ASSESSMENT OF MALLEEFOWL ACTIVITY AND HABITAT FOR THE FIMISTON SOUTH PROJECT.

KALGOORLIE CONSOLIDATED GOLD MINES PTY LTD

Alexander Holm & Associates

Natural Resource Management Services

April 14, 2023

Title page: The only confirmed Malleefowl nest found in the survey area, long abandoned.

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1 Summary

On February 6, 2023 the Environmental Protection Authority (EPA) issued Kalgoorlie Consolidated Gold Mines Pty Ltd (KCGM) with a Section 40(2)(a) notice requiring additional information (RFI) to support the Fimiston Gold Mine Operations Extension (Stage 3) and Mine Closure Planning: Revised Proposal.

In response to the above RFI statement, KCGM contracted Alexander Holm & Associates to assess the suitability of habitat for Malleefowl (targeted survey) within proposed impact areas adjacent to Fimiston Gold Mine Operations near Kalgoorlie-Boulder, Western Australia.

Following the completion of extensive field surveys conducted in March 2023 and the post survey data analysis on behalf of KCGM. Alexander Holm & Associates concluded the following:

1. None of the proposed impact areas contain critical or marginal habitat for Malleefowl breeding and survival.
2. The low rolling hillocks and footslopes of land unit 1f occupying 451ha within Fimiston II/III are rated as suitable habitat for Malleefowl foraging and dispersal.
3. Fimiston Eastern Floodway North and Western proposed impact areas are not suitable for Malleefowl.

No evidence of recent Malleefowl use was found. There were no active or recent nesting mounds, no Malleefowl footprints and no litter disturbance indicative of foraging activity.

Only one definite Malleefowl nesting mound was found within the 2303ha Development Envelope (DE). This long-unused mound was in highly restricted micro-habitats within the low rounded hills and footslopes of land unit 1f where local soil conditions were favourable for mound construction. For most of this land unit, slopes exceeded 2% and soils are skeletal sandy clay loams to light clays, conditions generally unsuitable for mound construction.

Proximity to the major urban centre of the City of Kalgoorlie-Boulder together with numerous tracks and trails encourages off-road vehicle activity, and this combined with unrestrained town dogs, whose tracks were noted throughout the DE, are major deterrents to present-day Malleefowl use of the area.

These limitations, together with limited cover and other factors important for successful Malleefowl breeding, render all land units within the DE unsuitable for breeding. A conclusion also reached by Phoenix (2022a) and Harwood (2015).

The overall habitat rating of land unit 1f for foraging and dispersal was 5 out of a maximum of 10. This land unit occurs in the eastern margins of the DE and has unrestricted access to habitat to the east. Malleefowl have been found 7km to the east and while it is possible that Malleefowl from these distant populations may travel to the edges of the DE; and while Harwood (2015) considered that transient individuals may occasionally frequent the area, it is likely that even transient individuals will be deterred by the level of off-road vehicle activity and presence of urban-based predators.

As such, when impacts of off-road vehicle activity and urban-based predators are taken into consideration, this land unit is considered at best marginally suitable for foraging and dispersal.

2 Introduction

On 6 February 2023 the Environmental Protection Authority (EPA) issued Kalgoorlie Consolidated Gold Mines Pty Ltd (KCGM) with a Section 40(2)(a) notice requiring additional information (RFI) to support the Fimiston Gold Mine Operations Extension (Stage 3) and Mine Closure Planning: Revised Proposal.

The EPA RFI identified:

- *'No signs of Malleefowl breeding sites were recorded within the study area however, targeted searches for Malleefowl mounds were not undertaken. The terrestrial fauna report relies on habitat assessment of 15 sites within study area with the results extrapolated across the impact areas.'*
- *The Malleefowl habitat was identified in the proposed impact areas thus, targeted surveys for Malleefowl mounds are required. The survey should be undertaken in accordance with Survey guidelines for Australia's threatened birds and the National Malleefowl Monitoring Manual.*

The proposed impact areas are contained within a DE adjacent to Fimiston Gold Mine Operations, near the City of Kalgoorlie-Boulder, Western Australia as shown in Figure 1.

3 Scope of Works

Alexander Holm & Associates were contracted by Kalgoorlie Consolidated Gold Mines Pty Ltd (KCGM) to conduct a targeted Malleefowl (*Leipoa ocellata*) survey and provide additional supporting information as requested in writing by the EPA.

The objectives of the survey were to:

- Conduct a targeted Malleefowl search for Malleefowl mounds and activity in accordance with relevant guidelines including:
    - Survey guidelines for Australia's threatened birds (Department of the Environment Water Heritage and Arts 2017)
    - National Malleefowl Monitoring Manual (National Malleefowl Recovery Team 2019)
- Systematically map habitat in accordance with EPA Technical Guidelines for Vertebrate Fauna Surveys (2020)

Using information from Malleefowl activity searches and habitat mapping assess the suitability for Malleefowl within the proposed impact areas of the DE as:

a) critical habitat for breeding;

b) suitable habitat for foraging/dispersal or

c) unsuitable habitat for breeding, foraging or dispersal.

