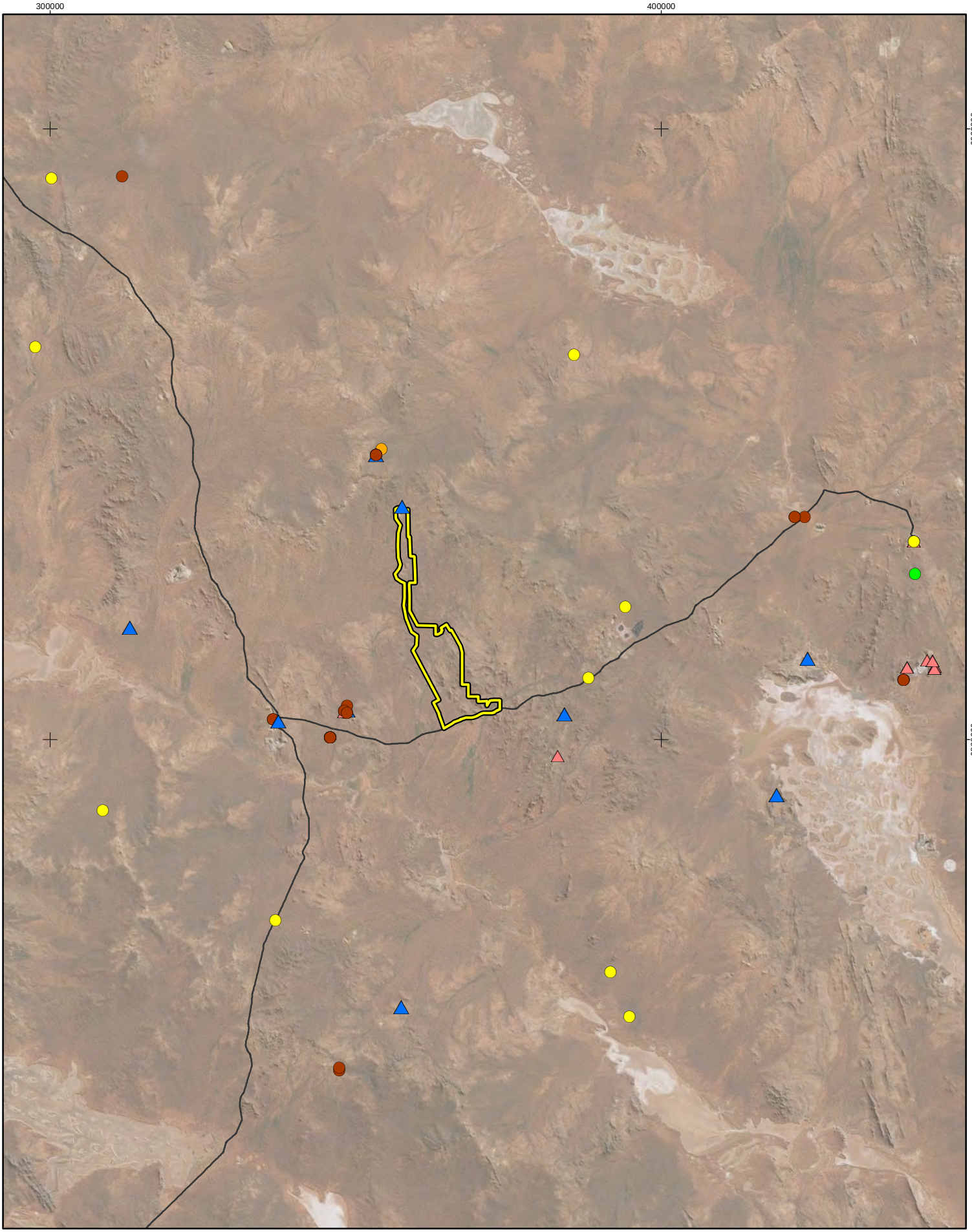
A total of 30 species of conservation significant vertebrate taxa were identified in the desktop review (23 birds, seven mammals) as potentially occurring, including 13 species listed under the EPBC Act and/or BC Act as Threatened or Specially Protected (Table 5-1). Seventeen species are listed as Migratory under the EPBC Act and BC Act (two also listed as Threatened). A further three are listed as Priority species by the DBCA (Table 5-1). The table also includes one taxon listed as Extinct at subspecies level, but Vulnerable in remaining parts of the species range.

Table 5-1 Conservation significant vertebrate fauna species identified in the desktop review

Species	Common name	Conservation status[1]		
		EPBC Act	BC Act	DBCA list
Birds (23)				
Leipoa ocellata	Malleefowl	VU	VU	
Apus pacificus	Fork-tailed Swift	Mig	Mig	
Plegadis falcinellus	Glossy Ibis	Mig	Mig	
Falco hypoleucos	Grey Falcon		VU	
Falco peregrinus	Peregrine Falcon		OS	
Charadrius veredus	Oriental Plover	Mig	Mig	
Thinornis rubricollis	Hooded Plover			P4
Pluvialis fulva	Pacific Golden Plover	Mig	Mig	
Limosa lapponica	Bar-tailed Godwit	VU/Mig	VU/Mig	
Actitis hypoleucos	Common Sandpiper	Mig	Mig	
Tringa nebularia	Common Greenshank	Mig	Mig	
Tringa glareola	Wood Sandpiper	Mig	Mig	
Tringa stagnatilis	Marsh Sandpiper	Mig	Mig	
Calidris canutus	Red Knot	EN/Mig	Mig	
Calidris melanotos	Pectoral Sandpiper	Mig	Mig	
Calidris ruficollis	Red-necked Stint	Mig	Mig	
Calidris subminuta	Long-toed Stint	Mig	Mig	
Calidris acuminata	Sharp-tailed Sandpiper	Mig	Mig	
Gelochelidon nilotica	Gull-billed Tern	Mig	Mig	
Polytelis alexandrae	Princess Parrot	VU		P4
Pezoporus occidentalis	Night Parrot	EN	CR	
Motacilla cinerea	Grey Wagtail	Mig	Mig	
Motacilla flava	Yellow Wagtail	Mig	Mig	
Mammals (7)				
Dasyurus geoffroii	Chuditch	VU	VU	
Sminthopsis longicaudata	Long-tailed Dunnart			P4

Species	Common name	Conservation status[1]		
		EPBC Act	BC Act	DBCA list
Myrmecobius fasciatus	Numbat	VU	VU	
Macrotis lagotis	Greater Bilby	VU	VU	
Bettongia lesueur	Boodie	VU/EX	VU/EX	
Lagostrophus fasciatus	Banded Hare-wallaby	VU	VU	
Leporillus conditor	Greater Stick-nest Rat	VU	VU	

[1] CR – Critically Endangered; EN – Endangered; VU – Vulnerable; OS – Specially Protected; Mig – Migratory; P4 – Priority 4.





Kin Mining
Terrestrial Fauna Survey for the Leonora Gold Project

Project No	1249
Date	15-Aug-19
Drawn by	AL
Map author	JS

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Study area

Conservation Code

- Endangered
- Endangered and Mig.
- Migratory
- Vulnerbale
- Other Specially Protected
- P4

Figure 5–1

Desktop records of conservation significant vertebrate fauna

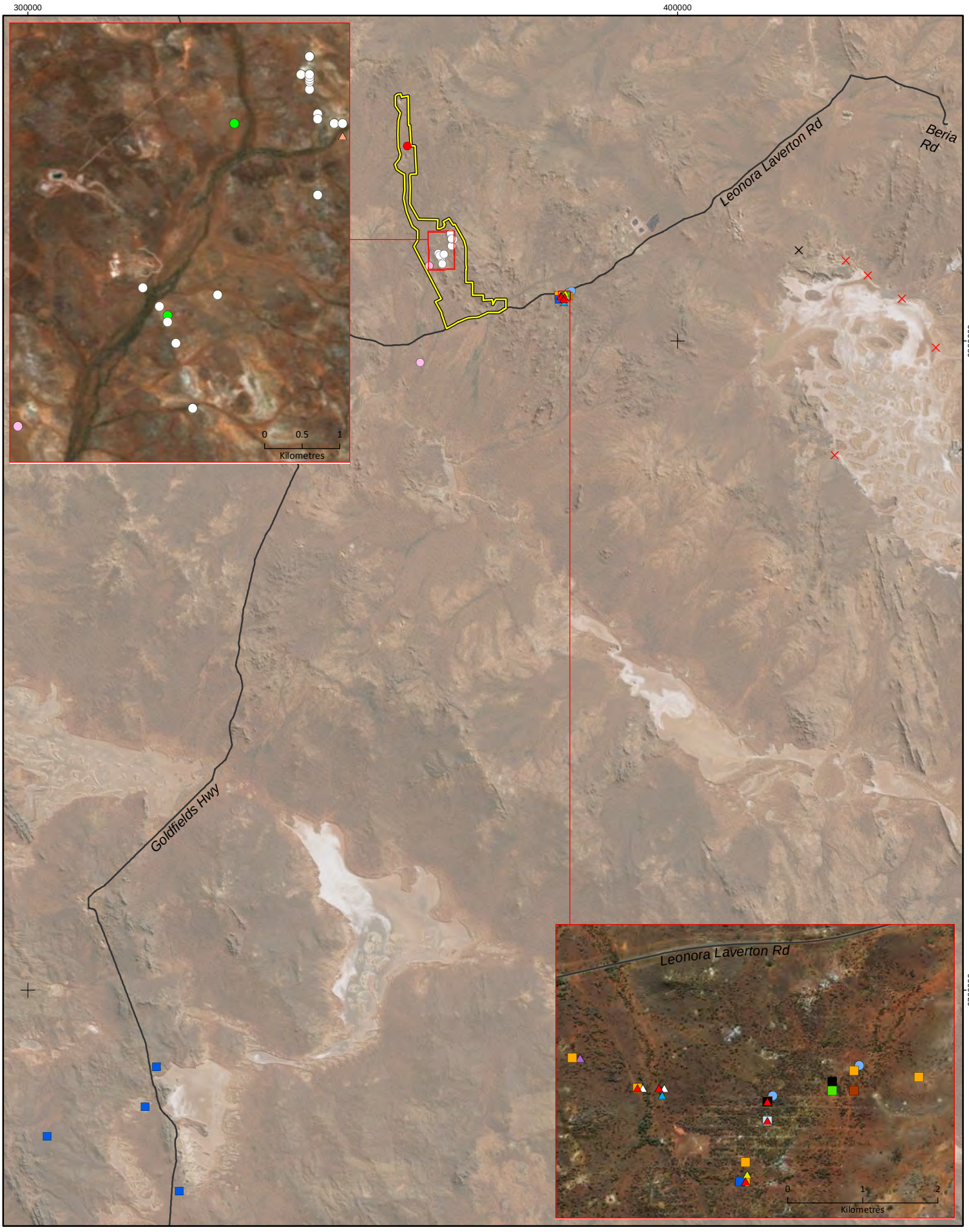
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5.1.2 SRE invertebrate fauna

The WA Museum database searches (WAM 2019) returned 42 records of terrestrial invertebrate taxa, none were potential or confirmed SREs. (Table 5-2; Figure 5-2). No molluscs were returned. The DBCA Threatened fauna database (DBCA 2019b) returned six records, representing two taxa of fairy shrimp. Both are P1 species and are currently, confirmed SREs. They are associated with Lake Carey, which is located approximately 50km to the east of the study area.

Table 5-2 Terrestrial invertebrate taxa identified in the desktop review

Taxa	Source
Anostraca (2)	
Thamnocephalidae (2)	
Branchinella apophysata	DBCA (2019b)
Branchinella simplex	DBCA (2019b)
Araneae (13)	
Araneomorphae (new world spiders) (12)	
Gnaphosidae (2)	
`*Eilica*?` `sp.`	WAM (2019)
Encoptarthria `Leonora sp. 1`	WAM (2019)
Miturgidae (2)	
Miturga `Leonora sp. 1`	WAM (2019)
Miturga `Leonora sp. 1`?	WAM (2019)
Sparassidae (1)	
Neosparassus `Leonora sp. 1`	WAM (2019)
Trochanteriidae (1)	
Longrita millewa	WAM (2019)
Zodariidae (6)	
`Leonora gen. 1` `Leonora sp. 1`	WAM (2019)
Habronestes `Leonora sp. 1`	WAM (2019)
Habronestes `Leonora sp. 2`	WAM (2019)
Neostorena `Leonora sp. 1`	WAM (2019)
Neostorena `Leonora sp. 2`	WAM (2019)
Storena `sp.`	WAM (2019)
Mygalomorphae (trap-door spiders) (1)	
Idiopidae (2)	
Eucyrtops eremaea	WAM (2019)
Scolopendrida (1)	
Scolopendridae (1)	
Cormocephalus `sp. (fragment)`	WAM (2019)





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Study area

Species

- *Branchinella apophysata* (Confirmed)
- *Branchinella simplex* (Confirmed)
- *Harpacticoida* 'Leonora'
- *Cormocephalus* `sp. (fragment)`
- *Encoptarthria* `Leonora sp. 1`
- *Eucyrtops eremaea*
- *Habronestes* `Leonora sp. 1`
- *Habronestes* `Leonora sp. 2`
- *Longrita millewa*
- *Miturga* `Leonora sp. 1`
- *Miturga* `Leonora sp. 1`?
- *Neosparassus* `Leonora sp. 1`
- *Neostorena* `Leonora sp. 1`
- *Neostorena* `Leonora sp. 2`
- *Storena* `sp.`
- *`Eilica*?` `sp.`
- *`Leonora* gen. 1``Leonora sp. 1`

Figure 5–2

Desktop records of invertebrate fauna (DBCA 2019b; WAM 2019)

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5.2 FIELD SURVEY

5.2.1 Fauna habitats

The study area forms part of an undulating plain sloping down from northeast to southwest, with low stony hills (mainly Leonora, Laverton and Wyarri land systems) and plains dissected by shallow, seasonal or ephemeral drainage lines. In terms of topography, hydrology and vegetation it has relatively low diversity (e.g. lacking major rock outcrops or natural clifflines, lakes, saltlakes, perennial streams, sandplains, *Triodia* hummock grasslands, or eucalypt-dominated woodland or mallee).

Seven broad fauna habitats were mapped within the study area (Table 5-3; Figure 5-3):

1. Mulga woodland on plain (6,073.62 ha)
2. Shrubland on plain (3,356.2 ha)
3. *Acacia* shrubland on stony hills (1,714.79 ha)
4. *Acacia* woodland in drainage lines and groves (1,570.13 ha)
5. Mulga woodland on stony hills (944.08 ha)
6. Cleared (212.99 ha)
7. Outcropping and breakaway (40.22 ha)
8. Vegetated gilgai/claypan (12.23 ha)

Mulga woodland on plain was the dominant habitat, occupying approximately 44% of the study area, followed by Shrubland on plain (24%), with the remaining fauna habitats occupying less than 35% of the study area combined (Table 5-3; Figure 5-3).

Individuals of most fauna species would use a combination of different habitat types within their home range for foraging, resting, breeding etc. Outcropping and breakaway habitats appear to have important ecological functions relative to their small area, providing both refuges (e.g. crevices used by Short-beaked Echidna, small dasyurids tentatively identified as Long-tailed Dunnart, and formerly by Stick-nest Rat; none of these species recorded in other habitat types) and dens or hunting perches of larger predators (Dingo, Wedge-tailed Eagle).

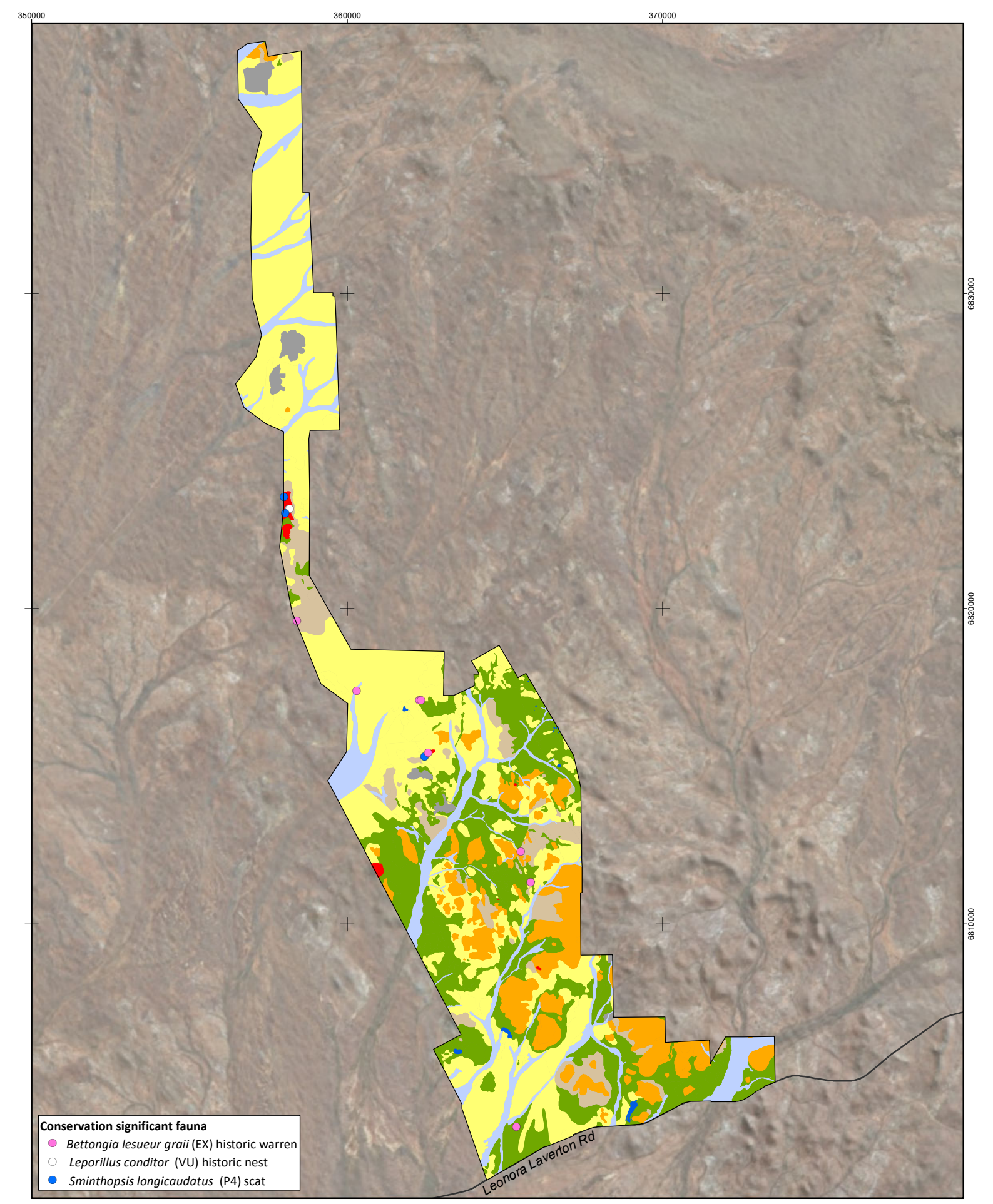
Calcrete hardpan is present at or just below the soil surface in much of the study area, including hills and plains, and associated with different vegetation types; Consequently, it is not used in the habitat classification. Where exposed either by abiotic weathering or by burrowing activity (e.g. old warrens of the regionally extinct Boodie) it provides similar habitat values (refugia) to outcrop and breakaway. However, most evidence of current use (fresh diggings, tracks and scats) represented monitor lizards and rabbits, which were broadly present in all habitat types.

Artificial outcrop and cliffs formed by mining activity within areas mapped as 'Cleared' are potentially important habitat to some species, e.g. Peregrine Falcon (see below). Artificial lakes are present in several old mine pits but are not treated as a distinct habitat; waterbirds were not observed in or around water during a brief visit to the two Mertondale pits, but are considered likely to offer very limited habitat value at present due to a lack of productive shallow-water habitat, level shorelines and lack of fringing vegetation (cf. Mine Lakes Consulting 2018). The value of these old pits to aquatic fauna was not investigated but is expected to be similarly low for the same reasons given above with respect to waterbirds. Indeed, if a diverse and abundant aquatic fauna assemblage were present, waterbirds would also be expected to be present .

Table 5-3 Fauna habitats of the study area

Habitat	Corresponding vegetation types and mapping units	Corresponding fauna sites	Area (ha)	% of study area
Mulga woodland on plain: Open to sparse woodland or shrubland of Mulga (*Acacia aneura* group) or Bastard Mulga (*A. papyrocarpa*) over varying mid- and understorey of lower shrubs and/or grasses.	Stantec: AaArEspp., AaAtEp, AaAtEspp., AcAtEo, AiElEc, AiMsTd, AkHpEs, Asp.MsEs, WB: Aa over Esp194, AaArAqEp, AaArEpLPoU, AaEmP, AaEpLEm, AaEpLSsppPoUMt, AaMsPoUMt, AaMsSsNPoG, AaPoUMt, ApEsMspp, ApMt, ApPoUMt, ApTdS, HPDS, HPMS, MUWA, SAES, mosaics M2, M3	LF003, LF010, LF016, LF017, LF018, LF022, LF024, LF027, LOPP01	6,071.59	43.62
Shrubland on plain: Open to sparse shrubland dominated by shrub Mulga, other *Acacia* species, *Hakea,* chenopods or hummock grasses on a range of substrates.	Stantec: HpCsMp, MpTdSd WB: AaEpLSsppPoUMt, AmCs, AvS, Cpn-B, EsFsppSspp, Fspp, HpEsMt, HpMpCs, HpMpEs, HpMpMsp59, HpPoGMt, HpTdMpS, MpMg, MpMsFspp, Msp59, Td, MtFsp, TdFsppMsp#59, mosaic M4	LF007, LF008, LF012, LF014	3,355.09	24.10
Acacia shrubland on stony hills: Rolling hills with gravel or cobble substrate, with shrubland vegetation dominated by *Acacia* other than Mulga.	Stantec: A?rSaMs, AkAbMs WB: AaEpLEm, AaEpLSsppPoUMt, AaMsSsNPoG, AaPoUMt, AbPoG, AdAspMPPoG, Amp, AmpAsAa, AvS, EsFsppSspp	LF005, LF006	1,714.20	12.31
Acacia woodland in drainage lines and groves: Drainage lines with associated riparian vegetation, usually Mulga or other *Acacia* over variable understory cover, often dominated by dense grass cover nearer to drainage line.	Stantec: AbAtTt WB: DRAbS, DRMS, GRMU	BAT01, BAT02, BAT03, LF001, LF004, LF013, LF023	1,569.58	11.28

Habitat	Corresponding vegetation types and mapping units	Corresponding fauna sites	Area (ha)	% of study area
Mulga woodland on stony hills: Mulga (*Acacia aneura* group) woodland on hill slopes and tops; also includes patches of *Casuarina pauper* woodland on calcrete outcrop.	Stantec: AaArAq, AaSaMs, AcHpEp, CpArEo WB: AaArEpLPoU, AaEpLEm, AaMsPoUMt, AaMsSsNPoG, AaPoUMt, AbSafAmpMt, HPMS, SIMS AaEcEf, SIMS AaElSe, CpW , WABS, mosaic M1	LF015, LF021, LF026, LF028	943.71	6.78
Cleared: Existing cleared and/or disturbed areas (i.e. existing tracks, roads and clearing for previous exploration or mining operations)	Disturbed	LOPP02	212.94	1.53
Outcropping and breakaway: Outcrop of calcrete, basalt or other rock types with boulder piles, small caves or crevices on hilltops, slopes and breakaways; woodland or shrubland vegetation.	Stantec: AiMsTd, AkAbMs WB: AaArEpLPoU, EsFsppSspp, Amp, AmpAsAa	LF002, LF011, LF019, LF020, LF025	40.22	0.29
Vegetated gilgai/claypan: Drainage foci with clay soils and perennial grasses, and with or without shrub vegetation.	WB: CPN-G, Gilgai	LF009	12.22	0.09
Total:			**13,919.54**	**100**





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Study area

Fauna habitat

- Acacia shrubland on stony hills
- Acacia woodland in drainage lines and groves
- Cleared
- Mulga woodland on plain
- Mulga woodland on stony hills
- Outcropping and breakaway
- Shrubland on plain
- Vegetated gilgai/claypan

Figure 5–3

Fauna habitats and conservation significant records in the study area

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5.2.2 Vertebrate fauna

A total of 65 terrestrial vertebrate fauna species were recorded during the field survey (Table 5-4; Appendix 2). This represents just under 24% of the species identified as potentially occurring based on the desktop review. Birds were the most diverse class of vertebrates recorded, consistent with the results of the desktop review. Of the 14 mammal species recorded during the field survey, seven were introduced species.

Table 5-4 Number of vertebrate taxa recorded and potentially occurring in the Project area

Taxa	No. of species recorded during field survey	No. of species potentially occurring from desktop
Amphibians	2	7
Reptiles	12	55
Birds – native	38	172
Birds - introduced	0	2
Mammals - native	7	26
Mammals - introduced	7	12
Total	**65**	**274**

No conservation significant species were positively identified as currently occurring during the field survey, but three were recorded based on secondary evidence (Figure 5-3):

1. Long-tailed Dunnart (P4)
2. Burrowing Bettong (EX)
3. Greater Stick-nest Rat (VU)

Long-tailed Dunnart is recorded provisionally based on small dasyurid scats associated with crevices on rocky hills and breakaways at three sites. Morphologically these could not be directly identified to the species and are also consistent with the other *Sminthopsis, Ningaui* or *Antechinomys* species that occur in the general area. However, the habitat is most-suitable for *S. longicaudata* denning and refuge sites, whereas the other small dasyurid species are not associated with rocky hills but inhabit grassland, heath, shrub and woodland. Long-tailed Dunnart may also occur more broadly across habitats surrounding denning sites to forage or disperse when conditions and cover are suitable.

Burrowing Bettong (Boodie) and Greater Stick-nest Rat were both recorded from historic secondary evidence within the study area. Evidence of past occurrence of Burrowing Bettong was recorded from six sites in the form of burrow complexes (warrens) extending under a layer of hardpan calcrete on plains or lower slopes of hills, and the Greater Stick-nest Rat from two old nests located in a breakaway (Figure 5-3).

The deposition of calcrete spoil on the surface (some due to continued use by varanids and/or rabbits) makes Boodie warrens quite conspicuous, and each of the sites identified as such in the field is also visible as a distinct light-coloured patch in aerial images. Many additional light patches can be seen that suggest these are abundant and widespread in the region (occurring in Nubev, Violet, Gundockerta, Leonora and Monitor land systems, but apparently absent in Jundee and Laverton), though some similar traces are certainly results of historic mining exploration. Despite this evidence of former occupation, both species are considered Extinct in the region (the inland Boodie subspecies,

Bettongia lesueur graii, is listed as completely Extinct) and are unlikely to be occurring within the study area currently (Burbidge 2004; Van Dyck & Strahan 2008).

Suitable habitat for (at least) foraging and dispersal was identified for a further seven conservation significant species identified in the desktop review (Table 5-5).

Fork-tailed Swift are likely to forage in the airspace above the study area; however, it is unlikely to land or nest as the species is a non-breeding visitor and almost exclusively aerial (DoEE 2019b).

Grey Falcon is likely to occur at least occasionally within the study area, as the species is broadly distributed in the area and individuals have large foraging ranges. Breeding could also occur, using stick nests of corvids or other raptors in tall trees (e.g. stands of *Acacia papyrocarpa* with crow nests at site LF010, previously reported as used for nesting by Australian Hobby; Western Botanical 2019) or power and telecommunications towers (if and when they are built). This species is not reported to nest on cliffs (Debus 2012).

Peregrine Falcon is known to occur adjacent to the study area, and this versatile aerial predator may use all habitat types present for foraging. Due to low relief of outcrop in the area, cliff-ledge nesting sites as typically used by this species do not naturally occur; however, stick nests of crows or other raptors may also be used (as in the case of Australian Hobby or Grey Falcon), and the steep rock walls of old mine pits and quarries provide highly suitable nesting sites (and hunting perches) within the study area.

Oriental Plover has been recorded close to the study area (ALA 2019) and ranges widely through coastal and inland northern parts of Australia during the non-breeding season (September to March), using a range of habitats including flat, open semi-arid grasslands and claypans (DoEE 2019b). It may therefore be expected to visit the study area occasionally.

Sharp-tailed Sandpiper mainly feeds in wetlands like other shorebirds, but is also recorded as foraging in open grassy areas after rain (DoEE 2019b), so may use parts of the study area occasionally.

While there are records of Malleefowl in the vicinity (Figure 5-3), habitat in the study area is generally of low suitability for this species. Nesting habitat requires sandy substrates and abundant leaf litter, whereas vegetation cover throughout much of the study area is open and sparse, with denser vegetation and canopy cover restricted to drainage lines and some hill slopes, where litter tends to be removed or disturbed during rainfall events, or overgrown with grass. Some litter suitable for foraging does occur in Mulga woodland habitats (including *A. papyrocarpa* and *Casuarina*), but of relatively low value due to its patchy occurrence and the mostly open canopy (cf. Benshemesh 2007). The species may occasionally occur when dispersing between areas of suitable habitat outside of the study area; however, it is unlikely to be a frequent visitor.

Typical habitats of Princess Parrot (sand dunes, open savannah eucalypt woodland, *Triodia* grassland) are not present within the study area, but it may also use a wider range of woodland and riparian habitat, and is an irregular and infrequent visitor to most sites within its range (DoEE 2019b). It is considered possible that the Princess Parrot will occur in the study area occasionally when conditions are favourable, particularly following rainfall in its core range, in the arid areas east and north of the study area.

The remaining conservation significant species identified in the desktop review (16 birds, four mammals) are considered unlikely to occur either due to lack of suitable habitat (i.e. suitable salt lakes or other wetlands for Migratory shorebirds), or lack of extant regional populations due to historic declines of Critical Weight Range mammals (Burbidge & McKenzie 1989) (Table 5-5).

Table 5-5 Likelihood of occurrence for conservation significant fauna in the Project area

Species	Common name	Conservation status[1]			Likelihood of occurrence	Fauna habitat								Summary of records and occurrence	Nearest record
		EPBC Act	BC Act	DBCA List		Outcropping & breakaway	Shrubland on stony hills	Mulga on stony hills	Mulga on plain	Shrubland on plain	Drainage lines & groves	Vegetated claypan	Cleared		
Invertebrate (2)															
Branchinella apophysata	a fairy shrimp (Laverton)			P1	Unlikely									One record, associated with Lake Carey.	~50 km E
Branchinella simplex	a fairy shrimp (inland WA)			P1	Unlikely									Five records, associated with lake Carey.	~50 km E
Birds (23)															
Leipoa ocellata	Malleefowl	VU	VU		Possible			●	●	●	●			Previously recorded at Murrin Murrin (Ecosmart Ecology 2012); however, unlikely to be resident due to the lack of suitable nesting habitat within the study area. Small areas of Mulga habitat potentially suitable for foraging, but likely to occur only infrequently during dispersal.	17 km E
Apus pacificus	Fork-tailed Swift	MI	MI		Possible	●	●	●	●	●	●	●	●	Species forages aerially in a variety of habitats, including those within the study area, but unlikely to land or nest.	~180 km SSW
Plegadis falcinellus	Glossy Ibis	MI	MI		Unlikely									Suitable wetland habitat not present within study area.	~60 km E

Species	Common name	Conservation status[1]			Likelihood of occurrence	Fauna habitat								Summary of records and occurrence	Nearest record
		EPBC Act	BC Act	DBCA List		Outcropping & breakaway	Shrubland on stony hills	Mulga on stony hills	Mulga on plain	Shrubland on plain	Drainage lines & groves	Vegetated claypan	Cleared		
Falco hypoleucos	Grey Falcon		VU		Likely		●	●	●	●	●	●		Likely to occur within the study area occasionally to forage. Breeding might also occur, as potential nesting habitat (crow nests in tall *Acacia papyrocarpa*) has recently been recorded as used by a breeding pair of Hobby (*F. longipennis*; Western Botanical 2019). (Western Botanical 2019).	~25 km E
Falco peregrinus	Peregrine Falcon		OS		Likely	●	●	●	●	●	●	●	●	Recorded (2009) at a drainage line that passes through the northern part of the study area. Likely to forage occasionally in any habitats within the study area. Less likely than other falcons to breed in stick nests of crows, but (contrary to MWH 2017) suitable nesting sites occur in artificial cliff faces of mines and quarries.	<1 km N
Charadrius veredus	Oriental Plover	MI	MI		Possible					●		●		Open areas of short, sparse grass and claypans are suitable foraging habitat for this non-breeding migrant. May occur occasionally.	~10 km W
Thinornis rubricollis	Hooded Plover			P4	Unlikely									Suitable salt lake habitat not present within study area.	~15 km W
Pluvialis fulva	Pacific Golden Plover	MI	MI		Unlikely									Rarely occurs inland; suitable riverine habitat not present within study area.	~19 km SW

Species	Common name	Conservation status[1]			Likelihood of occurrence	Fauna habitat								Summary of records and occurrence	Nearest record
		EPBC Act	BC Act	DBCA List		Outcropping & breakaway	Shrubland on stony hills	Mulga on stony hills	Mulga on plain	Shrubland on plain	Drainage lines & groves	Vegetated claypan	Cleared		
Limosa lapponica	Bar-tailed Godwit	CR/ VU, MI	CR/ VU, MI		Unlikely									Rarely occurs inland; suitable wetland habitat not present within study area.	~400 km WNW
Actitis hypoleucos	Common Sandpiper	MI	MI		Unlikely									Suitable wetland habitat not present within study area.	~15 km W
Tringa nebularia	Common Greenshank	MI	MI		Unlikely									Suitable wetland habitat not present within study area.	~10 km N
Tringa glareola	Wood Sandpiper	MI	MI		Unlikely									Recorded at Leonora, but suitable wetland habitat not present within study area.	~26 km SW
Tringa stagnatilis	Marsh Sandpiper	MI	MI		Unlikely									Suitable wetland habitat not present within study area.	~220 km NE
Calidris canutus	Red Knot	EN, MI	MI		Unlikely									Rarely occurs inland; suitable wetland habitat not present within study area.	~9 km N
Calidris melanotos	Pectoral Sandpiper	MI	MI		Unlikely									Rarely occurs inland; suitable wetland habitat not present within study area.	>320 km NW
Calidris ruficollis	Red-necked Stint	MI	MI		Unlikely									Suitable wetland habitat not present within study area.	~65 km E
Calidris subminuta	Long-toed Stint	MI	MI		Unlikely									Suitable wetland habitat not present within study area.	~500 km W
Calidris acuminata	Sharp-tailed Sandpiper	MI	MI		Possible					●		●		Open grassy areas in study area may be suitable for foraging after rain, but no suitable habitat at other times.	~18 km W

Species	Common name	Conservation status[1]			Likelihood of occurrence	Fauna habitat								Summary of records and occurrence	Nearest record
		EPBC Act	BC Act	DBCA List		Outcropping & breakaway	Shrubland on stony hills	Mulga on stony hills	Mulga on plain	Shrubland on plain	Drainage lines & groves	Vegetated claypan	Cleared		
Gelochelidon nilotica	Gull-billed Tern	MI	MI		Unlikely									Suitable wetland habitat not present within study area.	~60 km E
Polytelis alexandrae	Princess Parrot	VU		P4	Possible				●		●			Recorded at Leonora; not resident in area but may occasionally occur when conditions permit, particularly following rainfall in more arid areas to the east and north of the study area.	~75 km E
Pezoporus occidentalis	Night Parrot	EN	CR		Unlikely									Not recorded from Murchison region; suitable *Triodia* or similar refuge habitat not present within study area.	>350 km NNE
Motacilla cinerea	Grey Wagtail	MI	MI		Unlikely									Rare vagrant in WA; suitable habitat not present within study area.	~500 km NW
Motacilla flava	Yellow Wagtail	MI	MI		Unlikely									Not recorded from inland WA; suitable habitat not present within study area.	>900 km NNW
Mammals (7)															
Dasyurus geoffroii	Chuditch	VU	VU		Unlikely									Study area outside of species current known distribution. Recorded from an unconfirmed sighting at Goongarrie (2008), but considered regionally Extinct beyond the Wheatbelt (Burbidge 2004; Van Dyck & Strahan 2008).	~140 km SSW

Species	Common name	Conservation status[1]			Likelihood of occurrence	Fauna habitat								Summary of records and occurrence	Nearest record
		EPBC Act	BC Act	DBCA List		Outcropping & breakaway	Shrubland on stony hills	Mulga on stony hills	Mulga on plain	Shrubland on plain	Drainage lines & groves	Vegetated claypan	Cleared		
Sminthopsis longicaudata	Long-tailed Dunnart			P4	Likely	●	●	●						Known to occur in vicinity (Ecosmart Ecology 2012), recorded from secondary evidence in this study.	~12 km SE
Myrmecobius fasciatus	Numbat	VU	VU		Unlikely									Recorded near Laverton (1918) but now regionally Extinct.	~75 km E
Macrotis lagotis	Greater Bilby	VU	VU		Unlikely									Nearest sighting reported in 1981, but no later records within 400 km and considered regionally Extinct in the wild.	~65 km NW
Bettongia lesueur graii	Burrowing Bettong	EX	EX		Recorded historical evidence/ Unlikely									Recorded only from secondary evidence (historic warrens). Considered regionally Extinct(Burbidge 2004; Van Dyck & Strahan 2008) and unlikely to still occur.	~100 km SSE (2012), ~9 km SE (2018)
Lagostrophus fasciatus	Banded Hare-wallaby	VU	VU		Unlikely									Recorded sighting at Laverton (1910), but Extinct on the mainland.	~76 km E
Leporillus conditor	Greater Stick-nest Rat	VU	CD		Recorded historical evidence/ Unlikely									Recorded only from secondary evidence (historic nests). Considered Extinct in the wild on the mainland (Burbidge 2004; Van Dyck & Strahan 2008) and unlikely to still occur.	>340 km WSW (1973), 10-20 km E (2018)

[1] CR – Critically Endangered; EN – Endangered; VU – Vulnerable; OS – Specially Protected CD – Conservation Dependent; MI – Migratory; P4 – Priority 4.

5.2.3 SRE invertebrate fauna

As detailed in section 5.2.1 the study area is located within an area of low habitat and topographical diversity (e.g. hydrology, lacking major rock outcrops or natural clifflines, lakes, saltlakes, perennial streams, sandplains, or eucalypt-dominated woodland or mallee) and consequently no SRE sampling was undertaken.

The most prospective habitat for SREs in the study area are areas of significant outcropping, identified as having an important ecological function for vertebrate fauna (relative to its small area; providing both refuges and dens or hunting perches for larger predators) (see section 5.2.1); However, this habitat is generally limited and not planned to be impacted.

5.3 SURVEY LIMITATIONS

The limitations of the terrestrial fauna survey have been considered (Table 5-6) in accordance with Technical Guidance: Terrestrial fauna surveys for Environmental Impact Assessment (EPA 2016f).

Table 5-6 Survey limitations from EPA Technical Guidance: Terrestrial fauna surveys (EPA 2016f)

Limitations	Limitation for this survey?	Comments
Competency/experience of survey personnel, including taxonomy	No	The field personnel and report author have extensive experience in terrestrial fauna surveys within the region and across WA.
Scope and completeness - were all target groups sampled, were all planned survey methods implemented successfully, was the study area fully surveyed	No	All target groups, significant species and habitats within the study area were surveyed in accordance with the scope of work.
Intensity - in retrospect, was the intensity adequate	No	The survey intensity was appropriate for the area that was surveyed, and faunal groups targeted, including significant species.
Proportion of fauna identified, recorded and/or collected	No	All vertebrate fauna was identified to species level in the field apart from analysis of predator scats and bat echolocation recordings which were undertaken in Perth.
Availability of adequate contextual information	No	Previous survey reports and spatial datasets were available for the Leonora project area and the nearby Murrin Murrin project, providing adequate contextual information for the Project.
Timing, weather, season, cycle	No	Weather in several months preceding the survey was hot and dry relative to annual averages for previous years, so that fauna activity and observed diversity of mobile species was lower than expected. This does not represent a significant limitation in Level 1 survey.
Disturbances which affected the results of the survey	No	No disturbances occurred during the field survey which are considered to have impacted the overall results.

Limitations	Limitation for this survey?	Comments
Remoteness and/or access problems	No	All areas of the study area were accessible by vehicle or on foot.

6 DISCUSSION

In assessing development proposals, the EPA has the objective of protecting flora and vegetation, and terrestrial fauna so that biological diversity and ecological integrity are maintained (EPA 2016a, b). Considerations for flora, vegetation and terrestrial fauna in EIA at the State level include significance of values present, current state of knowledge of those values, potential impacts and the scale at which the impacts are assessed (EPA 2016a, b). At the Federal level, the Commonwealth publishes guidelines on assessing on significance of impacts to matters of NES (Department of the Environment 2013). The potential biological values of the study area are discussed below to inform an EIA for the Project.

Eight broad fauna habitats were mapped within the study area (Table 5-3) and all are well represented in the broader vicinity outside the study area and across the Eastern Murchison subregion.

In accordance with EPA (2016c), fauna habitats may be considered significant if they provide habitat important to the life history of a significant species or are unique or isolated within a landscape (see section 2.2.2). All habitats occurring within the study area have the potential to support significant fauna species at various capacities, but do not necessarily meet the criteria to be considered significant. Up to eight significant vertebrate fauna species have the potential to occur within the study area based on habitat suitability and presence, proximity of desktop records and current known distributions.

Of the eight significant vertebrate species known or considered to potentially occur within the study area, three have the potential to be resident: Grey Falcon (VU), Peregrine Falcon (OS) and Long-tailed Dunnart (P4). Both falcon species have large foraging ranges encompassing various habitats widespread inside and outside the study area. Potential nesting sites occur for both species, including stick nests constructed by crows or other raptors in tall *Acacia* woodland (recently reported being used by Australian Hobby; Western Botanical 2019), and artificial cliffs of old mine pits which are especially suitable for Peregrine Falcon nesting.

Most surface rocks in the study area are highly weathered and fragmented, forming a mantle on rounded hills and plains; the few small areas of more prominent natural outcrop and breakaway had abundant signs of use by vertebrate fauna, including scats likely to represent Long-tailed Dunnart. This species is therefore considered a likely resident.

The remaining significant species that may occur would be transient or occasional visitors, occurring within the study area while foraging and/or dispersing between other areas of suitable habitat outside of the study area.

The occurrence of Princess Parrot (VU) within the study area is likely to be infrequent and largely driven by rainfall in the areas to the east and north of the study area when the species may move into the study area when conditions and food resources are more favourable; no habitats in the study area are particularly suitable. Fort-tailed Swift (Mig.), Oriental Plover (Mig.), and Sharp-tailed Sandpiper (Mig.) are other species that may use habitats of the study area as part of their very wide foraging range but would be short-term and very occasional visitors.

Malleefowl (VU) will forage within and disperse across a range of habitats, including some present within the study area; however, the absence of suitable nesting habitat (sandy substrates and leaf litter accumulation) for mound construction indicates the species is likely an infrequent visitor and not a resident. Although the species was recorded within 20 km of the study area in 2011, habitat for the species in that area was considered marginal (Ecosmart Ecology 2012; MWH Australia 2018; Phoenix 2019), indicating the specimen recorded was likely a transient individual. The study area is dominated by sparse, open vegetation with stony substrates and sparse leaf litter cover, which do not provide optimal nesting conditions for the species. No habitats within the study area are considered significant for the species.

Historic evidence of two regionally Extinct species (Burrowing Bettong and Greater Stick-nest Rat) were also recorded. Both are today known only from translocated or managed populations across the remainder of their range.

Considering potential for breeding and refugia by conservation significant species likely to occur, the most significant vertebrate fauna habitats of the study area are the artificial cliffs of old mine pits, stands of relatively tall trees (e.g. *Acacia papyrocarpa*) previously used for nesting by crows and raptors, and the small areas of outcropping and breakaway with crevices and overhangs.

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Appendix 1 Terrestrial fauna survey site descriptions

Site:	**LF001 (Fauna site) (-28.801652, 121.598226)**
Habitat description:	Mulga shrubland with some taller tree mulga, over other *Acacia* shrubs
Habitat type:	shrubland
Topography:	drainage line
Slope:	moderate
Soil:	sandy loam
Soil colour:	red–orange
Rock type:	basalt
Fire age:	> 5 years
Disturbance:	road/tracks, clearing and mining operations adjacent, cattle grazing



Site:	**LF002 (Fauna site) (-28.790903, 121.620173)**
Habitat description:	Open Mulga shrubland over *Tecticornia* and mixed low shrubs, sparse grass
Habitat type:	shrubland
Topography:	hill top
Slope:	moderate
Soil:	clay loam
Soil colour:	brown, grey
Rock type:	quartz, calcrete
Fire age:	>5 years
Disturbance:	exploration (drill pads and access tracks)



Site:	**LF003 (Fauna site) (-28.782345, 121.630846)**
Habitat description:	*Acacia papyrocarpa* open woodland over *Maireana* spp. chenopod shrubland
Habitat type:	open woodland
Topography:	undulating plain
Slope:	gentle
Soil:	clay loam
Soil colour:	red–orange, brown
Rock type:	ferrous - Ironstone, quartz
Fire age:	> 5 years
Disturbance:	none



Site:	**LF004 (Fauna site) (-28.852419, 121.645414)**
Habitat description:	Mulga and some taller Acacia over mixed shrubs, grasses on creekline
Habitat type:	shrubland
Topography:	drainage line
Slope:	gentle
Soil:	sandy loam
Soil colour:	red–brown
Rock type:	quartz, basalt
Fire age:	> 5 years
Disturbance:	grazing – medium, livestock tracks



Site:	**LF005 (Fauna site) (-28.876619, 121.660756)**
Habitat description:	Mostly low-mid shrubs over sparse tussocks and herbs
Habitat type:	shrubland
Topography:	hill top
Slope:	moderate
Soil:	clay loam
Soil colour:	red–orange
Rock type:	quartz, basalt
Fire age:	> 5 years
Disturbance:	none



Site:	**LF006 (Fauna site) (-28.863535, 121.632144)**
Habitat description:	*Acacia* shrubland over sparse ground cover
Habitat type:	shrubland
Topography:	hill slope
Slope:	gentle
Soil:	sandy loam
Soil colour:	red–orange
Rock type:	ferrous - Ironstone, basalt
Fire age:	> 5 years
Disturbance:	none



Site:	**LF007 (Fauna site) (-28.873601, 121.610308)**
Habitat description:	Mulga shrubland over low shrubs and tussocks
Habitat type:	shrubland
Topography:	plain
Slope:	negligible
Soil:	clay loam
Soil colour:	red–orange
Rock type:	ferrous - Ironstone, quartz
Fire age:	> 5 years
Disturbance:	none



Site:	**LF008 (Fauna site) (-28.888624, 121.619058)**
Habitat description:	*Acacia* open woodland/shrubland
Habitat type:	open woodland
Topography:	plain
Slope:	negligible
Soil:	clay loam
Soil colour:	red–orange, brown, yellow
Rock type:	ferrous - Ironstone, quartz, calcrete
Fire age:	> 5 years
Disturbance:	none



Site:	**LF009 (Fauna site) (-28.883498, 121.657341)**
Habitat description:	Shrubs over grass, surrounded by open shrubland
Habitat type:	shrubland
Topography:	plain
Slope:	negligible
Soil:	clay loam
Soil colour:	red–orange
Rock type:	ferrous - Ironstone, quartz
Fire age:	> 5 years
Disturbance:	grazing – medium, livestock tracks, weed infestation



Site:	**LF010 (Fauna site) (-28.881628, 121.654117)**
Habitat description:	*Acacia papyrocarpa* open woodland over low shrubs and herbs
Habitat type:	woodland
Topography:	plain
Slope:	negligible
Soil:	sandy loam
Soil colour:	red–orange, brown
Rock type:	ferrous - Ironstone, quartz, calcrete
Fire age:	> 5 years
Disturbance:	none



Site:	**LF011 (Fauna site) (-28.843421, 121.627296)**
Habitat description:	Scattered tall/mid shrubs over low shrubs, grass, herbs
Habitat type:	shrubland
Topography:	hill top
Slope:	moderate
Soil:	sandy loam, clay loam
Soil colour:	red–orange
Rock type:	basalt
Fire age:	> 5 years
Disturbance:	none



Site:	**LF012 (Fauna site) (-28.841669, 121.602585)**
Habitat description:	Chenopod and *Acacia* spp. over grazed tussock grass and herbs
Habitat type:	chenopod shrubland
Topography:	plain
Slope:	negligible
Soil:	clay loam
Soil colour:	red–orange
Rock type:	ferrous - Ironstone, quartz, basalt
Fire age:	> 5 years
Disturbance:	grazing – medium



Site:	**LF013 (Fauna site) (-28.814909, 121.598694)**
Habitat description:	*Acacia* riparian open woodland, low shrubs, grass and herbs
Habitat type:	woodland
Topography:	drainage line
Slope:	gentle
Soil:	sandy loam
Soil colour:	red–orange
Rock type:	basalt
Fire age:	> 5 years
Disturbance:	grazing – medium



Site:	**LF014 (Fauna site) (-28.820789, 121.616648)**
Habitat description:	Scattered *Acacia* and *Allocasuarina* spp. over low to mid open shrubland over grass
Habitat type:	chenopod shrubland
Topography:	undulating plain
Slope:	gentle
Soil:	sandy loam
Soil colour:	brown, yellow
Rock type:	ferrous - Ironstone, quartz
Fire age:	> 5 years
Disturbance:	grazing – medium, livestock tracks, weed infestation



Site:	**LF015 (Fauna site) (-28.582003, 121.548582)**
Habitat description:	*Acacia* mid tall open shrubland over scattered low shrubs and grasses
Habitat type:	shrubland
Topography:	hill top
Slope:	gentle
Soil:	clay loam, rocks
Soil colour:	red–orange, yellow
Rock type:	granite - rocks
Fire age:	> 5 years
Disturbance:	none



Site:	**LF016 (Fauna site) (-28.601465, 121.543295)**
Habitat description:	Low open Mulga woodland over new grass
Habitat type:	open woodland
Topography:	plain
Slope:	negligible
Soil:	clay loam, clay
Soil colour:	red–orange
Rock type:	quartz
Fire age:	> 5 years
Disturbance:	none



Site:	**LF017 (Fauna site) (-28.619092, 121.551895)**
Habitat description:	Mid tall Mulga shrubland over grass
Habitat type:	shrubland
Topography:	plain
Slope:	negligible
Soil:	sandy clay
Soil colour:	red–orange
Rock type:	granite - rocks, quartz
Fire age:	> 5 years
Disturbance:	none



Site:	**LF018 (Fauna site) (-28.675869, 121.563497)**
Habitat description:	Mid open Mulga shrubland over sparse low shrubs
Habitat type:	shrubland
Topography:	hill slope
Slope:	gentle
Soil:	sandy clay
Soil colour:	red–orange
Rock type:	ferrous - Ironstone, granite - rocks, quartz, basalt
Fire age:	> 5 years
Disturbance:	none



Site:	**LF019 (Fauna site) (-28.706839, 121.547845)**
Habitat description:	Scattered *Eucalyptus ?lucasii* over open Mulga shrubland over *Eremophila* and other low shrubs
Habitat type:	open woodland
Topography:	breakaway
Slope:	moderate
Soil:	sandy loam, rocks
Soil colour:	brown, yellow
Rock type:	ferrous - Ironstone, quartz, calcrete
Fire age:	> 5 years
Disturbance:	none



Site:	**LF020 (Fauna site) (-28.711125, 121.547937)**
Habitat description:	Open low to mid shrubland
Habitat type:	shrubland
Topography:	breakaway
Slope:	moderate
Soil:	sandy clay, rocks
Soil colour:	red–orange, brown
Rock type:	ferrous - Ironstone, gypsum
Fire age:	> 5 years
Disturbance:	none



Site:	**LF021 (Fauna site) (-28.742749, 121.552399)**
Habitat description:	Scattered trees over mid tall open Mulga shrubland over mixed low shrubs and grass
Habitat type:	shrubland
Topography:	hill top
Slope:	gentle
Soil:	sandy loam
Soil colour:	brown, yellow
Rock type:	ferrous - Ironstone
Fire age:	> 5 years
Disturbance:	none



Site:	**LF022 (Fauna site) (-28.647504, 121.547584)**
Habitat description:	Mid tall Mulga shrubland over mixed low-mid shrubs, sparse grass and herbs
Habitat type:	shrubland
Topography:	hill slope
Slope:	gentle
Soil:	sandy clay, clay loam
Soil colour:	red–orange, brown
Rock type:	ferrous - Ironstone, quartz
Fire age:	> 5 years
Disturbance:	none



Site:	**LF023 (Fauna site) (-28.762849, 121.569145)**
Habitat description:	Mulga shrubland over low shrubs
Habitat type:	shrubland
Topography:	drainage line
Slope:	gentle
Soil:	sandy clay, sandy loam, clay
Soil colour:	red–orange
Rock type:	ferrous - Ironstone, quartz, siltstone / mudstone
Fire age:	> 5 years
Disturbance:	livestock tracks



Site:	**LF024 (Fauna site) (-28.764927, 121.58915)**
Habitat description:	Low open Mulga woodland and mid-tall shrubs over grass
Habitat type:	open woodland
Topography:	plain
Slope:	negligible
Soil:	clay loam, rocks
Soil colour:	red–orange
Rock type:	ferrous - Ironstone, calcrete, basalt
Fire age:	> 5 years
Disturbance:	none



Site:	**LF025 (Fauna site) (-28.781098, 121.591659)**
Habitat description:	Mid tall open Mulga woodland over mixed low to mid shrubs and almost no grass
Habitat type:	open woodland
Topography:	hill top
Slope:	moderate
Soil:	sandy loam
Soil colour:	red–orange
Rock type:	ferrous - Ironstone
Fire age:	> 5 years
Disturbance:	none



Site:	**LF026 (Fauna site) (-28.809893, 121.622255)**
Habitat description:	Mulga woodland over mixed shrubs, herbs and grass
Habitat type:	open woodland
Topography:	drainage line
Slope:	gentle
Soil:	sandy loam
Soil colour:	red–orange, brown
Rock type:	quartz, basalt
Fire age:	> 5 years
Disturbance:	none



Site:	**LF027 (Fauna site) (-28.817392, 121.627016)**
Habitat description:	Mulga low open woodland or tall shrubland over mixed lower shrubs, patchy grass and herbs
Habitat type:	open woodland
Topography:	undulating plain
Slope:	gentle
Soil:	sandy clay
Soil colour:	red–brown, red–orange
Rock type:	quartz, calcrete, basalt
Fire age:	> 5 years
Disturbance:	none



Site:	**LF028 (Fauna site) (-28.794687, 121.580542)**
Habitat description:	Mulga and *Casuarina* low open woodland over mixed shrubs and herbs
Habitat type:	shrubland
Topography:	hill top
Slope:	moderate
Soil:	sandy clay, sandy loam
Soil colour:	brown, yellow
Rock type:	granite - rocks, quartz
Fire age:	> 5 years
Disturbance:	none



Appendix 2 Vertebrate species records from desktop review and this survey

Family	Species	Common name	Conservation status	Protected Matters (DoEE	Threatened fauna (DBCA	NatureMap (DBCA 2019a)	ALA (ALA 2019)	Ecosmart Ecology (2012)	Phoenix (2019)	MWH Australia (2017, 2018)	This survey
Amphibians											
Hylidae	*Cyclorana maini*	Sheep Frog				•	1	•			
	Cyclorana occidentalis (ex *C. platycephala*)	Western Water-holding Frog				•	38	•	•		1
	Litoria rubella	Little Red Tree Frog				•	4	•	•		1
Limnodynastidae	*Neobatrachus kunapalari*	Kunapalari Frog				•	3				
	Neobatrachus sutor	Shoemaker Frog				•		•			
	Notaden nichollsi	Desert Spadefoot				•					
Myobatrachidae	*Pseudophryne occidentalis*	Western Toadlet				•		•			
Reptiles											
Cheluidae	*Chelodina steindachneri*	Dinner-plate Turtle					1				
Agamidae	*Ctenophorus caudicinctus*	Ringtailed Dragon							•		
	Ctenophorus isolepis	Military Dragon				•	6				
	Ctenophorus nuchalis	Central Netted Dragon				•	3				1
	Ctenophorus reticulatus	Western Netted Dragon				•	5	•			
	Ctenophorus scutulatus	Lozenge-marked Dragon				•	1	•	•		
	Ctenophorus sp. indet.										1
	Diporiphora amphiboluroides	Mulga Dragon				•				•	
	Moloch horridus	Thorny Devil					1		•		
	Pogona minor	Western Bearded Dragon				•	2	•			
	Tympanocryptis pseudopsephos (ex *T. cephalus*)	Goldfields Pebble Dragon				•	5				
Gekkonidae	*Gehyra montium*								•		

Family	Species	Common name	Conservation status	Protected Matters (DoEE	Threatened fauna (DBCA	NatureMap (DBCA 2019a)	ALA (ALA 2019)	Ecosmart Ecology (2012)	Phoenix (2019)	MWH Australia (2017, 2018)	This survey
	Gehyra purpurascens	Purple Dtella				•		•			
	Gehyra variegata	Common Dtella				•	9	•	•	•	2
	Heteronotia binoei	Bynoe's Prickly Gecko				•	19	•	•	•	2
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				•	1				
	Diplodactylus granariensis rex	Western Stone Gecko				•	1				
	Diplodactylus pulcher	Fine-faced Gecko				•	4	•	•		
	Lucasium squarrosum	Spotted Ground Gecko				•	3				
	Rhynchoedura ornata	Western Beaked Gecko				•	5	•			
	Strophurus assimilis	Goldfields Spiny-tail Gecko				•					
	Strophurus wellingtonae	Western Shield Spiny-tail Gecko				•	5	•		•	
Pygopodidae	*Aprasia picturata*	Black-headed Worm-lizard				•	2				
	Pygopus nigriceps	Western Hooded Scaly-foot				•	3	•			
Scincidae	*Cryptoblepharus australis*	Inland Snake-eyed Skink				•	1	•			
	Cryptoblepharus buchananii	Buchanan's Snake-eyed Skink				•			•		
	Ctenotus inornatus	Plain Ctenotus					7				
	Ctenotus leonhardii	Leonhard's Ctenotus				•	3			•	
	Ctenotus pantherinus ocellifer	Leopard Ctenotus				•	3				
	Ctenotus severus	Stern Ctenotus				•					
	Ctenotus uber uber	Spotted Ctenotus				•	2	•	•		1
	Egernia depressa	Southern Pygmy Spiny-tailed Skink				•			•	•	1

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	Eremiascincus richardsonii	Broad-banded Sandswimmer				•					1
	Lerista desertorum	Central Deserts Robust Slider				•	5	•	•		2
	Lerista kingi	King's Three-toed Slider					1				
	Lerista timida	Timid Slider				•	7	•	•		
	Liopholis inornata	Desert Skink				•	1				
	Menetia greyii	Common Dwarf Skink				•	2		•		
	Morethia butleri	Woodland Morethia Skink				•	9	•			
	Tiliqua rugosa rugosa	Bobtail							•		
Varanidae	*Varanus caudolineatus*	Stripe-tailed Monitor				•	2	•	•	•	
	Varanus gouldii	Gould's Sand Monitor				•	1		•		
	Varanus panoptes	Yellow-spotted Monitor				•		•	•	•	19
Typhlopidae	*Anilios hamatus*	Pale-headed Blindsnake				•	9				
	Anilios waitii	Beaked Blindsnake				•	2				
	Anilios sp. indet.								•		
Pythonidae	*Antaresia stimsoni*	Stimson's Python				•					1
Elapidae	*Parasuta monachus*	Monk Snake				•	2	•			
	Pseudechis australis	Mulga Snake, King Brown				•	1				
	Pseudechis butleri	Spotted Mulga Snake					1				1
	Pseudonaja mengdeni	Western Brown Snake				•	3				1
	Pseudonaja modesta	Ringed Brown Snake				•	3				
	Suta fasciata	Rosen's Snake				•	3	•	•		
Birds											
Casuariidae	*Dromaius novaehollandiae*	Emu				•	49		•	•	6

Family	Species	Common name	Conservation status	Protected Matters (DoEE	Threatened fauna (DBCA	NatureMap (DBCA 2019a)	ALA (ALA 2019)	Ecosmart Ecology (2012)	Phoenix (2019)	MWH Australia (2017, 2018)	This survey
Megapodiidae	*Leipoa ocellata*	Malleefowl	VU (EPBC & BC Acts)	•	•	•	1	•			(1)
Phasianidae	*Coturnix pectoralis*	Stubble Quail					1				
Anatidae	*Cygnus atratus*	Black Swan				•	44				
	Tadorna tadornoides	Australian Shelduck				•	45				
	Malacorhynchus membranaceus	Pink-eared Duck				•	25				
	Chenonetta jubata	Australian Wood Duck				•	36				
	Anas superciliosus	Pacific Black Duck				•	28	•			
	Anas rhynchotis	Australian Shoveler					2				
	Anas gracilis	Grey Teal				•	56	•	•		
	Aythya australis	Hardhead				•	18				
	Biziura lobata	Musk Duck				•	8				
Podicipedidae	*Tachybaptus novaehollandiae*	Australasian Grebe				•	15				
	Poliocephalus poliocephalus	Hoary-headed Grebe				•	37				
	Podiceps cristatus	Great Crested Grebe				•	1				
Columbidae	**Columba livia*	Rock Dove, Feral Pigeon		•		•	4				
	**Streptopelia senegalensis*	Laughing Dove		•		•	1				
	Phaps chalcoptera	Common Bronzewing				•	39	•		•	•
	Ocyphaps lophotes	Crested Pigeon				•	125	•	•	•	2
	Geopelia cuneata	Diamond Dove				•	14	•		•	
Podargidae	*Podargus strigoides*	Tawny Frogmouth				•	4	•			1
Eurostopodidae	*Eurostopodus argus*	Spotted Nightjar				•	13	•		•	
Aegothelidae	*Aegotheles cristatus*	Australian Owlet Nightjar				•	4	•			
Apodidae	*Apus pacificus*	Fork-tailed Swift	Mig. (EPBC & BC Acts)	•							

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Anhingidae	*Anhinga novaehollandiae*	Australasian Darter				•	7				
Phalacrocoracidae	*Microcarbo melanoleucos*	Little Pied Cormorant				•	20				
	Phalacrocorax carbo	Great Cormorant				•	6				
	Phalacrocorax sulcirostris	Little Black Cormorant				•	33				
Pelecanidae	*Pelecanus conspicillatus*	Australian Pelican				•	20				
Ardeidae	*Ardea pacifica*	White-necked Heron				•	43		•		
	Ardea modesta	Eastern Great Egret		•		•	6				
	Egretta novaehollandiae	White-faced Heron				•	44				1
	Nycticorax caledonicus	Nankeen Night-heron					2				
Threskiornithidae	*Plegadis falcinellus*	Glossy Ibis	Mig. (EPBC & BC Acts)		•						
	Threskiornis moluccus	Australian White Ibis				•	2				
	Threskiornis spinicollis	Straw-necked Ibis				•	8		•		
	Platalea regia	Royal Spoonbill					1				
	Platalea flavipes	Yellow-billed Spoonbill				•	15				
Accipitridae	*Elanus caeruleus axillaris*	Black-shouldered Kite				•	6	•		•	
	Lophoictinia isura	Square-tailed Kite					2				
	Hamirostra melanosternon	Black-breasted Buzzard					1				
	Haliastur sphenurus	Whistling Kite				•	31				2
	Milvus migrans	Black Kite				•	9				
	Accipiter fasciatus	Brown Goshawk				•	6			•	
	Accipiter cirrocephalus	Collared Sparrowhawk				•	9	•		•	
	Circus assimilis	Spotted Harrier				•	10	•			
	Circus approximans	Swamp Harrier				•	2				

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	Aquila audax	Wedge-tailed Eagle				•	66	•	•	•	2
	Hieraeetus morphnoides	Little Eagle				•	4				
Falconidae	*Falco cenchroides*	Nankeen Kestrel				•	80	•	•		4
	Falco berigora	Brown Falcon				•	44	•	•		
	Falco longipennis	Australian Hobby				•	33	•	•		
	Falco hypoleucos	Grey Falcon	VU (BC Act)		•	•					
	Falco subniger	Black Falcon					2				
	Falco peregrinus	Peregrine Falcon	OS (BC Act)		•	•	2	•	•		
Rallidae	*Gallinula tenebrosa*	Dusky Moorhen					3				
	Tribonyx ventralis	Black-tailed Native-hen				•	31		•		
	Fulica atra	Eurasian Coot				•	29				
Otididae	*Ardeotis australis*	Australian Bustard				•	6	•	•		1
Burhinidae	*Burhinus grallarius*	Bush Stone-curlew				•	2	•	•		
Recurvirostridae	*Cladorhynchus leucocephalus*	Banded Stilt					5				
	Himantopus himantopus	Black-winged Stilt				•	21	•			
	Recurvirostra novaehollandiae	Red-necked Avocet				•	20				
Charadriidae	*Charadrius ruficapillus*	Red-capped Plover				•	44				
	Charadrius veredus	Oriental Plover	Mig. (EPBC & BC Acts)	•			1				
	Elseyornis melanops	Black-fronted Dotterel				•	51	•			
	Peltohyas australis	Inland Dotterel					6				
	Thinornis rubricollis	Hooded Plover	P4 (DBCA list)	•	•	•	1				
	Erythrogonys cinctus	Red-kneed Dotterel				•	17				
	Pluvialis fulva	Pacific Golden Plover	Mig. (EPBC & BC Acts)		•		1				

Family	Species	Common name	Conservation status	Protected Matters (DoEE	Threatened fauna (DBCA	NatureMap (DBCA 2019a)	ALA (ALA 2019)	Ecosmart Ecology (2012)	Phoenix (2019)	MWH Australia (2017, 2018)	This survey
	Vanellus tricolor	Banded Lapwing				•	31	•	•		
Scolopacidae	*Limosa lapponica*	Bar-tailed Godwit	VU/Mig. (EPBC & BC Acts)				2				
	Actitis hypoleucos	Common Sandpiper	Mig. (EPBC & BC Acts)	•	•	•	10				
	Tringa nebularia	Common Greenshank	Mig. (EPBC & BC Acts)	•	•	•	11				
	Tringa glareola	Wood Sandpiper	Mig. (EPBC & BC Acts)		•	•	4				
	Tringa stagnatilis	Marsh Sandpiper	Mig. (EPBC & BC Acts)				1				
	Calidris canutus	Red Knot	EN/Mig. (EPBC & BC Acts)		•		1				
	Calidris melanotos	Pectoral Sandpiper	Mig. (EPBC & BC Acts)	•							
	Calidris ruficollis	Red-necked Stint	Mig. (EPBC & BC Acts)		•						
	Calidris subminuta	Long-toed Stint	Mig. (EPBC & BC Acts)								
	Calidris acuminata	Sharp-tailed Sandpiper	Mig. (EPBC & BC Acts)	•	•		5				
Turnicidae	*Turnix velox*	Little Button-quail				•	6	•			
Laridae	*Gelochelidon nilotica*	Gull-billed Tern	Mig. (EPBC & BC Acts)		•						
	Chlidonias hybrida	Whiskered Tern				•	14				
	Chroicocephalus novaehollandiae	Silver Gull				•	8				
Cacatuidae	*Lophochroa leadbeateri*	Major Mitchell's Cockatoo					2				
	Eolophus roseicapillus	Galah				•	78	•			1
	Nymphicus hollandicus	Cockatiel				•	32	•			
Pstittaculidae	*Barnardius zonarius*	Australian Ringneck				•	61	•	•	•	6
	Psephotus varius	Mulga Parrot				•	40	•	•	•	
	Melopsittacus undulates	Budgerigar				•	41	•	•	•	
	Neophema splendida	Scarlet-chested Parrot					3				
	Neopsephotus bourkii	Bourke's Parrot				•	22	•		•	

Family	Species	Common name	Conservation status	Protected Matters (DoEE	Threatened fauna (DBCA	NatureMap (DBCA 2019a)	ALA (ALA 2019)	Ecosmart Ecology (2012)	Phoenix (2019)	MWH Australia (2017, 2018)	This survey
	Pezoporus occidentalis	Night Parrot	EN (EPBC Act), CR (BC Act)	•							
	Polytelis alexandrae	Princess Parrot	VU (EPBC Act), P4 (DBCA)	•	•						
Cuculidae	*Chrysococcyx basalis*	Horsfield's Bronze-Cuckoo				•	9	•			
	Chrysococcyx osculans	Black-eared Cuckoo		•			5	•	•		
	Cacomantis pallidus	Pallid Cuckoo				•	25	•			
Strigidae	*Ninox boobook* (ex *novaeseelandiae*)	Boobook Owl					6	•			
Tytonidae	*Tyto javanica* (=*N. alba*)	Eastern Barn Owl				•	9				
Halcyonidae	*Todiramphus pyrrhopygius*	Red-backed Kingfisher				•	30	•			
	Todiramphus sanctus	Sacred Kingfisher				•	1				
Meropidae	*Merops ornatus*	Rainbow Bee-eater		•		•	11		•		2
Climacteridae	*Climacteris affinis*	White-browed Treecreeper				•	11				
	Climacteris rufa	Rufous Treecreeper					2				
Ptilonorhynchidae	*Ptilonorhynchus guttatus*	Western Bowerbird				•	21	•	•	•	1
Maluridae	*Malurus splendens*	Splendid Fairy-wren				•	20	•	•	•	
	Malurus leucopterus leuconotus	White-winged Fairy-wren				•	20	•	•	•	1
	Malurus lamberti	Variegated Fairy-wren				•	5	•	•	•	1
	Malurus pulcherrimus	Blue-breasted Fairy-wren				•					
Acanthizidae	*Pyrrholaemus brunneus*	Redthroat				•	4	•	•	•	
	Smicrornis brevirostris	Weebill				•	15	•			1
	Gerygone fusca	Western Gerygone					9				1
	Acanthiza robustirostris	Slaty-backed Thornbill				•	8	•	•	•	
	Acanthiza chrysorrhoa	Yellow-rumped Thornbill				•	45	•		•	2
	Acanthiza uropygialis	Chestnut-rumped Thornbill				•	31	•	•	•	4

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	Acanthiza iredalei	Slender-billed Thornbill							•		4
	Acanthiza apicalis	Broad-tailed (Inland) Thornbill				•	21	•		•	
	Aphelocephala leucopsis	Southern Whiteface				•	32	•	•	•	
Pardalotidae	*Pardalotus rubricatus*	Red-browed Pardalote				•		•			
	Pardalotus striatus	Striated Pardalote				•	29				
Meliphagidae	*Sugomel niger*	Black Honeyeater					1				
	Certhionyx variegatus	Pied Honeyeater				•	12		•		
	Lichmera indistincta	Brown Honeyeater				•	13		•		
	Epthianura tricolor	Crimson Chat				•	43	•			
	Epthianura aurifrons	Orange Chat				•	20				
	Epthianura albifrons	White-fronted Chat				•	11				
	Lacustroica whitei	Grey Honeyeater					1				
	Acanthagenys rufogularis	Spiny-cheeked Honeyeater				•	95	•	•		13
	Gavicalis virescens	Singing Honeyeater				•	131	•	•	•	18
	Manorina flavigula	Yellow-throated Miner				•	106	•	•	•	6
	Ptilotula keart6landi	Grey-headed Honeyeater					1				
	Ptilotula plumula	Grey-fronted Honeyeater				•	4				
	Ptilotula penicillata	White-plumed Honeyeater				•	3				
	Purnella albifrons	White-fronted Honeyeater				•	30	•			
Pomatostomidae	*Pomatostomus superciliosus*	White-browed Babbler				•	29	•	•	•	3
Cinclosomatidae	*Cinclosoma clarum* (ex *C. castanotum*)	Copperback Quail-thrush					3			•	
	Cinclosoma marginatum (ex *C. castaneothorax*)	Western Quail-thrush				•	22	•			
Psophodidae	*Psophodes occidentalis*	Chiming Wedgebill				•	23				

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Neosittidae	*Daphoenositta chrysoptera*	Varied Sitella								•	
Campephagidae	*Coracina maxima*	Ground Cuckoo-shrike				•	18	•			
	Coracina novaehollandiae	Black-faced Cuckoo-shrike				•	64	•	•	•	2
	Lalage tricolor (=*L. sueurii*)	White-winged Triller				•	32	•	•		1
Pachycephalidae	*Pachycephala occidentalis*	Western Golden Whistler				•	1				
	Pachycephala rufiventris	Rufous Whistler				•	41	•	•	•	5
	Colluricincla harmonica	Grey Shrike-thrush				•	36	•	•	•	
	Oreoica gutturalis	Crested Bellbird				•	92	•	•	•	12
Artamidae	*Artamus personatus*	Masked Woodswallow				•	28	•	•		
	Artamus cinereus	Black-faced Woodswallow				•	92	•	•	•	5
	Artamus minor	Little Woodswallow				•	2	•		•	
Cracticidae	*Cracticus torquatus*	Grey Butcherbird				•	49	•	•		2
	Cracticus nigrogularis	Pied Butcherbird				•	88	•	•	•	6
	Cracticus tibicen	Australian Magpie				•	69	•	•	•	5
	Strepera versicolor	Grey Currawong				•	17	•		•	
Rhipiduridae	*Rhipidura albiscapa*	Grey Fantail				•	4				
	Rhipidura leucophrys	Willie Wagtail				•	97	•	•	•	5
Corvidae	*Corvus coronoides*	Australian Raven				•	5		•		
	Corvus bennetti	Little Crow				•	88	•	•	•	5
	Corvus orru	Torresian Crow				•	15	•		•	
Monarchidae	*Grallina cyanoleuca*	Magpie-Lark				•	111	•	•	•	2
Petroicidae	*Microeca fascinans*	Jacky Winter				•	2	•			
	Petroica goodenovii	Red-capped Robin				•	71	•	•	•	5

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	Melanodryas cucullata	Hooded Robin				•	31	•		•	
Megaluridae	*Cincloramphus mathewsi*	Rufous Songlark				•	17	•			
	Cincloramphus cruralis	Brown Songlark				•	28	•			
Hirundinidae	*Cheramoeca leucosterna*	White-backed Swallow				•	40	•		•	
	Hirundo neoxena	Welcome Swallow				•	94	•	•	•	
	Petrochelidon ariel	Fairy Martin				•	26	•			
	Petrochelidon nigricans	Tree Martin				•	44	•		•	
Nectariniidae	*Dicaeum hirundinaceum*	Mistletoebird				•	8	•		•	
Estrildidae	*Emblema pictum*	Painted Finch					3				
	Taeniopygia guttata	Zebra Finch				•	103	•	•	•	9
Motacillidae	*Anthus australis*	Australasian Pipit				•	98	•			1
	Motacilla cinerea	Grey Wagtail	Mig. (EPBC & BC Acts)	•							
	Motacilla flava	Yellow Wagtail	Mig. (EPBC & BC Acts)	•							
Mammals											
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked Echidna				•		•			2
Dasyuridae	*Antechinomys laniger*	Kultarr				•	1	•			
	Dasyurus geoffroii	Chuditch	VU (EPBC & BC Acts)	•							
	Ningaui ridei	Wongai Ningaui				•					
	Sminthopsis crassicaudata	Fat-tailed Dunnart				•		•			
	Sminthopsis dolichura	Little Long-tailed Dunnart				•		•			
	Sminthopsis longicaudata	Long-tailed Dunnart	P4 (DBCA list)			•		•			(3)
	Sminthopsis macroura	Stripe-faced Dunnart				•					
Myrmecobiidae	*Myrmecobius fasciatus*	Numbat	VU (EPBC & BC Acts)		•						

Family	Species	Common name	Conservation status	Protected Matters (DoEE	Threatened fauna (DBCA	NatureMap (DBCA 2019a)	ALA (ALA 2019)	Ecosmart Ecology (2012)	Phoenix (2019)	MWH Australia (2017, 2018)	This survey
Thylacomyidae	*Macrotis lagotis*	Bilby	VU (EPBC & BC Acts)		•						
Potoroidae	*Bettongia lesueur graii*	Burrowing Bettong, Boodie	EX (EPBC & BC Acts)						•		(5)
Macropodidae	*Osphranter robustus* (ex *Macropus*)	Euro, Biggada				•		•	•	•	29
	Osphranter rufus (ex *Macropus*)	Red Kangaroo, Marlu				•		•	•	•	•
	Lagostrophus fasciatus	Banded Hare-wallaby	VU (EPBC & BC Acts)		•						
Emballonuridae	*Taphozous hilli*	Hill's Sheathtail-bat				•					
Molossidae	*Ozimops petersi* (=*Mormopterus* sp. 3)	Inland Free-tailed Bat				•					
	Austronomus australis (ex *Tadarida*)	White-striped Freetail-bat				•					
Vespertilionidae	*Chalinolobus gouldii*	Gould's Wattled Bat				•			•		3
	Chalinolobus morio	Chocolate Wattled Bat							•		
	Nyctophilus geoffroyi	Lesser Long-eared Bat				•	1				
	Scotorepens balstoni	Inland Broad-nosed Bat				•					
	Vespadelus baverstocki	Inland Forest Bat				•			•		
	Vespadelus finlaysoni	Finlayson's Cave Bat				•			•		
Muridae	*Leporillus conditor*	Greater Stick-nest Rat	VU (EPBC & BC Acts)						•		(1)
	Notomys alexis	Spinifex Hopping-mouse				•		•			
	Pseudomys hermannsburgensis	Sandy Inland Mouse				•	1	•			
	**Mus musculus*	House Mouse				•	7	•	•		1
Leporidae	**Oryctolagus cuniculus*	Rabbit		•		•		•	•	•	12
Camelidae	**Camelus dromedaries*	Camel		•			1			•	
Bovidae	**Bos taurus*	Domestic Cattle							•	•	18
	**Capra hircus*	Goat		•				•	•		3
	**Ovis aries*	Sheep									

Family	Species	Common name	Conservation status	Protected Matters (DoEE	Threatened fauna (DBCA	NatureMap (DBCA 2019a)	ALA (ALA 2019)	Ecosmart Ecology (2012)	Phoenix (2019)	MWH Australia (2017, 2018)	This survey
Suidae	**Sus scrofa*	Pig				•					
Equidae	**Equus asinus*	Donkey		•						•	5
	**Equus caballus*	Horse							•	•	
Canidae	**Canis familiaris*	Dog/Dingo		•			8		•	•	9
	**Vulpes vulpes*	Red Fox		•				•			
Felidae	**Felis catus*	Domestic Cat		•		•		•	•	•	3



APPENDIX F

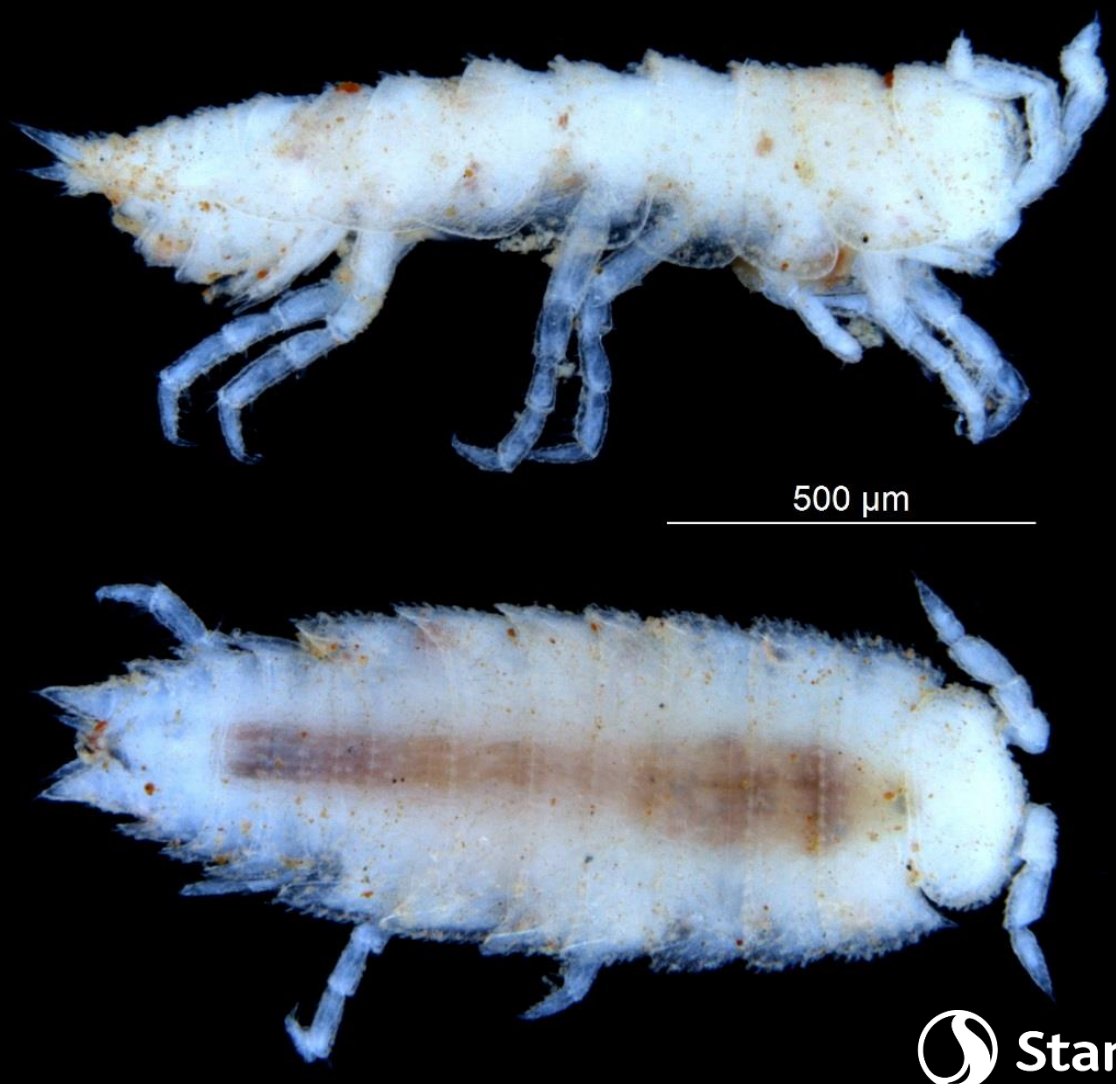
Stantec – Subterranean Fauna Level 2 Assessment, Leonora Gold Project 2021

FINAL REPORT

LEONORA GOLD PROJECT SUBTERRANEAN FAUNA LEVEL 2 ASSESSMENT

PREPARED FOR **KIN MINING NL**

March 2021



Stantec

Paraplatyarthrus nr *subterraneus* OES25

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Executive Summary

Kin Mining NL (Kin) is evaluating options to develop the Leonora Gold Project (LGP) that comprises three historically mined areas (Mertondale, Cardinia and Raeside). The LGP is located in the Eastern Goldfields between seven and 40 kilometres (km) east of the town of Leonora. The principal activities planned for the LGP include open pit mining within three main project areas: Greater Cardinia (comprised of Cardinia, Helens, and Rangoon), Mertondale, and Raeside.

Development of the LGP could potentially directly impact subterranean fauna through the physical removal of habitat from mining excavation and groundwater drawdown from the dewatering required to access the resource. The main objective of this assessment was to determine if subterranean fauna would represent a key environmental factor. This report presents the findings of the stygofauna and troglofauna surveys of the LGP Study Area and recommendations for future work to further investigate the subterranean fauna values present to support future applications for regulatory approval of the LGP.

Survey Effort

The stygofauna survey effort consisted of 100 stygofauna net haul samples collected from 76 sites across the LGP Study Area from four surveys: October 2008, December 2008, March 2009, and January–February 2017 (**ES Table 1**). The majority of samples (84) were collected from within proposed mining impact areas in or near proposed pits in the Cardinia, Helens, Mertondale, Raeside, and Rangoon project areas. Non-impact samples (16) were also collected from reference sites outside proposed mining pit boundaries and modelled groundwater drawdown zones.

The troglofauna survey effort consisted of 54 litter trap samples and 72 scrape samples collected from 70 sites (**ES Table 1**). Sixty-four troglofauna litter traps were deployed over one survey phase for seven weeks from January 31 to March 21, 2017, however, 10 traps could not be retrieved. Scrape samples were also collected as part of the stygofauna sampling undertaken in October and December 2008, March 2009, and January-February 2017. A large majority of samples (122; 97 %) were collected from within proposed mining impact areas. Only four non-impact samples (4) were able to be collected from reference sites outside the proposed mining impact areas.

ES Table 1: Subterranean fauna sample effort.

Project Area	Stygofauna		Troglofauna	
	Impact	Non-Impact	Impact	Non-Impact
Cardinia	36	0	53	0
Helens	18	0	35	0
Rangoon	16	0	30	0
Mertondale	8	10	0	2
Raeside	6	2	4	2
Southern Regional	0	4	0	0
Totals	**84**	**16**	**122**	**4**

Stygofauna Assessment

Mertondale and Raeside Project Areas

No stygofauna were recorded from the 30 samples collected from the Mertondale and Raeside project areas. The subterranean habitat in both areas was found to not be prospective for stygofauna as the overlying regolith was clay dominated and deep, extending to below the SWL, offering limited interstitial pore space and hydrological exchange. The non-prospective habitat in both Mertondale and Raeside projects was verified by two rounds of sampling that failed to record any stygobitic species. The

development of the Mertondale and Raeside project areas will not pose a conservation risk to any stygofauna species as these areas were found not to host any stygofauna values.

Greater Cardinia Project Areas

From the Greater Cardinia project areas, five stygobitic species, from three higher level taxonomic groups, Bathynellacea, Copepoda and Oligochaeta, were recorded from the 2008, 2009 and 2017 surveys. Stygofauna were recorded from 22 of the 61 sites sampled, and 23 of the 70 samples collected.

The majority of stygofauna records occurred from within the north-south trending shear structures present, however, this is also reflects the greater survey intensity as a result of the higher number of available sites due to the increased drilling effort targeting the gold mineralisation hosted within the shear zones. Stygofauna were also collected from areas beyond the shear structures present along the Cardinia Creek and associated tributaries with coarser grained alluvial and weathered and fractured rock geological units present.

The Bathynellacea was the most species rich group with 3 species recorded: *Atopobathynella* OES2 was relatively commonly collected (122 specimens from 10 sites) and widespread in distribution throughout the Greater Cardinia project areas; *Atopobathynella* OES29 was recorded from only two sites located within Rangoon; Bathynellidae OES28 found from three sites in Cardinia. The Copepoda was represented by a single stygobitic species, *Hirtaleptomesochra "multispinosa"* that was relatively common with 448 specimens collected in 20 samples from 18 sites from across the Greater Cardinia project areas. The Oligochaeta was represented by one stygobitic species, Phreodrilidae OES22, collected from four sites across Cardinia and Rangoon.

The findings for the Greater Cardinia project areas are summarised as follows:

- Cardinia — From a stygofauna ecology perspective, Cardinia appears to be divided into two distinct areas with different stygofauna values as a result of the southern-most dolerite dyke in the project area that intrudes along, east to west, the southern boundary of the Lewis pit:
    - *Cardinia South* — Four stygobitic species were recorded from 10 of the 24 samples taken, and 9 of the 18 sites sampled. These were: Bathynellidae OES28 and *Atopobathynella* OES2, *Hirtaleptomeshchra "multispinosa"* and Phreodrilidae OES22. Three species, *Atopobathynella* OES2, *Hirtaleptomeshchra "multispinosa"* and Phreodrilidae OES22, were also recorded from other Project Areas (Helens and Rangoon).
    - Cardinia North — No stygofauna species were recorded from the 12 samples taken from 11 sites.
- Helens — Three stygobitic species were recorded from 5 of the 18 samples taken and 5 of 17 sites sampled. These were: *Atopobathynella* OES2, *Hirtaleptomeshchra "multispinosa"* and Phreodrilidae OES22. All three species were also recorded from other Project Areas (Cardinia and Rangoon).
- Rangoon — Three stygobitic species were recorded from 8 of the 16 samples collected and 8 of 15 sites sampled. These were: *Atopobathynella* OES2, *Atopobathynella* OES29, and *Hirtaleptomeshchra "multispinosa"*. *Atopobathynella* OES29 was recorded from two Rangoon sites only. The remaining two species were also recorded from other Project Areas (Cardinia and Helens).

The broader distributions of *Atopobathynella* OES2, Bathynellidae-OES28, *Hirtaleptomesochra "multispinosa"* and Phreodrilidae OES22 beyond the shear structures hosting the target mineralisation, indicate that stygofauna habitat present is not restricted to the deposit areas only. The stygofauna findings, in conjunction with the habitat assessment, indicated that the main habitat hosting the Cardinia Creek stygofauna assemblage occurs within the fractured rock aquifer systems in association with the main Cardinia Creek drainage line and associated tributaries where the overlying alluvial/colluvial regolith is thinner and less clay dominated. The presence of a thinner overlying alluvial/colluvial regolith would allow greater hydrological exchange (i.e. infiltration of resources, such as dissolved oxygen and nutrients) with the underlying aquifer system.

The degree of hydrological exchange with alluvial/colluvial and fractured rock aquifer systems has been shown to greatly influence the distribution and diversity of stygofauna assemblages, with diversity higher in areas with greater rates of exchange compared to areas lacking surface water interactions. The coarser alluvial sediments present along the main drainage lines would also not only provide zones of greater hydrological exchange, but would also provide suitable habitat when saturated. Further away from the main drainage lines, the prospectiveness of the habitat for stygofauna is considered to decrease as the degree of hydrological exchange declines, often as a result of the increasing depth and clay content of the overlying regolith.

All five stygobitic species recorded are of potential conservation concern because each of their current recorded distributions have not been demonstrated to extend beyond the likely proposed impact zones associated with pit excavation and associated pit dewatering groundwater drawdown. The distribution of the stygofauna assemblage associated with the upper Cardinia Creek catchment is considered likely to extend beyond the LGP impact zone along the Cardinia Creek. There is a likelihood that the distribution of the Cardinia Creek stygofauna assemblage may extend as far southwards to the main Raeside palaeochannel drainage system, approximately 25 km southwards of the Cardinia project area. However, targeted sampling would be required to demonstrate the broader distribution of the Cardinia Creek catchment stygofauna assemblage.

Troglofauna Assessment

Mertondale and Raeside Project Areas

No troglofauna were recorded from the 14 samples collected from the Mertondale and Raeside project areas. The unsaturated subterranean habitat in both project areas was found to not be prospective for troglofauna as the overlying regolith was clay dominated and deep, extending to below the SWL, offering limited to no habitat in the absence of sufficient interstitial pore space for colonisation and which would restrict the influx of resources (e.g. oxygen and nutrients). The non-prospective habitat in both Mertondale and Raeside projects was verified by scrape samples, collected over two sample rounds that failed to record any troglofauna species. The development of the Mertondale and Raeside project areas will not pose a conservation risk to any troglofauna species as these areas were found not to host any troglofauna values.

Greater Cardinia Project Areas

From the Greater Cardinia project areas, six troglobitic species, from four higher level taxonomic groups, Diplura, Isopoda, Pseudoscorpiones and Symphyla, were recorded from the 2008, 2009 and 2017 surveys. The net haul scrape sample method was more efficient in collecting troglofauna species than the litter trap sample method that failed to collect any troglofauna. Troglofauna were recorded from 9 of the 67 sites sampled, and 9 of the 117 samples collected.

The majority of troglofauna records occurred from within the unsaturated regolith associated with the north-south trending shear structures present, however, this is likely to reflect the greater survey intensity completed as a result of the higher number of available sites due to the increased drilling effort targeting the gold mineralisation hosted within the shear zones. Troglofauna were also collected from within the unsaturated alluvial/colluvial sediments present near the Cardinia Creek and associated tributaries.

The isopod order was the most diverse group recorded with 44 specimens collected representing two species, *Troglarmadillo* OES1 (Armadillidae) and *Paraplatyarthrus* nr *subterraneus* OES25 (Paraplatyarthridae). Both isopod species exhibit relatively widespread distributions within the Greater Cardinia Area, occurring across multiple project areas. The remaining four troglofauna species recorded, the dipluran *Injapx* OES6, the pseudoscorpion *Tyrannochthonius* OE17, and both symphylan species, *Hanseniella* nr *indecisa* and *Symphylella* nr *cylindrica*, are singletons (known from a single specimen only).

The findings for the Greater Cardinia project areas are summarised as follows:

- Cardinia — From a troglofauna ecology perspective, Cardinia appears to be divided into two distinct areas with different troglofauna values, likely as a result of the southern-most dolerite dyke in the project area that intrudes along, east to west, the southern boundary of the Lewis pit:
    - *Cardinia South* — Four troglofauna species were recorded from 2 of the 34 samples taken, and 2 of the 18 sites sampled. These were: *Injapx* OES6, *Troglarmadillo* OES1, *Paraplatyarthrus* nr *subterraneus* OES25, and *Hanseniella* nr *indecisa*. Three species, *Injapx* OES6, *Troglarmadillo* OES1 and *Paraplatyarthrus* nr *subterraneus* OES25, were collected sympatrically in the same sample from site BH006. Both *Troglarmadillo* OES1 and *Paraplatyarthrus* nr *subterraneus* OES25 were recorded from other project areas (Helens and Rangoon).
    - *Cardinia North* — No troglobitic species were recorded from the 20 samples taken from 11 sites.
- Helens — Three troglofauna species were recorded from 3 of the 35 samples taken and 3 of 19 sites sampled. The species recorded were: *Troglarmadillo* OES1, *Tyrannochonius* OE17, and *Symphylella* nr *cylindrica*. *Troglarmadillo* OES1 and *Tyrannochonius* OE17 were collected sympatrically from Helens Well. *Troglarmadillo* OES1 was recorded from other project areas (Cardinia and Rangoon).
- Rangoon — Two troglofauna species were recorded from 4 of the 28 samples taken and 5 of 19 sites sampled. The species recorded were *Paraplatyarthrus* nr *subterraneus* OES25 and *Troglarmadillo* OES1. Both species were collected sympatrically from three Rangoon sites and occur in other project areas (Cardinia and Helens).

The troglofauna findings and habitat assessment indicated that the prospective habitat present in the LGP Study Area was not confined to the shear zones but also occurred in areas, similar to stygofauna, that were near to the Cardinia Creek drainage line where the upper part of the weathered and fractured rock geological units remained unsaturated and overlain by relatively thin alluvial/colluvial strata that was less clay dominated. Therefore, sufficient interstitial pore space would be present in the weathered and fractured rock as well as within the overlying coarser grained alluvial/colluvial strata. In the other project areas that are more distant from the main drainage lines, the overlying clay dominated regolith extends to below the SWL offering limited to no habitat in the absence of sufficient interstitial pore space.

The proposed development of the Greater Cardinia LGP pits and associated groundwater drawdown pose varying degrees of direct impact and subsequent conservation risk to all six troglobitic species recorded. The distributions of all six troglobitic species recorded have not been demonstrated to extend beyond the proposed direct impact zones. As with the stygofauna findings, the seemingly restricted distribution of the troglofauna assemblage to the proposed impact areas is an artefact of the disproportionate sampling effort conducted. All samples collected in the upper Cardinia Creek catchment area, encompassing the Greater Cardinia project areas, were from within the proposed impact zones. The distribution of the troglofauna assemblage associated with the unsaturated alluvial/colluvial and weathered and fractured rock geological units within the upper Cardinia Creek catchment is considered likely to extend beyond the LGP impact zones. However, targeted sampling would be required to demonstrate the broader distribution of the Cardinia Creek catchment troglofauna assemblage.

Conclusion and Recommendations

The assessment found that stygofauna and troglofauna do not represent environmental factors for the development of the Mertondale and Raeside components of the LGP.

The Greater Cardinia project area was found to host moderately diverse stygofauna and troglofauna assemblages. The proposed development of the Greater Cardinia LGP pits does pose varying conservation risks to all subterranean fauna species recorded as none of the species have been collected from beyond the proposed impact zones. Therefore, stygofauna and troglofauna do represent key environmental factors for the proposed Greater Cardinia component of the LGP and will require further assessment.

The subterranean fauna sample effort did provide a reliable characterisation of the stygofauna and troglofauna values present within the LGP Study Area in relation to the proposed direct impact zones.

However, the survey effort in the Greater Cardinia project areas lacked the geographical coverage required to investigate the potential broader distribution of the Cardinia Creek stygofauna and troglofauna assemblages beyond the proposed impact zones. At the time of the 2017 survey round no suitable sample sites beyond the proposed impact zones within the Cardinia Creek catchment were known to be present.

It is recommended that additional targeted sampling is undertaken to demonstrate that the distribution of the Cardinia Creek stygofauna and troglofauna assemblages do extend more broadly within the Cardinia Creek catchment beyond the proposed impact areas. However, suitable bores are required to be found or made available to enable further sampling in non-impact reference areas to the southwest and northeast of the Greater Cardinia Project Area.

Kin Mining NL

Leonora Gold Project Subterranean Fauna Level 2 Assessment

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APPENDICES

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1. Introduction

Kin Mining NL (Kin) is evaluating options to develop the Leonora Gold Project (LGP) that comprises three historically mined areas (Mertondale, Cardinia and Raeside) and a proposed haul road that links the three mining areas. The LGP is located within the Eastern Goldfields between seven and 40 kilometres (km) east of the town of Leonora (**Figure 1-1**). The principal activities planned for the LGP include (**Figure 1-2**):

- Open pit mining within three main project areas:
  - Greater Cardinia — comprised of three sub-project areas:
    - *Cardinia* — comprised of one existing and seven proposed pits; Bruno (existing pit; 5.95 ha), Bruno East (1.25 ha), Bruno Extension (4.7 ha), Bruno-Lewis Link (24 ha), Kyte (3.95 ha), Lewis (12.1 ha), Lewis South (3.72 ha), and Lewis Far South (1.41 ha);
    - *Helens* — comprised of five proposed pits; Fiona (1.79 ha), Helens East (2.03 ha), Helens Main (6.29 ha), Helens Mid (1.74 ha), and Helens South (2.88 ha); and
    - *Rangoon* — comprised of four proposed pits; East Lynne (1.07 ha), Rangoon (4.44ha), Rangoon North (0.62 ha), and Rangoon West (1.62 ha);
  - Mertondale — comprised of proposed pit expansions of three existing pits: Mertondale 2 (6.29 ha), Mertondale 3 / 4 (34.36 ha), and Mertondale 5 (31.72 ha); and
  - Raeside — comprised of proposed pit expansion of one existing pit, Forgotten Four (6.22 ha).
- Additional associated mining infrastructure such as on-site Processing Plant facility, waste rock landforms (WRL), a tailings storage facility (TSF), access and haul roads, and water management infrastructure (pipelines, bunds, drains, storage ponds).

Development of the LGP could potentially directly impact subterranean fauna through the physical removal of habitat from mining excavation and groundwater drawdown from the dewatering required to access the resource. This report presents the findings of the stygofauna and troglofauna surveys of the LGP Study Area and recommendations for future work to further investigation of the subterranean fauna values present to support future applications for regulatory approval of the LGP.

1.1 Scope and Objectives

The main objective of this assessment was to determine if subterranean fauna would represent a key environmental factor. The subterranean fauna values were assessed in the context of an earlier draft of the proposed LGP footprint and surrounding areas and to investigate the potential environmental impacts and conservation risks for any species recorded within the Study Area, posed by the removal or modification of potential subterranean fauna habitat. The assessment was designed in accordance with the Western Australian Environmental Protection Authority (EPA) Technical Guidance Statements (2016a, b) that outline considerations and sampling methods for subterranean fauna in Western Australia. The specific objectives of the assessment were to:

- document the species richness, abundance and distribution of subterranean fauna species within the Study Area;
- evaluate the potential of habitat to support subterranean fauna within the Study Area;
- identify potential risks to obligate subterranean fauna from the proposed mining activities;
- consider the conservation significance of any subterranean fauna assemblage or species occurring within the Study Area to determine if subterranean fauna will represent a key environmental factor; and
- provide recommendations for future targeted survey work to further investigate subterranean values in relation to the recent expansion of the proposed LGP footprint post earlier subterranean fauna surveys.

The scope of this subterranean fauna assessment encompassed a literature review, database searches and a Level 2 Baseline subterranean fauna survey.

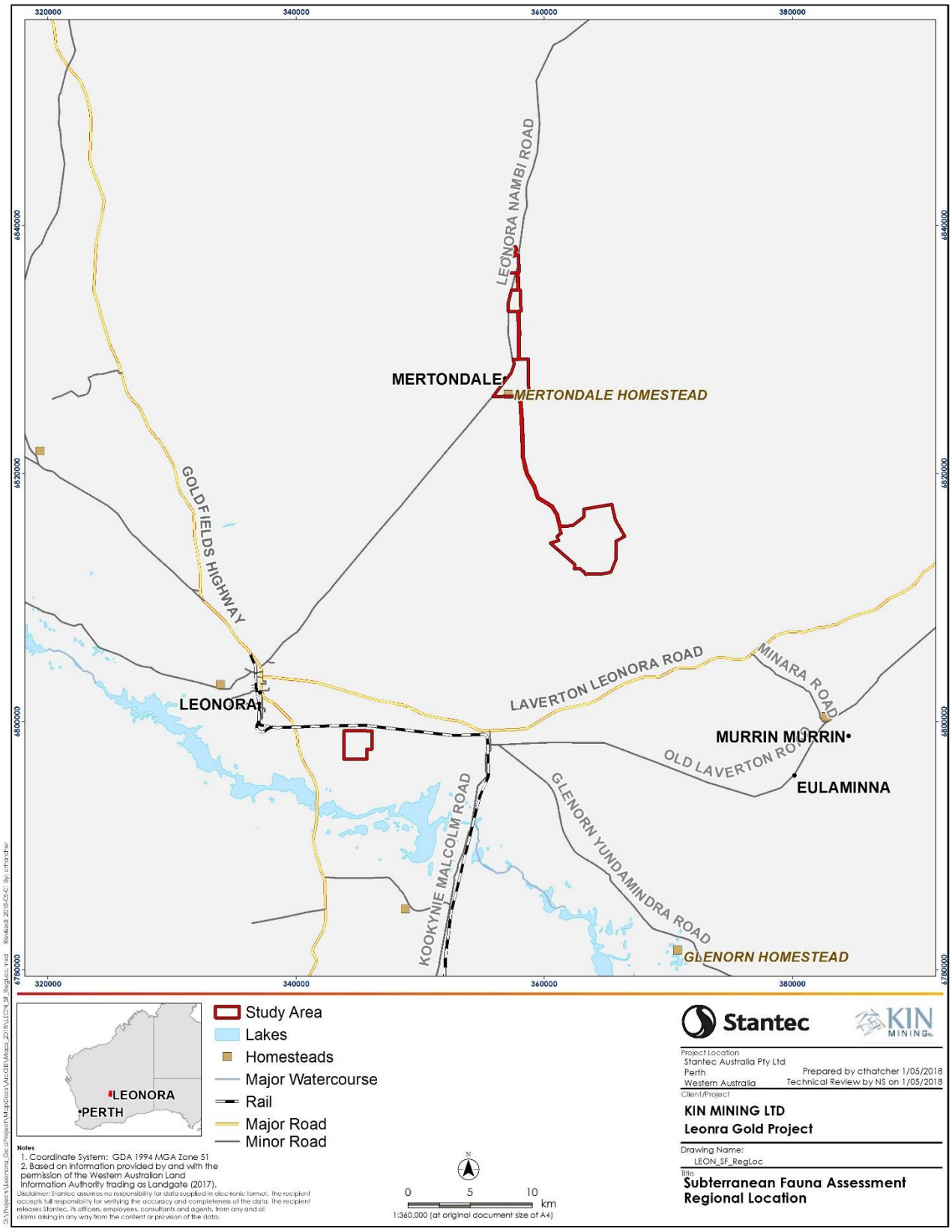


Figure 1-1: Regional location of the Leonora Gold Project and extent of Study Area.

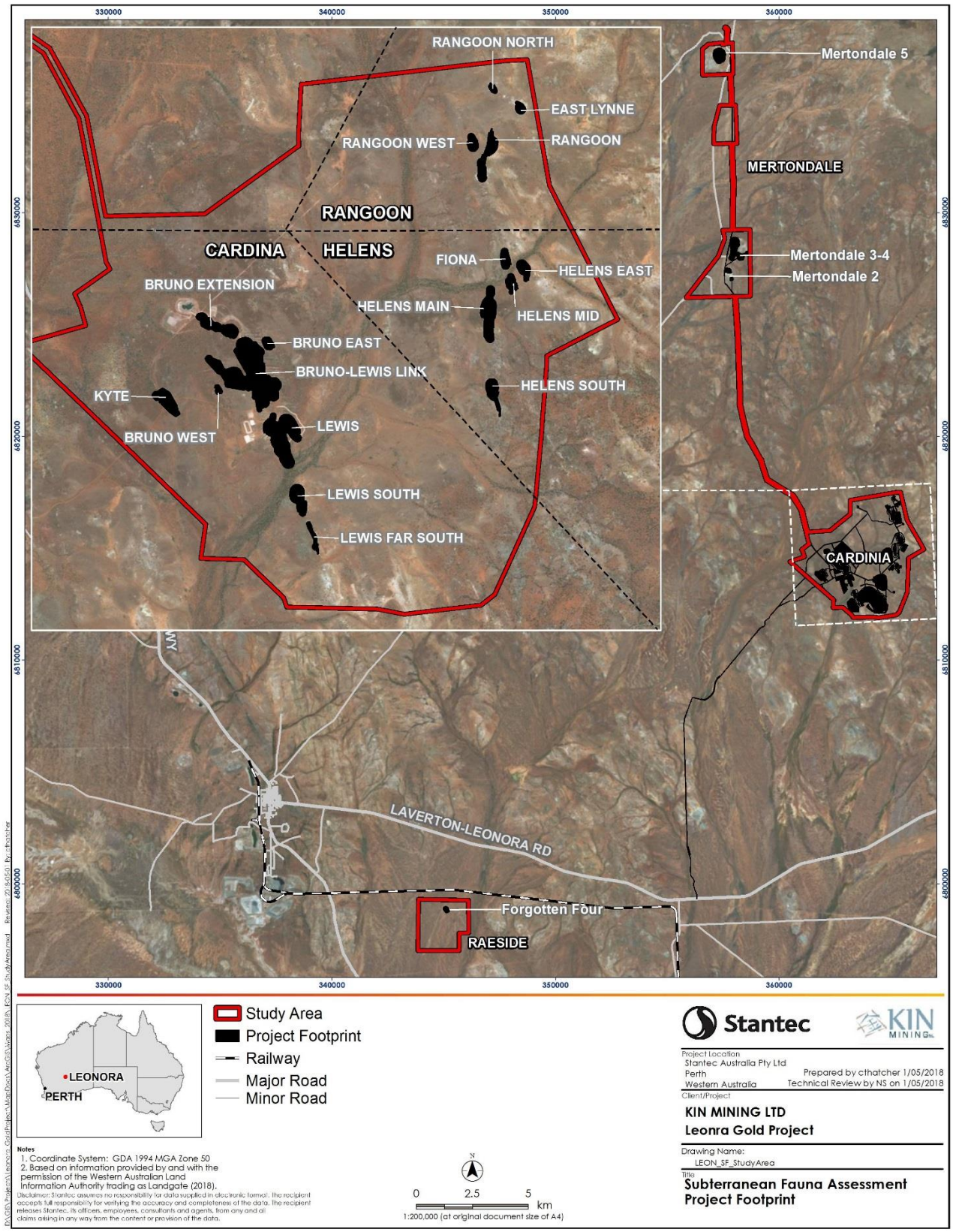


Figure 1-2: Proposed Leonora Gold Project Footprint within the Project Study Area.

2. Existing Environment

2.1 Biogeographic Region

As defined by the Interim Biogeographic Regionalisation for Australia (IBRA), the Project Area is located in the East Murchison (MUR1) subregion of the Murchison bioregion in Western Australia (Department of Sustainability Environment Water Population and Communities 2012a, b). This subregion consists of extensive areas of elevated red/red-brown desert sandplains with minimal dune development, breakaway complexes and internal drainage and saline lake systems associated with occluded palaeodrainage systems which have been found to host diverse subterranean fauna assemblages (Cooper *et al.* 2002, Humphreys 2008, Outback Ecology 2008, 2011b, 2012b, c, d, Subterranean Ecology 2011a).

2.2 Land Use

The dominant land use (85%) within the Eastern Murchison subregion is grazing of sheep and cattle on native pastures (Australian Natural Resources Atlas 2010, Cowan 2001). Other land uses include Unallocated Crown Land (UCL), Crown reserves, and mining (predominantly gold and nickel). Most mining lease areas in the subregion, including the Project Area are still required to be stocked, as they are on pastoral leases which come under the Pastoral Lands Act (Cowan 2001).

Conservation estate was reported to make up 1.4% (Australian Natural Resources Atlas 2010) to 1.8% (Cowan 2001) of the Murchison bioregion. More recently, a comprehensive land acquisition program has contributed additional land for conservation, and in 2009 land vested in reserves had increased to 8% (Department of Environment and Conservation 2010).

2.3 Climate

The region has an arid climate, with hot summers and cool winters (Gentilli 1979) (**Figure 2-1**). Limited annual rainfall across the region, averaging approximately 220 mm, coincides with high evaporation rates (2,400 mm/yr) and is generally characterised by a bimodal distribution (Beard 1976). Winter rainfall is typically associated with low-pressure frontal systems from the south and tends to be widespread and of variable intensity. Summer rainfall is mainly linked to local thunderstorms or the influence of tropical cyclones to the north (Beard 1990, Pringle *et al.* 1994).

Rainfall data from Leonora Airport Weather Station (012241) highlights the variability in rainfall patterns (**Figure 2-2**). While the mean rainfall for the local Leonora area is approximately 238 mm per annum, rainfall received at Leonora Airport in 2017 was 438 mm, over 1.8 times the yearly average (Bureau of Meteorology 2017). The well above average rainfall recorded was largely due to tropical systems moving south early in the year with 381 mm received from January and April. Rainfall received in 2008 (188 mm) and 2009 (210 mm) were below average. The minimum and maximum temperatures recorded in 2008, 2009 and 2017 were largely consistent with the mean temperatures recorded since 1949.

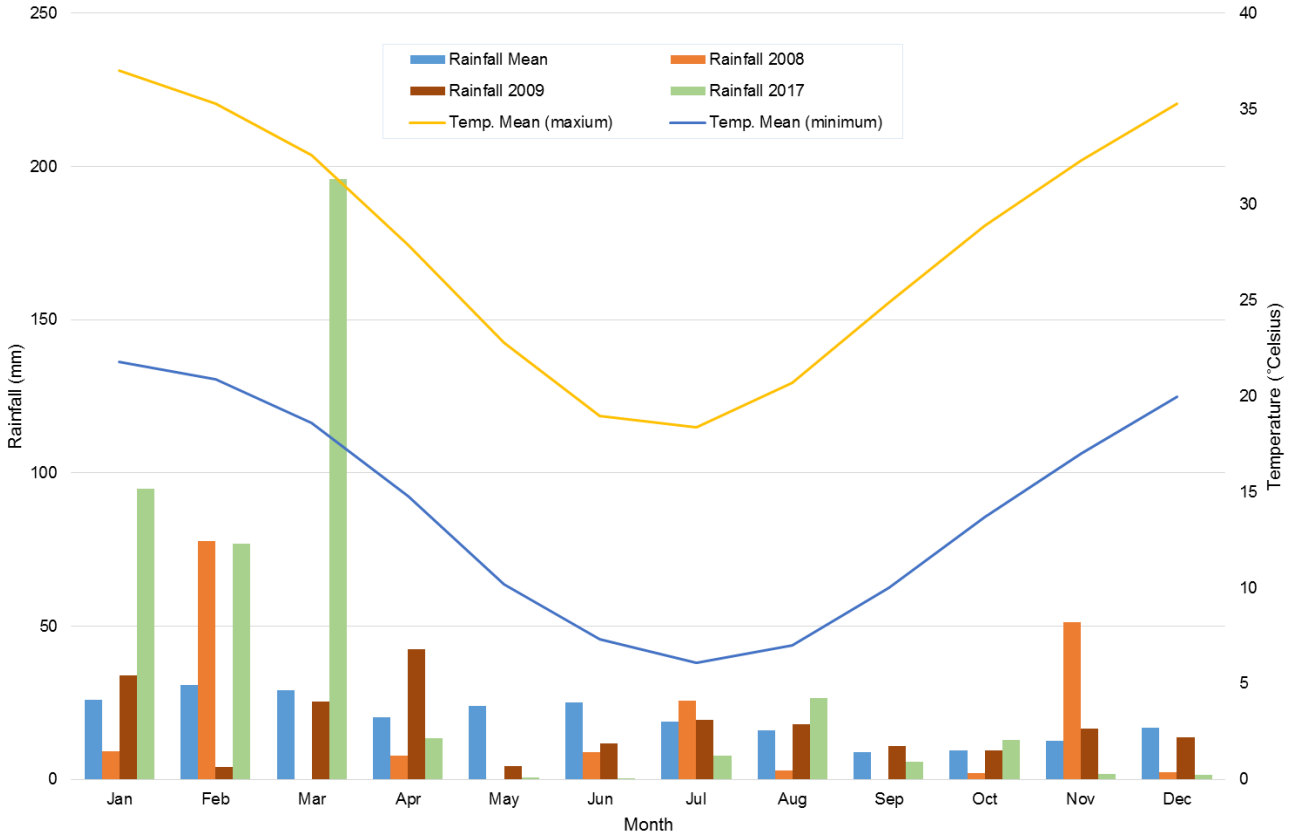


Figure 2-1: Long-term average monthly rainfall, minimum and maximum temperatures for Leonora Weather Station (012046; 1898 to 2006) and Leonora Aero Weather Station (012241; 2007 to 2017) (Bureau of Meteorology 2017).

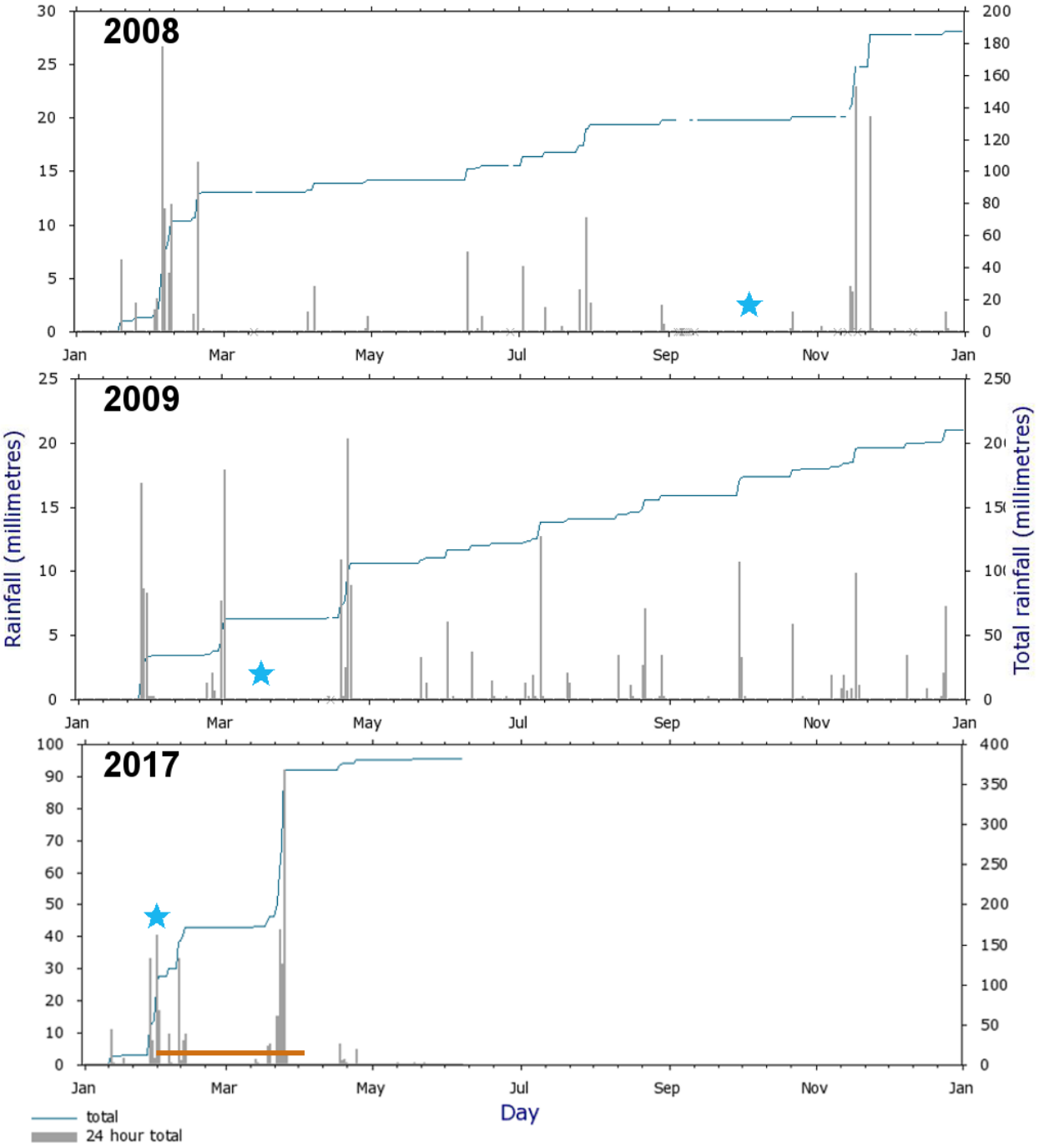


Figure 2-2: Rainfall data recorded for Leonora Aero Weather Station (Station no. 012241) in 2008, 2009 and 2017 (Bureau of Meteorology 2017). Blue stars indicate when stygofauna net haul / troglofauna scrape samples were collected; orange bar indicates period of troglofauna litter trap deployment.

2.4 Geology

The northeastern Goldfields Region is characterised by north-trending greenstone belts that are intruded by Archaean granites within the Archaean Yilgarn Craton (Rockwater 2017). The LGP is located in the Eastern Goldfields Province within the Murrin Murrin greenstone belt (Kin Mining NL 2017). The sedimentary greenstones and volcanic geology present in the LGP Study Area have been extensively folded, with low to medium grade metamorphism, intruded by granitoids, and subjected to major faulting events along northerly trends (Kin Mining NL 2017).

The gold mineralisation targeted by the LGP occurs primarily in north-south striking shear zones. The Greater Cardinia deposits occur within three parallel north-south shear zones. Within the Cardinia area, the eastern edge of the Bruno-Lewis system has been intruded by a dolerite sill with mineralised structures evident as quartz-ironstone veining. Mineralised zones at Helen's and Rangoon are associated with narrow (<5m wide) steeply dipping zones of shearing and quartz vein development. Mineralisation within the Raeside prospect is hosted in a series of stacked, irregular, sub-parallel structures that dip shallowly to the east. Higher gold grades are generally associated with increased quartz/carbonate veining and varying levels of iron alteration. Widths of massive veining are generally less than a metre. The Mertondale deposits are hosted within the Mertondale Shear Zone, a major regional structure. The Mertondale deposits span approximately 12 km of strike in length within the parallel eastern and western branches of the Mertondale Shear, from Merton's Reward in the south to Mertondale 5 in the north (Kin Mining NL 2017). Bedrock to the west of the Shear comprises Archaean age conglomerates, while bedrock to the east of the shear consists mainly of metabasalts and metadolerites, intruded by Proterozoic dolerite dykes and overlain by felsic volcanic rocks (Stewart, cited in Rockwater Pty Ltd 2009). The gold mineralisation is contained in mylonitic and sheared carbonate or sericite schists and is associated with strong carbonate alteration and disseminated pyrites and arsenopyrites (Rockwater Pty Ltd 1990).

Easterly trending parallel Proterozoic dolerite / gabbro dykes have intruded the Archaean bedrock to the north of both Mertondale 5 and Mertondale 3-4 pits, as well across the Greater Cardinia Area (Rockwater 2017). In the Mertondale area outcropping is poor with generally a deeply weathered profile, commonly to depths of 50 to 100 mbgl along shears and 20 to 50 mbgl adjacent to shears. ocalised elongate deposits of Permian glacial tills occur in southern parts of the LGP. These deposits lie within channels incised into the Archaean bedrock and consist of poorly sorted boulder conglomerates. In the greater project area basement rocks (and, where it occurs, the Permian glacial sediments) are overlain by a thin cover (< 5 m) of Cainozoic alluvium and colluvium sequences. The channels of the modern drainage lines present are composed of Holocene alluvial sands and gravels.

2.5 Hydrology

The LGP is located within the Raeside-Ponton catchment that is situated within the South Western Plateau drainage division. The natural landforms within the region are strongly controlled by bedrock lithology and structure, with large outcrops of granite, known as the East and West Terraces, forming interfluves plateau between the Lake Raeside and Lake Carey drainage systems. Within the upper reaches of Station Creek, the topography is typically subdued, but the pattern of drainage is still strongly influenced by bedrock lithology and structure(Rockwater Pty Ltd 2008). The topography of the area is low to gently undulating plains, rising from around 365 mAHD at Raeside, 410 mAHD at Lewis, 455 mAHD at Mertondale to in excess of 500 mAHD at the catchment divide to the northeast.

All of the surface water drainages in the LGP are ephemeral with significant surface water flows only produced after high-intensity rainfall events, mainly during the summer associated tropical systems that extend southwards (Rockwater Pty Ltd 2009). Drainage channels are wide and generally poorly defined. Given the flat terrain and poorly defined channels, surface water movement is mostly by sheetflow. Heavier rainfall events tend to exceed the infiltration capacity of the soil and produce localised runoff for discrete periods. An investigation of water sources for the Cardinia mine by Resource Investigations (1987) concluded that about four rainfall events of sufficient magnitude to produce surface runoff (12 to 30 mm)

can be expected to occur each year, and that a rainfall event of greater than 30 mm will occur about every two years.

The Mertondale project area lies in the upper reaches of the Station Creek surface water catchment (Rockwater Pty Ltd 2009) (**Figure 2-3**). Surface hydrology at Mertondale is influenced by a bedrock ridge situated about 3 km east of the Mertondale 3/4 pit. This ridge separates the headwaters of westward flowing Station Creek from the headwaters of an un-named creek that drains towards the south and west through the Raeside project area into Lake Raeside, approximately 15 km southeast of Leonora. Other drainage systems associated with LGP areas include the headwaters of Cardinia Creek that drains in a south-westerly direction through the Greater Cardinia project areas towards Lake Raeside. In contrast to the predominantly south-westerly flow direction of the modern surface drainage in the project area, the Raeside palaeochannel flow occurs in a south-easterly direction. The existing Mertondale pits are located near the western margin of the Carey palaeochannel, but do occur within the Raeside palaeochannel catchment system.

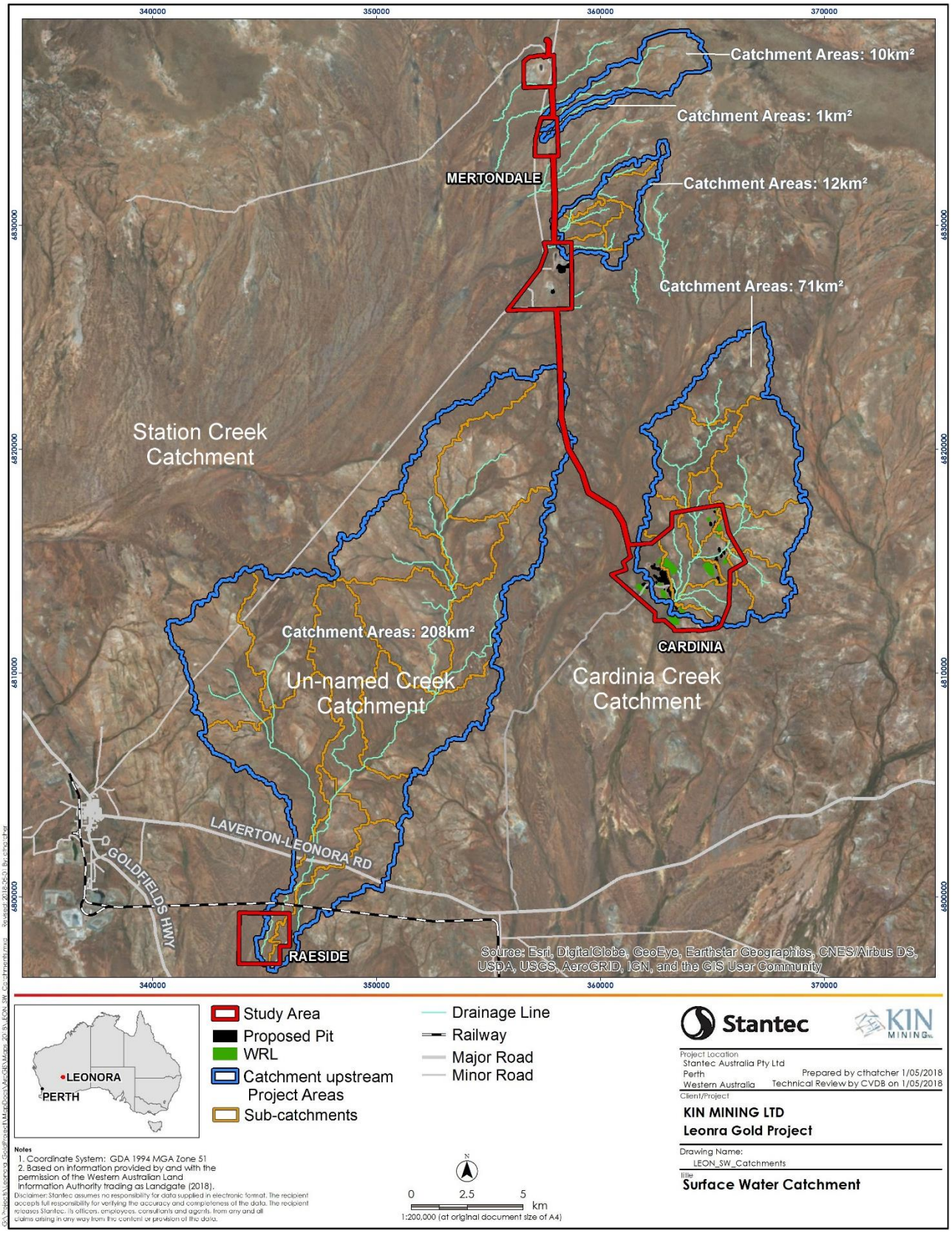


Figure 2-3: Catchments associated with the Leonora Gold Project areas.

2.6 Hydrogeology

The geological units present in the LGP Study Area recognised as having potential to host reasonable groundwater resources include (Rockwater 2017):

- Regional shear zones;
- Faults, shears and contacts in the adjoining Precambrian country rock;
- Porous materials formed by weathering of the Precambrian bedrock;
- Permian glacial sediments;
- Tertiary alluvial sediments located in the base of palaeochannels; and
- Quaternary alluvial sands and gravels occupying the channels of major tributary drainages;

Of the recognised units, the north to south trending regional shear zones are considered the most prospective aquifer resource present in the Mertondale and Greater Cardinia areas (Groundwater Development Services (GDS) 2018). Secondary aquifers are hosted within the fractured rock aquifer systems associated with the Precambrian country rocks surrounding the regional shear zones, and within the coarse-grained alluvial sediments associated with the main drainages channels (Groundwater Development Services (GDS) 2018, Rockwater 2017). These geological units are considered the most prospective for stygofauna in the LGP Study Area. No groundwater associated calcrete deposits occur within or near the LGP Study Area.

There are numerous intrusive dolerite dykes that trend west to east, so cut across the north to south trending shear zones, and have very low hydraulic conductivity thereby representing aquitards to groundwater flow along shear zones (Groundwater Development Services (GDS) 2018, Rockwater 2017, Rockwater Pty Ltd 2009). Dolerite dykes are known to occur to the north of Mertondale 5 pit and to the north of Mertondale 3-4 pit (Rockwater Pty Ltd 2009). The depth to groundwater abruptly changes (by approximately 15 m) from north to south, indicating restriction of southerly groundwater flow from the Mertondale Shear towards the Greater Cardinia area. The regional groundwater flow direction across the LGP Study Area is primarily in a north to south direction (Rockwater Pty Ltd 2009).

3. Subterranean Fauna

3.1 Habitat

The prospective habitat for subterranean fauna (stygofauna and troglofauna) is dependent on the presence of voids of suitable size and connectivity to satisfy biological requirements. Subterranean fauna were previously believed to be mostly restricted to karst landscapes that provide a relatively high degree of secondary porosity, but in more recent times have been found to occur in various types of non-karstic geologies and aquifer systems that exhibit suitable voids for colonisation (Humphreys 2008). Stygofauna are now known to occur in non-karstic aquifers in coarse alluvial sediments, fractured rock, pisolites and thin rocky regoliths (Halse *et al.* 2014, Humphreys 2006, 2008, MWH 2016a, Outback Ecology 2014). Likewise, recent surveys have identified troglofauna from non-karstic geologies such as vuggy pisolite ore beds, and fractured and weathered rock formations in the Pilbara and Yilgarn regions (Barranco and Harvey 2008, Bennelongia 2009, Halse et al. 2002, MWH 2015, Outback Ecology 2011b, Subterranean Ecology 2008b).

The extent of subterranean fauna habitat is dependent on the interconnection of sub-surface crevices, fractures and voids, within suitable geological and hydrogeological units and aquifer systems. In addition to allowing for the movement of subterranean fauna, adequate interconnected void spaces and associated high permeability can provide pathways for infiltration (vertical or lateral) of resources such as oxygen and nutrients, key factors influencing subterranean fauna persistence and distribution (Humphreys 2008, Strayer 1994). Geological, hydrological, and hydrogeological studies can give an indication of the extent of subterranean fauna habitat present by providing information on the geological units and structures present, as well as recharge zones, groundwater flow or aquifer characteristics.

3.2 Stygofauna

Stygofauna (groundwater fauna) are predominantly comprised of invertebrates, particularly crustaceans. Other invertebrate stygofauna groups can include gastropods, insects, water mites and worms. In Western Australia, studies have shown that the calcrete and alluvial aquifers associated with palaeodrainage channels of the arid and semi-arid zones can contain rich stygofauna communities. The Pilbara and to a lesser extent the Yilgarn, stand out as global hotspots for stygofauna diversity (Halse *et al.* 2014, Humphreys 2008). Stygofauna can be further classified according to their level of dependency on the subterranean environment:

- stygoxenes are animals that enter groundwaters passively or accidentally;
- stygophiles inhabit groundwaters on a permanent or temporary basis; and
- stygobites are obligate groundwater dwellers (and the focus of this stygofauna assessment).

Stygobites are restricted to their subterranean environment and as such are often classified as short range endemics. Short-range endemic species (SRE's) have geographically restricted ranges of less than 10,000 km^2 and are considered more vulnerable to extinction because of their limited distribution range (Harvey et al. 2011, Harvey 2002). Stygobites can often be distinguished from surface or soil dwelling animals by morphological characteristics typical of a subterranean existence, such as a reduction or absence of pigmentation, absence or reduction of eyes, and the presence of extended locomotory and sensory appendages (Humphreys 2008). They can also be defined by ecological parameters such as longer life history stages, and lower rates of metabolism and fecundity (Cooper et al. 2002, Danielopol and Pospisil 2000).

Ecologically, there are many factors that influence the distribution of stygofauna at a range of habitat and temporal scales (Boulton 2000). Some of the more influential factors at the microhabitat (sediment) scale include suitable interstitial pore size (i.e. provision of connected network of habitable cavities), inflow rates of energy resources (e.g. organic carbon, biofilm growth, prey), and water quality parameters such as temperature, pH, dissolved oxygen and organic carbon levels. At the mesohabitat (catchment) scale, factors include surface water flow patterns influencing infiltration zones and influx rates into the groundwater systems of energy resources or dissolved oxygen according to geomorphological features, as well as interactions with riparian vegetation and parafluvial sediments (Boulton *et al.* 1998, Schmidt *et al.* 2007).

3.3 Troglofauna

Troglofauna (air-breathing subterranean fauna) are often relictual forms related to surface dwelling (epigean) groups and can be distinguished by characteristics associated with a below-ground existence (Humphreys 2000b). Troglofauna can be divided into:

- troglophiles, which carry out most of their lifecycle underground but are able to survive in epigean habitats;
- trogloxenes, which can enter subsurface habitats passively or incidentally; and
- troglobites (the focus of this assessment), which are obligate or permanent subterranean inhabitants (Thurgate et al. 2001) that generally lack pigmentation, are blind (or have reduced eyes), have elongated limbs and may possess enhanced non-visual sensory adaptations (Culver and Sket 2000).

Troglofauna are found worldwide and historically had been generally classified as cave organisms (Culver and Sket 2000). However, the discovery of diverse troglofauna communities inhabiting sub-surface rock fractures in non-karst areas in Europe in the 1980s prompted broader consideration of potential habitat (Juberthie 2000). The most common environments in which troglofauna occur are those that support suitably sized and extensively connected crevices, small cavities or vugs associated with secondary porosity from erosion, fractures and shears zones, that remain relatively humid, an important condition considered to be a key requirement for troglofauna existence (EPA 2003). Like stygofauna, troglobites are restricted to their subterranean environment and often have locally-restricted distributions so most species are considered to

be SRE's that are more vulnerable to extinction because of their limited distribution range (Harvey *et al.* 2011, Harvey 2002).

The most researched areas in Western Australia are the Cape Range and Barrow Island karst cave systems where large, diverse communities have been discovered(Hamilton-Smith and Eberhard 2000, Humphreys 1991, 2000a). However, extensive sampling in areas of the Pilbara Craton has identified diverse troglofauna assemblages from non-karstic geologies such as vuggy pisolite ore beds (Biota 2006, MWH 2014a, b). Diverse troglofauna assemblages are commonly collected from groundwater associated calcrete (i.e. non-pedogenic calcrete) and alluvial/colluvial geologies within palaeodrainage channels of the arid and semi-arid zones, particularly in the Pilbara and Yilgarn regions (Harrison *et al.* 2014, MWH 2015, Outback Ecology 2011b, 2012a, c, Platnick 2008), but less so in the more arid interior of Australia (Outback Ecology 2011c). Less diverse troglofauna assemblages have also been recorded from weathered fractured rock (Outback Ecology 2011a, 2014) and metamorphic mafic rock systems (Bennelongia Environmental Consultants 2009). Continued studies are likely to increase the understanding of prospective troglofauna habitat in Western Australia. It is only recently that troglofauna have become a focus of environmental assessment in Western Australia, and there is still relatively little information on their distribution compared to stygofauna (Eberhard *et al.* 2007, Environmental Protection Authority 2016a).

3.4 Risks and Relevant Legislation

Development and operation of mines in Western Australia pose a number of risks to subterranean fauna and their habitat, which include:

- direct removal of, or disturbance to, habitats through mining excavation;
- lowering the groundwater table through groundwater abstraction for pit dewatering and supply; and
- altering water quality parameters, to levels which may exceed species tolerance limits.

Subterranean fauna are protected under State and Federal legislation, governed by three Acts:

- Biodiversity Conservation Act 2016 (WA) (BC Act);
- Environmental Protection Act 1986 (WA) (EP Act); and
- Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act).

With this legislation in mind, the EPA developed the *Technical Guidance Subterranean Fauna Survey* (2016b)(equivalent to EPA (2013) EAG 12 *Environmental Assessment Guideline for Consideration of Subterranean Fauna in Environmental Impact Assessment in Western Australia*) and the *Technical Guidance Sampling Methods for Subterranean Fauna Survey* (2016a)(equivalent to EPA (2007) *Guidance Statement No. 54A Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia*) which outline considerations and sampling methods for subterranean fauna in Western Australia. These documents provide advice to proponents and the public on the requirements for environmental impact assessment (EIA) and management of subterranean fauna. The assessment reported here was designed in accordance with both the EPA (2016a, b) guidance documents.

Mining proposals that will potentially impact on groundwater, or hypogean habitats that support subterranean fauna, require a risk assessment to ensure mining operations do not threaten the viability of important species or communities. Proponents must demonstrate that any species existing within potential mine-related impact zones also occur outside this area. For taxa restricted to impact zones, a suitable management plan must be developed, which includes ongoing monitoring of subterranean fauna to ensure the persistence of the species.

3.5 Regulatory Survey Adequacy Guidelines

The EPA (2016a) stipulates that the appropriate level of survey depends on the likely presence of subterranean fauna, the degree of impact proposed, and adequacy to reliably inform decisions as part of

the EIA process as to whether a proposal meets the EPA's objective and is tailored to the circumstances of the proposal.

For Level 1 low intensity (pilot) surveys the recommended survey intensity considered to provide a reliable indication of the habitat present hosting subterranean fauna is:

- Troglofauna — 10 to 15 samples; and
- Stygofauna — 6 to 10 samples.

If the findings from a desktop assessment and pilot survey indicate that a project area is not prospective for subterranean fauna then no further survey would be required. If a pilot survey does collect stygofauna and / or troglofauna species, thereby demonstrating that subterranean fauna are a potential environmental factor, then a Level 2 (baseline or comprehensive) survey would be required.

The EPA (2016b) recommends that for Level 2 (baseline) stygofauna surveys in areas that have been demonstrated to host a stygofauna assemblage, a minimum of 40 net haul samples are to be collected over at least two survey seasons from within proposed impact areas. The minimum survey effort is considered to relate to proposed impacts across an interconnected habitat, not a collated impact survey effort of separate habitats that are each likely to host distinct stygofauna assemblages with no, or restricted, gene flow occurring among each system.

For Level 2 (baseline) troglofauna surveys in areas that are likely to host 'significant troglofaunal values', a minimum of 60 litter trap samples deployed over two rounds for a minimum of six weeks each are recommended (EPA 2016b). The definition of 'significant values' is not specified or quantified but has been interpreted to relate to the presence of a relatively diverse troglofauna assemblage in or associated with the proposed development area.

4. Methods

4.1 Database searches and lists

Searches of both federal and state databases were undertaken as part of the desktop review to reveal if any stygofauna or troglofauna taxa had been previously recorded from within or near the Project Area, and to identify if any threatened or priority ecological communities (TEC's and PEC's) were in the vicinity. Search areas were from a central point in the Project Area (28.75547° S, 121.54228°E) using the following database and internet tools:

- Western Australian Museum's (WAM) collection databases were searched for subterranean arachnids, crustaceans and myriapods within a 50 km radius; and,
- Department of Biodiversity, Conservation and Attractions (DBCA) TEC/PEC database was searched for TEC's and PEC's occurring within a 30 km radius to obtain TEC and PEC buffer zones in the Project area.

The following Federal and State government lists were also checked against the database results, to identify any threatened or priority subterranean fauna that may occur within the search area:

- WC Act Schedule Species List;
- EPBC Act TEC List; and
- EPBC Act Threatened Fauna List.

4.2 Literature Review

A literature review was conducted to gather existing information on subterranean fauna from within the vicinity of the Project Area. The review included technical reports, scientific journal articles and government publications. The areas of focus for the literature review were drainage and palaeochannel systems associated with and/or near to the Project Area, as well as calcrete systems associated with the Raeside palaeochannel within approxiamately 75 km of the Study Area.

4.3 Field Personnel and Licences

The field survey methods and sampling effort employed for the LGP subterranean fauna survey followed both the EPA (2016a, b) technical documents. Regulation 17 licences to take fauna for scientific purposes (*Wildlife Conservation Act 1950*, Regulation 17) was obtained from the DBCA prior to survey (Licence Numbers: SF006612 (October 2008), SF006729 (December 2008), SF006780 (March 2009), 08-000278-1 (January-February 2017). Personnel involved in the field sampling were: Dr Erin Thomas and Carly Weston 2008, Dr Nihara Gunawardene and Jay Puglisi (2009), and Dr Nicholas Stevens and Benjamin Leonard (2017).

4.4 Groundwater Properties

Groundwater properties can have an important influence on the occurrence and distribution of stygofauna. A number of basic groundwater physicochemical parameters (electrical conductivity (EC), pH, water temperature, dissolved oxygen (DO), and reduction-oxidation potential (Redox)) were recorded in the field from a water sample collected by a bailer from the upper one to two metres of the bore column using a calibrated YSI water quality meter. If the diameter and inclination of a hole would permit (> 50mm and vertical), groundwater depth profiles were obtained by lowering the YSI water quality meter down the bore and recording water parameters at measured intervals below the standing water level (SWL). The three more important parameters in regard to influencing stygofauna habitat are considered to be pH, DO and salinity.

Standing water level (SWL) was measured as metres below ground level (m bgl) using a Solinst 101 water level meter. The end of hole depth (EoH) was calculated from the number of rotations of the stygofauna sampling winch reel required to retrieve stygofauna nets.

4.5 Stygofauna Assessment

4.5.1 Net Haul Sampling

Stygofauna samples were taken from a mixture of wells, exploration drill holes and bores (collectively referred to hence forth as sites) using haul nets, which have been found to be the most efficient retrieval method (Allford *et al.* 2008). The details of sites sampled are presented in **Appendix A**. Sampling was consistent with the procedures outlined in the EPA (2016b) technical document. The sampling method was as follows:

- samples were collected using two weighted haul nets with mesh sizes of 150 µm and 50 µm. Each net was fitted with a collection vial with a base mesh of 50 µm;
- the 150 µm net was lowered first, to near the bottom of the site;
- once at the bottom, the net was gently raised up and down to agitate the sediments;
- the net was then raised slowly, to minimise the 'bow wave' effect that may result in the loss of specimens, filtering the stygofauna from the water column on retrieval;
- once retrieved, the collection vial was removed, the contents emptied into a 250 ml polycarbonate vial, and preserved with 100% undenatured ethanol;
- this process was repeated three times alternating with three samples with the 50 µm net;
- to prevent cross-contamination, all sampling equipment was washed thoroughly with Decon 90 (2 to 5% concentration) and rinsed with potable water after each site;
- in the field, samples were placed into eskies with ice bricks prior to being transferred into a refrigerated environment on-site at the end of each survey day; and
- samples were couriered back to the Stantec laboratory in Perth, where they were stored in 100% ethanol and refrigerated at approximately minus 20°C.

4.5.2 Stygofauna Survey Effort

A total of 100 stygofauna net haul samples were collected from 76 sites across the LGP Study Area from four surveys: October 2008, December 2008, March 2009, and January–February 2017 (**Table 4-1**, **Figure 4-1, Appendix A**). The majority of samples (84) were collected from within proposed mining impact areas in or near proposed pits in the Cardinia, Helens, Mertondale, Raeside, and Rangoon project areas. Non-impact samples (16) were also collected from reference sites outside proposed mining pit boundaries and modelled groundwater drawdown zones.

The survey effort meets the minimum number of 40 impact samples for a Level 2 baseline stygofauna survey, as recommended by the Western Australia EPA *Technical Guidance Sampling Methods for Subterranean Fauna Survey* (2016a). The survey intensity undertaken, in conjunction with the habitat present, is considered to be sufficient to enable a reliable characterisation to be made of the stygofauna values present in the Project Area and in relation to the proposed direct impact zones in accordance with EPA *Technical Guidance Subterranean Fauna Survey* (2016b).

Table 4-1: Total stygofauna sample effort.

Project Area	Net Haul Samples						Total Samples	Total Sites
	2008	2009	2017	Impact		Non-Impact		
				In Pit	Drawdown >0.5 mbSWL			
Cardinia	5	5	26	18	18	0	36	29
Helens	1	1	16	8	10	0	18	17
Rangoon	1	1	14	3	13	0	16	15
Mertondale	9	9	0	2	6	10	18	9
Raeside	4	4	0	0	6	2	8	4
Southern Regional	2	2	0	0	0	4	4	2
Totals	**22**	**22**	**56**	**31**	**53**	**16**	**100**	**76**

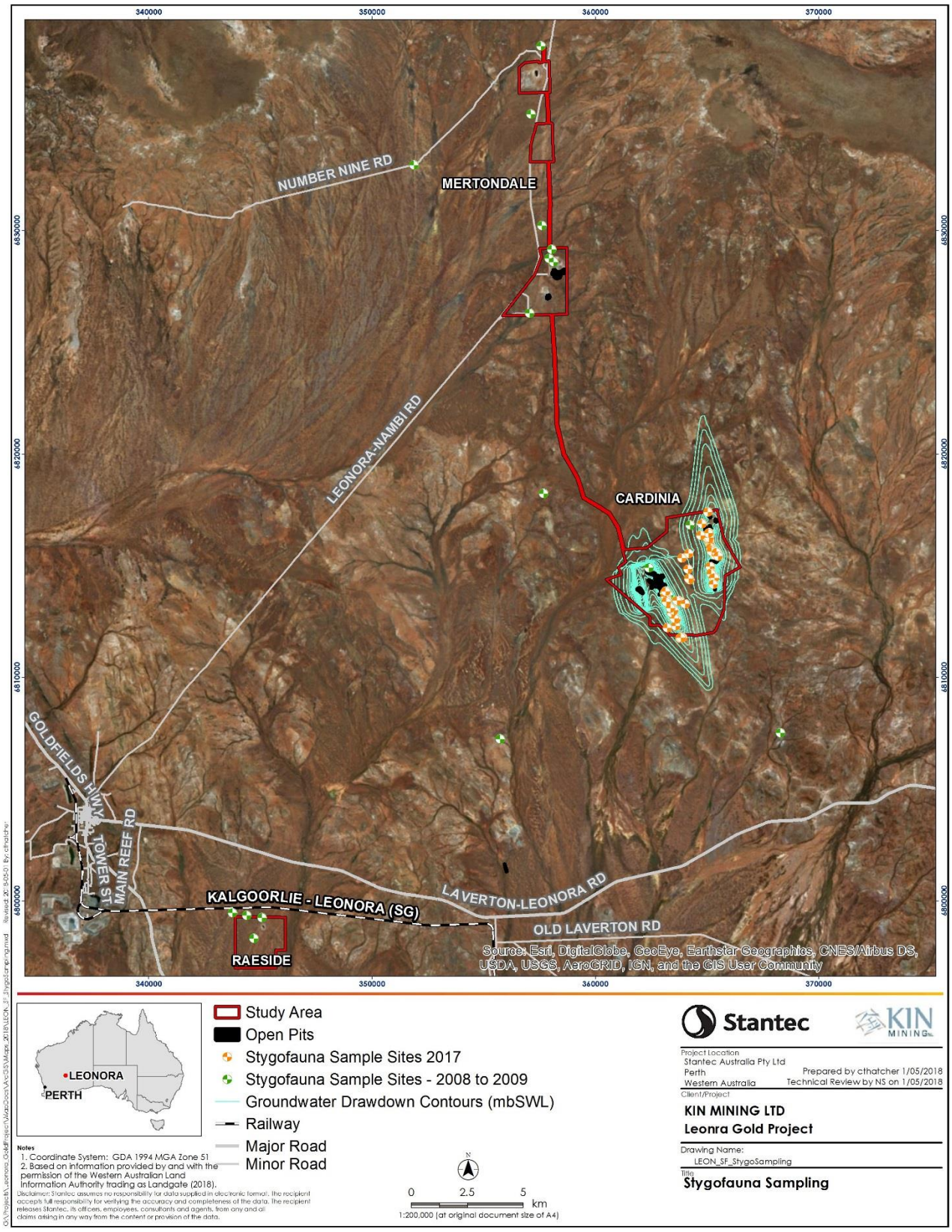


Figure 4-1: Stygofauna sample locations.

4.6 Troglofauna Survey

Troglofauna samples were taken from a mixture of wells, exploration drill holes and bores (collectively referred to hence forth as sites) using litter traps and net haul scrapes. The details of sites sampled are presented in **Appendix A.**

4.6.1 Litter Traps

Troglofauna were sampled using litter traps as follows:

- litter traps were packed with sterilised organic material and sealed to maintain moist, sterile conditions prior to field deployment;
- traps were then moistened with water prior to deployment in sites;
- once installed in the sites, traps were left in place for eight weeks to allow adequate time for colonisation by troglofauna; and
- on retrieval, traps were sealed in zip lock bags, labelled, and couriered to the Stantec laboratory in Perth for sorting and identification.

In the laboratory, troglofauna specimens were extracted from the litter using Tullgren funnels. Litter was placed into funnels, and light and low heat was applied from overhead lamps to create a temperature gradient of approximately 14°C in the litter. This method was applied to encourage any troglofauna, which are light sensitive and prefer humid conditions, to migrate down through the litter as it dried. Troglofauna specimens then fell through a mesh layer into collection vials at the base of the funnels, containing 100% ethanol. After collection of troglofauna in the vials, the litter was removed from the funnels and manually searched under magnification for any troglofauna specimens that might be remaining (**Figure 4-2**).



Figure 4-2: Troglofauna collection and extraction methods: A) Litter trap; B) Tullgren funnels.

4.6.2 Net Haul Scraping

Net haul scraping has been found to be an efficient method for sampling for troglofauna that compliments troglofauna trapping (Halse and Pearson 2014, Outback Ecology 2011b, Subterranean Ecology 2008a). Net haul scraping involves the following:

- lowering of a stygofauna net to the bottom of a dry site or at least 1 m below the standing water level if groundwater is present.
- scraping the net up along the uncased wall surface of the site on retrieval with the aim of dislodging and collecting any invertebrates that may be present.
- this process is repeated four times per site with each scrape sampling a different side of the wall surface of the site.

Scraping for troglofauna can also be conducted simultaneously when sampling uncased bores with water present for stygofauna so that the stygofauna sample also counts as a troglofauna scrape sample. The only difference is the sample effort is greater with six net hauls taken per sample rather than four. Stygofauna sampling of fully-cased bores are not regarded as net haul scrape samples, regardless of whether potential troglofauna taxa may have been collected.

All haul samples were preserved in 100% ethanol prior to shipment back to the Stantec laboratory in Perth for processing. To enhance preservation of specimens and their DNA, samples were kept cool onsite in eskies with ice bricks then refrigerated at the end of each survey day. All samples were then shipped back to Perth in eskies with ice bricks then placed in freezers (at minus 20 Celsius) to further promote fixation of DNA.

4.6.3 Troglofauna Survey Effort

A total of 54 litter trap samples and 72 scrape samples were collected from 70 sites (**Table 4-1**, **Appendix A**). Sixty four troglofauna litter traps were deployed over one survey phase for seven weeks from January 31 to March 21, 2017, however, 10 traps could not be retrieved. Scrape samples were also collected as part of the stygofauna sampling undertaken in October and December 2008, March 2009, and January-February 2017. A large majority of samples (122; 97 %) were collected from within proposed mining impact areas (**Figure 4-3**). Only four non-impact samples (4) were able to be collected from reference sites outside the proposed mining impact areas.

The survey effort undertaken meets the recommended number of 60 samples for a Level 2 comprehensive baseline troglofauna survey, as recommended by the Western Australia EPA *Technical Guidance Sampling Methods for Subterranean Fauna Survey* (2016a). The survey intensity undertaken, in conjunction with the habitat present, is considered to be of a sufficient quantity to enable a reliable characterisation to be made of the troglofauna values present in the Project Area and in relation to the proposed direct impact zones in accordance with EPA *Technical Guidance Subterranean Fauna Survey* (2016b).

Table 4-2: Summary of troglofauna sample effort.

Project Area	Scrape Samples			Litter Trap Samples	Scrape & Litter Trap Samples			Total Samples	Total Sites
	2008	2009	2017	2017	Impact		Non-Impact		
					In Pit	Drawdown >0.5 mbSWL			
Cardinia	3	3	24	23	25	28	0	53	28
Helens	1	1	16	17	15	20	0	35	19
Rangoon	1	1	14	14	5	25	0	30	19
Mertondale	1	1	0	0	0	0	2	2	1
Raeside	3	3	0	0	0	4	2	6	3
Totals	**9**	**9**	**54**	**54**	**45**	**77**	**4**	**126**	**70**

4.7 Sorting and Identification of Specimens

Preserved samples were sorted manually using Leica MZ6, MZ7.5, M80 and M205C stereomicroscopes by Dr Nicholas Stevens and Syngeon Rodman. Once sorted, any potential subterranean fauna specimens found were preserved in 100% ethanol and stored at minus 20°C to ensure viability for future DNA analysis (if required). Taxa were identified by Dr Nicholas Stevens of Stantec, using published and unpublished keys and taxon descriptions. Undescribed taxa were assigned morphospecies names based on morphological features. Bathynellacea species determinations were confirmed with genetic analysis. Copepoda and Ostracoda species were examined by world renown specialist taxonomists, Dr Tom Karanovic and Dr Ivana, respectively. The identification of the pseudoscorpion, *Tyrannochthonius* OE17 was confirmed by Dr Mark Harvey (Western Australian Museum).

4.8 DNA Sequencing

Twelve representative specimens of three bathynellacean morphospecies from the Study Area were sent to Dr Remko Leijs from the South Australian Museum (SAM) for genetic analysis (**Appendix D: D-**1). The main aim of the molecular analyses were test the robustness of identifications based on morphological characters, including juvenile specimens, and align morphospecies with any described and/or previously sequenced taxa.

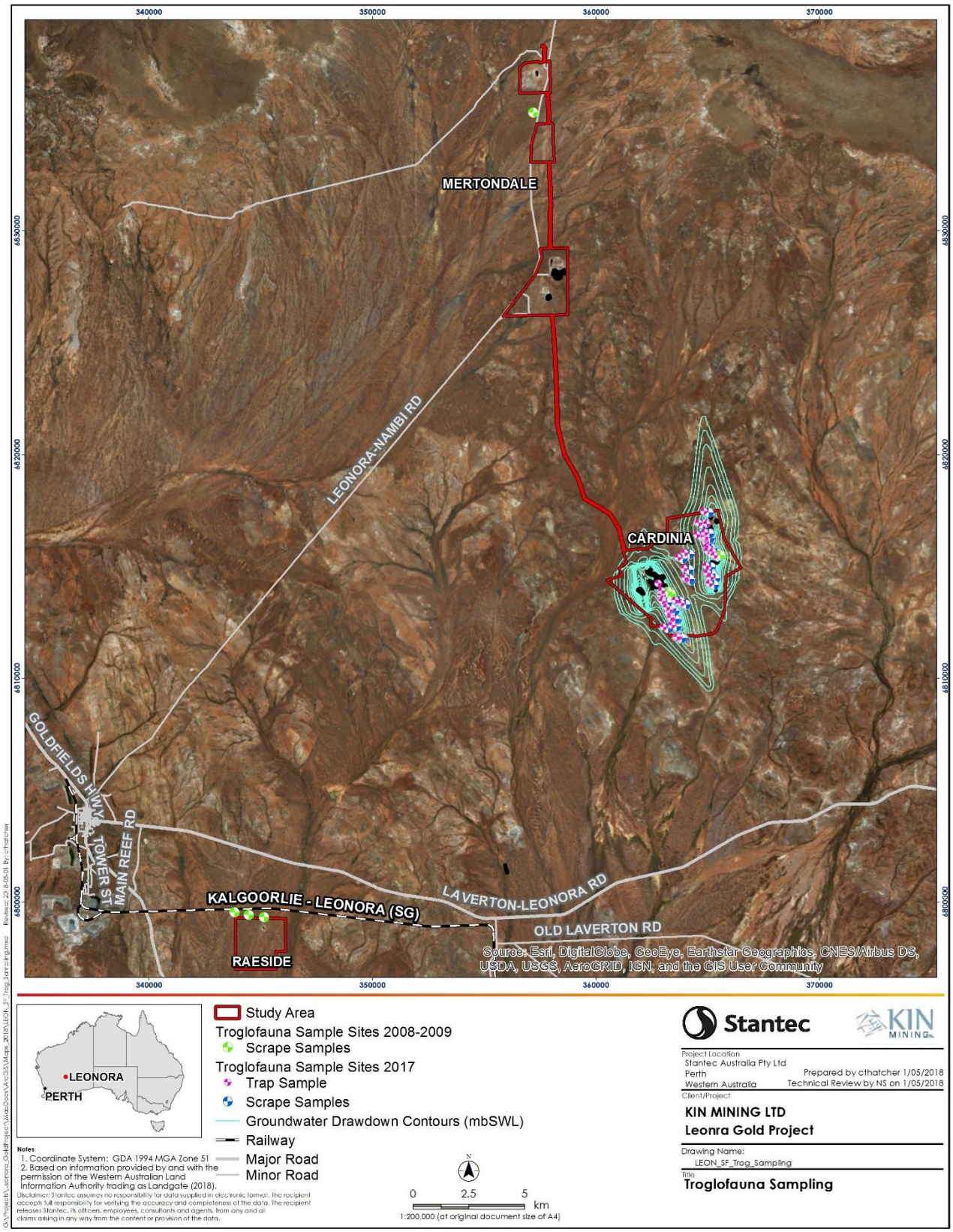


Figure 4-3: Troglofauna sample sites.

4.9 Diversity Analysis

The EstimateS software package (Colwell (2013) Version 9.1.0) was used to assess the survey adequacy by investigating the stygofauna species richness recorded in the LGP area. The species richness was analysed using species accumulation rarefaction and extrapolation curves, and various species richness estimators (using incidence and abundance data).

The species richness analyes provide a statistical evaluation of the proportion of the stygofauna assemblage detected. A range in the number of species predicted to form the assemblage was developed using seven species richness estimators (ACE, Bootstrap, Chao1, Chao2, ICE, Jack 1 and Jack 2). Statistically, it is more robust to show the results of several estimators to provide a range in predicted richness rather than present only one prediction (Hortal *et al.* 2006).

4.10 Limitations of the Assessment

The availability of suitable sites for sampling was limited with few sites present beyond the proposed impact zone. A number of sites sampled that were initially considered to be reference sites were later determined to be within the modelled groundwater drawdown impact zone or within expanded pit boundaries. The disparity in survey effort between the respective impact and non-impact areas has significant implications when considering the distribution ranges of subterranean fauna within the Study Area. The seemingly restricted distributions of subterranean fauna species to within the proposed impact areas can largely be an artefact of the disproportionate sampling effort conducted between reference and impact areas.

Specimens were identified to the lowest taxonomic level where possible. However, specimens may not always be identified to the level of species or morphospecies due to:

- loss or damage of important taxonomic features during collection and/or sorting of specimens;
- lack of adult specimens; or
- limitation in taxonomy, in that the current state of taxonomy for a particular group is insufficiently advanced, and/or relevant taxonomic keys and descriptions are lacking.

While every effort has been made to assess the taxonomy, distribution and conservation significance of the subterranean fauna collected using in-house data collections, publications, publicly available reports, and information provided by specialist taxonomists, some accounts may be limited if specialist information was unavailable.

5. Results

5.1 Database Searches and Literature Review

5.1.1 Database Searches

There were no threatened or priority subterranean fauna species previously noted in the Project Area or surrounds, based on a search of the DBCA's threatened and priority fauna database (DBCA 2018).

A search of the DBCA's threatened and ecological communities database did identify one priority ecological stygofauna community (PEC) within a 30 km radius of a Project Area. The Melita calcrete groundwater assemblage PEC is hosted in the Raeside Palaeodrainage channel on Melita (Sons of Gwalia) Station, 9 km to the west of the proposed Forgotten Four pit in the Raeside project area of the LGP (**Figure 5-1**, **Figure 5-2**) (DBCA 2017). The Melita calcrete stygofauna PEC has been classified as priority 1, under the *Western Australian Wildlife Conservation Act (1950)*, due to the 'poorly known ecological communities' that are 'known from very few occurrences with a very restricted distribution' (DBCA 2018). The Melita calcrete stygofauna PEC occurs close to the Gwalia Mine with the associated 2 km buffer zone encompassing the south-western portion of the mine's infrastructure such as waste rock landforms and tailings storage facility. The proposed development of the LGP, in particular the Raeside project area, does not encroach on the Melita calcrete stygofauna PEC and will not have any impact on the PEC as the PEC is located up-stream of the drainage inflows from the Raeside project area into the Raeside Palaeodrainage channel (**Figure 5-3**).

A search of the WAM Arachnida, Crustacea and Myriapoda databases did not identify any stygofauna or troglofauna records within a 50 km radius of the Study Area. The closest records were beyond the 50km radius and consisted of numerous stygofauna and troglofauna collections from the Sturt Meadows calcrete system (60 km west of the LGP Study Area) (**Figure 5-1**, **Figure 5-2**, **Figure 5-3**).

A search of the DBCA's NatureMap database, and Atlas of Living Australia (ALA) for the Study Area did not return any listings of stygofauna or troglofauna species.

5.1.2 Stygofauna

A number of stygofauna surveys have been undertaken in the area surrounding the LGP (≤100 km), predominantly within calcrete associated aquifers (**Table 5-1**). Stygofauna have been recorded from the Laverton Downs, Melita, Mt Morgan, Nambi, and Sturt Meadows calcrete systems. Calcrete aquifer systems are recognized as providing optimal habitat for stygofauna in the Pilbara and Yilgarn, typically hosting more diverse stygofauna assemblages than regolith or fractured rock associated aquifers (Allford *et al.* 2008, Environmental Protection Authority 2007, Humphreys 2008, Outback Ecology 2012d). Relatively well-studied calcrete systems that have formed in the northern Carey paleodrainage channel, Barwidgee, Hinkler Well, Lake Violet, Uramurdah, and Yeelirrie, each host diverse stygofauna assemblages in excess of 30 stygofauna species with more than 70 species recorded from Yeelirrie, the most intensively sampled calcrete system in the region, if not Australia (Bennelongia 2015, MWH 2015, Outback Ecology 2012b, d, Subterranean Ecology 2011b).

Genetic studies have indicated that calcrete systems can represent closed 'subterranean islands' in that the species of the stygofauna assemblage present are restricted in distribution to a particular calcrete (Cooper *et al.* 2002, Cooper *et al.* 2008, Guzik *et al.* 2008). The Lake Way calcrete systems have been shown to be unique in that genetic data has demonstrated that for some taxa gene flow does occur among the close neighbouring calcrete systems, particularly among the northern lake-associated calcretes, with amphipod, Bathynellacea and dytiscid species distributions shown to extend from Millbillillie Bubble Well calcrete to Lake Violet and Uramurdah calcretes (Abrams *et al.* 2012, Outback Ecology 2012d). The genetic data was consistent with the hydrogeological assessment that found the surficial alluvial and regolith aquifers associated with the main drainage pathways do provide hydraulic connections among the main calcrete aquifer systems.

There are times when evidence of stygofauna distribution can seemingly be at odds with hydrogeological data. Genetic studies have demonstrated in some cases that hydraulic connections do exist between aquifers that hydrogeological data had indicated were largely separate systems. As an example, genetic data showed that *Atopobathynella wattsi* has a distribution extending from the Lake Violet calcrete, on the northern shore of Lake Way, to the Hinkler Well calcrete, more than 12 km away on the western shore of Lake Way (Guzik *et al.* 2008). In a further example, the Browns Range Metamorphics and Gardiner Sandstone fractured rock aquifer systems in northern WA, each exhibited distinctly different hydrogeological characteristics and were considered to be isolated from one another (Klohn Crippen Berger 2013). However, genetic analysis demonstrated that hydraulic connections did exist between the two fractured rock aquifer systems, with two bathynellicean species clearly shown to be distributed in both (Outback Ecology 2014).

Sampling of non-calcrete associated aquifer systems in the Study Area region have not recorded any stygobitic species (**Table 5-1**). Sampling of the weathered and fractured bedrock habitat at Gwalia and Tower Hill, 6 km west of the Raeside Project Area, did not yield any stygofauna, however, this may also have been due to the historic mining disturbance resulting in altered hydrogeological regimes. Sampling of similar weathered and fractured bedrock habitat at St Barbara, 11 km north west of the Raeside Project Area, did record a stygophilic cyclopoid but no stygobites were found.

5.1.3 Troglofauna

Information on troglofauna from the area surrounding the LGP is limited in comparison to stygofauna. Studies undertaken in the Yilgarn region of calcrete habitats associated with Lake Way, Lake Maitland, and Yeelirrie, have shown that troglofauna occur in relatively low abundance and diversity compared to stygofauna (MWH 2015, Outback Ecology 2011b, 2012a, c, Subterranean Ecology 2011b). Surveys of non-calcrete associated geology from the broader Yilgarn region have collected troglofauna from weathered and fractured banded ironstone formations (BIF) and mafic units (Bennelongia 2009, ecologia Environment 2008a, b, Environmental Protection Authority 2010, MWH 2016a). In comparison, calcretes in the broader Yilgarn region are known to host more diverse troglofauna assemblages (MWH 2015, Outback Ecology 2011b, 2012c, Subterranean Ecology 2011a). The closest known records of troglofauna to the Study Area (11 km northwest of Raeside) are of an isopod from colluvial habitat at St Barbara (**Table 5-1**).

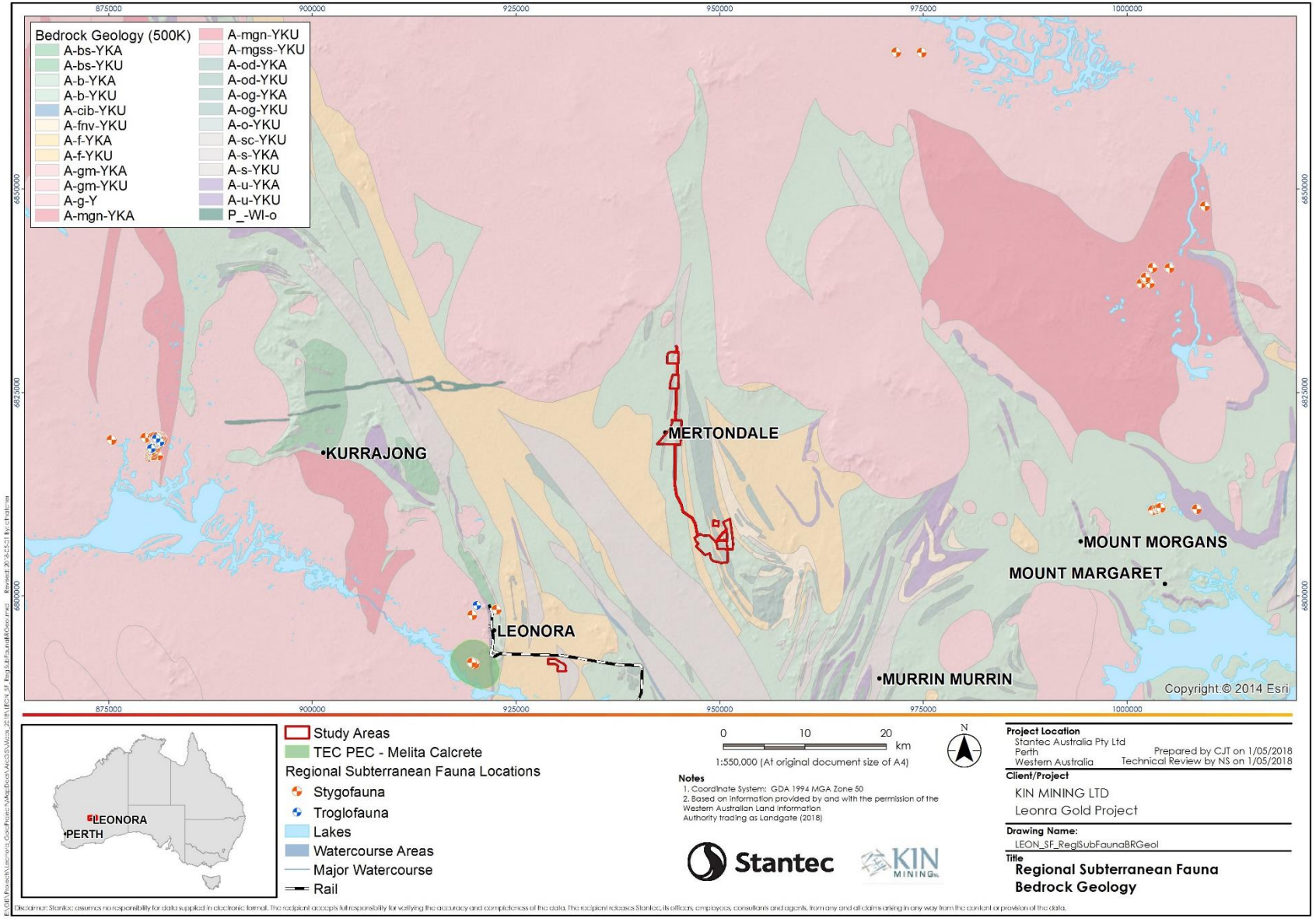


Figure 5-1: Subterranean fauna records for the region surrounding the Project Area relevant to bedrock geology.

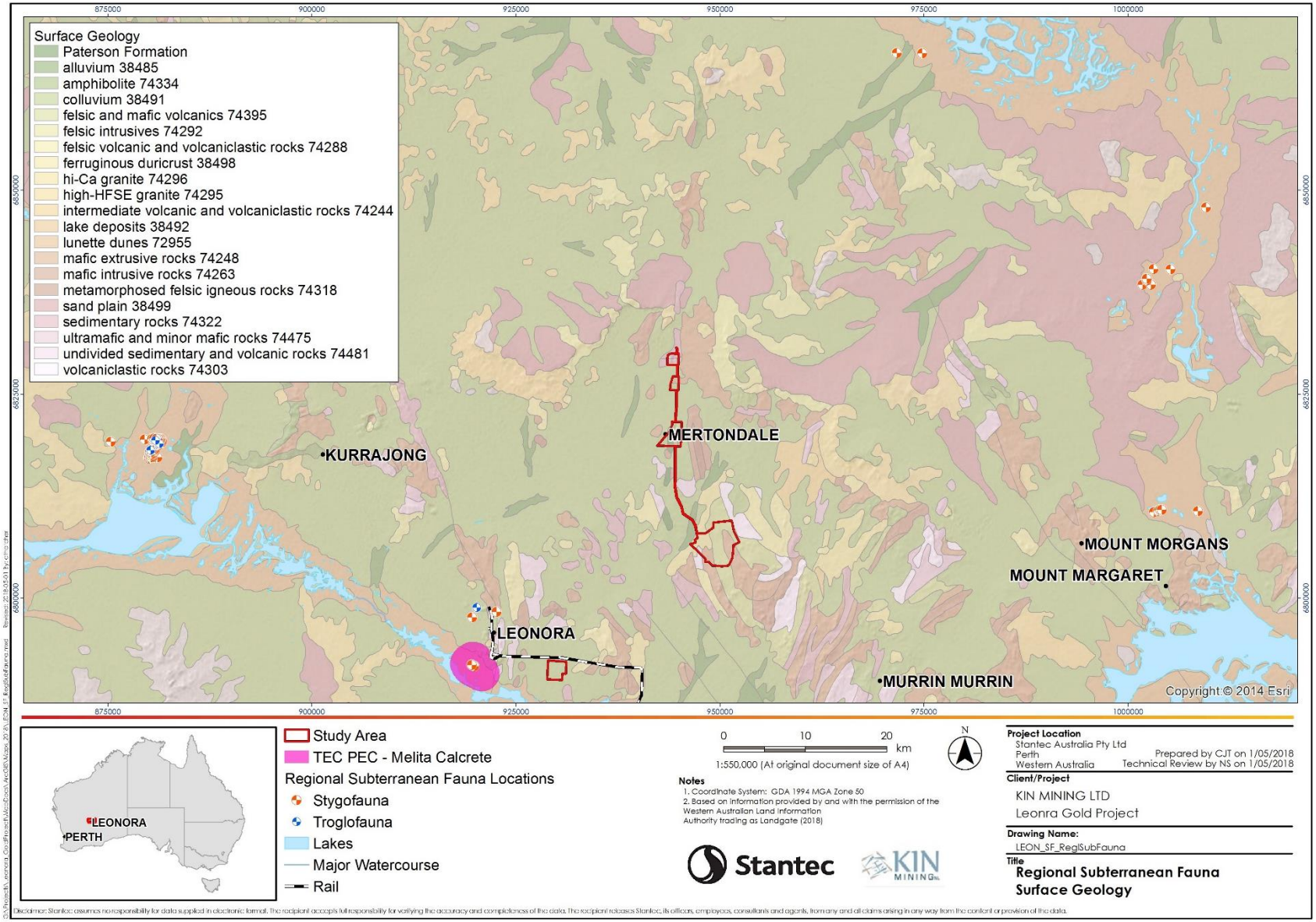


Figure 5-2: Subterranean fauna records for the region surrounding the Project Area relevant to surface geology.

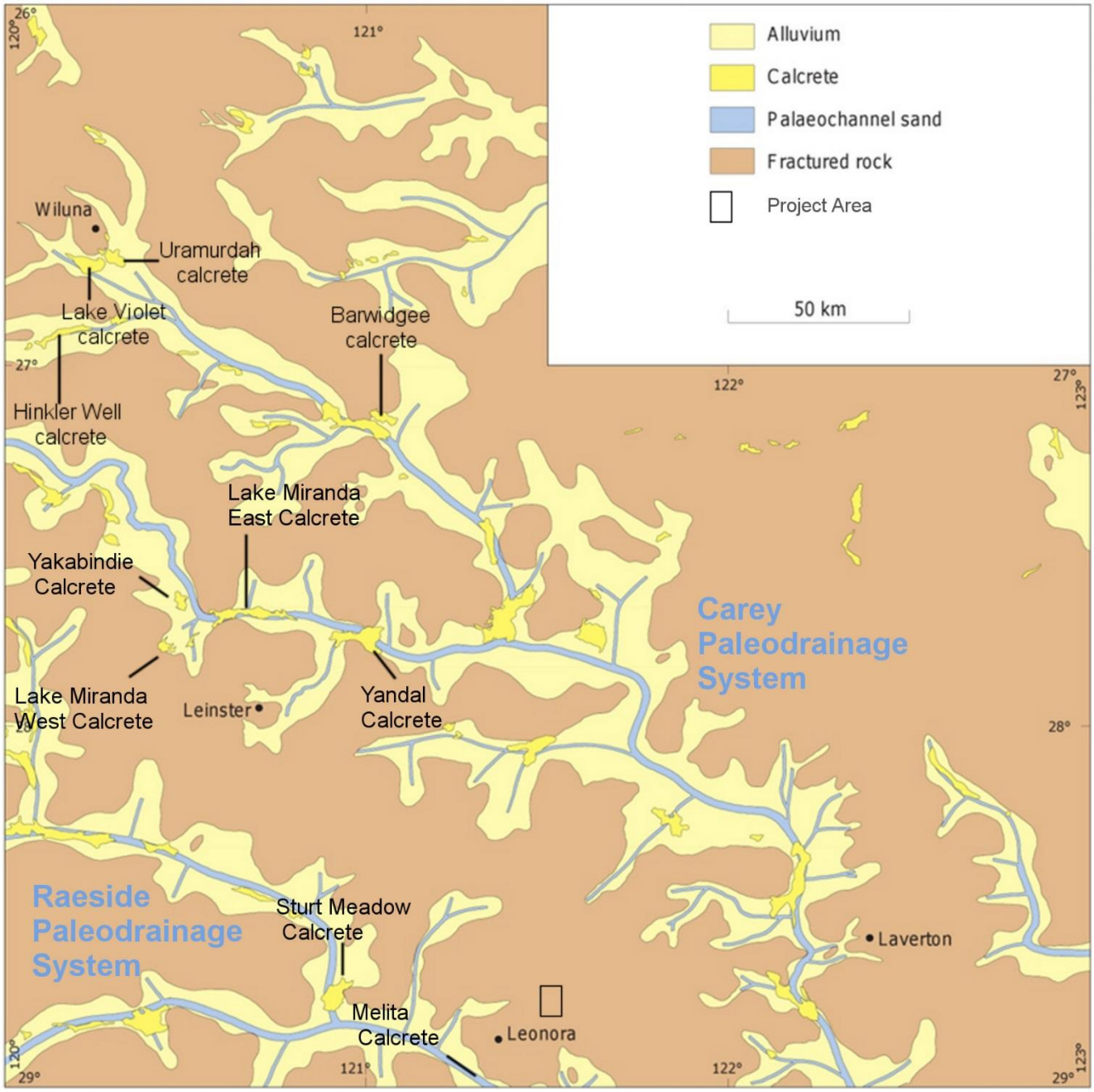


Figure 5-3: Regional occurrence of the main aquifer types. Figure adapted from Johnson *et al*. (1999).

Table 5-1: Summary of subterranean fauna surveys undertaken within the region surrounding the Project Area.

Fauna	Area	Distance	Taxa	Geology	Reference
STYGOFAUNA	Gwalia & Tower Hill	6 km W Raeside	No stygofauna collected	Colluvium over fractured rock system	Subterranean Ecology 2008
	Melita Calcrete PEC	11 km E Raeside; 32 km SW Cardinia	Coleoptera (Dytyscidae)	Calcrete system	Watts and Humphreys 2006
	St Barbara	11 km NW Raeside; 28 km SW Cardinia	stygophilic Copepoda (Cyclopoida)	Colluvium over fractured rock system	Subterranean Ecology 2008
	Nambi	45 km NE	Coleoptera (Dytyscidae)	Calcrete system	Watts and Humphreys 2006
	Mt Morgan	52 km ENE	Coleoptera (Dytyscidae), Isopoda	Calcrete system	Watts and Humphreys 2006, Cooper *et al*. 2008
	Laverton Downs	57 km E Mertondale	Amphipoda, Coleoptera (Dytyscidae), Isopoda	Calcrete system	Watts and Humphreys 2006, Guzik *et al*. 2011, Bradford *et al*. 2013
	Sturt Meadows	58 km W Mertondale	Amphipoda, Bathynellacea (Parabathynellidae, Bathynellidae), Coleoptera (Dytyscidae), Copepoda (Harpacticoida, Cyclopoida), Isopoda, Ostracoda, Oligocheatea	Calcrete system	Watts and Humphreys 2006; Cooper *et al*. 2002, 2007, 2008; Allford *et al*. 2008; Bradford *et al*. 2010; Guzik *et al*. 2008, 2009, 2011; Abrams *et al*. 2012; King *et al*. 2012;
Troglofauna	St Barbara	11 km NW Raeside; 28 km SW Cardinia	Isopoda	Colluvium over fractured rock system	Subterranean Ecology 2008
	Sturt Meadows	58 km W	Palpigradi, Pseudoscorpione	Calcrete system	Barrannco and Harvey 2008; Edwards and Harvey 2008

5.2 Subterranean Habitats

The subterranean habitat within the LGP Study Area is considered less prospective for stygofauna and troglofauna with the absence of extensive groundwater associated calcrete systems. The most prospective habitat for stygofauna in the LGP Study Area occur in association with geological structures present within the fractured rock aquifer systems (e.g. primarily regional shear zones and faults, but also in more localised fractures, and unconformities), and in the coarse-grained alluvial sediments present along the main drainage lines and associated tributaries.

The suitability of the fractured rock aquifer systems and alluvial deposits as stygofauna habitat will depend upon a number of factors, including the size, conductivity and continuity of voids and on the stability of the hydrological regime. The size and extent (lateral and vertical) of the aquifer systems present have not been assessed in detail. The most prospective habitat for troglofauna in the LGP Study Area that would be most likely to provide the cavities and voids required for troglofauna habitation would be the unsaturated alluvial/colluvial sediments, and weathered and fractured rock systems. Non-prospective areas for troglofauna would be where the weathered and fractured rock profiles are overlain by relatively deep sand or clay dominated strata with little or no interstitial pore space.

In the Mertondale and Greater Cardinia areas, there are numerous intrusive dolerite dykes that trend west to east, so cut across the north to south trending shear structures (Groundwater Development Services (GDS) 2018, Rockwater 2017, Rockwater Pty Ltd 2009). The dolerite dykes are characterised as having low hydraulic conductivity so are considered to represent aquitards to groundwater flow along the shear zones. In the Mertondale project area the dykes do restrict groundwater flow as evidenced by the abrupt changes in the depth to groundwater by approximately 15 m from north to south across the dolerite dyke present to the north of Mertondale 5 pit and by 32 m across the dolerite dyke present to the north of Mertondale 3-4 pit (**Appendix B**) (Rockwater Pty Ltd 2009). Therefore, the northern dolerite dykes present do appear to restrict the southerly groundwater flow from the Mertondale Shear towards the Greater Cardinia area. The regional groundwater flow direction across the LGP Study Area is primarily in a north to south direction (Rockwater Pty Ltd 2009).

The dolerite dykes to the south cutting across the Greater Cardinia Area do not appear to restrict groundwater flow to such an extent as the Mertondale dykes that occur higher in the landscape. In the Rangoon project area, groundwater levels drop by 3.3 m from north (BH023: 409 AHD) to south (BH037: 405.7 AHD) across the dolerite dyke present to the south of the proposed Rangoon Pit (**Appendix B**). In the Cardinia project area, groundwater levels drop by 2.2 m from north (BH064: 400.3 AHD) to south (BH011: 398.1 AHD) across the dolerite dyke along the southern boundary of the proposed Lewis Pit (**Appendix B**).

A selection of representative diamond drill core images from within each project area show varying depth and structure of the alluvial/colluvial strata overlying the weathered and fractured rock (**Figures 5-4 to 5-9**). Within the southern part of the Cardinia project area the overlying alluvial/colluvial regolith is shallower and less clay dominated compared to the northern Cardinia project area. At diamond drill hole CA17DD004, located in the northern part of the proposed Lewis South pit located near to Cardinia Creek, the upper alluvial/colluvial strata extends to approximately to 7 to 8 mbgl (**Figure 5-4**). In the vicinity of CA17DD004, at site BH011 (65 m to the north east), the recorded SWL of 14.9 mbgl indicates that the upper 7 m of fractured and weathered bedrock would remain unsaturated under the relatively thin overlying alluvial/colluvial strata. In the northern Cardinia project area at diamond drill hole CA17DD002, located within the eastern part of the proposed Bruno-Lewis Link pit, the upper alluvial/colluvial strata extends to approximately 37 mbgl (**Figure 5-5**). In the vicinity of CA17DD002, at site HB061 (230 m to the south east), the recorded SWL of 12.7 mbgl indicates that approximately the lower 25 m of the overlying alluvial/colluvial regolith would be saturated, with no unsaturated weathered and fractured bedrock present.

In the Helens project area at diamond drill hole NCDD009, located in the northern part of the proposed Helens East pit, near Cardinia Creek, a relatively thin alluvial/colluvial strata, extending to approximately 8 mbgl, overlies heavily weathered rock with extensive ferric oxide staining evident, with stained water bearing structures present down to 32 mbg (**Figure 5-6**). The extensive and deep staining indicates an area

of relatively high surface water infiltration (i.e. hydrological exchange). In the vicinity of NCDD009, at Helens Well (20 m to the north), the recorded SWL of 15.4 mbgl indicates that the upper 7 m of fractured and weathered bedrock would remain unsaturated under the relatively thin overlying alluvial/colluvial strata.

In the Rangoon project area at diamond drill hole NCDD008, located within the northern part of the proposed Rangoon pit, the upper colluvial strata is heavily clay dominated and extends to approximately 22 mbgl (**Figure 5-7**). In the vicinity of NCDD008, at sites BH33 and BH34 (180 m to the south), the recorded SWL ranged from 19.5 to 20.8 mbgl, indicating that in the northern part of the Rangoon pit, approximately the lower 2 to 3 m of the overlying clay strata would be saturated, with no unsaturated weathered and fractured bedrock present.

In the Mertondale project area at diamond drill hole NMDD012, located near the southern boundary of the Mertondale 3-4 pit pit, and south of a cross-cutting dolerite dyke, the upper colluvial strata is heavily clay dominated and extends to approximately 32 mbgl (**Figure 5-8**). The recorded SWL in the area, at Piezo 1 (MW9P) (820 m to the north), was 42 mbgl, indicating that in the southern part of the Mertondale project area, approximately the upper 10 m of the weathered and fractured bedrock present would remain unsaturated. In the northern part of the Mertondale project area, north of the cross cutting dolerite dyke where SLW is around 12 bgl, NMDD007 diamond drill results (not figured) indicate the overlying clay dominate colluvial is deeper (extending to 48.6 mbgl), with greater than 36 m remaining saturated above the weathered and fractured bedrock.

In the Raeside project area at diamond drill hole NRDD001, located 900 m to the south east of the Forgotten Four pit boundary, the upper colluvial strata is also heavily clay dominated and extends to approximately 22 mbgl (**Figure 5-9**). In the vicinity of NRDD001, at sites Raeside 1 and 2 (over 1 km to the east), the recorded SWL ranged from 10.8 to 12.8 mbgl, indicating that approximately the lower 10 to 12 m of the overlying clay strata would be saturated, with no unsaturated weathered and fractured bedrock present.

The diamond drill core images indicated that the overlying alluvial/colluvial strata is relatively thin (extending to around 7 to 8 mbgl) and less clay dominated in areas near to the Cardinia Creek drainage line (e.g. northern part of the southern Cardinia area) compared to other project areas more distant from the main drainage lines where the overlying clay dominated regolith extended for depths exceeding 22 to 48 mbgl. The deep clay dominated regolith would greatly reduce the influx of resources (e.g. oxygen and nutrients) from the surface into the underlying unsaturated and saturated weathered and fractured rock.



Figure 5-4: Diamond drill core images of Cardinia hole CA17DD004 (0 to 54.2 mbgl) within northern part of proposed Lewis South pit near Cardinia Creek (SWL in area around 14.9 mbgl).



Figure 5-5: Diamond drill core images of Cardinia hole CA17DD002 (0 to 54.9 mbgl) within eastern part of proposed Bruno-Lewis Link pit (SWL in area around 12.7 mbgl).

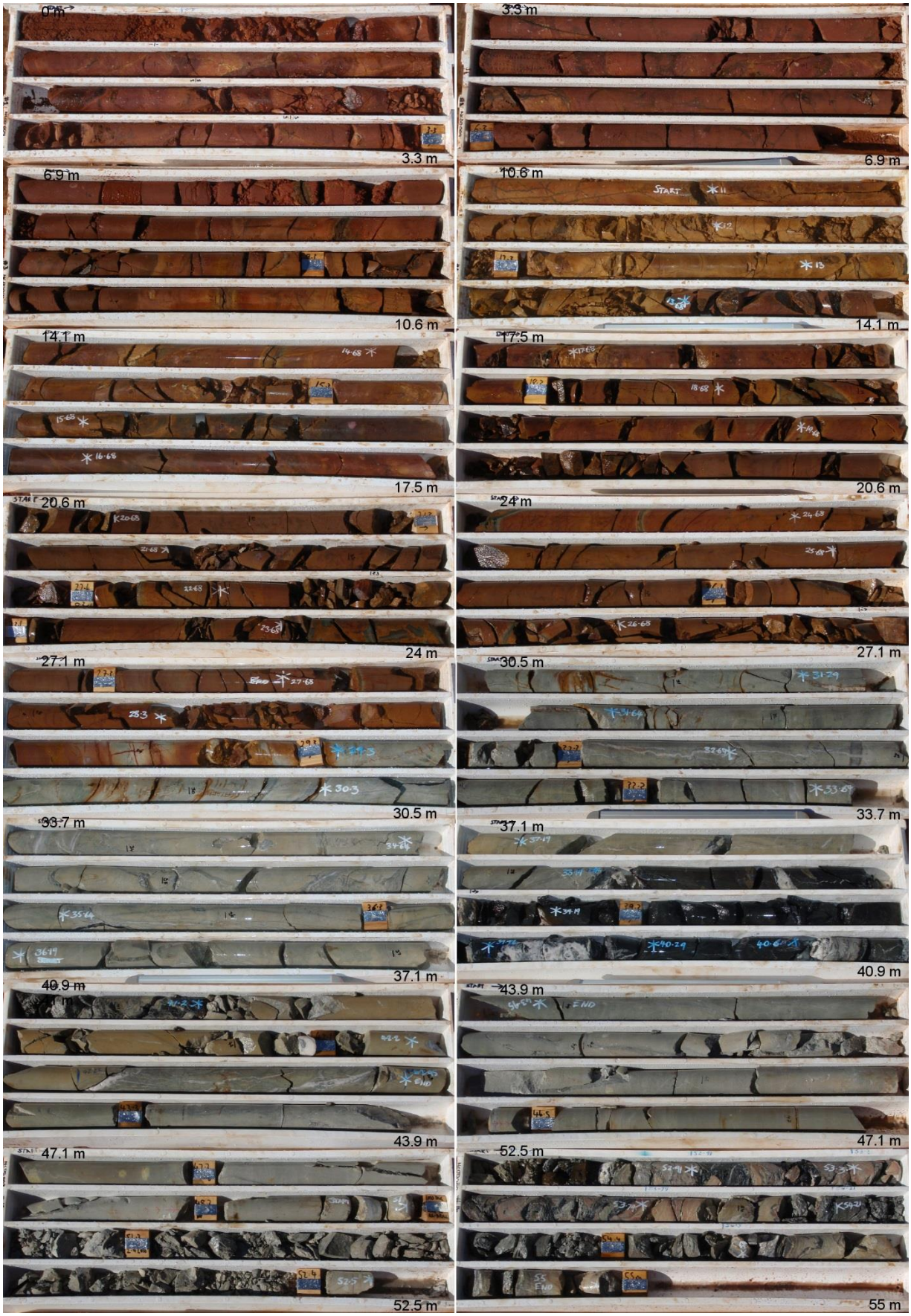


Figure 5-6: Diamond drill core images of Helens hole NCDD009 (0 to 55 mbgl) within northern part of proposed Helens East pit near Cardinia Creek (SWL in area around 15.4 mbgl).



Figure 5-7: Diamond drill core images of Rangoon hole NCDD008 (0 to 25 mbgl) within northern part of proposed Rangoon pit (SWL in area around 20 mbgl).



Figure 5-8: Diamond drill core images of Mertondale hole NMDD012 (0 to 58.4 mbgl) near southern boundary of Mertondale 3-4 pit (SWL in area around 41 mbgl).

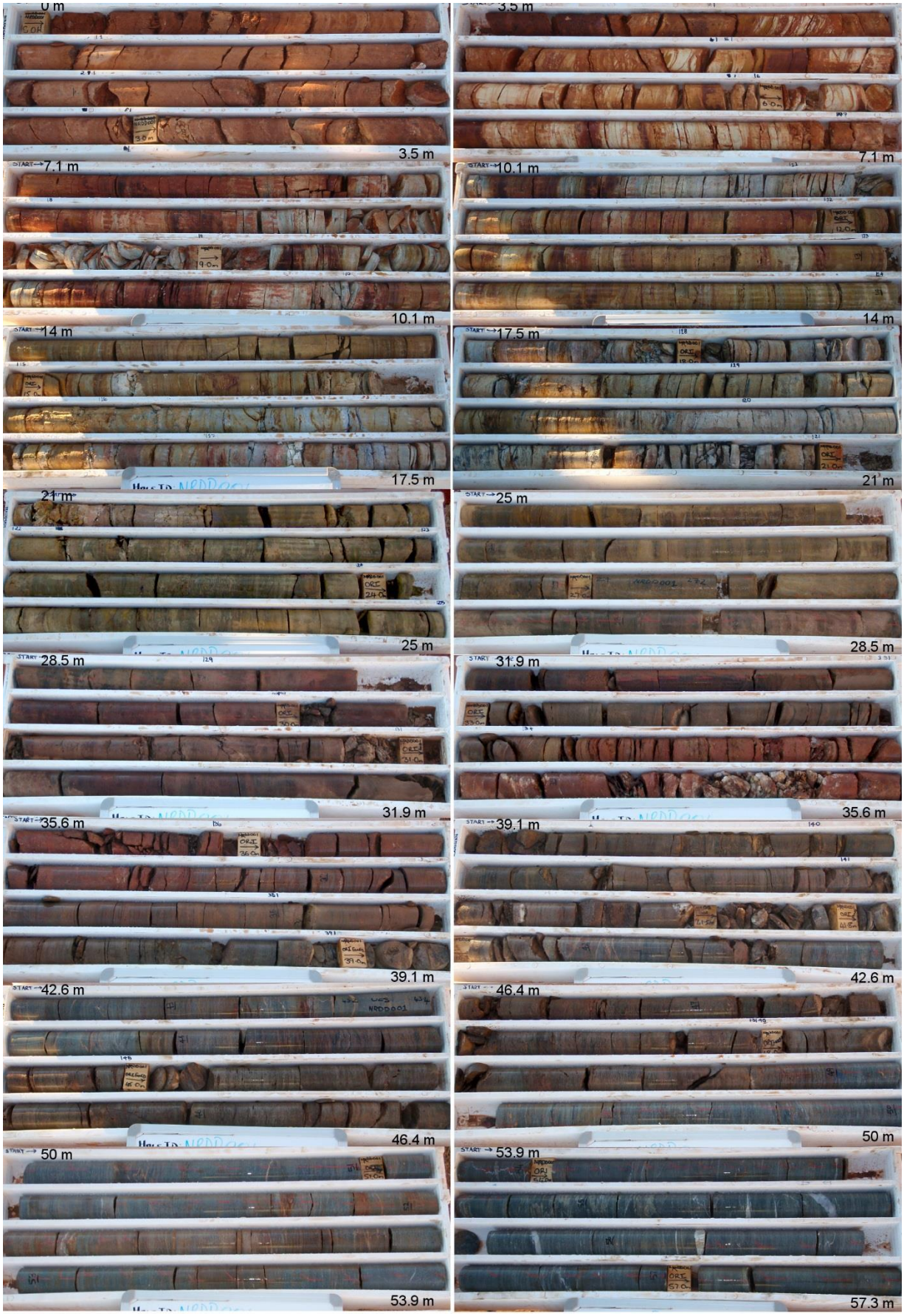


Figure 5-9: Diamond drill core images of Raeside hole NRDD001 (0 to 57.3 mbgl) within south-eastern part of Raeside project area (SWL in area around 12 mbgl).

5.3 Groundwater Properties

5.3.1 Standing Water Level

The standing water level (SWL) measured against the Australian Height Datum (AHD) largely reflected the local topography across the LGP (**Figure 5-10**). Within the Greater Cardinia project area, the higher mean SWL for Rangoon (409 AHD) reflects the project area's higher position in the landscape (mean elevation 488 AHD) compared to Helens (mean elevation 423 AHD) and Cardinia (mean elevation 415 AHD) that each recorded lower mean SWL of 405 and 401 AHD, respectively. The Mertondale project area is higher in the landscape (mean elevation 488 AHD) than the other project areas and displayed a broader range in the depth to groundwater, from 12.5 to 42.7 mbgl (442 to 488 AHD). The Raeside project area and the Southern Regional sites are lower in the landscape (mean elevation 372 and 408 AHD, respectively) and host lower mean SWL, 359 and 393 AHD, respectively. In general the SWL were closer to the surface in areas situated in or closer to a valley floor with the distance to groundwater greater within regions of higher elevation.

The recorded SWL were higher in 2009 or 2017, following significant summer rainfall events, compared to 2008, following relatively dry winter and spring seasons (**Figure 2-2**). The variations in SWL for sites sampled on two or more occasions were mostly less than 0.3 m except within the Cardinia project area where fluctuations in SWL between 2008 and 2009 commonly exceeded 0.6 m (**Appendix B**). The greatest variation (13.2 m) was recorded at Raeside 1 between 2008 and 2009. However, this large fluctuation is inconsistent with other Raeside sites that each recorded less than 0.3 m across the same sample rounds. Therefore, there was either water abstracted from Raeside 1 or the SWL recorded in 2009 was incorrect.

The modelled drawdown contour of 0.5 m below the natural standing water level (m bSWL) is designated as the outer extent of drawdown impact because groundwater drawdowns of less than 0.5 m bSWL fall within the natural variation in standing water levels recorded from the LGP Study Area. The criterion of 0.5 m bSWL for the delineation of the minimum groundwater drawdown limit (drawdown impact boundary) to be considered to represent a direct impact as a result of borefield abstraction or mine pit dewatering has been extensively discussed and adopted in previous subterranean fauna assessments in Western Australia (MWH 2015, 2016b, Outback Ecology 2012d).

5.3.2 Salinity

The groundwater salinity, measured as electrical conductivity (EC), across the aquifer systems intercepted in the LGP area generally ranged from fresh to mesosaline (163.3 to 38,927 µS/cm), *sensu* Hammer (1986), with the highest salinities (>10,000 µS/cm) recorded from within the Greater Cardinia project areas, Cardinia (29,234 µS/cm), Helens (38,927 µS/cm), and Rangoon (37,004 µS/cm) (**Figure 5-11**). For reasons unknown, atypically high saline conditions were recorded from the Raeside site, Raeside 1, during each sample phase: 54,400 and 81,500 µS/cm in 2008 and 2009, respectively. In sharp contrast, the other three Raeside sites had low salinities, ranging from 1,512 to 5,050 µS/cm. Low groundwater salinity conditions were recorded for Mertondale (maximum 6,038 µS/cm) and in the southern regional sites sampled (2,210 µS/cm). The salinity levels in sites within the Greater Cardinia project that stygofauna were collected from ranged from hyposaline to mesosaline conditions (4,025 to 37,004 µS/cm) (**Figure 5-11**).

Stygofauna are known to occur in conditions ranging from fresh to hypersaline (≥70 mS/cm) *sensu* Hammer (1986). While values below approximately 40 mS/cm are typically associated with significant stygofauna communities, studies have identified some stygofauna species in groundwaters exceeding 100 mS/cm (MWH 2015, Outback Ecology 2011b, 2012b). With all records (excluding atypical Raeside 1 results) falling below 40 mS/cm, the salinity levels documented from the various LGP Study Areas are well within the range conducive to stygofauna habitation.

5.3.3 pH

Across all the LGP areas, the groundwater pH ranged from circumneutral (6.5-7.5) to alkaline (>7.5) (**Figure 5-11**). The most diverse stygal communities inhabit calcareous environments between pH 7.2 and 8.2 (Humphreys 2008). Acidic groundwaters, which are generally associated with igneous and metamorphic sedimentary rocks, provide less suitable conditions for stygofauna (Humphreys 2008). However, stygal ostracods within the Pilbara region have been recorded from acidic groundwaters with pH as low as 4.4, although greater diversity was observed in association with higher pH values (Reeves *et al.* 2007). This suggests that although stygal diversity may decline with increasing acidity, the occurrence of some stygofauna taxa cannot be discounted. The pH values of groundwaters across the LGP Study Areas are considered to be within the range suitable for stygofauna.

5.3.4 Dissolved Oxygen

Dissolved oxygen levels recorded for the Greater Cardinia project areas (range 1.1 mg/L to 6.35 mg/L) indicated oxygenated groundwater conditions were present. In 2017, the Cardinia site, Cardinia SE, had anoxic (zero mg/L) conditions in the upper five metres of the water column due to the decomposition of a lizard that had managed to access the bore. Depth profiling of the bore (results not presented) indicated oxygenated conditions prevailed below 5 mbSWL.

Dissolved oxygen concentrations are often patchy in the subterranean environment, commonly ranging from suboxic (<0.3 mg/L) to oxic (>3 mg/L) over time, in addition to small and large spatial scales. Given the variability of these environments, stygofauna tend to be more resistant to low levels of oxygen than are surface water species (Malard and Hervant 1999, Strayer 1994). While concentrations below 5 mg/L may adversely affect surface aquatic biota, stygofauna have been documented from sub-oxic conditions well below 1 mg/L (Chapman and Kimstach 1996, Humphreys 2008).

5.3.5 Groundwater Assessment

The groundwater properties, as represented by the basic suite of physicochemical parameters measured, indicate suitable conditions for stygofauna throughout the LGP Study Area sampled. It is considered unlikely that stygofauna would be precluded from the groundwaters of the LGP Study Area on the basis of the conditions recorded.

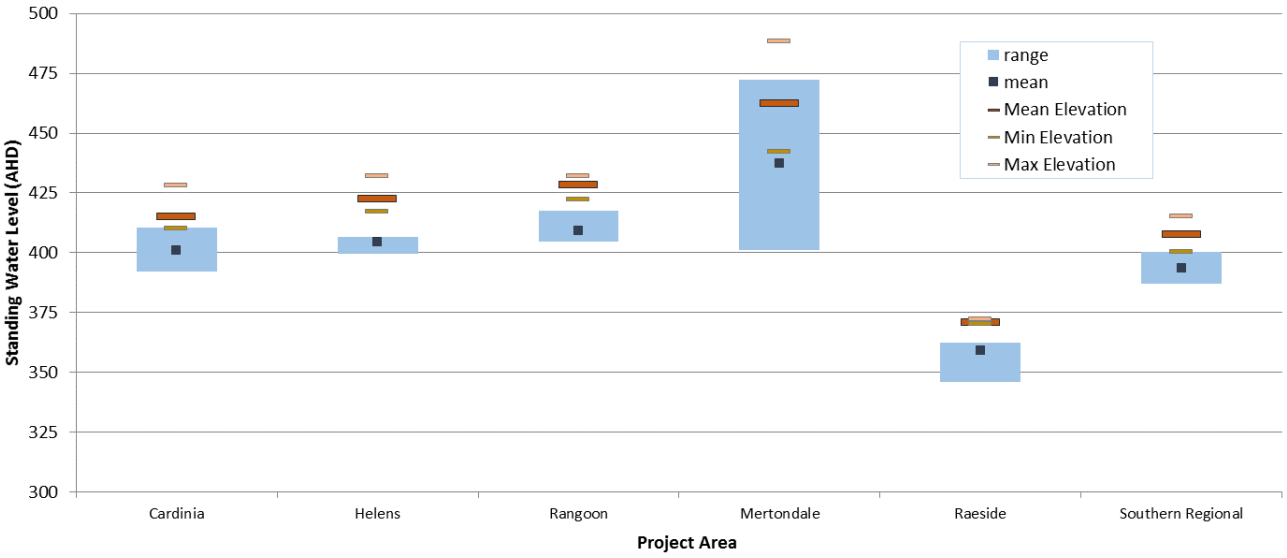


Figure 5-10: Minimum, maximum and mean of standing water levels (SWL) recorded compared to the mean elevation.

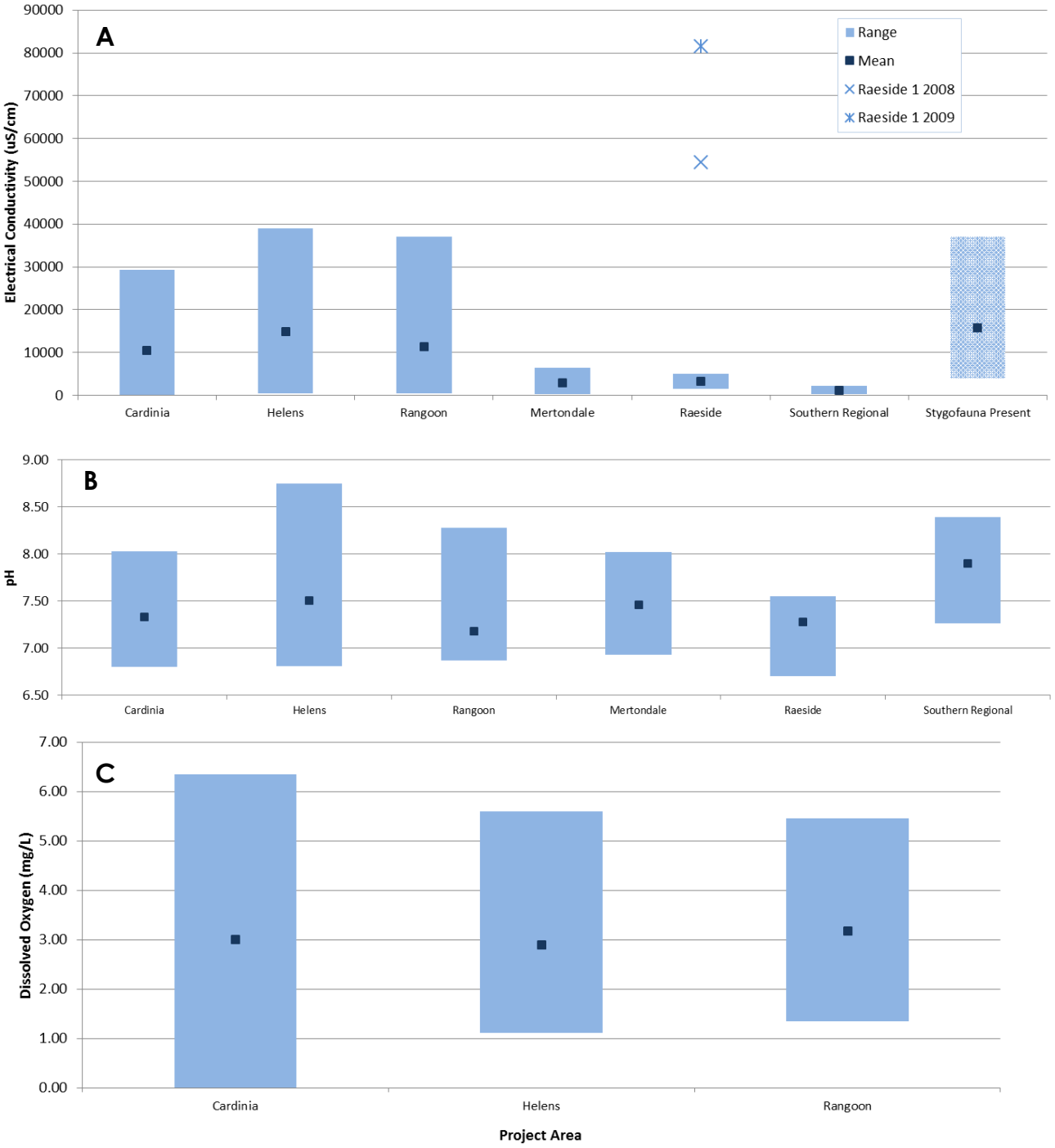


Figure 5-11: Minimum, maximum and mean of groundwater parameters recorded: A) electrical conductivity (EC); B) pH; C) dissolved oxygen (DO).

5.4 Stygofauna Findings

5.4.1 Overview

In total, 595 stygofauna specimens, representing five species from three higher level taxonomic groups, Bathynellacea, Copepoda and Oligochaeta, were recorded from the 2008, 2009 and 2017 surveys in the Greater Cardinia project areas (Cardinia, Helens and Rangoon) (**Table 5-2**, **Figure 5-12**, **Appendix C**). No stygofauna were recorded from the 30 samples collected from the Mertondale, Raeside and Southern Regional areas (**Figure 5-13**).

Within the Greater Cardinia project areas, stygofauna were recorded from 22 of the 61 sites sampled, and 23 of the 70 samples collected. The majority of stygofauna records occurred from within the north-south trending shear structures present, however, this is likely to also reflect the greater survey intensity completed as a result of the higher number of available sites due to the increased drilling effort targeting the gold mineralisation hosted within the shear zones (**Figure 5-14** Stygofauna were also collected from areas present along the Cardinia Creek and associated tributaries with coarse-grained alluvial and weathered and fractured rock geological units present.

The Bathynellacea order was the most species rich group with 3 species recorded (**Table 5-2**). One of these species, *Atopobathynella* OES2, was relatively commonly collected (122 specimens from 10 sites) and widespread in distribution throughout the Greater Cardinia project areas (**Figure 5-14**). In contrast, *Atopobathynella* OES29, was recorded from only two sites located within Rangoon. Bathynellidae OES28 was also not commonly collected, found from three sites in Cardinia. The Copepoda was represented by three species: a single stygobitic species, *Hirtaleptomesochra "multispinosa"* that was relatively common with 448 specimens collected in 20 samples from 18 sites from across the Greater Cardinia project areas; and two stygophilic species, *Mesocyclops brooksi* and *Australocamptus hamondi* (as *Australocamptus similis*). The Oligochaeta was represented by one stygobitic species, Phreodrilidae OES22, as well as an abundant and relatively widespread semi-aquatic stygoxene species, Enchytraeidae OES21 (**Appendix C: Table 3C**) that was collected in both net haul and litter trap samples.

5.4.2 Taxa Recorded and Genetic Analysis

5.4.2.1 Bathynellacea

All species of Bathynellacea globally are stygobitic and short range endemics (SRE), believed to have evolved to be obligate inhabitants of fresh groundwater systems during the late Permian, early Mesozoic eras, approximately 250 to 240 million years ago (Coineau and Camacho 2013). Of the three bathynellacean species recorded in this study, *Atopobathynella* OES2 was found to have a relatively widespread distribution across the Greater Cardinia project areas, exhibiting a linear distance of over 5 km from the most northern site collected (Rangoon: BH033) to the most southern (Cardinia: BH002) (**Figure 5-14**, **Appendix C**). The linear distributions demonstrated for *Atopobathynella* OES29 (10 m) and Bathynellidae-OES28 (575 m) were considerably less, however, both their distributions are considered likely to be similar to *Atopobathynella* OES2. The Bathynellacea dominated stygofauna assemblage found at the Greater Cardinia project areas is similar to other studies that have also found bathynellaceans to be the more commonly recorded group from fractured rock aquifer systems, composed of species known from only a few specimens and/or one site while other species were abundant and widespread with linear distances exceeding 15 km (Hancock and Boulton 2008, MWH 2016a, Outback Ecology 2014, Stantec 2017c).

Genetic analysis of 12 of the 16 Parabathynellidae specimens submitted confirmed the identity and distribution of *Atopobathynella* OES2 with CO1 sequence divergences ranging from 0.14 to 1.29 % among the diverse number of haplotypes present ((Leijs (2017), **Appendix D**). The co-occurrence of a high level of haplotype diversity among specimens collected within a limited geographical area is considered to be an indication of a relatively large, stable population with a long evolutionary history that would likely be more widespread than location records may show (Guzik *et al.* 2011). Interestingly, the diverse number of haplotypes sequenced of *Atopobathynella* OES2 did not display a consistent geographical structure

amongst the project areas. For example, the highest genetic divergence (1.29 %) was found to occur between specimens located less than 600m apart, from Rangoon sites BH026 and BH041. Yet sequenced individuals from both sites had much lower levels of divergence (0.82 and 0.43 %, respectively) with conspecific material located more than 2.7 km to the southwest from Cardinia site BH013. Similarly, *Atopobathynella* OES2 material from Rangoon sites BH033 and BH034, approximately 20 m apart, displayed the same level of genetic divergence (0.86 %) between each site as with material approximately 4 km to the southwest, from Cardinia sites BH010 and BH011. In fact material from Rangoon sites BH033 and BH034 was more closely related (0.72 %) to material from Cardina site BH013. The genetic results for *Atopobathynella* OES2 have demonstrated that there is no physical barrier preventing gene flow for this species among the Greater Cardinia project areas, from the northern most sites sampled in Rangoon to Helens and the southern sites within Cardinia; i.e. the northern and southern dolerite dykes do not represent barriers to the dispersal of *Atopobathynella* OES2.

Atopobathynella OES2 was recorded from 15 sites, all of which occur within proposed impact zones ranging from within a pit boundary (Rangoon), to significant groundwater drawdown (exceeding 5 mbSWL), to limited groundwater drawdown (approximately 1 mbSWL). *Atopobathynella* OES2 was recorded from within shear zones as well as outside within coarse-grained alluvial sediments present along the Cardinia Creek and associated tributaries.

Atopobathynella OES29 was demonstrated to be a close relative of *Atopobathynella* OES2, exhibiting a genetic divergence of 8.17 to 9.03 % for the barcoding CO1 gene fragment sequenced ((Leijs (2017), **Appendix D**). *Atopobathynella* OES29 was only recorded from two Rangoon sites, BH028 and BH027, near to other sites from which *Atopobathynella* OES2 was recorded (**Figure 5-14**). The genetic divergence displayed between the two *Atopobathynella* OES29 specimens, collected less than 10 m from one another, was 0.3 %. This level of genetic divergence between such closely occurring specimens is similar to that found for other parabathynellid species sequenced from the Browns Range fractured rock aquifer system, whereby intraspecific divergence levels as low as 0.1 % were found between specimens collected approximately 11 km apart, yet specimens of the same species exhibited divergences of 0.4 % between material collected within 300m of each other (Outback Ecology 2014).

To date, *Atopobathynella* OES29 has only been recorded less than 50 m from the proposed Rangoon pit within a modelled groundwater drawdown zone in excess of 35 mbSWL. Both recorded locations of *Atopobathynella* OES29 occur within a shear structure.

The two Bathynellidae-OES28 specimens sequenced from Cardinia sites BH008 and BH010, approximately 220 m apart, had the same haplotypes with no genetic divergence exhibited (Leijs (2017), **Appendix D**). Bathynellid species are generally not as commonly collected as parabathynellid species, and are often only known from a single site (Outback Ecology 2012b, d, 2014, Perina *et al.* 2018, Stantec 2017a). However, DNA anaylsis has demonstrated that more commonly recorded bathynellid species can have distribution ranges along alluvial aquifer systems that can extend for at least 7 km (Outback Ecology 2014) to, less commonly, 60 km (Perina *et al.* 2018).

Bathynellidae-OES28 was recorded from 3 sites, two of which occur within the proposed Lewis South pit boundary (within a shear structure), the third from within the 15 to 20 mbSWL modelled groundwater drawdown contour that intercepts the southern dolerite dyke. All three sites are located along the main Cardinia Creek drainage zone and likely are inhabiting the coarse-grained alluvial sediments present.

5.4.2.2 Copepoda

The Copepoda are a large and ecologically diverse group with many species occurring in surface waters as well as in groundwater ecosystems. A total of three species were recorded from the LGP Study Area: a single stygobitic species, *Hirtaleptomesochra "multispinosa"* that was relatively common across the Greater Cardinia project areas with 448 specimens collected in 20 samples from 18 sites (**Figure 5-14**, **Appendix C**); and two stygophilic species, *Mesocyclops brooksi* and *Australocamptus similis* ((Karanovic (2009, 2017), **Appendix E**).

The distribution of *Hirtaleptomesochra "multispinosa"* is considered likely to extend throughout much of the Cardinia Creek catchment and potentially neighbouring catchments, based on the survey results and extent of the distribution range for closely related species, *Hirtaleptomesochra bispinosa*, with published records demonstrating a range of a linear distance of approximately 100 km spanning neighbouring catchments (Karanovic 2004). The distribution of *Hirtaleptomesochra "multispinosa"* demonstrated that the northern and southern dolerite dykes do not represent barriers to the dispersal for this species.

Hirtaleptomesochra "multispinosa" was recorded from 19 sites, all of which occur within proposed impact zones ranging from within pit boundaries (Lewis South, Lewis Far South, and Rangoon), to significant modelled groundwater drawdown exceeding 5 mbSWL. As with *Atopobathynella* OES2, the majority of *Hirtaleptomesochra "multispinosa"* records were from within the north-south trending shear structures present, however, was also recorded from outside the shear zones within coarse-grained alluvial sediments present along the Cardinia Creek and associated tributaries.

Mesocyclops brooksi is a widely distributed Western Australian copepod species, recorded all over the Yilgarn region and in part of the Pilbara region (Karanovic 2004, 2006), as well as in parts of the WA Weatbelt region (mostly unpublished records). The species is considered to be a stygophile rather than a stygobiont. *Australocamptus similis* was originally considered a stygobiont that was closely related to the widespread and commonly collected stygophile *Australocamptus hamondi* (Karanovic (2004, 2009). However, later examination of a greater amount of material from calcrete systems associated with Lake Way, Lake Maitland and Yeelirrie in the northern Carey paleodrainage system lead to *Australocamptus similis* being considered to be a synonym (same species) as *Australocamptus hamondi*, a widely distributed stygophile (Karanovic (2010b) in Outback Ecology (2012b); Karanovic (2010a) in Subterranean Ecology (2011b)).

5.4.2.3 Oligochaeta

Phreodrilidae

Phreodrilidae species are commonly associated with groundwater systems and have been recorded in stygofauna surveys within the Pilbara, Western Desert, and Yilgarn regions (Biota Environmental Services 2010, Brown *et al.* 2015, Halse *et al.* 2002, Outback Ecology 2012d, 2013, Pinder 2001, 2008, Rockwater 2012, Subterranean Ecology 2012). While some species of Phreodrilidae have only been recorded from aquifers, other species have been recorded from a range of habitats including springs, spring-fed creeks and pools and large surface water systems (Pinder 2008). Although mostly aquatic, there can be some uncertainty as to the level of aquatic dependence of these worms, with one species having been recorded from ephemeral seepages on granite outcrops that dry out periodically (Pinder 2008). In addition, it is difficult to determine if species are stygobitic or stygophilic. Species recorded from both groundwater and surface water environments (e.g. *Phreodrilus peniculus*) are considered to be stygophilic (Pinder 2003). However, it is difficult to determine the groundwater dependence for a species recorded from a stygofauna assessment. In the arid zone it is considered likely that many taxa take refuge in groundwater environments until significant rainfall events occur. Some species are only known from a limited number of sites and often restricted in distribution to a single creek catchment , other species have been found to have widespread distributions that can occur across disjunct aquifers and drainage catchments (Biota Environmental Sciences 2010, Brown *et al.* 2015, Pinder 2008).

Phreodrilidae OES22 was collected from four sites across the Cardinia and Helens Project Areas occurring in impact areas ranging from near (within 15 m) a proposed pit boundary (Helens Main) and within significant modelled groundwater drawdown exceeding 5 mbSWL, to limited groundwater drawdown between 0.5 to 1 mbSWL (**Figure 5-14**). Phreodrilidae OES22 has been recorded from within the north-south trending shear structures present as well as beyond the shear zones within coarse-grained alluvial sediments present along the Cardinia Creek associated tributaries.

Enchytraeidae

The taxonomy and ecology of the Enchytraeidae is poorly known, with no stygal species described to date (Pinder 2009, Pinder 2007). These worms are commonly recorded in subterranean fauna surveys, and occur in both surface and subterranean aquatic systems (freshwater and marine), or semi-aquatic and terrestrial habitats (Outback Ecology 2011b, 2012d, 2013, 2014, Rota *et al.* 2007, van Vliet *et al.* 1997). Genetic analyses have demonstrated that enchytraeids can either form a relatively species rich component of the invertebrates recorded in a stygofauna program (Outback Ecology 2013) or be represented by a single widespread species (Outback Ecology 2014). Terrestrial invertebrate fauna are often collected in stygofauna nets having either being dislodged from the soil profile during retrieval of the nets or collected from the water column into which they may have fallen (Outback Ecology 2011b, Subterranean Ecology 2008a, b). Some Enchytraeidae species have been demonstrated to not be obligate groundwater inhabitants, with genetic data showing material collected in troglofauna traps were conspecific (same species) with material collected from stygofauna net hauls (Leijs 2013, Outback Ecology 2011c).

Enchytraeidae-OES21 is considered to be a semi-aquatic stygoxene as was collected in both stygofauna net haul samples as well as troglofauna litter traps from sites across all LGP areas (Greater Cardinia, Mertondale, Raeside and Southern Regional). Therefore, the species is not of conservation concern as is not stygobitic and has a relatively widespread distribution that is likely to extend beyond the distribution recorded across the broader catchment area.

5.4.3 Project Areas

The findings for each of the project areas sampled within the LGP Study Area are summarised as follows:

- Mertondale — No stygobitic stygofauna species were recorded from the 2008 and 2009 sample rounds. Non-stygobitic taxa (i.e. surface water species that are either stygophiles or stygoxenes) were recorded and these included the copepod *Microcyclops varicans*, the ostracod *Sarscypridopsis ochracea*, and the semi-aquatic oligochaete Enchytraeidae OES21 ((Outback Ecology 2009)). These taxa are considered to have widespread distributions that extend well beyond the LGP Study Area.

- Raeside — No stygobitic stygofauna species were recorded from the 2008 and 2009 sample rounds. Non-stygobitic taxa recorded included the copepod *Australocamptus hamondi* (as *Australocamptus similis*) and Enchytraeidae OES21 (Outback Ecology 2009). Both taxa are considered to have widespread distributions that extend beyond the LGP Study Area.

- Cardinia — From a stygofauna ecology perspective, Cardinia appears to be divided into two distinct areas with different stygofauna values as a result of the southern-most dolerite dyke in the project area that intrudes along, east to west, the southern boundary of the Lewis pit:

    - *Cardinia South* (Lewis South, and Lewis Far South pits) — Four stygobitic species were recorded from 10 of the 24 samples taken, and 9 of the 18 sites sampled. These were: the bathynellaceans Bathynellidae OES28 and *Atopobathynella* OES2, the copepod *Hirtaleptomeshchra "multispinosa"* and the oligochaete Phreodrilidae OES22. All four species are of potential conservation concern because each of their current recorded distributions have not been demonstrated to extend beyond the likely proposed impact zones associated with pit excavation and potential groundwater drawdown associated with pit dewatering. Three species, *Atopobathynella* OES2, *Hirtaleptomeshchra "multispinosa"* and Phreodrilidae OES22, have each been recorded from other Project Areas (Helens and Rangoon).

    - *Cardinia North* (Bruno East, Bruno Extension, Bruno-Lewis Link, Bruno West, Kyte, and Lewis pits) — No stygofauna species were recorded from the 12 samples taken from 11 sites.

- Helens — Three stygobitic species were recorded from 5 of the 18 samples taken and 5 of 17 sites sampled. These were: the bathynellacean *Atopobathynella* OES2, the copepod *Hirtaleptomeshchra "multispinosa"* and the oligochaete Phreodrilidae OES22. All three species have each been recorded from other Project Areas (Cardinia and Rangoon) but their distributions have not been demonstrated to extend beyond the likely proposed impact zones associated with pit excavation and dewatering.

- Rangoon — Three stygobitic species were recorded from 8 of the 16 samples collected and 8 of 15 sites sampled. These were: the bathynellaceans *Atopobathynella* OES2 and *Atopobathynella* OES29, and the copepod *Hirtaleptomeshchra "multispinosa"*. Of these three species, *Atopobathynella* OES29, has only been recorded from two Rangoon sites. The remaining two species have each been recorded from other Project Areas (Cardinia and Helens). The distributions of all three have not been demonstrated to extend beyond the likely proposed impact zones associated with pit excavation and dewatering.

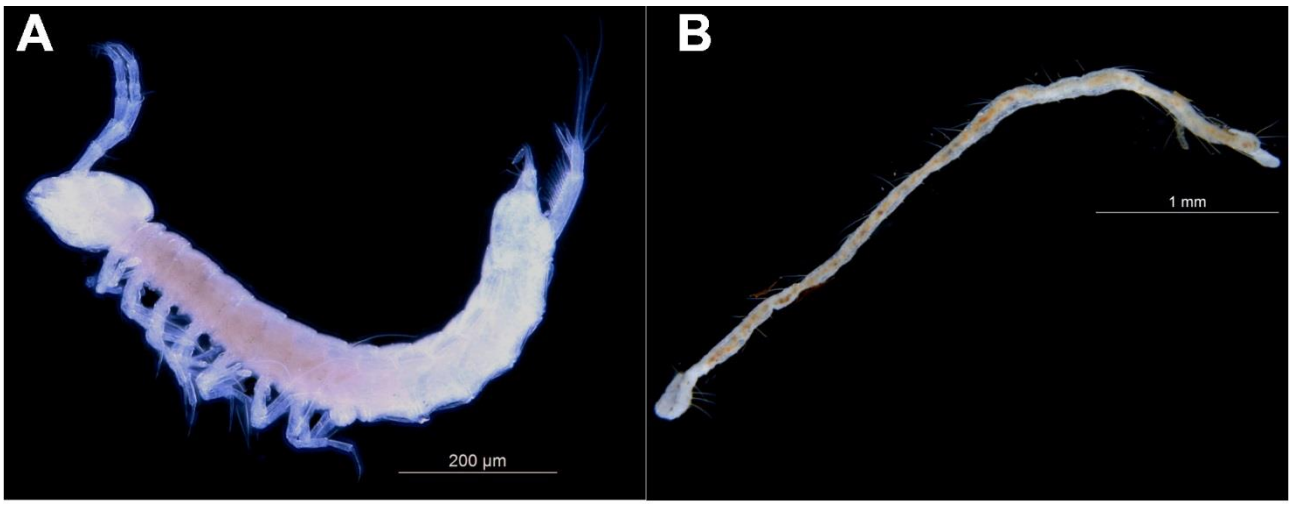


Figure 5-12: Representative stygofauna images. A) *Atopobathynella* sp.; B) Phreodrilidae sp.

Table 5-2: Stygofauna diversity and distribution recorded.

Taxon	Abundance	Project Area	Impact		Max. Distance from Pit (m)	Comments
			Inside Pit	Drawdown >0.5 m		
Bathynellacea						
Bathynellidae OES28	3	Cardinia	•	•	360	Occurs at low population density. Single specimens collected from three bores in Cardinia only. Recorded in 2009 and 2017. Is an SRE with distribution potentially confined to Cardinia Creek Catchment.
Atopobathynella OES2	122	Cardinia, Helens, Rangoon	•	•	1,090	Relatively commonly collected. Occurs throughout Greater Cardinia. Recorded in 2008, 2009 & 2017. Is an SRE with distribution potentially confined to Cardinia Creek Catchment.
Atopobathynella OES29	4	Rangoon		•	55	Recorded from two bores in Rangoon in 2017. Is an SRE with distribution potentially confined to Cardinia Creek Catchment
Copepoda: Harpacticoida						
Hirtaleptomesochra "multispinosa"	448	Cardinia, Helens, Rangoon	•	•	700	Most common and widespread stygobiont collected in Project. Recorded in 2008, 2009 & 2017. SRE status uncertain. Distribution considered likely to extend throughout Cardinia Creek catchment and potentially into neighbouring connected catchments
Oligochaeta						
Phreodrilidae OES22	18	Cardinia, Helens		•	1,150	Collected from four bores in 2017 only. Considered likely to be relatively widespread within broader catchment system

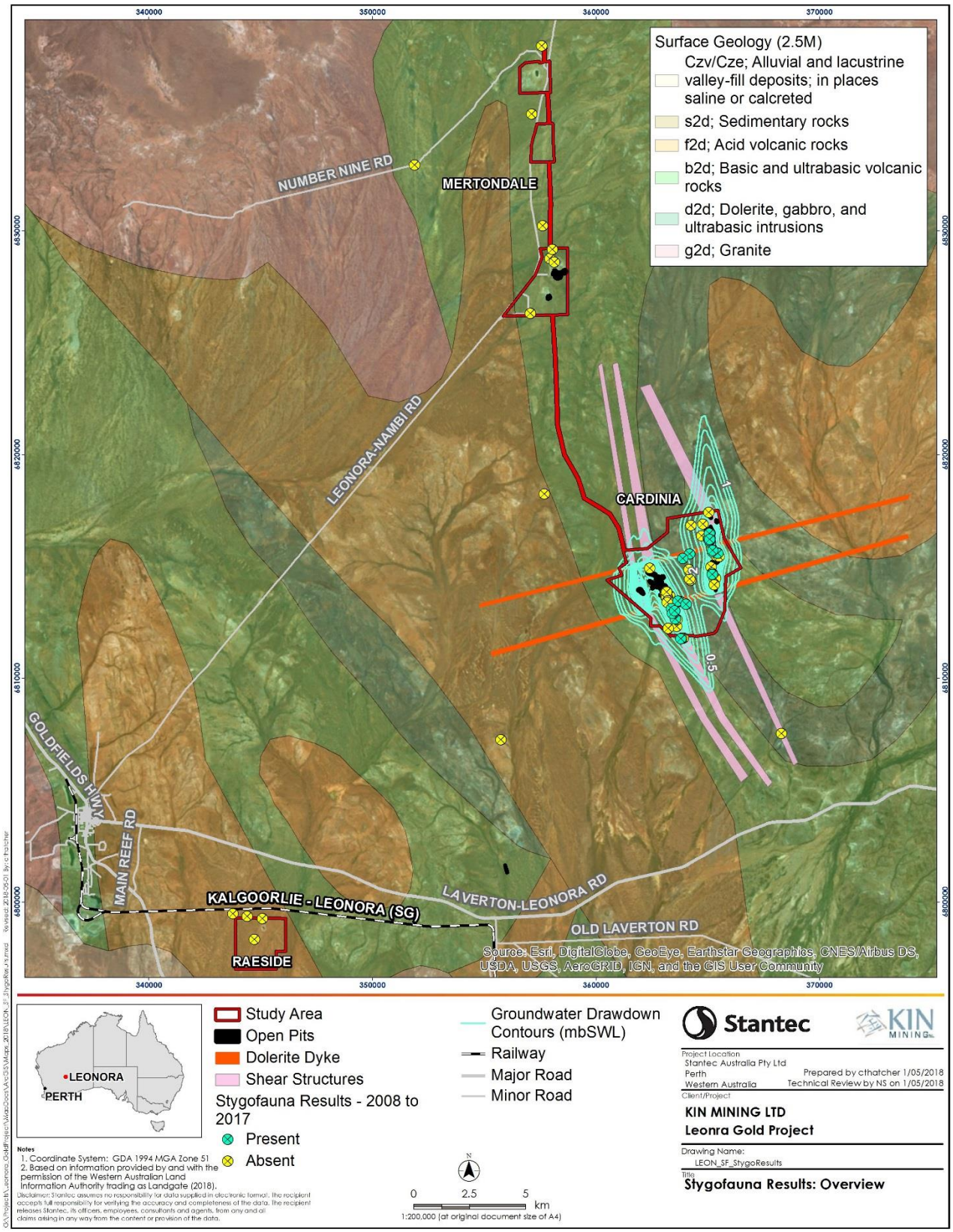


Figure 5-13: Presence / absence of stygofauna species recorded.

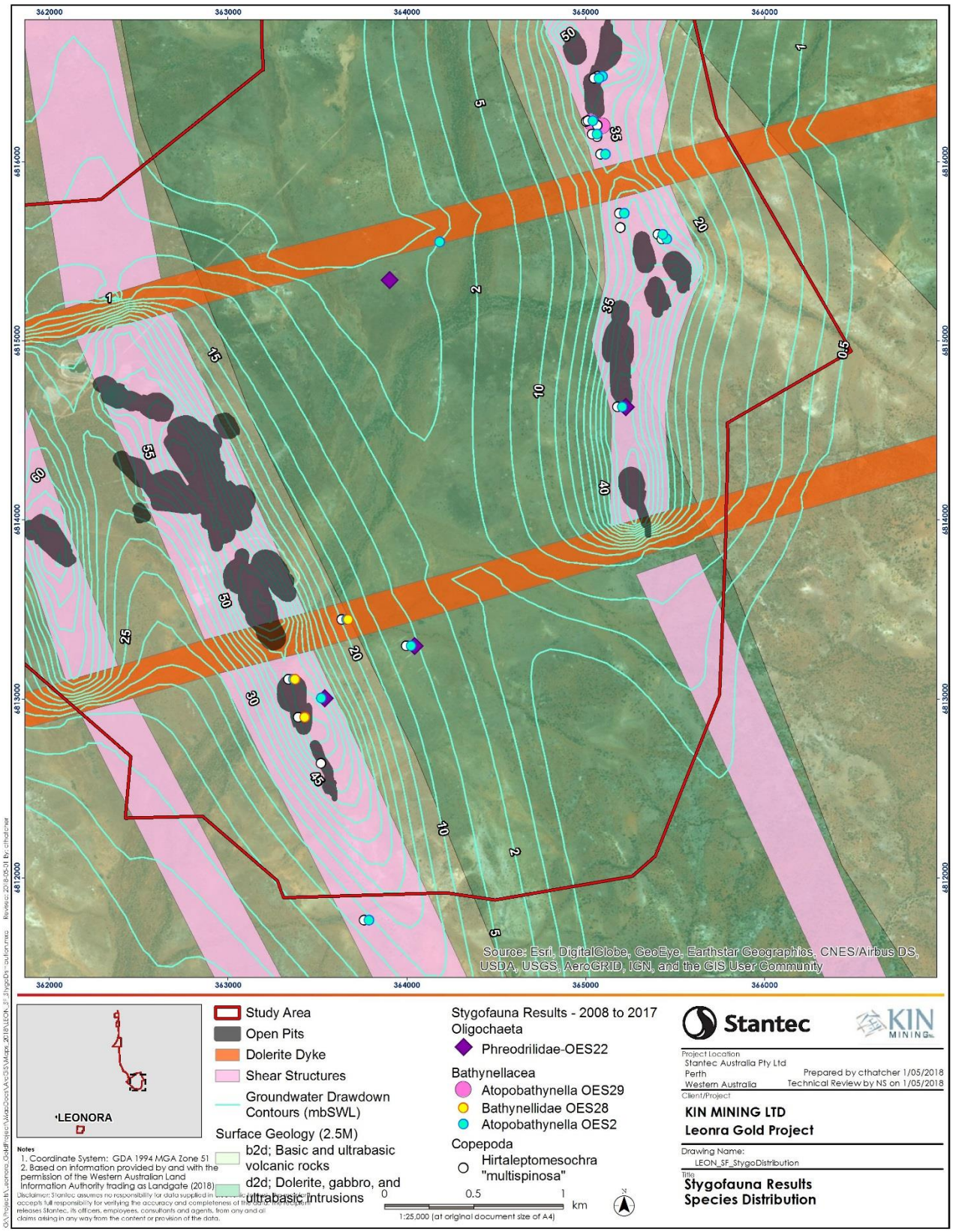


Figure 5-14: Distribution of stygofauna species recorded.

5.4.4 Stygofauna Species Richness Estimates and Survey Adequacy

The seven species richness estimators used were largely consistent with the actual number of stygofauna species recorded (5) (**Figure 5-15**, **Table 5-3**). Only two estimators did not estimate that five species would occur. The Bootstrap mean was only marginally higher predicting 5.2 species and Jack 2 mean strangely estimated fewer species (4) would occur than the actual observed species richness. The five species collected in the study represent an estimated 96.2% to 124.1% of the total species predicted to occur in the Study Area. The species accumulation curves for all diversity estimators had plateaued or were declining by survey's end. The extrapolation of the observed species accumulation curve (S(ext)) indicates that increasing the survey effort by 100% (i.e. double) would not record any additional stygofauna species.

The species capture rate (5 species from 100 samples at an overall capture rate of 0.05 species per sample) is relatively consistent with the range in findings for other stygofauna assemblages recorded from other fractured rock aquifer systems dominated by Bathynellacea:

- Browns Range — 18 species from 160 samples (capture rate 0.11) (Outback Ecology 2014a);
- Yakabindie — 10 species from 221 samples (capture rate 0.05) (Stantec 2017c); and
- Camelot — one species from 61 samples (capture rate 0.02) (Stantec 2018).

The species accumulation curves and comparison of capture rates with other similar studies, in terms of habitat hosted in fractured rock aquifer systems, indicate that the survey intensity undertaken has been sufficient in providing a reliable level of knowledge of the stygofauna assemblage present in the Study Area and gives a high level of confidence in assessing the potential impacts posed by the proposed Project in accordance with EPA (2016a, b) guidelines. The sampling effort conducted to date within the proposed impact areas (84 samples), has exceeded the recommended minimum requirements of 40 impact samples for a Level 2 stygofauna survey (EPA 2016a, b).

The total number of stygofauna samples collected as part of this assessment (100) does provide a reliable characterisation of the stygofauna values present within the LGP Study Area and in relation to the proposed direct impact zones. However, the survey effort in the Greater Cardinia project areas lacked the geographical spread required to demonstrate that the distribution of the Cardinia Creek stygofauna assemblage extends beyond the proposed impact zones. Additional targeted sampling in non-impact reference areas within the Cardinia Creek catchment is required to further investigate the extent of distribution of the Cardinia stygofauna assemblage.

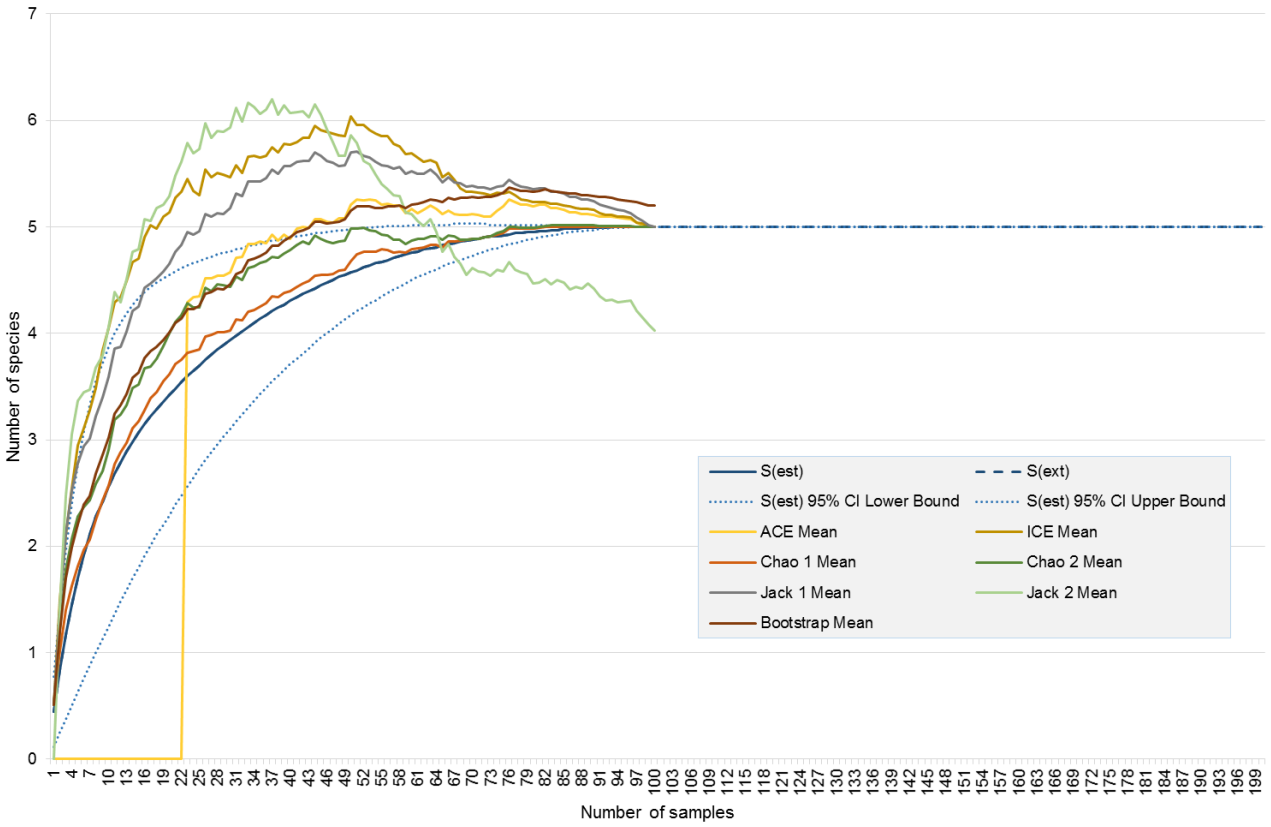


Figure 5-15: Stygofauna species accumulation curves for various diversity estimators and rarefaction curves for observed (S(est)) and extrapolated (S(ext) for the Project.

Table 5-3: Observed stygofauna species diversity from the Study Area compared to estimated diversity using EstimateS (Colwell 2013) diversity estimators.

Observed vs Estimated		Obs. & Pred. spp richness	% Predicted collected
Obs.	Sobs	5	
	Extrapolated (200 samples)	5	100.0%
Diversity estimators	Jack 2 Mean	4.0	124.1%
	ACE Mean	5.0	100.0%
	Chao 1 Mean	5.0	100.0%
	Chao 2 Mean	5.0	100.0%
	ICE Mean	5.0	100.0%
	Jack 1 Mean	5.0	100.0%
	Bootstrap Mean	5.2	96.2%
	Range	4 — 5.2	96.2 — 124.1%

5.5 Troglofauna Findings

5.5.1 Overview

A total of 48 troglofauna specimens, representing six species from four higher level taxonomic groups, Diplura, Isopoda, Pseudoscorpiones and Symphyla, were recorded from the 2008, 2009 and 2017 surveys in the Greater Cardinia Project Areas (Cardinia, Helens and Rangoon) (**Figure 5-16, Table 5-4**, **Appendix C**). No troglofauna were recorded from the 14 samples collected from the Mertondale and Raeside Areas (**Figure 5-17**). The net haul scrape sample method was more efficient in collecting troglofauna species than the litter trap sample method that failed to collect any troglofauna from the 52 litter traps retrieved.

Within the Greater Cardinia Project Area, troglofauna were recorded from 9 of the 67 sites sampled, and 9 of the 117 samples collected. The majority of troglofauna records occurred from within the unsaturated regolith associated with the north-south trending shear structures present, however, this is likely to also reflect the greater survey intensity completed as a result of the higher number of available sites due to the increased drilling effort targeting the gold mineralisation hosted within the shear zones (**Figure 5-14**). Troglofauna were also collected from within the unsaturated alluvial sediments present along the Cardinia Creek and associated tributaries.

The isopod order was the most diverse group recorded with 44 specimens collected representing two species, *Troglarmadillo* OES1 (Armadillidae) and *Paraplatyarthrus* nr *subterraneus* OES25 (Paraplatyarthridae). Both isopod species exhibit relatively widespread distributions within the Greater Cardinia Area, occurring across multiple project areas (**Figure 5-18**). The remaining four troglofauna species recorded, the dipluran *Injapx* OES6, the pseudoscorpion *Tyrannochthonius* OE17, and both symphylan species, *Hanseniella* nr *indecisa* and *Symphylella* nr *cylindrica*, are each known from a single specimen only (i.e. are singletons). In addition to the six troglobitic species collected, three troglophilic taxa, a Polyxenida, Pauropoda and a Meenoplidae were also recorded (**Appendix C**).

5.5.2 Taxa Recorded

5.5.2.1 Diplura

All dipluran species have evolved to be largely unpigmented with no eye development and rely on highly specialised antennae for sensing their environment. Most species are known to be soil dwelling (edaphofauna), particularly in more mesic environments (Naumann 1991). Dipluran taxa are often recorded in subterranean fauna assessments from cavernous subterranean habitats (Subterranean Ecology 2010) as well as alluvial soil profiles (Outback Ecology 2011b). Not enough is known about the group to conclusively determine if specimens collected are true troglobites or if they are edaphofauna, particularly as all species are pale and blind. A dipluran taxonomist has considered that most diplurans collected in Western Australia are likely to be soil dwelling species (A. Sendra pers. comm. in Subterranean Ecology 2011b). An important factor for distinguishing between the two ecological niches relates to the differences in likely distribution range; i.e true troglobites are more likely to have restricted distributions and be SREs compared to soil dwelling species that may also be a SRE but would be less likely to have as restricted a distribution as a troglobite. For this assessment, *Injapx* OES6 is regarded as putative troglofauna, because although it may likely be a soil dwelling species, this cannot be conclusively determined.

Injapx OES6 is known from a single specimen only collected from Cardinia site BH006 near to Lewis Far South pit boundary within the 45 to 50 mbSWL modelled groundwater drawdown contour (**Figure 5-18**, **Appendix C**). Dipluran taxa recorded from subterranean fauna surveys are collected in low abundances, often as singletons, making determination of their likely extent of distribution and habitat requirements difficult to reliably determine (Outback Ecology 2011b, 2014, Subterranean Ecology 2010, 2011b). Where two or more specimens of a species have been collected, linear distributions have ranged from 3.6 km, in colluvial geology overlying fractured and weathered bedrock (Outback Ecology 2014a), to 13.4 km occurring across an extensive calcrete system (Subterranean Ecology 2011b). It is considered highly likely

that *Injapx* OES6 possesses a much broader distribution that is likely to extend beyond the Cardinia Project Area within the contiguous expanse of surface regolith that is present.

5.5.2.2 Isopoda

A recent study of the Western Australian isopod fauna has established a new family, Paraplatyarthridae, comprised of a single genus, *Paraplatyarthrus*, containing six described species, four of which are troglobitic (Javidkar *et al.* 2015, Javidkar *et al.* 2017). These newly described species, along with many other undescribed species collected in subterranean fauna assessments (e.g. Outback Ecology 2012b, 2013) would previously have been assigned to the genus *Trichorhina* (Platyarthridae). Paraplatyarthrus species have been more commonly recorded from calcrete habitats in the Yilgarn, however, are known from similar habitat, regolith over fractured and weathered bedrock units, as present in the Study Area from which *Paraplatyarthrus* nr *subterraneus* OES25 was collected (Outback Ecology 2013).

Both isopod species exhibit relatively widespread distributions within the Greater Cardinia Area, occurring across multiple project areas (**Figure 5-18**). The distributions of both *Paraplatyarthrus* nr *subterraneus* OES25 and *Troglarmadillo* OES1 extend for a linear distance of 5 km from near the proposed Rangoon pit boundary to near to Lewis Far South pit boundary. *Troglarmadillo* OES1 has also been collected from within the proposed Helens East pit. Neither species have been collected from outside the proposed impact zones, however, it is considered likely that the distribution of both species do extend into non-impact reference areas associated with the contiguous expanse of surface regolith present.

5.5.2.3 Pseudoscorpiones

The pseudoscorpion genus *Tyrannochthonius* is composed of epigean (surface) species (possess eyes) and troglobitic species (no eye development and elongated appendages), that are all considered to be SREs (Edward and Harvey 2008). Troglobitic *Tyrannochthonius* species are relatively commonly recorded in subterranean fauna surveys, often with numerous species recorded in a limited geographic area, but in low abundances (MWH 2015, Outback Ecology 2011b, 2012c, Subterranean Ecology 2011a).

Tyrannochonius OE17 is known from a single specimen collected in 2008 from Helens site, Helens Well, located within the proposed Helens East pit (**Figure 5-18**, **Appendix C**). Genetic analyses has demonstrated that the distributions of several troglobitic *Tyrannochonius* species can extend for at least 3.5 km or 5.5 km across a number of Yilgarn calcrete system (Subterranean Ecology 2011b, 2012b, Subterranean Ecology 2011b). The recorded distributions have also shown the ranges of some *Tyrannochthonius* species to extend across close neighbouring calcrete systems and range in habitat from colluvial sands fringing salt lake playa systems to more extensive calcrete geology (Harrison *et al.* 2014, MWH 2015, Outback Ecology 2011b, 2012c, Subterranean Ecology 2011a). It is considered likely that the troglobitic *Tyrannochonius* OE17 has a broader distribution than currently known that is likely to extend beyond the Helens Project Area within the contiguous expanse of surface regolith present.

5.5.2.4 Symphyla

Symphyla, like diplurans, are known to include many soil dwelling (edaphofauna) species as well as some troglobitic species (Scheller 1996). It can be difficult to establish the troglobitic status of symphylan taxa as all species have evolved to be unpigmented with no eye development and rely on highly specialised antennae for sensing their environment. Documented troglobitic symphylans do display distinctly elongated appendages, however, the evolution of such adaptations may not have occurred for all potential troglobitic species.

Both symphylan species, *Hanseniella* nr *indecisa* and *Symphylella* nr *cylindrical*, are each known from a single specimen only, collected within proposed impact areas (**Figure 5-18**). *Hanseniella* nr *indecisa* was collected from within the modelled 5 to 10 mbSWL groundwater drawdown contour that would represent a relatively low level of impact for a potential troglobitic species. *Symphylella* nr *cylindrical* was collected from within a modelled drawdown exceeding 40 mbSWL, which would represent a significant level of impact for a potential troglobitic species. It is considered likely that the distribution of both species do extend into non-impact reference areas associated with the contiguous expanse of surface regolith present.

5.5.2.5 Troglophiles

Three troglophilic taxa, a Polyxenida, a Pauropoda and a Meenoplidae, Nisia OES12, were also recorded in addition to the troglofauna species (**Appendix C**). Each of these troglophiles are not considered to be SRE species and so would have distributions that would extend well beyond the LGP Study Area and so they are not considered further in this assessment from an EIA perspective.

The meenoplid species, *Nisia* OES12, was relatively abundant with 12 specimens collected, represented by early and late juvenile stages as well as fully winged adult with full eye development; therefore, as with cicadas, this species has a highly mobile dispersive adult stage. The blind juveniles are troglophilic confined to the hypogean environment feeding on plant roots with the adults representing the epigean dispersal stage. Published and unpublished genetic studies have indicated that some Meenoplidae species collected in subterranean fauna surveys are relatively widely distributed and not SRE (Subterranean Ecology 2008a).

Pauropods are soil and organic litter inhabitants with all species blind and pale. In Australia, pauropods are relatively well documented from wetter regions in Australia, particularly Tasmania and the southwest of Western Australia, compared to the more arid regions of the continent where they are less common (Greenslade 2008, Scheller 2013). A described species, *Decapauropus tenuis*, known to occur in the Pilbara from Hope Downs, is considered to be a widespread species across the tropical, sub-tropical regions of the world (Scheller 2010).

The troglophilic polyxenid was represented by a single specimen from a scrape sample in 2017. Studies using genetic investigations of troglomorphic polyxenida material have indicated that many polyxenid species are not short range endemics as they have extensive distributions ranging across hundreds of kilometres from the northern Goldfields region of Western Australia to the Pilbara (MWH 2014a, Outback Ecology 2011b, 2013, Stantec 2017b).

5.5.3 Project Areas

The findings for each of the project areas sampled within the LGP Study Area are summarised as follows:

- Mertondale — No troglofauna species were recorded from the 2008 and 2009 sample rounds.
- Raeside — No troglofauna species were recorded from the 2008 and 2009 sample rounds.
- Cardinia — From a troglofauna ecology perspective, Cardinia appears to be divided into two distinct areas with different troglofauna values, likely as a result of the southern-most dolerite dyke in the project area that intrudes along, east to west, the southern boundary of the Lewis pit:
    - *Cardinia South* (Lewis South, and Lewis Far South pits) — Four troglofauna species were recorded from 2 of the 34 samples taken, and 2 of the 18 sites sampled. These were: the dipluran *Injapx* OES6; the isopods *Troglarmadillo* OES1 and *Paraplatyarthrus* nr *subterraneus* OES25; and the symphylan *Hanseniella* nr *indecisa*. Three species, *Injapx* OES6, *Troglarmadillo* OES1 and *Paraplatyarthrus* nr *subterraneus* OES25, were collected sympatrically in the same sample from site BH006 (**Appendix C**).
    - *Cardinia North* (Bruno East, Bruno Extension, Bruno-Lewis Link, Bruno West, Kyte, and Lewis pits) — No troglobitic species were recorded from the 20 samples taken from 11 sites.
- Helens — Three troglofauna species were recorded from 3 of the 35 samples taken and 3 of 19 sites sampled. The species recorded were: *Troglarmadillo* OES1, *Tyrannochonius* OE17, and *Symphylella* nr *cylindrica*. Both *Troglarmadillo* OES1 and *Tyrannochonius* OE17 were collected sympatrically in the same sample taken in 2008 from Helens Well (**Appendix C**).

- Rangoon — Two troglofauna species were recorded from 4 of the 28 samples taken and 5 of 19 sites sampled. The species recorded were the isopods *Paraplatyarthrus* nr *subterraneus* OES25 and *Troglarmadillo* OES1. Both species were collected sympatrically in three samples from sites BH022, BH025 and BH027 (**Appendix C**).

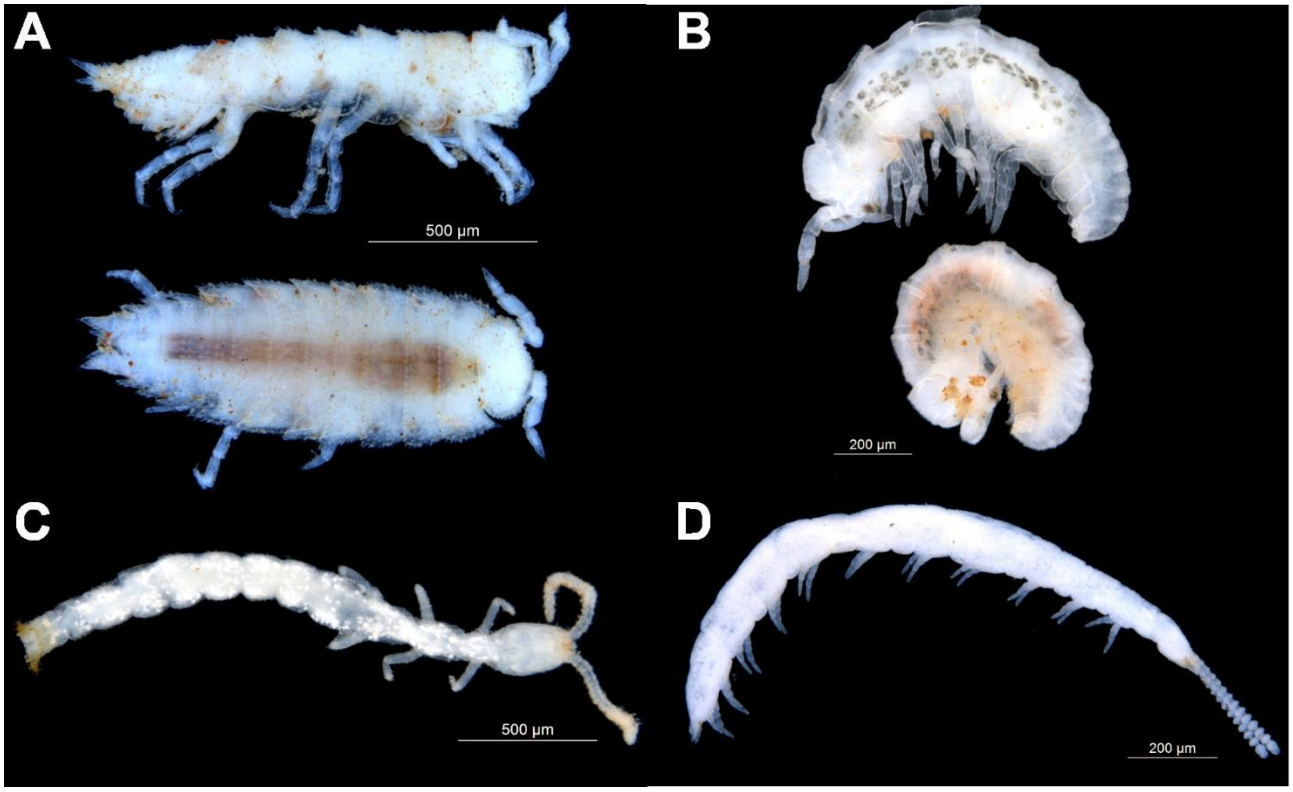


Figure 5-16: Representative troglofauna images. A) *Paraplatyarthrus nr subterraneus OES25*; B) *Troglarmadillo* OES1; C) *Indjapx* OES6; D) *Symphylella* nr *cylindrica*.

Table 5-4: Troglofauna diversity and distribution in relation to Project areas.

Taxon		Abundance	Project Area	Impact		Max. Distance from Pit (m)	Comments
				Inside Pit	Drawdown >0.5 m		
Diplura							
Japygidae	*Indjapx* OES6	1	Cardinia		●	50	Singleton species collected in 2017. Is an SRE but likely to have a broader distribution beyond LGP
Isopoda							
Armadillidae	*Troglarmadillo* OES1	30	Cardinia, Helens, Rangoon	●	●	115	Relatively commonly collected. Occurs throughout Greater Cardinia. Recorded in 2008 & 2017. Is an SRE likely to have a broader distribution likely to extend beyond LGP
Paraplatyarthridae	*Paraplatyarthrus* nr *subterraneus* OES25	14	Cardinia, Rangoon		●	115	Relatively commonly collected. Likley to occur throughout Greater Cardinia. Recorded in 2017 only. Is an SRE likely to have a broader distribution likely to extend beyond LGP
Pseudoscorpiones							
Chthoniidae	*Tyrannochthonius OE17*	1	Helens	●			Singleton species collected in 2008. Is an SRE but likely to have a broader distribution beyond LGP
Symphyla							
Symphyla	*Symphylella* nr *cylindrica*	1	Helens		●	140	Both singleton species, each collected in 2017. Are SRE but likely to have a broader distribution beyond LGP
Symphyla	*Hanseniella* nr *indecisa*	1	Cardinia		●	640	

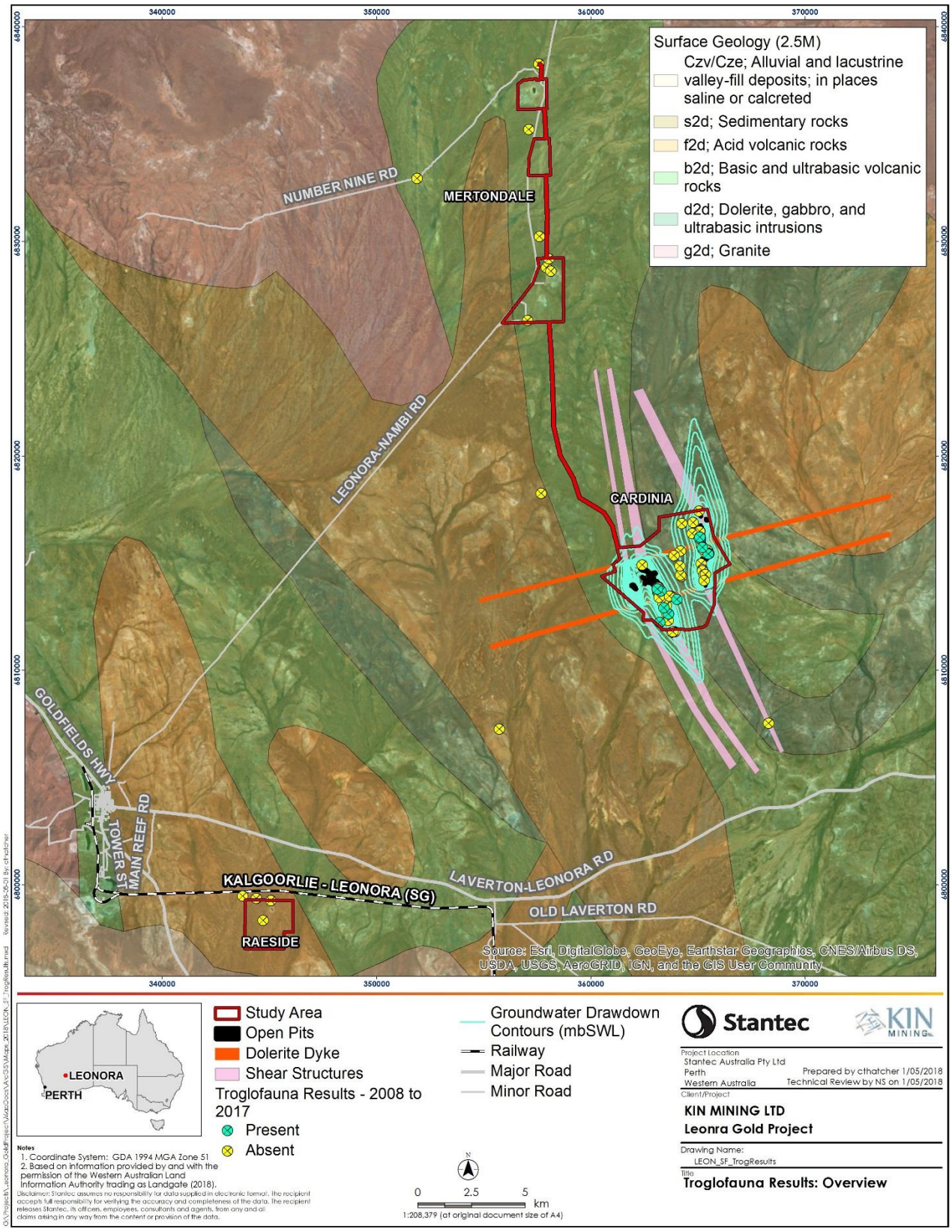


Figure 5-17: Presence / absence of troglofauna species recorded.

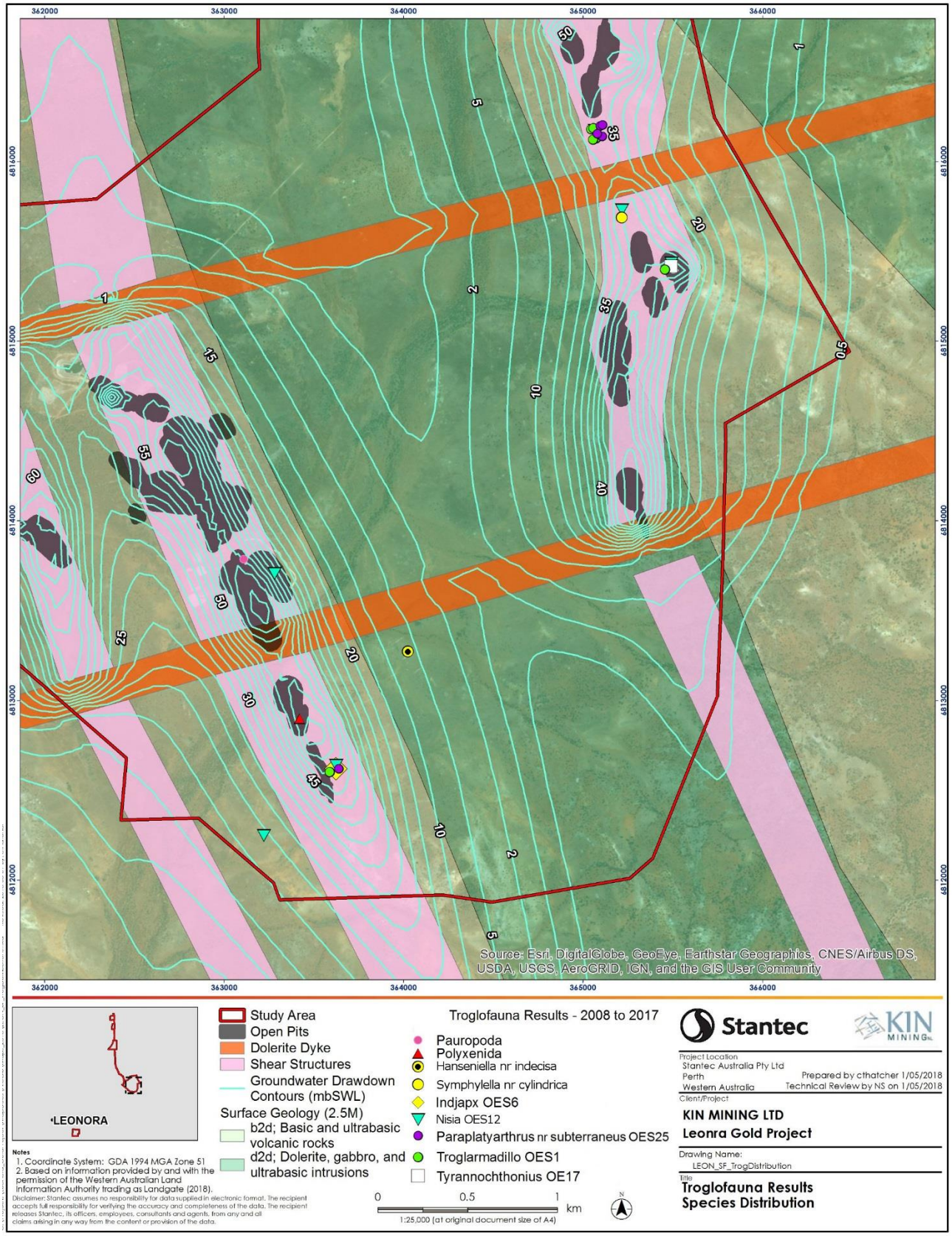


Figure 5-18: Distribution of troglofauna species recorded.

5.5.4 Troglofauna Species Richness Estimates and Survey Adequacy

The various species richness estimators indicated the total species richness to range from 7.5 to 14 species (**Figure 5-19**, **Table 5-5**). The six taxa collected in the study represent an estimated 43.1% to 80.3% of the total species predicted to occur in the LGP Study Area. The species accumulation curves for all richness estimators were still trending upwards to varying degrees indicating that additional survey effort is estimated to collect numerous new species. The richness estimators are sensitive to the presence of singleton species, particularly if singletons are collected in the latter part of the survey. The results of a previous species richness estimate analysis (not shown) where the symphylan taxa were treated as the same species were in stark contrast, with all richness estimators trending downwards with eight the maximum number of species predicted to occur. The trends depicted are consistent with species accumulation curves for other subterranean fauna surveys in Australia (e.g. Eberhard *et al.* 2007) and overseas, many of which do not plateau even after many years of intensive survey effort (Pipan and Culver 2007(Stantec 2017a)). The extrapolation of the observed species accumulation curve (S(ext)) indicates that increasing the survey effort by 100 % (i.e. from 126 to 252 samples) will likely record three additional troglofauna species.

The species capture rate (6 species from 126 samples at an overall capture rate of 0.05 species per sample) exceeds findings for other troglofauna assemblages recorded from other similar study areas with fractured bedrock overlain by regolith:

- Browns Range — 2 species from 209 samples (capture rate 0.01) (Outback Ecology 2014a);
- Yakabindie — 2 species from 81 samples (capture rate 0.024) (MWH 2016a); and
- Camelot — 2 species from 104 samples (capture rate 0.019) (Stantec 2018).

The species accumulation curves and comparison of capture rates with other similar studies, in terms of non-calcrete habitat present, indicate that the survey intensity undertaken has been sufficient in providing a reliable level of knowledge of the troglofauna assemblage present in the LGP Study Area and gives a high level of confidence in assessing the potential impacts posed by the proposed LGP in accordance with EPA (2016a, b) guidelines. The sampling effort conducted to date within the proposed impact areas (122 samples), has exceeded the recommended minimum requirements of 60 impact samples for a Level 2 troglofauna survey (EPA 2016a, b).

The total number of troglofauna samples collected as part of this assessment (126) does provide a reliable characterisation of the troglofauna values present within the LGP Study Area and in relation to the proposed direct impact zones. However, the survey effort in the Greater Cardinia project areas lacked the geographical spread required to demonstrate that the distribution of the Cardinia Creek troglofauna assemblage extends beyond the proposed impact zones. Additional targeted sampling in non-impact reference areas within the Cardinia Creek catchment would be required to further investigate the extent of distribution of the Cardinia troglofauna assemblage.

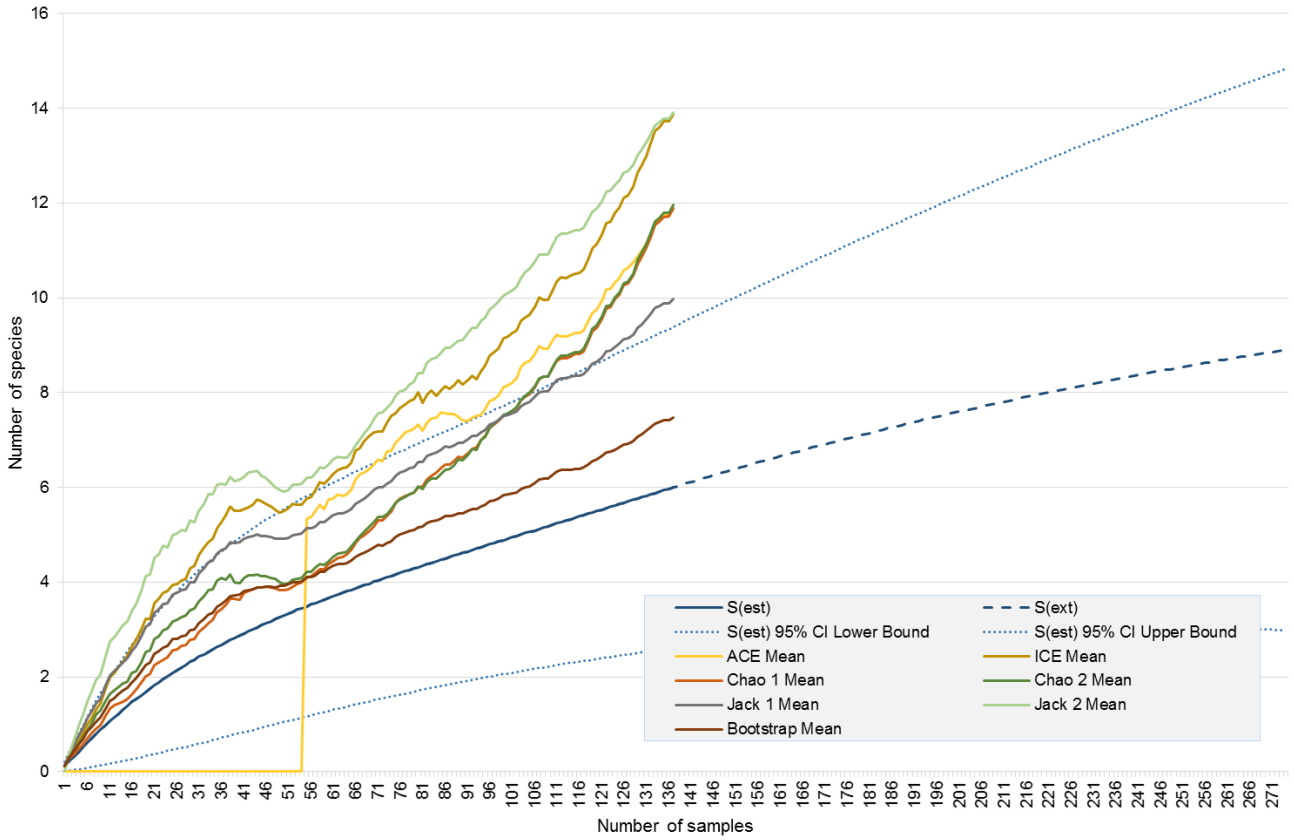


Figure 5-19: Troglofauna species accumulation curves for various diversity estimators and rarefaction curves for observed (S(est)) and extrapolated (S(ext) for the Project.

Table 5-5: Observed troglofauna species diversity from the Study Area compared to estimated diversity using EstimateS (Colwell 2013) diversity estimators.

Observed vs Estimated		Obs. & Pred. spp richness	% Predicted collected
Obs.	Sobs	6	
	Extrapolated (274 samples)	8.91	67.3%
Diversity estimators	Bootstrap Mean	7.5	80.3%
	Jack 1 Mean	10.0	60.2%
	ACE Mean	11.9	50.5%
	Chao 1 Mean	11.9	50.5%
	Chao 2 Mean	12.0	50.2%
	ICE Mean	13.9	43.2%
	Jack 2 Mean	13.9	43.1%
	Range	7.5 — 13.9	80.3 — 43.1%

6. Impact Assessment

6.1 Proposed Impacts

6.1.1 Direct Impacts

The two main direct potential impacts on subterranean fauna associated with the development of the LGP are:

- removal of habitat through excavation of the proposed mining pits; and
- drying out of habitat through the lowering of the groundwater table associated with mine pit dewatering.

The removal of habitat through mining excavation poses the greater risk to the conservation of stygofauna and troglofauna species relative to the lowering of the groundwater table only. Groundwater drawdowns are considered to have greater impacts on stygofauna compared to troglofauna because lowering of the groundwater table can directly reduce the extent of habitat available for stygofauna. Groundwater drawdown of 0.5 mbSWL is considered to represent the extent of the groundwater drawdown impact for both stygofauna and troglofauna. However, in the case of troglofauna, the lowering of the water table by less than 5 mbSWL is less likely to reduce the relative humidity of the overlying inhabited strata to such an extent to render them uninhabitable. In addition, troglofauna can migrate downwards to avoid uninhabitable conditions, provided suitable habitable voids are available for colonisation. Therefore, it is considered likely that troglofauna habitat will remain beyond the modelled groundwater drawdown of 5 mbSWL.

6.1.2 Indirect Impacts

Potential indirect impacts posed by proposed mining developments that can impact subterranean habitats and lead to reduced abundance of include:

- Reduction in influx of resources (e.g. nutrients, oxygen) through clearing of vegetation (reduced organic inputs) and changes to hydrological regimes as a result of mining associated landforms (e.g. pits, waste rock landforms, access infrastructure, etc);
- Contamination through chemical seepage or fuel spills; and
- increase in sediment load in run-off from mining activities that could reduce surface-subsurface water exchange during flow periods (e.g., lessen input of resources) and alter groundwater chemistry (Marmonier 1991).

These potential indirect impacts to groundwater quality are not considered further here as part of this risk assessment because they can be greatly reduced or avoided through project design and best practice environmental management procedures. For example, limit clearing of vegetation to immediate areas of planned development footprint, avoid significant changes / diversions to main drainage flow paths present, and reduce sediment run-off from roads and landforms. In addition, the indirect impacts are considered difficult to assess, and likely to lead to the reduction in the abundance of subterranean fauna species but less likely to reduce the species richness present. Appropriate management and mitigation measures will need to be addressed in the relevant approvals documentation and related environmental management plan in relation to potential indirect impacts.

6.2 Stygofauna

The stygofauna findings and habitat assessment indicated that the prospective habitat present in the LGP primarily occurred in areas near to the Cardinia Creek drainage line (e.g. northern part of the southern Cardinia area) where the overlying alluvial/colluvial strata is relatively thin (extending to around 7 to 8 mbgl) and less clay dominated, enabling a higher degree of hydrological exchange (i.e. influx of resources such as oxygen and nutrients) with the underlying fractured rock aquifer system (refer section 5.2). In the other

project areas that are more distant from the main drainage lines, the overlying clay dominated regolith extends to depths exceeding 22 to 48 mbgl, to below the SWL. The deep clay dominated regolith would greatly reduce the degree of hydrological exchange.

The development of the Mertondale and Raeside project areas will not pose a conservation risk to any stygofauna species as these areas were found not to host any stygofauna values. The subterranean habitat in both areas was found to not be prospective for stygofauna as the overlying regolith was clay dominated and deep, extending to below the SWL, offering limited interstitial pore space and hydrological exchange. The non-prospective habitat in both Mertondale and Raeside projects was verified by two rounds of sampling that failed to record any stygofauna species (**Figure 5-13**).

The proposed excavation of the Greater Cardinia LGP pits and associated groundwater drawdown pose varying degrees of direct impact and subsequent conservation risk to all five stygobitic species recorded. The distributions of all five stygobitic species recorded from the Greater Cardinia project areas have not been recorded to extend beyond the proposed direct impact zones associated with pit excavations and dewatering (**Figure 5-14**). The seemingly restricted distribution of the stygofauna assemblage to the proposed impact areas is an artefact of the disproportionate sampling effort conducted between impact and non-impact sites. All samples collected in the upper Cardinia Creek catchment area, encompassing the Greater Cardinia project areas, were from within the proposed impact zones (**Figure 5-13**). When sampling was conducted in early 2017, the proposed project footprint was not as extensive with fewer and shallower pits. Therefore, the potential groundwater drawdown was not considered to extend to a number of sites that were initially treated as occurring in reference areas located outside the potential impact zones.

Only two of the five species collected, *Atopobathynella* OES2 and Phreodrilidae OES22, have been recorded from beyond the modelled 5 mbSWL groundwater drawdown, each from the 0.5 to 1 mbSWL drawdown contour. Bathynellidae-OES28 and *Hirtaleptomesochra "multispinosa"* were the only stygofauna species to be collected from within proposed pit boundaries, however, both species were also recorded from habitat occurring outside proposed pits and associated shear structures. The remaining stygobitic species, *Atopobathynella* OES29, was found to have the most restricted distribution recorded, only collected from two neighbouring sites (approximately 10 m apart) within 50 m of the southern boundary of the proposed Rangoon pit.

All stygobitic species were recorded from sites near to Cardinia Creek and/or associated tributaries except for *Atopobathynella* OES29 (**Figure 5-14**). *Atopobathynella* OES29 was collected from two sites in an area near Rangoon pit within a shear structure zone that is not associated with any distinctly incised drainage line. Both *Atopobathynella* OES2 and *Hirtaleptomesochra "multispinosa"* were also recorded from multiple sites (five and eight, respectively) from the same area, with *Hirtaleptomesochra "multispinosa"* collected sympatrically with *Atopobathynella* OES29 on each occasion the parabathynellid species was recorded. The sympatry with *Atopobathynella* OES29 and broader distributions of both *Atopobathynella* OES2 and *Hirtaleptomesochra "multispinosa"* that extend well beyond the Rangoon project area, demonstrates that the habitat from which *Atopobathynella* OES29 was recorded is not an isolated system cut off by the intersecting dolerite dyke (refer section 5.2), but is instead connected to the broader Cardinia Creek aquifer system.

The broader distributions of *Atopobathynella* OES2, Bathynellidae-OES28, *Hirtaleptomesochra "multispinosa"* and Phreodrilidae OES22 beyond the shear structures hosting the target mineralisation, indicate that stygofauna habitat present is not restricted to the deposit areas only. The distribution records indicate that the main habitat hosting the Cardinia Creek stygofauna assemblage occurs within the fractured rock aquifer systems in association with the main Cardinia Creek drainage line and associated tributaries where the overlying alluvial/colluvial regolith is thinner and less clay dominated (refer section 5.2). The presence of a thinner overlying alluvial/colluvial regolith would allow greater hydrological exchange (i.e. infiltration of resources, such as dissolved oxygen and nutrients) with the underlying aquifer system. The degree of hydrological exchange with alluvial/colluvial and fractured rock aquifer systems has been shown to greatly influence the distribution and diversity of stygofauna assemblages, with diversity higher in areas with greater rates of exchange compared to areas lacking surface water interactions (Schmidt *et al.* 2007). The coarser

alluvial sediments present along the main drainage lines would also not only provide zones of greater hydrological exchange, but would also provide suitable habitat when saturated. Further away from the main drainage lines, the prospectiveness of the habitat for stygofauna is considered to decrease as the degree of hydrological exchange declines, often as a result of the increasing depth and clay content of the overlying regolith.

The distribution of the stygofauna assemblage associated with the upper Cardinia Creek catchment is considered likely to extend beyond the LGP impact zone to the south-west along the Cardinia Creek for at least 12 km beyond where the flow path becomes braided and diverges into two main channels north of the Laverton-Leonora Road (**Figure 5-13**). South of the Laverton-Leonora Road the main flow paths do converge back into one main drainage line. There is a likelihood that the distribution of the Cardinia Creek stygofauna assemblage extends further southwards throughout much of the creek's catchment beyond the Laverton-Leonora Road, to the main Raeside paleochannel drainage system, approximately 25 km south south-west of the Cardinia project area. The stygofauna assemblage may also likely extend further northward within the Cardinia Creek beyond the proposed impact zones (**Figure 2-3**). The basis for considering the broader distribution of the Cardinia Creek stygofauna assemblage is the likely presence of suitable habitat along the main Cardinia Creek and the wider distributions of other bathynellacean stygofauna assemblages recorded from alluvial/colluvial and fractured rock aquifer systems that can extend for greater than 15 km, less commonly 60 km (MWH 2015, Outback Ecology 2012d, 2014, Perina *et al.* 2018) (refer section 5.4.2).

Targeted sampling is recommended to demonstrate that the distribution of the Cardinia Creek stygofauna assemblage does extend more broadly within the Cardinia Creek catchment beyond the proposed impact areas. The stygofauna sample effort for this assessment does provide a reliable characterisation of the stygofauna values present within the LGP Study Area in relation to the proposed direct impact zones. However, the survey effort in the Greater Cardinia project areas lacked the geographical coverage required to investigate the distribution of the Cardinia Creek stygofauna assemblage beyond the proposed impact zones. Further sampling would require suitable bores to be found or made available in non-impact reference areas to the southwest and northeast of the Greater Cardinia Project Area. At the time of the 2017 survey round no suitable sample sites beyond the proposed impact zones within the Cardinia Creek catchment were known to be present.

6.3 Troglofauna

The troglofauna findings and habitat assessment indicated that the prospective habitat present in the LGP Study Area primarily occurred in areas, similar to stygofauna, that were near to the Cardinia Creek drainage line where the upper part of the weathered and fractured rock geological units remained unsaturated and overlain by relatively thin (extending to around 7 to 8 mbgl) alluvial/colluvial strata that was not clay dominated. Therefore, sufficient interstitial pore space remains available in the weathered and fractured rock as well as within the overlying coarser grained alluvial/colluvial strata. In the other project areas that are more distant from the main drainage lines, the overlying clay dominated regolith extends to below the SWL offering limited to no habitat in the absence of sufficient interstitial pore space.

The development of the Mertondale and Raeside project areas will not pose a conservation risk to any troglofauna species as these areas were found not to host any troglofauna values. The unsaturated subterranean habitat in both project areas were found to not be prospective for troglofauna as the overlying regolith was clay dominated, offering limited interstitial pore space, and deep, extending to below the SWL. The non-prospective habitat in both Mertondale and Raeside projects was verified by scrape samples, collected over two sample rounds that failed to record any troglofauna species (**Figure 5-17**).

The proposed development of the Greater Cardinia LGP pits and associated groundwater drawdown pose varying degrees of direct impact and subsequent conservation risk to all six troglobitic species recorded. The distributions of all six troglobitic species recorded from the Greater Cardinia project areas have not been demonstrated by the collection of specimens to extend beyond the proposed direct impact zones associated with pit excavations and dewatering (**Figure 5-18**). As with the stygofauna findings, the seemingly

restricted distribution of the troglofauna assemblage to the proposed impact areas is an artefact of the disproportionate sampling effort conducted between impact and non-impact sites. All samples collected in the upper Cardinia Creek catchment area, encompassing the Greater Cardinia project areas, were from within the proposed impact zones (**Figure 5-17**). When sampling was conducted in early 2017, the proposed project footprint was not as extensive with fewer and shallower pits. Therefore, the potential groundwater drawdown was not considered to extend to a number of sites that were initially treated as occurring in reference areas located outside the potential impact zones.

No troglofauna species were collected from beyond the modelled 5 mbSWL groundwater drawdown contour (**Figure 5-18**). However, the broader distributions of both isopod species, *Paraplatyarthrus* nr *subterraneus* OES25 and *Troglarmadillo* OES1, do indicate that suitable and contiguous habitat is present among the Greater Cardinia project areas beyond the modelled 5 mbSWL contour. The singleton pseudoscorpion, *Tyrannochonius* OE17, was the only troglobitic species that has not been found to date from outside a proposed pit boundary. Additional sampling in 2009 and 2017 failed to record this species again, further indicating that this species is uncommon and likely occurs at low population density. *Tyrannochonius* OE17 was collected sympatrically with *Troglarmadillo* OES1 from Helens Well within the proposed Helens East pit. The presence of a more widely occurring troglobite does indicate that the habitat in and around Helens Well is not isolated from the more extensive suitable regolith habitat present.

The distribution of the troglofauna assemblage associated with the unsaturated alluvial/colluvial and weathered and fractured rock geological units within the upper Cardinia Creek catchment is considered likely to extend beyond the LGP impact zone to the south-west and to the north east along the Cardinia Creek and associated tributaries. Targeted sampling is recommended to demonstrate that the distribution of the Cardinia Creek troglofauna assemblage does extend more broadly within the Cardinia Creek catchment. Targeted sampling would require suitable bores to be found or made available to the southwest and northeast of the Greater Cardinia Project Area. At the time of the 2017 survey round no suitable sample sites beyond the proposed impact zones were known to be present.

7. Conclusion

The subterranean fauna assessment reported here has demonstrated that the Mertondale and Raeside project areas do not host any stygofauna or troglofauna values. Therefore, stygofauna and troglofauna do not represent environmental factors for the development of the Mertondale and Raeside project areas.

The assessment did find the Greater Cardinia project area to have subterranean fauna values with the prospective habitat present verified to host stygofauna and troglofauna assemblages. From a subterranean fauna ecology perspective, Cardinia was shown to be divided into two distinct areas: Cardinia North (containing proposed Bruno East, Bruno Extension, Bruno-Lewis Link, Bruno West, Kyte, and Lewis pits) was found to not host any stygofauna or troglofauna values; In contrast, Cardinia South (containing proposed Lewis South, and Lewis Far South pits) was found to host relatively diverse stygofauna and troglofauna assemblages within the more prospective habitat present. The distributions of the recorded stygofauna and troglofauna assemblages were found to extend to the Helens and Rangoon Project Areas. However, none of the subterranean fauna species recorded have been collected from beyond the proposed impact zones within the Greater Cardinia study area. Stygofauna and troglofauna do represent key environmental factors for the proposed Greater Cardinia component of the LGP and will require further assessment.

Additional, targeted sampling is recommended to demonstrate that the distribution of the Cardinia Creek subterranean fauna assemblages do extend beyond the proposed impact zones. Although the distributions of the stygofauna and troglofauna assemblages associated with the alluvial/colluvial and weathered and fractured rock systems within the upper Cardinia Creek catchment are considered likely to extend beyond the Greater Cardinia impact zones, further survey will be required to investigate this likelihood more and establish the broader distribution patterns of recorded species.

8. Glossary

alluvium – sediment deposited by a stream or river

aquatic – relating to water

aquifer – a body of permeable rock or sediment capable of storing groundwater

arid – a region characterised by a severe lack of available water, to the extent that the growth and development of biota is hindered or prevented

bedrock – consolidated rock attached to the earth's crust

biodiversity – the diversity of biota in a particular environment or region

calcrete – carbonate deposits that form in arid environments, as a result of groundwater evaporation

cave – a subsurface cavity of sufficient size that a human could enter

dissolved oxygen – a measure of the amount of gaseous oxygen dissolved in a solution; oxic = > 3 mg/L; dysoxic = 0.3 to 3.0 mg/L; suboxic = < 0.3 mg/L levels

distribution range – the overall geographic area that a species is known to occur in

divergence – degree of separation from a common ancestor

diversity – a combination of species richness and abundance

drawdown – the lowering of the adjacent water table or piezometric surface as a result of groundwater extraction

ecotone – zone of transition among different ecosystems

electrical conductivity – an estimate of the total dissolved salts in a solution, or salinity

endemic – having a distribution restricted to a particular geographic region

epigean – pertaining to the surface zone

fractured rock – a rock formation characterized by separation or discontinuity, usually as a result of geological stress (e.g. faulting)

geological ages (e.g. Cainozoic) – distinct time periods within the geological history of the earth

groundwater – water occurring below the ground surface

habitat – an ecological or environmental area that is inhabited by a particular animal or plant species

hypogean – pertaining to the subterranean zone

hyporheic zone – spatially fluctuating ecotone within the bed of a river or stream between surface and groundwater. Considered important component of groundwater ecosystems and involved in the 'interstitial highway', forming hyporheic corridor linking associated aquifers.

invertebrates – animals lacking vertebrae

karst – a region of limestone or other soluble rock, characterized by distinctive features such as caves, caverns, sinkholes, underground streams and springs

lineage – a group of organisms related by descent from a common ancestor

molecular – pertaining to the genetic characteristics of an organism or group

morphology – the specific form and structure of an organism or taxon

morphospecies – a general grouping of organisms that share similar morphological traits, but is not necessarily defined by a formal taxonomic rank

palaeoriver, palaeochannel, palaeodrainage – a remnant of a stream or river channel cut in older rock and filled by the sediments of younger overlying rock

pH – a measure of the hydrogen ion concentration of a soil or solution (values below pH of 6.5 are 'acidic', and those above pH 7.5 are 'alkaline')

relictual – having survived as a remnant

salinity – the concentration of all dissolved salts in a solution. The salinity level classification *sensu* Hammer (1986): freshwater = salinity less than 5 mS/cm (3 ppt); hyposaline = salinity ranging from 5–30 mS/cm (3–20 ppt); mesosaline = salinity ranging from 30–70 mS/cm (20–50 ppt); hypersaline = salinity equal to or greater than 70 mS/cm (50 ppt)

semi-arid – a climatic region that receives low annual rainfall (250 – 500 mm)

species – a formal taxonomic unit defining a group or population of organisms that share distinctive characters or traits, are reproductively viable and/or are otherwise identifiable as a related group

species richness – the number of species present in a particular habitat, ecosystem or region

species accumulation curve – a model used to estimate species diversity or richness

standing water level (SWL) – the depth to groundwater from a particular reference point (e.g. in a monitoring bore)

stygal – pertaining to groundwater habitat or biota

stygobite – an obligate aquatic species of groundwater habitats

stygobiont – another term used to describe obligate inhabitants of groundwater systems

stygofauna – a general term for aquatic groundwater fauna

stygophile – an aquatic species that temporarily or permanently inhabits groundwater habitats

stygoxene – an aquatic species that has no fixed affinity with groundwater habitats, but may nonetheless occur in groundwater habitats

sympatry / sympatric – two or more species that are considered to exist in the same or overlapping geographic area and may regularly interact with, or encounter, each another (without interbreeding)

taxon (singular), taxa (plural) – an identifiable group of organisms, usually based on a known or inferred relationship or a shared set of distinctive characteristics

troglobite – an obligate terrestrial species of subterranean habitats

troglofauna – a general term for terrestrial subterranean fauna

troglomorphic features – morphological characteristics resulting from an adaptation to subterranean habitats (e.g. a reduction in pigment)

troglophile – a terrestrial species that temporarily or permanently inhabits subterranean habitats

trogloxene – a terrestrial species that has no fixed affinity with subterranean habitats, but may nonetheless occur in subterranean habitats

void – a pore space in the rock or stratum

Yilgarn – pertaining to the Yilgarn Craton, a 65,000 km2 body of the earth's crust in south-western Australia that dates back to the Archaean period, 2.6 to 3.7 million years ago

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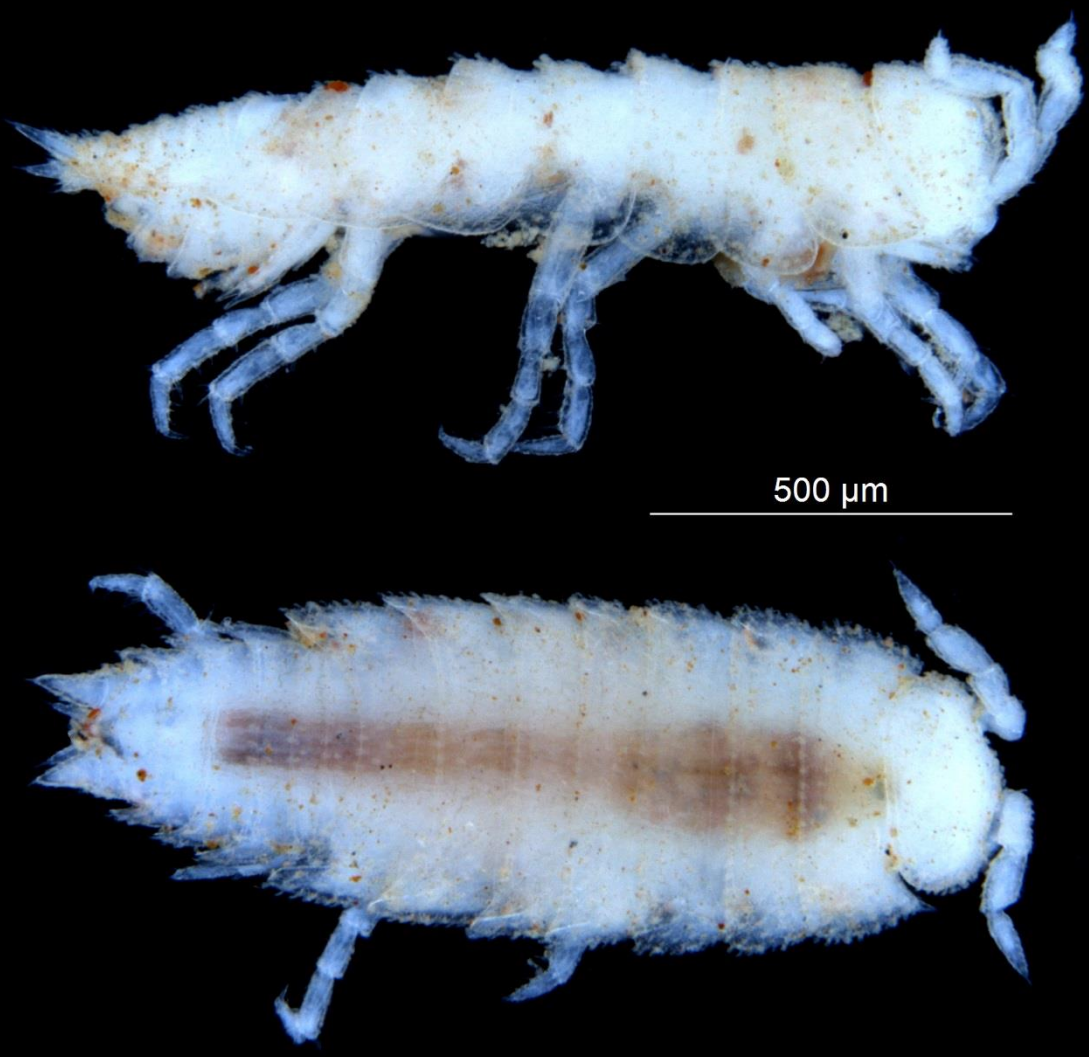
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Appendices



Paraplatyarthrus nr *subterraneus* OES25

Appendix A Subterranean Fauna Survey Effort and Bore Details

Table A-1: Subterranean Fauna Survey Effort and Bore Details.

Project Area	Site Name	Latitude	Longitude	Start Date	End Date	Collection method	Angle of Bore
Cardinia	BH001	-28.81432	121.60534	31 Jan, 2017	20 Mar, 2017	Litter Trap	60 degrees
Cardinia	BH001	-28.81432	121.60534	31 Jan, 2017	31 Jan, 2017	Net Haul	60 degrees
Cardinia	BH002	-28.81454	121.60409	31 Jan, 2017	20 Mar, 2017	Litter Trap	Vertical
Cardinia	BH002	-28.81454	121.60409	31 Jan, 2017	31 Jan, 2017	Net Haul	Vertical
Cardinia	BH003	-28.81429	121.60459	31 Jan, 2017	20 Mar, 2017	Litter Trap	60 degrees
Cardinia	BH003	-28.81429	121.60459	31 Jan, 2017	31 Jan, 2017	Net Haul	60 degrees
Cardinia	BH004	-28.80954	121.60233	31 Jan, 2017	21 Mar, 2017	Litter Trap	60 degrees
Cardinia	BH004	-28.80954	121.60233	31 Jan, 2017	31 Jan, 2017	Net Haul	60 degrees
Cardinia	BH005	-28.81028	121.59832	3 Feb, 2017	21 Mar, 2017	Litter Trap	Vertical
Cardinia	BH005	-28.81028	121.59832	3 Feb, 2017	3 Feb, 2017	Net Haul	Vertical
Cardinia	BH006	-28.80679	121.60249	3 Feb, 2017	21 Mar, 2017	Litter Trap	60 degrees
Cardinia	BH006	-28.80679	121.60249	3 Feb, 2017	3 Feb, 2017	Net Haul	60 degrees
Cardinia	BH007	-28.80661	121.60171	3 Feb, 2017	3 Feb, 2017	Net Haul	60 degrees
Cardinia	BH008	-28.80427	121.60044	3 Feb, 2017	21 Mar, 2017	Litter Trap	60 degrees
Cardinia	BH008	-28.80427	121.60044	3 Feb, 2017	3 Feb, 2017	Net Haul	60 degrees
Cardinia	BH009	-28.80318	121.60065	3 Feb, 2017	21 Mar, 2017	Litter Trap	60 degrees
Cardinia	BH010	-28.80332	121.6015	3 Feb, 2017	21 Mar, 2017	Litter Trap	60 degrees
Cardinia	BH010	-28.80332	121.6015	3 Feb, 2017	3 Feb, 2017	Net Haul	60 degrees
Cardinia	BH011	-28.80235	121.59992	3 Feb, 2017	21 Mar, 2017	Litter Trap	60 degrees
Cardinia	BH011	-28.80235	121.59992	3 Feb, 2017	3 Feb, 2017	Net Haul	60 degrees
Cardinia	BH012	-28.79954	121.60399	3 Feb, 2017	21 Mar, 2017	Litter Trap	60 degrees
Cardinia	BH012	-28.79954	121.60399	3 Feb, 2017	3 Feb, 2017	Net Haul	60 degrees
Cardinia	BH013	-28.80073	121.60668	3 Feb, 2017	21 Mar, 2017	Litter Trap	Vertical
Cardinia	BH013	-28.80073	121.60668	3 Feb, 2017	3 Feb, 2017	Net Haul	Vertical
Cardinia	BH043	-28.78038	121.60859	3 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Cardinia	BH043	-28.78038	121.60859	3 Feb, 2017	3 Feb, 2017	Net Haul	60 degrees
Cardinia	BH044	-28.78227	121.60549	3 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Cardinia	BH044	-28.78227	121.60549	3 Feb, 2017	3 Feb, 2017	Net Haul	60 degrees
Cardinia	BH055	-28.79621	121.59738	31 Jan, 2017	21 Mar, 2017	Litter Trap	Vertical
Cardinia	BH055	-28.79621	121.59738	31 Jan, 2017	31 Jan, 2017	Net Haul	Vertical
Cardinia	BH056	-28.79801	121.5983	31 Jan, 2017	31 Jan, 2017	Net Haul	60 degrees
Cardinia	BH057	-28.79779	121.59814	31 Jan, 2017	21 Mar, 2017	Litter Trap	60 degrees
Cardinia	BH057	-28.79779	121.59814	31 Jan, 2017	31 Jan, 2017	Net Haul	60 degrees
Cardinia	BH058	-28.79763	121.59769	31 Jan, 2017	21 Mar, 2017	Litter Trap	60 degrees
Cardinia	BH058	-28.79763	121.59769	31 Jan, 2017	31 Jan, 2017	Net Haul	60 degrees
Cardinia	BH059	-28.79767	121.59752	31 Jan, 2017	21 Mar, 2017	Litter Trap	60 degrees
Cardinia	BH059	-28.79767	121.59752	31 Jan, 2017	31 Jan, 2017	Net Haul	60 degrees
Cardinia	BH060	-28.79764	121.59786	31 Jan, 2017	21 Mar, 2017	Litter Trap	60 degrees
Cardinia	BH060	-28.79764	121.59786	31 Jan, 2017	31 Jan, 2017	Net Haul	60 degrees
Cardinia	BH061	-28.79548	121.59778	30 Jan, 2017	21 Mar, 2017	Litter Trap	Vertical
Cardinia	BH061	-28.79548	121.59778	30 Jan, 2017	30 Jan, 2017	Net Haul	Vertical
Cardinia	BH062	-28.79567	121.59787	31 Jan, 2017	31 Jan, 2017	Net Haul	Vertical
Cardinia	BH063	-28.79921	121.59834	31 Jan, 2017	21 Mar, 2017	Litter Trap	60 degrees
Cardinia	BH063	-28.79921	121.59834	31 Jan, 2017	31 Jan, 2017	Net Haul	60 degrees
Cardinia	BH064	-28.79987	121.59803	31 Jan, 2017	21 Mar, 2017	Net Haul	60 degrees
Cardinia	BH064	-28.79987	121.59803	31 Jan, 2017	31 Jan, 2017	Net Haul	60 degrees
Cardinia	Cardinia 1	-28.78603	121.59031	16 Mar, 2009	16 Mar, 2009	Net Haul	Vertical
Cardinia	Cardinia 1	-28.78603	121.59031	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Cardinia	Cardinia 2	-28.79712	121.59911	16 Mar, 2009	16 Mar, 2009	Net Haul	Vertical
Cardinia	Cardinia 2	-28.79712	121.59911	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Cardinia	Cardinia 3	-28.79629	121.59726	16 Mar, 2009	16 Mar, 2009	Net Haul	Vertical
Cardinia	Cardinia 3	-28.79629	121.59726	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Cardinia	Cardinia 4	-28.7961	121.59772	16 Mar, 2009	16 Mar, 2009	Net Haul	Vertical
Cardinia	Cardinia 4	-28.7961	121.59772	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Cardinia	Cardinia SE	-28.79937	121.603	16 Mar, 2009	16 Mar, 2009	Net Haul	Vertical
Cardinia	Cardinia SE	-28.79937	121.603	3 Feb, 2017	3 Feb, 2017	Net Haul	Vertical
Cardinia	Cardinia SE	-28.79937	121.603	8 Oct, 2008	9 Oct, 2008	Net Haul	Vertical

Table A-1 (cont.): Subterranean Fauna Survey Effort and Bore Details.

Project Area	Site Name	Latitude	Longitude	Start Date	End Date	Collection method	Angle of Bore
Helens	BH014	-28.7911	121.60895	2 Feb, 2017	2 Feb, 2017	Net Haul	60 degrees
Helens	BH015	-28.7905	121.60849	2 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Helens	BH015	-28.7905	121.60849	2 Feb, 2017	2 Feb, 2017	Net Haul	60 degrees
Helens	BH024	-28.78127	121.62068	1 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Helens	BH024	-28.78127	121.62068	1 Feb, 2017	1 Feb, 2017	Net Haul	60 degrees
Helens	BH037	-28.7783	121.61874	1 Feb, 2017	21 Mar, 2017	Litter Trap	60 degrees
Helens	BH037	-28.7783	121.61874	1 Feb, 2017	1 Feb, 2017	Net Haul	60 degrees
Helens	BH038	-28.77905	121.61918	1 Feb, 2017	21 Mar, 2017	Litter Trap	60 degrees
Helens	BH038	-28.77905	121.61918	1 Feb, 2017	1 Feb, 2017	Net Haul	60 degrees
Helens	BH039	-28.77895	121.61945	1 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Helens	BH040	-28.77977	121.61923	1 Feb, 2017	1 Feb, 2017	Net Haul	60 degrees
Helens	BH040	-28.77977	121.61923	3 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Helens	BH041	-28.78036	121.6216	1 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Helens	BH041	-28.78036	121.6216	1 Feb, 2017	1 Feb, 2017	Net Haul	60 degrees
Helens	BH042	-28.78014	121.62137	1 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Helens	BH042	-28.78014	121.62137	1 Feb, 2017	1 Feb, 2017	Net Haul	60 degrees
Helens	BH045	-28.78159	121.62219	3 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Helens	BH045	-28.78159	121.62219	3 Feb, 2017	3 Feb, 2017	Net Haul	60 degrees
Helens	BH046	-28.78578	121.61837	2 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Helens	BH046	-28.78578	121.61837	2 Feb, 2017	2 Feb, 2017	Net Haul	60 degrees
Helens	BH047	-28.78834	121.61896	2 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Helens	BH047	-28.78834	121.61896	2 Feb, 2017	2 Feb, 2017	Net Haul	60 degrees
Helens	BH048A	-28.7888	121.61895	2 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Helens	BH048A	-28.7888	121.61895	2 Feb, 2017	2 Feb, 2017	Net Haul	60 degrees
Helens	BH048B	-28.788659	121.618899	2 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Helens	BH049	-28.79056	121.61976	2 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Helens	BH049	-28.79056	121.61976	2 Feb, 2017	2 Feb, 2017	Net Haul	60 degrees
Helens	BH050	-28.79035	121.62034	2 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Helens	BH050	-28.79035	121.62034	2 Feb, 2017	2 Feb, 2017	Net Haul	60 degrees
Helens	BH051	-28.79293	121.61967	2 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Helens	BH051	-28.79293	121.61967	2 Feb, 2017	2 Feb, 2017	Net Haul	60 degrees
Helens	BH053	-28.78673	121.60816	3 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Helens	BH053	-28.78673	121.60816	3 Feb, 2017	3 Feb, 2017	Net Haul	60 degrees
Helens	Helens Well	-28.78174	121.62197	16 Mar, 2009	16 Mar, 2009	Net Haul	Vertical
Helens	Helens Well	-28.78174	121.62197	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Mertondale	M5WB11	-28.60225	121.53861	17 Mar, 2009	17 Mar, 2009	Net Haul	Vertical
Mertondale	M5WB11	-28.60225	121.53861	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Mertondale	M5WB8P	-28.57478	121.54373	17 Mar, 2009	17 Mar, 2009	Net Haul	Vertical
Mertondale	M5WB8P	-28.57478	121.54373	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Mertondale	Mertondale (Homestead) Well	-28.68265	121.5369	17 Mar, 2009	17 Mar, 2009	Net Haul	Vertical
Mertondale	Mertondale (Homestead) Well	-28.68265	121.5369	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Mertondale	Mertondale 3/4	-28.66052	121.54614	17 Mar, 2009	17 Mar, 2009	Net Haul	Vertical
Mertondale	Mertondale 3/4	-28.66052	121.54614	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Mertondale	Merton's Reward	-28.75547	121.54228	17 Mar, 2009	17 Mar, 2009	Net Haul	Vertical
Mertondale	Merton's Reward	-28.75547	121.54228	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Mertondale	MW3P	-28.65686	121.54744	17 Mar, 2009	17 Mar, 2009	Net Haul	Vertical
Mertondale	MW3P	-28.65686	121.54744	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Mertondale	Piezo 1 (MW9P)	-28.66206	121.54826	17 Mar, 2009	17 Mar, 2009	Net Haul	Vertical
Mertondale	Piezo 1 (MW9P)	-28.66206	121.54826	7 Oct, 2008	7 Oct, 2008	Net Haul	Vertical
Mertondale	Piezo 2 (Mertondale 3/4 B)	-28.64735	121.54303	17 Mar, 2009	17 Mar, 2009	Net Haul	Vertical
Mertondale	Piezo 2 (Mertondale 3/4 B)	-28.64735	121.54303	7 Oct, 2008	7 Oct, 2008	Net Haul	Vertical

Table A-1 (cont.): Subterranean Fauna Survey Effort and Bore Details.

Project Area	Site Name	Latitude	Longitude	Start Date	End Date	Collection method	Angle of Bore
Mertondale Regional	Old Homestead Well	-28.6222	121.48485	17 Mar, 2009	17 Mar, 2009	Net Haul	Vertical
Mertondale Regional	Old Homestead Well	-28.6222	121.48485	7 Oct, 2008	7 Oct, 2008	Net Haul	Vertical
Raeside	Raeside 1	-28.93366	121.40668	16 Mar, 2009	16 Mar, 2009	Net Haul	Vertical
Raeside	Raeside 1	-28.93366	121.40668	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Raeside	Raeside 2	-28.92539	121.41065	16 Mar, 2009	16 Mar, 2009	Net Haul	Vertical
Raeside	Raeside 2	-28.92539	121.41065	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Raeside	Raeside 3	-28.92325	121.39705	16 Mar, 2009	16 Mar, 2009	Net Haul	Vertical
Raeside	Raeside 3	-28.92325	121.39705	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Raeside	Raeside 4	-28.92428	121.4036	16 Mar, 2009	16 Mar, 2009	Net Haul	Vertical
Raeside	Raeside 4	-28.92428	121.4036	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Rangoon	BH017	-28.76849	121.61486	2 Feb, 2017	2 Feb, 2017	Net Haul	60 degrees
Rangoon	BH018	-28.76842	121.61499	2 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Rangoon	BH019	-28.7684	121.61511	2 Feb, 2017	21 Mar, 2017	Litter Trap	60 degrees
Rangoon	BH020	-28.76378	121.61767	1 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Rangoon	BH020	-28.76378	121.61767	1 Feb, 2017	1 Feb, 2017	Net Haul	60 degrees
Rangoon	BH021	-28.77465	121.61785	1 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Rangoon	BH021	-28.77465	121.61785	1 Feb, 2017	1 Feb, 2017	Net Scrape	60 degrees
Rangoon	BH022	-28.7751	121.61811	1 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Rangoon	BH022	-28.7751	121.61811	1 Feb, 2017	1 Feb, 2017	Net Scrape	60 degrees
Rangoon	BH023	-28.77606	121.61814	1 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Rangoon	BH023	-28.77606	121.61814	1 Feb, 2017	1 Feb, 2017	Net Haul	60 degrees
Rangoon	BH025	-28.77517	121.61795	1 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Rangoon	BH025	-28.77517	121.61795	1 Feb, 2017	1 Feb, 2017	Net Haul	60 degrees
Rangoon	BH026	-28.77504	121.61768	1 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Rangoon	BH026	-28.77504	121.61768	1 Feb, 2017	1 Feb, 2017	Net Haul	60 degrees
Rangoon	BH027	-28.7746	121.61797	1 Feb, 2017	1 Feb, 2017	Net Haul	60 degrees
Rangoon	BH028	-28.7744	121.61735	1 Feb, 2017	1 Feb, 2017	Net Haul	60 degrees
Rangoon	BH029	-28.77436	121.61744	1 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Rangoon	BH029	-28.77436	121.61744	1 Feb, 2017	1 Feb, 2017	Net Haul	60 degrees
Rangoon	BH030	-28.77442	121.61759	1 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Rangoon	BH031	-28.77413	121.61799	1 Feb, 2017	1 Feb, 2017	Net Haul	60 degrees
Rangoon	BH032	-28.76882	121.61886	2 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Rangoon	BH033	-28.77212	121.61802	2 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Rangoon	BH033	-28.77212	121.61802	2 Feb, 2017	2 Feb, 2017	Net Haul	60 degrees
Rangoon	BH034	-28.77223	121.61783	2 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Rangoon	BH034	-28.77223	121.61783	2 Feb, 2017	2 Feb, 2017	Net Haul	60 degrees
Rangoon	BH035	-28.77311	121.61424	2 Feb, 2017	20 Mar, 2017	Litter Trap	60 degrees
Rangoon	BH035	-28.77311	121.61424	2 Feb, 2017	2 Feb, 2017	Net Haul	60 degrees
Rangoon	Snowden Well	-28.76885	121.6094	16 Mar, 2009	16 Mar, 2009	Net Haul	Vertical
Rangoon	Snowden Well	-28.76885	121.6094	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Southern Regional	Allen Well (Shaft)	-28.85441	121.52098	16 Mar, 2009	16 Mar, 2009	Net Haul	Vertical
Southern Regional	Allen Well (Shaft)	-28.85441	121.52098	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical
Southern Regional	Webster Well	-28.85328	121.64977	16 Mar, 2009	16 Mar, 2009	Net Haul	Vertical
Southern Regional	Webster Well	-28.85328	121.64977	8 Oct, 2008	8 Oct, 2008	Net Haul	Vertical

Appendix B Groundwater Properties Recorded

Table B-1: Groundwater Properties Data.

Project Area	Site Name	Latitude	Longitude	Sample Date	Elevation (AHD)	SWL (AHD)	SWL (mbgl)	DO (mg/L)	EC (uS/cm)	pH	Redox (mV)	Water Temp. (C)
Cardinia	BH001	-28.81432	121.60534	31 Jan, 2017	413	396.6	16.4	1.91	29234	7.14	45.4	26.8
Cardinia	BH002	-28.81454	121.60409	31 Jan, 2017	413	397.82	15.18	3.14	26193	6.87	71.6	26.1
Cardinia	BH003	-28.81429	121.60459	31 Jan, 2017	414	398.5	15.5	2.1	4441	6.8	51.6	26.1
Cardinia	BH004	-28.80954	121.60233	31 Jan, 2017	413	397.9	15.1	1.1	25444	7	28.6	26.3
Cardinia	BH005	-28.81028	121.59832	3 Feb, 2017	410	396.14	13.86	2.79	9171	7.43	-12.7	27.1
Cardinia	BH006	-28.80679	121.60249	3 Feb, 2017	414	399.1	14.9	2.24	19684	7.55	-53.7	27.2
Cardinia	BH007	-28.80661	121.60171	3 Feb, 2017	415	397.78	17.22	4.51	23402	7.18	1.2	26.8
Cardinia	BH008	-28.80427	121.60044	3 Feb, 2017	413	397.2	15.8	4.69	20379	7.19	4.1	27.7
Cardinia	BH010	-28.80332	121.6015	3 Feb, 2017	415	392	23	3.32	22354	7.14	-28.1	27.2
Cardinia	BH011	-28.80235	121.59992	3 Feb, 2017	413	398.1	14.9	3.57	7339	7.11	-4.6	26.7
Cardinia	BH012	-28.79954	121.60399	3 Feb, 2017	413	400.53	12.47	3.5	14940	7.34	57.7	27
Cardinia	BH013	-28.80073	121.60668	3 Feb, 2017	415	400.27	14.73	2.08	24565	7.02	-30.6	27.2
Cardinia	BH016	-28.79723	121.60157	2 Feb, 2017	428	410.5	17.5	1.87	8156	6.89	36.6	24.2
Cardinia	BH043	-28.78038	121.60859	3 Feb, 2017	419	403.1	15.9	3.72	7819	7.34	52.7	25.9
Cardinia	BH044	-28.78227	121.60549	3 Feb, 2017	419	404.5	14.5	2.85	16630	7.19	58.8	27.4
Cardinia	BH055	-28.79621	121.59738	31 Jan, 2017	414	400.7	13.3	4.88	4469	7.62	129	25.8
Cardinia	BH056	-28.79801	121.5983	31 Jan, 2017	412	401.6	10.4	1.52	440.3	7.14	-54.6	26.6
Cardinia	BH057	-28.79779	121.59814	31 Jan, 2017	413	401.8	11.2	1.74	916	7.62	-36.6	26.6
Cardinia	BH058	-28.79763	121.59769	31 Jan, 2017	413	401.3	11.7	1.86	777	7.66	-6.5	25.9
Cardinia	BH059	-28.79767	121.59752	31 Jan, 2017	413	401	12	4.76	4941	7.63	121.5	25.8
Cardinia	BH060	-28.79764	121.59786	31 Jan, 2017	413	401.2	11.8	2.48	222.1	7.88	70.5	26.5
Cardinia	BH061	-28.79548	121.59778	30 Jan, 2017	414	401.28	12.72	4.85	12973	7.35	47.9	29.1
Cardinia	BH062	-28.79567	121.59787	31 Jan, 2017	414	401.46	12.54	4.69	1903	7.82	137.6	25.6
Cardinia	BH063	-28.79921	121.59834	31 Jan, 2017	411	400.4	10.6	1.62	163.3	7.11	-36.8	26.6
Cardinia	BH064	-28.79987	121.59803	31 Jan, 2017	411	400.3	10.7	6.35	1957	7.41	-84.4	25.5
Cardinia	Cardinia 1	-28.78603	121.59031	16 Mar, 2009	421	401.1	19.9		9220	6.97		28.4
Cardinia	Cardinia 1	-28.78603	121.59031	8 Oct, 2008	421	401.7	19.3		10520	6.89		26.5
Cardinia	Cardinia 2	-28.79712	121.59911	16 Mar, 2009	414	403.13	10.87		1128	7.56		27.4
Cardinia	Cardinia 2	-28.79712	121.59911	8 Oct, 2008	414	403.8	10.2		1901	7.66		27.8
Cardinia	Cardinia 3	-28.79629	121.59726	16 Mar, 2009	414	401.04	12.96		8880	7.38		27.1
Cardinia	Cardinia 3	-28.79629	121.59726	8 Oct, 2008	414	401.8	12.2		13290	7.41		27.9

Table B-1 (cont.): Groundwater Properties Data.

Project Area	Site Name	Latitude	Longitude	Sample Date	Elevation (AHD)	SWL (AHD)	SWL (mbgl)	DO (mg/L)	EC (uS/cm)	pH	Redox (mV)	Water Temp. (C)
Cardinia	Cardinia 4	-28.7961	121.59772	16 Mar, 2009	414	401.19	12.81		11450	7.54		28.4
Cardinia	Cardinia 4	-28.7961	121.59772	8 Oct, 2008	414	402	12		12710	7.49		25.6
Cardinia	Cardinia SE	-28.79937	121.603	16 Mar, 2009	414	401.88	12.12					
Cardinia	Cardinia SE	-28.79937	121.603	8 Oct, 2008	414	402	12		14220	7.18		26.2
Cardinia	Cardinia SE	-28.7994	121.603	3 Feb, 2017	414	401.72	12.28	0	2258	6.9	-195.6	24.8
Cardinia	Snowden Well	-28.76885	121.6094	16 Mar, 2009	424	408.8	15.2		7110	7.87		26.5
Cardinia	Snowden Well	-28.76885	121.6094	8 Oct, 2008	424	409.1	14.9		4740	8.03		22.1
Helens	BH014	-28.7911	121.60895	2 Feb, 2017	417	406.3	10.7	5.6	1345	8.18	29.1	26.8
Helens	BH015	-28.7905	121.60849	2 Feb, 2017	417	404.4	12.6	1.98	12452	6.98	41.4	26.2
Helens	BH045	-28.78159	121.62219	3 Feb, 2017	421	405.6	15.4	1.12	31350	7.01	-30.7	24.5
Helens	BH046	-28.78578	121.61837	2 Feb, 2017	423	405.5	17.5	1.29	38927	6.81	40.7	26.6
Helens	BH047	-28.78834	121.61896	2 Feb, 2017	425	406.1	18.9	4.3	25508	6.99	37	26.4
Helens	BH048A	-28.7888	121.61895	2 Feb, 2017	425	405.9	19.1	4.64	16938	7.16	17.9	27.2
Helens	BH049	-28.79056	121.61976	2 Feb, 2017	432	401	31	1.51	32844	6.99	-75.9	26.5
Helens	BH050	-28.79035	121.62034	2 Feb, 2017	426	401	25	1.45	14524	7.2	-58.7	26.2
Helens	BH053	-28.78673	121.60816	3 Feb, 2017	418	405.7	12.3	4.13	2348	7.32	39.2	25.2
Helens	Helens Well	-28.78174	121.62197	16 Mar, 2009	422	399.46	22.54		412	8.75		28.1
Helens	Helens Well	-28.78174	121.62197	8 Oct, 2008	422	406.5	15.5		404	8.36		26.7
Mertondale	M5WB11	-28.60225	121.53861	8 Oct, 2008	481	455.77	25.23		322	6.93		28.9
Mertondale	M5WB8P	-28.57478	121.54373	17 Mar, 2009	488	472.45	15.55		3800	7.61		25.3
Mertondale	M5WB8P	-28.57478	121.54373	8 Oct, 2008	488	472.5	15.5		6360	7.58		26.9
Mertondale	Mertondale (Homestead) Well	-28.68265	121.5369	17 Mar, 2009	453	434.08	18.92		4530	7.4		26.9
Mertondale	Mertondale (Homestead) Well	-28.68265	121.5369	8 Oct, 2008	453	433.8	19.2		3330	7.58		23.1
Mertondale	Mertondale 3/4	-28.66052	121.54614	17 Mar, 2009	457	415.26	41.74		1562	7.29		26.5
Mertondale	Mertondale 3/4	-28.66052	121.54614	8 Oct, 2008	457	415.22	41.78		1554	7.35		26.7
Mertondale	Merton's Reward	-28.75547	121.54228	17 Mar, 2009	442	401.14	40.86		4470	7.55		21.9
Mertondale	Merton's Reward	-28.75547	121.54228	8 Oct, 2008	442	402.12	39.88		5070	7.71		22.88
Mertondale	MW3P	-28.65686	121.54744	17 Mar, 2009	462	449.47	12.53		982	7.48		28.2
Mertondale	MW3P	-28.65686	121.54744	8 Oct, 2008	462	449.46	12.54		888	7.4		28

Table B-1 (cont.): Groundwater Properties Data.

Project Area	Site Name	Latitude	Longitude	Sample Date	Elevation (AHD)	SWL (AHD)	SWL (mbgl)	DO (mg/L)	EC (uS/cm)	pH	Redox (mV)	Water Temp. (C)
Mertondale	Piezo 1 (MW9P)	-28.66206	121.54826	17 Mar, 2009	460	417.53	42.47		2860	7.24		27.2
Mertondale	Piezo 1 (MW9P)	-28.66206	121.54826	7 Oct, 2008	460	417.3	42.7		2850	7.29		26.9
Mertondale	Piezo 2 (Mertondale 3/4B)	-28.64735	121.54303	17 Mar, 2009	465	452.15	12.85		1749	7.13		27.7
Mertondale	Piezo 2 (Mertondale 3/4B)	-28.64735	121.54303	7 Oct, 2008	465	452.08	12.92		1777	7.19		25.3
Mertondale Regional	Old Homestead Well	-28.6222	121.48485	17 Mar, 2009	463	445.84	17.16		3880	8.02		24.5
Mertondale Regional	Old Homestead Well	-28.6222	121.48485	7 Oct, 2008	463	445.5	17.5		3830	8.02		21.7
Raeside	Raeside 1	-28.93366	121.40668	16 Mar, 2009	370	346.07	23.93		54400	7.02		26.6
Raeside	Raeside 1	-28.93366	121.40668	8 Oct, 2008	370	359.22	10.78		81500	6.7		26.5
Raeside	Raeside 2	-28.92539	121.41065	16 Mar, 2009	372	359.17	12.83		4950	7.12		26
Raeside	Raeside 2	-28.92539	121.41065	8 Oct, 2008	372	359.25	12.75		5050	7.54		26.2
Raeside	Raeside 3	-28.92325	121.39705	16 Mar, 2009	370	362.04	7.96		2244	7.49		26.7
Raeside	Raeside 3	-28.92325	121.39705	8 Oct, 2008	370	362.52	7.48		2880	7.55		25
Raeside	Raeside 4	-28.92428	121.4036	16 Mar, 2009	371	361.24	9.76		2880	7.3		26.6
Raeside	Raeside 4	-28.92428	121.4036	8 Oct, 2008	371	361.6	9.4		1512	7.48		24.2
Rangoon	BH018	-28.76842	121.61499	2 Feb, 2017	428	410.2	17.8	4.65	1854	7.31	34.4	24.9
Rangoon	BH019	-28.7684	121.61511	2 Feb, 2017	428	410.29	17.71	2.84	7163	6.96	43.1	24.8
Rangoon	BH020	-28.76378	121.61767	1 Feb, 2017	430	410	20	4.12	5026	7.24	115.1	24.5
Rangoon	BH021	-28.77465	121.61785	1 Feb, 2017	431	410.3	20.7	1.48	7395	6.97	-141.4	25.6
Rangoon	BH022	-28.7751	121.61811	1 Feb, 2017	430	409.8	20.2	2.18	11055	6.87	126.6	24.9
Rangoon	BH023	-28.77606	121.61814	1 Feb, 2017	430	409	21	1.37	5291	7.1	-104.4	26
Rangoon	BH024	-28.78127	121.62068	1 Feb, 2017	423	407.7	15.3	2.48	35237	7.1	-6.7	25.2
Rangoon	BH025	-28.77517	121.61795	1 Feb, 2017	430	409.4	20.6	3.15	10240	7.01	-99	25.3
Rangoon	BH026	-28.77504	121.61768	1 Feb, 2017	431	410	21	3.68	4067	7.08	-95.7	26.5
Rangoon	BH027	-28.7746	121.61797	1 Feb, 2017	430	409.3	20.7	3.46	13258	6.96	-112.5	25.8
Rangoon	BH028	-28.7744	121.61735	1 Feb, 2017	432	408.7	23.3	4.42	4025	7.13	-91.9	25.7
Rangoon	BH029	-28.77436	121.61744	1 Feb, 2017	431	408.1	22.9	2.98	7750	7.15	-83.3	25.4

Table B-1 (cont.): Groundwater Properties Data.

Project Area	Site Name	Latitude	Longitude	Sample Date	Elevation (AHD)	SWL (AHD)	SWL (mbgl)	DO (mg/L)	EC (uS/cm)	pH	Redox (mV)	Water Temp. (C)
Rangoon	BH031	-28.77413	121.61799	1 Feb, 2017	430	417.5	12.5	4.91	341.3	8.28	-112.1	26.1
Rangoon	BH033	-28.77212	121.61802	2 Feb, 2017	430	410.5	19.5	3.86	16040	7.11	45	24.6
Rangoon	BH034	-28.77223	121.61783	2 Feb, 2017	431	410.2	20.8	2.99	15915	6.91	47.8	25.2
Rangoon	BH035	-28.77311	121.61424	2 Feb, 2017	429	409	20	2.64	5518	7.18	37.7	24.7
Rangoon	BH037	-28.7783	121.61874	1 Feb, 2017	426	405.7	20.3	5.46	804	8.17	-77	26.2
Rangoon	BH038	-28.77905	121.61918	1 Feb, 2017	425	404.6	20.4	1.84	29187	7	-47.4	26.8
Rangoon	BH040	-28.77977	121.61923	1 Feb, 2017	424	405.5	18.5	2.52	10988	6.97	-22.1	26.4
Rangoon	BH041	-28.78036	121.6216	1 Feb, 2017	422	406.59	15.41	4.34	11249	7.31	-0.8	25.4
Rangoon	BH042	-28.78014	121.62137	1 Feb, 2017	422	405.8	16.2	1.35	37004	6.94	-0.8	25.1
Southern Regional	Allen Well (Shaft)	-28.85441	121.52098	16 Mar, 2009	400	387.31	12.69		269	7.26		23.4
Southern Regional	Allen Well (Shaft)	-28.85441	121.52098	8 Oct, 2008	400	387	13		524	7.92		20.7
Southern Regional	Webster Well	-28.85328	121.64977	16 Mar, 2009	415	400.23	14.77		2210	8.39		28.2
Southern Regional	Webster Well	-28.85328	121.64977	8 Oct, 2008	415	398.8	16.2		1823	8.03		22.1

Appendix C Subterranean Fauna Survey Results

Table C-1: Stygofauna survey results arranged by taxon. Shaded rows indicate site location relative to proposed pits and estimated groundwater drawdown as follows: Orange = site within a proposed pit; Light Orange = site within 25 m of a proposed pit boundary; Blue = site within modelled groundwater drawdown contour > 0.5 m bSWL; Unshaded rows indicate sites in non-impact zone.

Group	Family	Taxon	Abundance	Project Area	Site Name	Sample Date
Bathynellacea	Bathynellidae	Bathynellidae-OES28	1	Cardinia	BH008	3 Feb, 2017
Bathynellacea	Bathynellidae	Bathynellidae-OES28	1	Cardinia	BH011	3 Feb, 2017
Bathynellacea	Bathynellidae	Bathynellidae-OES28	1	Cardinia	Cardinia SE	16 Mar, 2009
Bathynellacea	Parabathynellidae	Atopobathynella OES2	4	Cardinia	BH002	31 Jan, 2017
Bathynellacea	Parabathynellidae	Atopobathynella OES2	7	Cardinia	BH010	3 Feb, 2017
Bathynellacea	Parabathynellidae	Atopobathynella OES2	1	Cardinia	BH011	3 Feb, 2017
Bathynellacea	Parabathynellidae	Atopobathynella OES2	52	Cardinia	BH013	3 Feb, 2017
Bathynellacea	Parabathynellidae	Atopobathynella OES2	5	Cardinia	BH043	3 Feb, 2017
Bathynellacea	Parabathynellidae	Atopobathynella OES2	7	Cardinia	Cardinia SE	8 Dec, 2008
Bathynellacea	Parabathynellidae	Atopobathynella OES2	2	Cardinia	Cardinia SE	16 Mar, 2009
Bathynellacea	Parabathynellidae	Atopobathynella OES2	1	Helens	BH038	1 Feb, 2017
Bathynellacea	Parabathynellidae	Atopobathynella OES2	2	Helens	BH041	1 Feb, 2017
Bathynellacea	Parabathynellidae	Atopobathynella OES2	2	Helens	BH042	1 Feb, 2017
Bathynellacea	Parabathynellidae	Atopobathynella OES2	3	Helens	BH048A	2 Feb, 2017
Bathynellacea	Parabathynellidae	Atopobathynella OES2	1	Rangoon	BH023	1 Feb, 2017
Bathynellacea	Parabathynellidae	Atopobathynella OES2	3	Rangoon	BH026	1 Feb, 2017
Bathynellacea	Parabathynellidae	Atopobathynella OES2	6	Rangoon	BH029	1 Feb, 2017
Bathynellacea	Parabathynellidae	Atopobathynella OES2	6	Rangoon	BH033	2 Feb, 2017
Bathynellacea	Parabathynellidae	Atopobathynella OES2	20	Rangoon	BH034	2 Feb, 2017
Bathynellacea	Parabathynellidae	Atopobathynella OES29	1	Rangoon	BH027	1 Feb, 2017
Bathynellacea	Parabathynellidae	Atopobathynella OES29	3	Rangoon	BH028	1 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	1	Cardinia	BH002	31 Jan, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	13	Cardinia	BH007	3 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	42	Cardinia	BH008	3 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	22	Cardinia	BH011	3 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	23	Cardinia	BH013	3 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	7	Cardinia	Cardinia SE	8 Dec, 2008
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	12	Cardinia	Cardinia SE	16 Mar, 2009
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	175	Helens	BH038	1 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	3	Helens	BH040	1 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	5	Helens	BH041	1 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	1	Helens	BH042	1 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	4	Helens	BH048A	2 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	1	Rangoon	BH023	1 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	16	Rangoon	BH025	1 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	17	Rangoon	BH026	1 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	50	Rangoon	BH027	1 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	7	Rangoon	BH028	1 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	12	Rangoon	BH029	1 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	7	Rangoon	BH033	2 Feb, 2017
Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	30	Rangoon	BH034	2 Feb, 2017
Oligochaeta	Phreodrilidae	Phreodrilidae-OES22	1	Cardinia	BH010	3 Feb, 2017
Oligochaeta	Phreodrilidae	Phreodrilidae-OES22	5	Cardinia	BH013	3 Feb, 2017
Oligochaeta	Phreodrilidae	Phreodrilidae-OES22	2	Cardinia	BH044	3 Feb, 2017
Oligochaeta	Phreodrilidae	Phreodrilidae-OES22	10	Helens	BH048A	2 Feb, 2017

Table C-2: Stygofauna survey results arranged by site. Shaded rows indicate site location relative to proposed pits and estimated groundwater drawdown as follows: Orange = site within a proposed pit; Light Orange = site within 25 m of a proposed pit boundary; Blue = site within modelled groundwater drawdown contour > 0.5 m bSWL; Unshaded rows indicate sites in non-impact zone.

Project Area	Site Name	Sample Date	Group	Family	Taxon	Abundance
Cardinia	BH002	31 Jan, 2017	Bathynellacea	Parabathynellidae	Atopobathynella OES2	4
Cardinia	BH002	31 Jan, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	1
Cardinia	BH007	3 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	13
Cardinia	BH008	3 Feb, 2017	Bathynellacea	Bathynellidae	Bathynellidae-OES28	1
Cardinia	BH008	3 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	42
Cardinia	BH010	3 Feb, 2017	Bathynellacea	Parabathynellidae	Atopobathynella OES2	7
Cardinia	BH010	3 Feb, 2017	Oligochaeta	Phreodrilidae	Phreodrilidae-OES22	1
Cardinia	BH011	3 Feb, 2017	Bathynellacea	Bathynellidae	Bathynellidae-OES28	1
Cardinia	BH011	3 Feb, 2017	Bathynellacea	Parabathynellidae	Atopobathynella OES2	1
Cardinia	BH011	3 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	22
Cardinia	BH013	3 Feb, 2017	Bathynellacea	Parabathynellidae	Atopobathynella OES2	52
Cardinia	BH013	3 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	23
Cardinia	BH013	3 Feb, 2017	Oligochaeta	Phreodrilidae	Phreodrilidae-OES22	5
Cardinia	BH043	3 Feb, 2017	Bathynellacea	Parabathynellidae	Atopobathynella OES2	5
Cardinia	BH044	3 Feb, 2017	Oligochaeta	Phreodrilidae	Phreodrilidae-OES22	2
Cardinia	Cardinia SE	16 Mar, 2009	Bathynellacea	Bathynellidae	Bathynellidae-OES28	1
Cardinia	Cardinia SE	8 Dec, 2008	Bathynellacea	Parabathynellidae	Atopobathynella OES2	7
Cardinia	Cardinia SE	16 Mar, 2009	Bathynellacea	Parabathynellidae	Atopobathynella OES2	2
Cardinia	Cardinia SE	8 Dec, 2008	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	7
Cardinia	Cardinia SE	16 Mar, 2009	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	12
Helens	BH038	1 Feb, 2017	Bathynellacea	Parabathynellidae	Atopobathynella OES2	1
Helens	BH038	1 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	175
Helens	BH040	1 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	3
Helens	BH041	1 Feb, 2017	Bathynellacea	Parabathynellidae	Atopobathynella OES2	2
Helens	BH041	1 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	5
Helens	BH042	1 Feb, 2017	Bathynellacea	Parabathynellidae	Atopobathynella OES2	2
Helens	BH042	1 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	1
Helens	BH048A	2 Feb, 2017	Bathynellacea	Parabathynellidae	Atopobathynella OES2	3
Helens	BH048A	2 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	4
Helens	BH048A	2 Feb, 2017	Oligochaeta	Phreodrilidae	Phreodrilidae-OES22	10
Rangoon	BH023	1 Feb, 2017	Bathynellacea	Parabathynellidae	Atopobathynella OES2	1
Rangoon	BH023	1 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	1
Rangoon	BH025	1 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	16
Rangoon	BH026	1 Feb, 2017	Bathynellacea	Parabathynellidae	Atopobathynella OES2	3
Rangoon	BH026	1 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	17
Rangoon	BH027	1 Feb, 2017	Bathynellacea	Parabathynellidae	Atopobathynella OES29	1
Rangoon	BH027	1 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	50
Rangoon	BH028	1 Feb, 2017	Bathynellacea	Parabathynellidae	Atopobathynella OES29	3
Rangoon	BH028	1 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	7
Rangoon	BH029	1 Feb, 2017	Bathynellacea	Parabathynellidae	Atopobathynella OES2	6
Rangoon	BH029	1 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	12
Rangoon	BH033	2 Feb, 2017	Bathynellacea	Parabathynellidae	Atopobathynella OES2	6
Rangoon	BH033	2 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	7
Rangoon	BH034	2 Feb, 2017	Bathynellacea	Parabathynellidae	Atopobathynella OES2	20
Rangoon	BH034	2 Feb, 2017	Copepoda: Harpacticoida	Ameiridae	Hirtaleptomesochra "multispinosa"	30

Table C-3: Survey results for semi-aquatic Oligochaeta, Enchytraeidae-OES21. Shaded rows indicate site location relative to proposed pits and estimated groundwater drawdown as follows: Orange = site within a proposed pit; Light Orange = site within 25 m of a proposed pit boundary; Blue = site within modelled groundwater drawdown contour > 0.5 m bSWL; Unshaded rows indicate sites in non-impact zone.

Project Area	Site Name	Sample Date	Group	Family	Taxon	Abundance	Collection method
Cardinia	BH001	31 Jan, 2017	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	2	Litter Trap
Cardinia	BH004	31 Jan, 2017	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	5	Net Haul
Cardinia	BH005	3 Feb, 2017	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	4	Net Haul
Cardinia	BH005	3 Feb, 2017	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	2	Litter Trap
Cardinia	BH006	3 Feb, 2017	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	11	Net Haul
Cardinia	BH007	3 Feb, 2017	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	13	Net Haul
Cardinia	BH013	3 Feb, 2017	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	5	Net Haul
Cardinia	BH044	3 Feb, 2017	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	3	Net Haul
Cardinia	BH063	31 Jan, 2017	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	6	Net Haul
Cardinia	BH063	31 Jan, 2017	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	2	Litter Trap
Cardinia	BH064	31 Jan, 2017	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	1	Net Haul
Cardinia	BH064	31 Jan, 2017	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	15	Net Haul
Cardinia	Cardinia 2	8 Oct, 2008	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	13	Net Haul
Cardinia	Cardinia 2	16 Mar, 2009	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	1	Net Haul
Cardinia	Cardinia 3	8 Oct, 2008	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	18	Net Haul
Cardinia	Cardinia 3	16 Mar, 2009	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	1	Net Haul
Cardinia	Cardinia 4	8 Oct, 2008	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	1	Net Haul
Cardinia	Cardinia 4	16 Mar, 2009	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	1	Net Haul
Mertondale	M5WB11	8 Dec, 2008	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	1	Net Haul
Raeside	Raeside 2	16 Mar, 2009	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	1	Net Haul
Raeside	Raeside 4	16 Mar, 2009	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	1	Net Haul
Southern Regional	Allen Well (Shaft)	8 Oct, 2008	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	2	Net Haul
Southern Regional	Webster Well	8 Oct, 2008	Oligochaeta	Enchytraeidae	Enchytraeidae-OES21	1	Net Haul

Table C-4: Troglofauna survey results arranged by taxon. Shaded rows indicate site location relative to proposed pits and estimated groundwater drawdown as follows: Orange = site within a proposed pit; Light Orange = site within 25 m of a proposed pit boundary; Blue = site within modelled groundwater drawdown contour > 0.5 m bSWL; Unshaded rows indicate sites in non-impact zone.

Group	Family	Taxon	Abundance	Project Area	Site Name	Sample Date
Diplura	Japygidae	Indjapx OES6	1	Cardinia	BH006	3 Feb, 2017
Isopoda	Armadillidae	Troglarmadillo OES1	21	Cardinia	BH006	3 Feb, 2017
Isopoda	Armadillidae	Troglarmadillo OES1	1	Helens	Helens Well	8 Dec, 2008
Isopoda	Armadillidae	Troglarmadillo OES1	1	Rangoon	BH021	1 Feb, 2017
Isopoda	Armadillidae	Troglarmadillo OES1	1	Rangoon	BH022	1 Feb, 2017
Isopoda	Armadillidae	Troglarmadillo OES1	4	Rangoon	BH025	1 Feb, 2017
Isopoda	Armadillidae	Troglarmadillo OES1	2	Rangoon	BH027	1 Feb, 2017
Isopoda	Paraplatyarthridae	Paraplatyarthrus nr_subterraneus_OES25	9	Cardinia	BH006	3 Feb, 2017
Isopoda	Paraplatyarthridae	Paraplatyarthrus nr_subterraneus_OES25	1	Rangoon	BH021	1 Feb, 2017
Isopoda	Paraplatyarthridae	Paraplatyarthrus nr_subterraneus_OES25	2	Rangoon	BH025	1 Feb, 2017
Isopoda	Paraplatyarthridae	Paraplatyarthrus nr_subterraneus_OES25	1	Rangoon	BH026	1 Feb, 2017
Isopoda	Paraplatyarthridae	Paraplatyarthrus nr_subterraneus_OES25	1	Rangoon	BH027	1 Feb, 2017
Pseudoscorpiones	Chthoniidae	Tyrannochthonius OE17	1	Helens	Helens Well	8 Dec, 2008
Symphyla		Hanseniella nr indecisa	1	Cardinia	BH013	3 Feb, 2017
Symphyla		Symphylella nr cylindrica	1	Helens	BH038	1 Feb, 2017

Table C-5: Troglofauna survey results arranged by site. Shaded rows indicate site location relative to proposed pits and estimated groundwater drawdown as follows: Orange = site within a proposed pit; Light Orange = site within 25 m of a proposed pit boundary; Blue = site within modelled groundwater drawdown contour > 0.5 m bSWL; Unshaded rows indicate sites in non-impact zone.

Project Area	Site Name	Sample Date	Group	Family	Taxon	Abundance
Cardinia	BH006	3 Feb, 2017	Diplura	Japygidae	Indjapx OES6	1
Cardinia	BH006	3 Feb, 2017	Isopoda	Armadillidae	Troglarmadillo OES1	21
Cardinia	BH006	3 Feb, 2017	Isopoda	Paraplatyarthridae	Paraplatyarthrus nr_subterraneus_OES25	9
Cardinia	BH013	3 Feb, 2017	Symphyla		Hanseniella nr indecisa	1
Helens	Helens Well	8 Dec, 2008	Isopoda	Armadillidae	Troglarmadillo OES1	1
Helens	Helens Well	8 Dec, 2008	Pseudoscorpiones	Chthoniidae	Tyrannochthonius OE17	1
Helens	BH038	1 Feb, 2017	Symphyla		Symphylella nr cylindrica	1
Rangoon	BH021	1 Feb, 2017	Isopoda	Armadillidae	Troglarmadillo OES1	1
Rangoon	BH021	1 Feb, 2017	Isopoda	Paraplatyarthridae	Paraplatyarthrus nr_subterraneus_OES25	1
Rangoon	BH022	1 Feb, 2017	Isopoda	Armadillidae	Troglarmadillo OES1	1
Rangoon	BH025	1 Feb, 2017	Isopoda	Armadillidae	Troglarmadillo OES1	4
Rangoon	BH025	1 Feb, 2017	Isopoda	Paraplatyarthridae	Paraplatyarthrus nr_subterraneus_OES25	2
Rangoon	BH026	1 Feb, 2017	Isopoda	Paraplatyarthridae	Paraplatyarthrus nr_subterraneus_OES25	1
Rangoon	BH027	1 Feb, 2017	Isopoda	Armadillidae	Troglarmadillo OES1	2
Rangoon	BH027	1 Feb, 2017	Isopoda	Paraplatyarthridae	Paraplatyarthrus nr_subterraneus_OES25	1

Table C-6: Records of troglophiles collected. Shaded rows indicate site location relative to proposed pits and estimated groundwater drawdown as follows: Orange = site within a proposed pit; Light Orange = site within 25 m of a proposed pit boundary; Blue = site within modelled groundwater drawdown contour > 0.5 m bSWL; Unshaded rows indicate sites in non-impact zone.

Group	Family	Taxon	Abundance	Project Area	Site Name	Sample Date
Hemiptera	Meenoplidae	Nisia OES12	1	Cardinia	BH005	3 Feb, 2017
Hemiptera	Meenoplidae	Nisia OES12	2	Cardinia	BH006	3 Feb, 2017
Hemiptera	Meenoplidae	Nisia OES12	3	Cardinia	Cardinia 2	16 Mar, 2009
Hemiptera	Meenoplidae	Nisia OES12	4	Helens	BH038	1 Feb, 2017
Hemiptera	Meenoplidae	Nisia OES12	1	Helens	Helens Well	16 Mar, 2009
Hemiptera	Meenoplidae	Nisia OES12	1	Rangoon	BH026	1 Feb, 2017
Pauropoda		Pauropoda	1	Cardinia	BH055	31 Jan, 2017
Polyxenida		Polyxenida	1	Cardinia	BH008	3 Feb, 2017

Appendix D Molecular Analysis

Prepared for MWH - Stantec, 11 April 2017
by Dr Remko Leijs, South Australian Museum.

Molecular assessment of the Syncarida of the Leonora Goldfields

Summary

- Three unnamed species of Syncarida were identified, one species in the family Bathynellidae and two species in the family Parabathynellidae. The latter two do not group with described species of *Atopobathynella* and it is therefore likely that they belong to a so far unnamed genus.

Methods

Biodiversity assessment of the collected fauna (Table 1) was performed using PCR amplification and sequencing in both directions of a 677 bp fragment of CO1, commonly used for DNA barcoding (Hebert et al. 2003). The sequences were added to large datasets that consists of related taxa from other areas complemented with published data from Genbank and unpublished sequence data at the South Australian Museum and the Western Australian Museum.
Phylogenetic analyses using neighbour joining of uncorrected sequence distances in PAUP* (Swofford 1998) were used to match the received specimens with previously identified analysed specimens. Results of phylogenetic analyses are presented as partial phylogenetic trees showing the target species with some closest related species.

Results

Table 1. Overview of the analysed specimens. The first column gives the DNA extraction number, the last column indicates whether the DNA sequencing was successful. Yellow highlighted specimens indicate unsuccessful sequencing.

Extraction	Code	MWH identification	SAM identification	Extr.date	Coll.Date	Site	CO1
ST2009	LN10821	Atopobathynella OE2		30-Mar-17	16 Mar, 2009	Leonora, Goldfields	no PCR
ST2010	LN12018	Atopobathynella		30-Mar-17	31 Jan, 2017	Leonora, Goldfields	no PCR
ST2011	LN12008	Bathynellidae	n.sp. Leon1	30-Mar-17	3 Feb, 2017	Leonora, Goldfields	good seq
ST2012	LN12035	Atopobathynella	n.sp. Leon2	30-Mar-17	3 Feb, 2017	Leonora, Goldfields	good seq
ST2013	LN11455	Atopobathynella	n.sp. Leon2	30-Mar-17	3 Feb, 2017	Leonora, Goldfields	good seq
ST2014	LN11454	Bathynellidae	n.sp. Leon1	30-Mar-17	3 Feb, 2017	Leonora, Goldfields	good seq
ST2015	LN12025	Atopobathynella	n.sp. Leon2	30-Mar-17	3 Feb, 2017	Leonora, Goldfields	good seq
ST2016	LN10822	Atopobathynella	n.sp. Leon2	30-Mar-17	1 Feb, 2017	Leonora, Goldfields	good seq
ST2017	LN11431	Atopobathynella	n.sp. Leon3	30-Mar-17	1 Feb, 2017	Leonora, Goldfields	good seq
ST2018	LN12019	Atopobathynella	n.sp. Leon3	30-Mar-17	1 Feb, 2017	Leonora, Goldfields	good seq
ST2019	LN12028	Atopobathynella	n.sp. Leon2	30-Mar-17	1 Feb, 2017	Leonora, Goldfields	good seq
ST2020	LN11448	Atopobathynella	n.sp. Leon2	30-Mar-17	2 Feb, 2017	Leonora, Goldfields	good seq
ST2021	LN10820	Atopobathynella	n.sp. Leon2	30-Mar-17	2 Feb, 2017	Leonora, Goldfields	good seq
ST2022	LN11444	Atopobathynella	n.sp. Leon2	30-Mar-17	1 Feb, 2017	Leonora, Goldfields	good seq
ST2023	LN11446	Atopobathynella	n.sp. Leon2	30-Mar-17	1 Feb, 2017	Leonora, Goldfields	good seq
ST2024	LN12022	Atopobathynella	n.sp. Leon2	30-Mar-17	1 Feb, 2017	Leonora, Goldfields	good seq
ST2025	LN12023	Atopobathynella	n.sp. Leon2	30-Mar-17	3 Feb, 2017	Leonora, Goldfields	good seq
ST2026	LN12029	Atopobathynella	n.sp. Leon2	30-Mar-17	2 Feb, 2017	Leonora, Goldfields	good seq

Bathynellidae

The two Bathynellidae specimens had identical sequences. The closest relative in the neighbour joining analysis appeared to be the distantly related (uncorrected pairwise sequence divergence 17.48%) with ST1729-LN4532 from Austin Downs. The specimens belong to an unnamed species.

Parabathynellidae

Fourteen out of the sixteen available Parabathynellidae samples resulted in good sequences. The specimens consisted out of two so far unnamed species that appear to be sister species in a neighbour joining analysis with respect to two distantly related species from the Yakabindie Calcrete (ST1648-LN3285 and ST1581-LN2450) (Figure 1). Pairwise sequence divergence values between specimens from the Yakabindie Calcrete and the Leonora Goldfields varied from 14.04-15.33% (Table 2 blue highlighted values), while the pairwise sequence divergence between the two Leonora Goldfield species varied from 8.09-9.03% (Table 2 purple highlighted values), intra specific pairwise sequence divergence varied from 0.14-1.29% (Table 2 yellow highlighted values).

Table 2. Pairwise sequence divergences from uncorrected neighbour joining analysis of Leonora Goldfields Parabathynellidae with two closest related species.

Uncorrected ("p") distance matrix

		275	276	362	363	364	365
275	>ST1581cons	-					
276	>ST1648cons	0.10287	-				
362	>ST2017 LN11431	0.14988	0.15000	-			
363	>ST2018 LN12019	0.14259	0.14040	0.00302	-		
364	>ST2012 LN12035	0.15003	0.15043	0.08542	0.08596	-	
365	>ST2013 LN11455	0.15004	0.15043	0.08541	0.08596	0.00430	-
366	>ST2015 LN12025	0.15051	0.15229	0.08699	0.08762	0.00144	0.00288
367	>ST2016 LN10822	0.14855	0.15473	0.08990	0.09026	0.01003	0.01146
368	>ST2019 LN12028	0.14606	0.15085	0.08246	0.08332	0.00574	0.00575
369	>ST2020 LN11448	0.15001	0.15186	0.08687	0.08739	0.00860	0.01003
370	>ST2021 LN10820	0.14852	0.15186	0.08094	0.08166	0.00860	0.00860
371	>ST2022 LN11444	0.14856	0.15186	0.08392	0.08453	0.00573	0.00716
372	>ST2023 LN11446	0.14856	0.15186	0.08389	0.08453	0.00430	0.00573
373	>ST2024 LN12022	0.15200	0.15229	0.08701	0.08762	0.00575	0.00719
374	>ST2025 LN12023	0.14565	0.15186	0.08393	0.08166	0.00716	0.00860
375	>ST2026 LN12029	0.15295	0.15330	0.08989	0.09026	0.00430	0.00573

Uncorrected ("p") distance matrix (continued)

		366	367	368	369	370	371
366	>ST2015 LN12025	-					
367	>ST2016 LN10822	0.00861	-				
368	>ST2019 LN12028	0.00431	0.00717	-			
369	>ST2020 LN11448	0.00718	0.00716	0.00574	-		
370	>ST2021 LN10820	0.00719	0.01003	0.00432	0.00860	-	
371	>ST2022 LN11444	0.00431	0.00716	0.00287	0.00573	0.00573	-
372	>ST2023 LN11446	0.00287	0.00573	0.00143	0.00430	0.00430	0.00143
373	>ST2024 LN12022	0.00431	0.01292	0.00862	0.00862	0.01150	0.00862
374	>ST2025 LN12023	0.00575	0.00860	0.00431	0.00716	0.00716	0.00430
375	>ST2026 LN12029	0.00287	0.01146	0.00717	0.01003	0.01003	0.00716

Uncorrected ("p") distance matrix (continued)

		372	373	374	375
372	>ST2023 LN11446	-			
373	>ST2024 LN12022	0.00718	-		
374	>ST2025 LN12023	0.00287	0.01006	-	
375	>ST2026 LN12029	0.00573	0.00718	0.00860	-

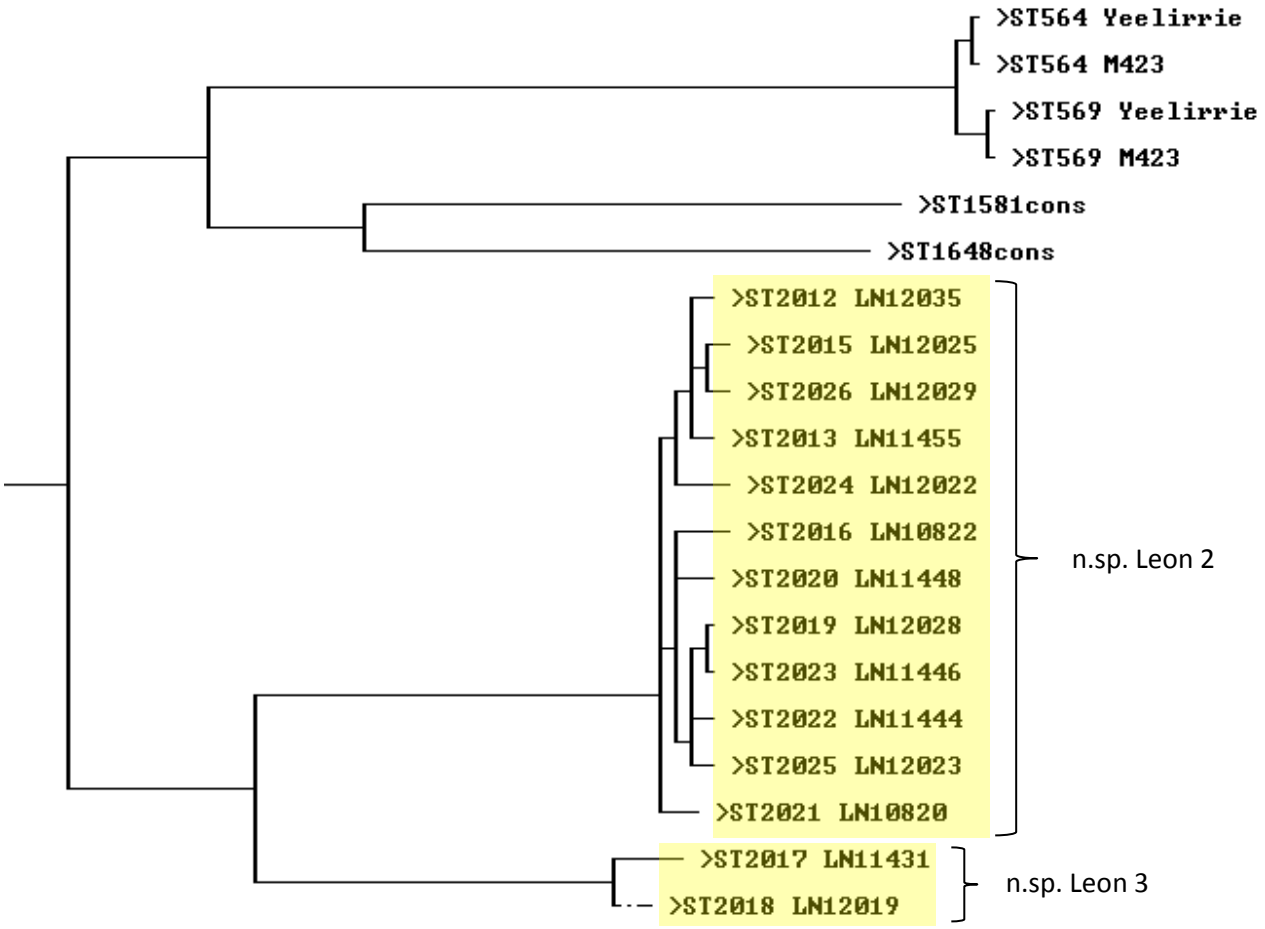


Figure 1. Cladogram of uncorrected neighbour joining analysis showing the Leonora Goldfields Parabathynellidae (yellow highlighted) with their nearest sister clades.

Sequences

>ST2011_LN12008 [n.sp.Leon1(Bathynellidae)]
CATAAAGATATTGGCACACTTTATTTATTACTGGGAACCTGGGCAGGAATGGTAGGAACAGGTATAAGAGTAATTATTCG
TATAGAGCTTGGCCAACCTGGCACTATAATTGGTGATGACCAAATCTATAATACTATTGTTACAGCACATGCTTTTATTA
TAATTTTTTTTATAGTTATACCATTAATAATTGGTGGATTTGGAAATTGACTTGTTCCAATAATAATTAGAGCTCCAGAT
ATATCATTTCCACGAATAAATAATCTAAGATTTTGGTTATTATTACCATCTCTAACTTTACTATTAAGAAGAAGGATGCT
TGAAAGAGGGGTAGGAACTGGTTGAACAGTTTATCCTCCTTTAGCAAGAAATCTTGCTCATAGAGGGGTATCAGTAGACT
TGGCGATCTTTTCTCTTCATCTTGCAGGAGCCTCATCAATTTTAGGAGCTATTAATTTTATTAGGACTTTAAGCAATATG
CGTACTATAGGAATATTAATAGAACTTGTTCCATTATTTGGCTGAGCTGTAATGGTTACCGCTATCTTGTTGTTAATTTC
TTTACCTGTATTAGCAGGTGGAATTACTATATTATTGACTGATCGTAATTTAAATACATCTTTTTTTGATCCTGCTGGGG
GCGGCGACCCAATTTTATACCAACACTTATTTTGATTTTTTGGTCACCCTGAAGTTTA

>ST2014_LN11454 [n.sp.Leon1(Bathynellidae)]
CATAAAGATATTGGCACACTTTATTTATTACTGGGAACCTGGGCAGGAATGGTAGGAACAGGTATAAGAGTAATTATTCG
TATAGAGCTTGGCCAACCTGGCACTATAATTGGTGATGACCAAATCTATAATACTATTGTTACAGCACATGCTTTTATTA
TAATTTTTTTTATAGTTATACCATTAATAATTGGTGGATTTGGAAATTGACTTGTTCCAATAATAATTAGAGCTCCAGAT
ATATCATTTCCACGAATAAATAATCTAAGATTTTGGTTATTATTACCATCTCTAACTTTACTATTAAGAAGAAGGATGCT
TGAAAGAGGGGTAGGAACTGGTTGAACAGTTTATCCTCCTTTAGCAAGAAATCTTGCTCATAGAGGGGTATCAGTAGACT
TGGCGATCTTTTCTCTTCATCTTGCAGGAGCCTCATCAATTTTAGGAGCTATTAATTTTATTAGGACTTTAAGCAATATG
CGTACTATAGGAATATTAATAGAACTTGTTCCATTATTTGGCTGAGCTGTAATGGTTACCGCTATCTTGTTGTTAATTTC
TTTACCTGTATTAGCAGGTGGAATTACTATATTATTGACTGATCGTAATTTAAATACATCTTTTTTTGATCCTGCTGGGG
GCGGCGACCCAATTTTATACCAACACTTATTTTGATTTTTTGGTCACCCTGAAGTTTA

>ST2017_LN11431 [n.sp.Leon3]
CATAAAGATATTGGAACAATATATCTATTATTCGGAGCTTGAGGAGGGATAGTTGGCACTGGTTTAAGAATAATTATTCG
ATTTGAACTAGGGCAACCAGGCCCTTTCATTGGAAATGACCAAGTTTATAATGTTCTTGTTACTGCKCATGCATTTATTA
TAATTTTCTTTATAGTGATACCTGTAATAATTGGCGGGTTTGGTAACTGATTGATTCCATTAATAATTAATTGTGCTGAT
ATAGCTTTTCCACGTATAAATAATATAAGATTTTGATTGCTACCCCCATCTTTATTTCTTTTATTAATAAGAGGAATAAT
TGAAAGGGGGGTTGGAACTGGATGAACTGTTTACCCTCCTTTGGCTTCCAATATATTTCATAGAGGCCCTTCTGTCGATT
TAGCTATCTTTTCATTACATCTTGCTGGGGTTTCTTCAATTTTGGGTGCTATTAATTTTATTACTACTATTATTAATATA
CGATCTTTAGGTTTATTAATAGATCGAATACCTTTATTTTGTTGAGCTATCTTTATTACTGCAATTTTACTATTGGTTTC
TTTACCTGTTTTAGCTGGAGGGTTAACTATACTTTTAACTGATCGAAATTTAAATACTTCATTTTTTGACCCTGCAGGAG
GAGGAGATCCTATCCTCTATCAACA

>ST2018_LN12019 [n.sp.Leon3]
CATAAAGATATTGGAACAATATATCTATTATTCGGAGCTTGAGGAGGGATAGTTGGCACTGGTTTAAGAATAATTATTCG
ATTTGAACTAGGGCAACCAGGCCCTTTCATTGGAAATGACCAAGTTTATAATGTTCTTGTTACTGCTCATGCATTTATTA
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TTTACCTGTTTTAGCTGGAGGGTTAACTATACTTTTAACTGATCGAAATTTAAATACTTCATTTTTTGACCCTGCAGGAG
GAGGAGATCCTATCCTTTATCAACATTTATTTTGATTTTTTGGTCACCCTGAAGTTTA

>ST2012_LN12035 [n.sp.Leon2]
CATAAAGATATTGGGACAATATATTTATTATTTGGAGCTTGAAGTGGGATAATTGGGACAGGATTAAGAATAATTATTCG
ATTTGAACTAGGCCAACCAGGCCCTTTTATTGGGAATGACCAAATCTATAATGTTCTCGTAACTGCTCATGCATTTATTA
TAATTTTCTTCATGGTGATACCTGTAATAATTGGAGGGTTTGGTAACTGGCTAATTCCATTAATAATTAATTGTGCTGAT
ATAGCTTTCCCACGTATAAATAATATAAGATTTTGGTTATTACCCCCATCTTTATTTCTTCTGTTAATAAGAGGAATAAT
CGAAAGGGGGGTTGGGACCGGATGAACTGTTTATCCTCCTTTAGCTTCTAATATATTTCATAGAGGGCCTTCTGTAGATT
TAGCTATTTTTTCTTTGCATCTTGCTGGGGCTTCCTCAATTTTAGGTGCCATTAATTTTATTACTACTATTATTAATATA
CGGTCTTTAGGTTTATTAATAGATCGAATACCTTTATTCTGTTGAGCTATTTTTATCACTGCAATCTTACTATTAGTTTC
TTTACCTGTTTTAGCTGGCGGATTGACTATACTTTTAACCGATCGAAATTTAAATACTTCATTTTTTGATCCTGCAGGGG
GAGGAGACCCTATCCTCTATCAGCACTTATTTTGATTTTTTGGTCACCCTGAAGTTTA

>ST2013_LN11455 [n.sp.Leon2]
CATAAAGATATTGGGACAATATATTTATTATTTGGAGCTTGAAGTGGGATAATTGGAACAGGATTAAGAATAATTATTCG
ATTTGAACTAGGCCAACCAGGCCCTTTTATTGGGAATGACCAAATCTATAATGTTCTCGTAACTGCTCATGCATTTATTA
TAATTTTCTTCATGGTGATACCTGTAATAATTGGAGGGTTTGGTAACTGGCTAATTCCATTAATAATTAATTGTGCTGAT
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CGAAAGGGGGGTTGGGACCGGATGAACTGTTTATCCTCCTTTAGCTTCTAATATATTTCATAGAGGGCCTTCTGTAGATT
TAGCTATTTTTTCTTTGCATCTTGCTGGGGCTTCCTCAATTTTAGGTGCCATTAATTTTATTACTACTATTATTAATATA
CGGTCTTTAGGTTTATTAATAGATCGAATACCTTTATTCTGTTGAGCTATTTTTATCACTGCAATCTTACTATTAGTTTC
TTTACCTGTTTTAGCTGGCGGATTAACTATACTTTTAACCGATCGAAATTTAAATACTTCATTTTTTGATCCTGCAGGGG
GAGGGGACCCTATCCTCTATCAGCACTTATTTTGATTTTTTGGTCACCCTGAAGTTTA

>ST2015_LN12025 [n.sp.Leon2]
CATAAAGATATTGGGACAATATATTTATTATTTGGAGCTTGAAGTGGGATAATTGGGACAGGATTAAGAATAATTATTCG
ATTTGAACTAGGCCAACCAGGCCCTTTTATTGGGAATGACCAAATCTATAATGTTCTCGTAACTGCTCATGCATTTATTA
TAATTTTCTTCATGGTGATACCTGTAATAATTGGAGGGTTTGGTAACTGGCTAATTCCATTAATAATTAATTGTGCTGAT
ATAGCTTTCCCACGTATAAATAATATAAGATTTTGGTTATTACCCCCATCTTTATTTCTTCTGTTAATAAGAGGAATAAT
CGAAAGGGGGGTTGGGACCGGATGAACTGTTTATCCTCCTTTAGCTTCTAATATATTTCATAGAGGGCCTTCTGTAGATT
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GAGGGGACCCTATCCTCTATCAGCACTTATTTTGATTTTTTGGTCACCCTGAAGTT

>ST2016_LN10822 [n.sp.Leon2]
CATAAAGATATTGGGACAATATATTTATTATTTGGAGCTTGAAGTGGGATAATTGGGACAGGACTAAGAATAATTATTCG
ATTTGAACTAGGCCAACCAGGCCCTTTTATTGGGAATGACCAAATCTATAATGTTCTCGTAACTGCTCATGCATTTATTA
TAATTTTCTTCATGGTGATACCTGTAATAATTGGAGGGTTTGGTAACTGGCTAATTCCATTAATAATTAATTGTGCTGAT
ATAGCTTTCCCACGTATAAATAATATAAGATTTTGGTTATTACCCCCATCTTTATTTCTTCTATTAATAAGAGGAATAAT
CGAAAGGGGGGTTGGGACCGGATGAACTGTTTATCCTCCTTTAGCTTCTAATATATTTCATAGAGGGCCTTCTGTAGATT

TAGCTATTTTTTCTTTGCATCTTGCTGGGGCCTCCTCAATTTTAGGTGCCATTAATTTTATTACTACTATTATTAATATA
CGGTCTTTAGGTTTATTAATAGATCGAATACCTTTATTCTGTTGAGCTATTTTTATCACCGCAATCTTATTATTAGTTTC
TTTACCTGTTTTAGCTGGCGGATTGACTATACTTTTAACCGATCGAAATTTAAATACTTCATTTTTTGACCCTGCAGGGG
GAGGGGACCCTATCCTCTATCAGCACTTATTTTGATTTTTTGGTCACCCTGAAGTTTA

>ST2019_LN12028 [n.sp.Leon2]
CATAAAGATATTGGGACAATATATTTATTATTTGGAGCTTGAAGTGGGATAATTGGCACAGGATTAAGAATAATTATTCG
ATTTGAACTAGGCCAACCAGGCCCTTTTATTGGGAATGACCAAATCTATAATGTTCTCGTAACTGCTCATGCATTTATTA
TAATTTTCTTCATGGTGATACCTGTAATAATTGGAGGGTTTGGTAACTGGCTAATTCCATTAATAATTAATTGTGCTGAT
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Appendix E Copepoda Specialist Reports: Karanovic 2009 February and 2017 April

E.1 Karanovic (2009 February) Copepoda Morphological Assessment I

COPEPODA, WA, Yilgarn - Outback Ecology, Job No. NRM-SY-0708_1, Invoice No. OES 0301 (received and IDed February 2009)

1.Vial Code: NRM 005, Bore Code: Cardinia SE, GPS Coordinates: 51J 363663 6813441, 09 December 2008, 7 Harpacticoida, Identifier NRG

Hirtaleptomesochra multispinosa n. sp. – 2 males (1 badly damaged) + 1 damaged female + 4 copepodis in alcohol

2.Vial Code: NRM 006, Bore Code: Raeside 3, GPS Coordinates: 51J 343747 6799460, 09 December 2008, 2 Harpacticoida, Identifier NRG

Australocamptus similis Karanovic, 2004 – 2 females in alcohol

SYSTEMATIC LIST

Order Harpacticoida Sars, 1903
Family Ameiridae Monard, 1927
Genus *Hirtaleptomesochra* Karanovic, 2004

1. *Hirtaleptomesochra multispinosa* n. sp.

Family Canthocamptidae Sars, 1906
Genus *Australocamptus* Karanovic, 2004

2. *Australocamptus similis* Karanovic, 2004

COMMENTS

Hirtaleptomesochra multispinosa n. sp.

Until now only one species was known in the endemic Murchison genus *Hirtaleptomesochra* Karanovic, 2004: *Hirtaleptomesochra bispinosa* Karanovic, 2004. This species was present in ten different localities around Austin Downs Station and it was very easy to recognize by (among other things) its two large spinules on the anal operculum. The new species found here fits well into the diagnosis of the genus, but can be distinguished from *H. bispinosa* by many characters, including seven spinules on the anal operculum. The most important characters of the new species are: A1 8-segm.; ExpA2 with 3 setae; Gsg free (not fused to first abdominal); An Op with 7 spinules; Fu very similar to *H. bispinosa*; Exp3P1 with 5 elements; Exp3P2 with 3 outer spines (5 elements altogether); Exp3P2 with 2 outer spines (4 elements altogether); Enp1P2-P4 with inner seta; Enp2P2-P4 with 2 apical elements only (outer spine and inner seta); P5 female 4/4(3); P5 male 5(4)/3; P6 male with 2 setae. Unfortunately, there is only one undamaged adult specimen (male) in the sample, so the material was not dissected. Observations were made from *in toto* specimens. Most of the specimens have their appendages broken partly or completely. I think this species is also a stygobiont, just like *H. bispinosa.*

Australocamptus similis Karanovic, 2004

I found this rare species only a couple of times since its original description, always in low numbers. This is in contrast to its close relative, *Australocamptus hamondi* Karanovic, 2004, which is relatively widely distributed in the Murchison region and Eastern Goldfields. This may be due to their different ecology.

Australocamptus similis seems to be an obligate subterranean dweller (a stygobiont), while *A. hamondi* can survive in wells and other surface water habitats and is in my opinion a stygophile rather than a stygobiont. I have six or seven new *Australocamptus* species (in preparation) from surface waters of the Western Australian weatbelt region, as well as two new species from the NSW subterranean waters. This publication should be prepared by the end of this year and will elucidate more phylogenetical and ecological relationships among members of this widely distributed (but endemic) Australian genus.

Best wishes,

Tom Karanovic

E.2 Karanovic (2017 April) Copepoda Morphological Assessment II

Leonora (30 km NE) Copepoda Morphological Assessment II
6 April, 2017

Prepared by
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KOREA
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RE:
Job Number: **83503810.040000 PCN02**
Purchase Order: **MWH3370**
Taxa: Copepoda
Region: **Murchison (WA)**
Total Number of Samples: 19 vials

I. RESULTS:

LN10275, BH002, "28°48'52""S", "121°36'15""E", "31 Jan, 2017", 1, Harpacticoida, WAM C66817, Ameiridae, *Hirtaleptomesochra multispinosa*, 1 female

LN10833, BH007, "28°48'24""S", "121°36'06""E", "3 Feb, 2017", 13, Harpacticoida, WAM C66818, Ameiridae, *Hirtaleptomesochra multispinosa*, 5 males + 9 females

LN9697, BH008, "28°48'15""S", "121°36'02""E", "3 Feb, 2017", 42, Harpacticoida, WAM C66819, Ameiridae, *Hirtaleptomesochra multispinosa*, 11 males + 30 females

LN10871, BH011, "28°48'08""S", "121°36'00""E", "3 Feb, 2017", 22, Harpacticoida, WAM C66820, Ameiridae, *Hirtaleptomesochra multispinosa*, 19 females

LN10850, BH013, "28°48'03""S", "121°36'24""E", "3 Feb, 2017", 23, Harpacticoida, WAM C66821, Ameiridae, *Hirtaleptomesochra multispinosa*, 5 males + 19 females

LN10276, BH023, "28°46'34""S", "121°37'05""E", "1 Feb, 2017", 1, Harpacticoida, WAM C66822, Ameiridae, *Hirtaleptomesochra multispinosa*, 1 female

LN10864, BH025, "28°46'31""S", "121°37'05""E", "1 Feb, 2017", 16, Harpacticoida, WAM C66823, Ameiridae, *Hirtaleptomesochra multispinosa*, 6 males + 15 females

LN10269, BH026, "28°46'30""S", "121°37'04""E", "1 Feb, 2017", 17, Harpacticoida, WAM C66824, Ameiridae, *Hirtaleptomesochra multispinosa*, 2 males + 13 females

LN9705, BH027, "28°46'29""S", "121°37'05""E", "1 Feb, 2017", 50, Harpacticoida, WAM C66825, Ameiridae, *Hirtaleptomesochra multispinosa*, 17 males + 28 females + 5 copepodids

LN9712, BH028, "28°46'28""S", "121°37'02""E", "1 Feb, 2017", 7, Harpacticoida, WAM C66826, Ameiridae, *Hirtaleptomesochra multispinosa*, 1 male + 4 females + 2 copepodids

LN9111, BH029, "28°46'28""S", "121°37'03""E", "1 Feb, 2017", 12, Harpacticoida, WAM C66827, Ameiridae, *Hirtaleptomesochra multispinosa*, 6 males + 7 females

LN11413, BH033, "28°46'20""S", "121°37'05""E", "2 Feb, 2017", 7, Harpacticoida, WAM C66828, Ameiridae, *Hirtaleptomesochra multispinosa*, 2 males + 5 females

LN10279, BH034, "28°46'20""S", "121°37'04""E", "2 Feb, 2017", 30, Harpacticoida, WAM C66829, Ameiridae, *Hirtaleptomesochra multispinosa*, 6 males + 22 females

LN10862, BH038, "28°46'45""S", "121°37'09""E", "1 Feb, 2017", 175, Harpacticoida, WAM C66830, Ameiridae, *Hirtaleptomesochra multispinosa*, 50 males + 120 females

LN10852, BH040, "28°46'47""S", "121°37'09""E", "1 Feb, 2017", 3, Harpacticoida, WAM C66831, Ameiridae, *Hirtaleptomesochra multispinosa*, 3 males + 1 females

LN9713, BH041, "28°46'49""S", "121°37'18""E", "1 Feb, 2017", 5, Harpacticoida, WAM C66832, Ameiridae, *Hirtaleptomesochra multispinosa*, 1 male + 2 females + 1 copepodid

LN10271, BH042, "28°46'49""S", "121°37'17""E", "1 Feb, 2017", 1, Harpacticoida, WAM C66833, Ameiridae, *Hirtaleptomesochra multispinosa*, 1 female

LN12034, BH048A, "28°47'20""S", "121°37'08""E", "2 Feb, 2017", 4, Harpacticoida, WAM C668134, Ameiridae, *Hirtaleptomesochra multispinosa*, 1 female + 2 copepodids

LN9707, BH064, "28°48'00""S", "121°35'53""E", "31 Jan, 2017", 4, Cyclopoida, WAM C66835, Cyclopidae, *Mesocyclops brooksi*, 2 males + 1 female + 1 copepodid

II. SYSTEMATIC LIST:

Sybphylum Crustacea Brünich, 1772
Class Maxillopoda Dahl, 1956
Subclass Copepoda H. Milne Edwards, 1840
Order Cyclopoida Rafinesque, 1815
Family Cyclopidae Rafinesque, 1815
Subfamily Cyclopinae Rafinesque, 1815
Genus *Mesocyclops* Sars, 1914
1. *Mesocyclops brooksi* Pesce, De Laurenttis & Humphreys, 1996
Order Harpacticoida Sars, 1903
Family Ameiridae Monard, 1927
Subfamily Ameirinae Monard, 1927
Genus *Hirtaleptomesochra* Karanovic, 2004
2. *Hirtaleptomesochra multispinosa* n. sp.

III. COMMENTS:

Mesocyclops brooksi is a well-known and widely distributed WA copepod, described by Pesce et al. (1996) and redesribed from numerous localities by Karanovic (2004). It was not present in your previous samples from this area, but this is an opportunistic species and probably only a stygophile, not a real stygobiont.

Hirtaleptomesochra multispinosa is a new species belonging to the monotypic and endemic Murchison genus described by Karanovic (2004). This species was first discovered in your samples from this area in 2009 (Job No. NRM-SY-0708_1). The new species fits well into the diagnosis of the genus, but can be distinguished from the type species (*H. bispinosa*) by many characters, including five to eight spinules on the anal operculum. The most important characters of the new species are: A1 8-segm.; ExpA2 with 3 setae; Gsg free (not fused to first abdominal); An Op with 7 spinules; Fu very similar to *H. bispinosa*; Exp3P1 with 5 elements; Exp3P2 with 3 outer spines (5 elements altogether); Exp3P2 with 2 outer spines (4 elements altogether); Enp1P2-P4 with inner seta; Enp2P2-P4 with 2 apical elements only (outer spine and inner seta); P5 female 4/4(3); P5 male 5(4)/3; P6 male with 2 setae.

One species that was present in your samples from this area, and is missing now, is *Australocamptus similis* Karanovic, 2004 (Vial Code: NRM 006, Bore Code: Raeside 3, GPS Coordinates: 51J 343747 6799460, 09 December 2008). However, this is a rare species, which I found only a couple of times since its original description, and always in low numbers. This is in contrast to its close relative, *Australocamptus hamondi* Karanovic, 2004, which is relatively widely distributed in the Murchison region and Eastern Goldfields. This may be due to their different ecology.

IV. REFERENCES

Karanovic T. (2004) Subterranean Copepdoa from arid Western Australia. *Crustaceana Monographs* 3: 366p.

Pesce G.L., de Laurenttis P., Humphreys W.F. (1996) Copepods from ground waters of Western Australia, I. The genera *Metacyclops, Mesocyclops,* and *Apocyclops* (Crustacea: Copepoda: Cyclopidae). *Records of the Western Australian Museum* 18: 67-76.

With best wishes,

Tom Karanovic

Seoul, 6 April 2017

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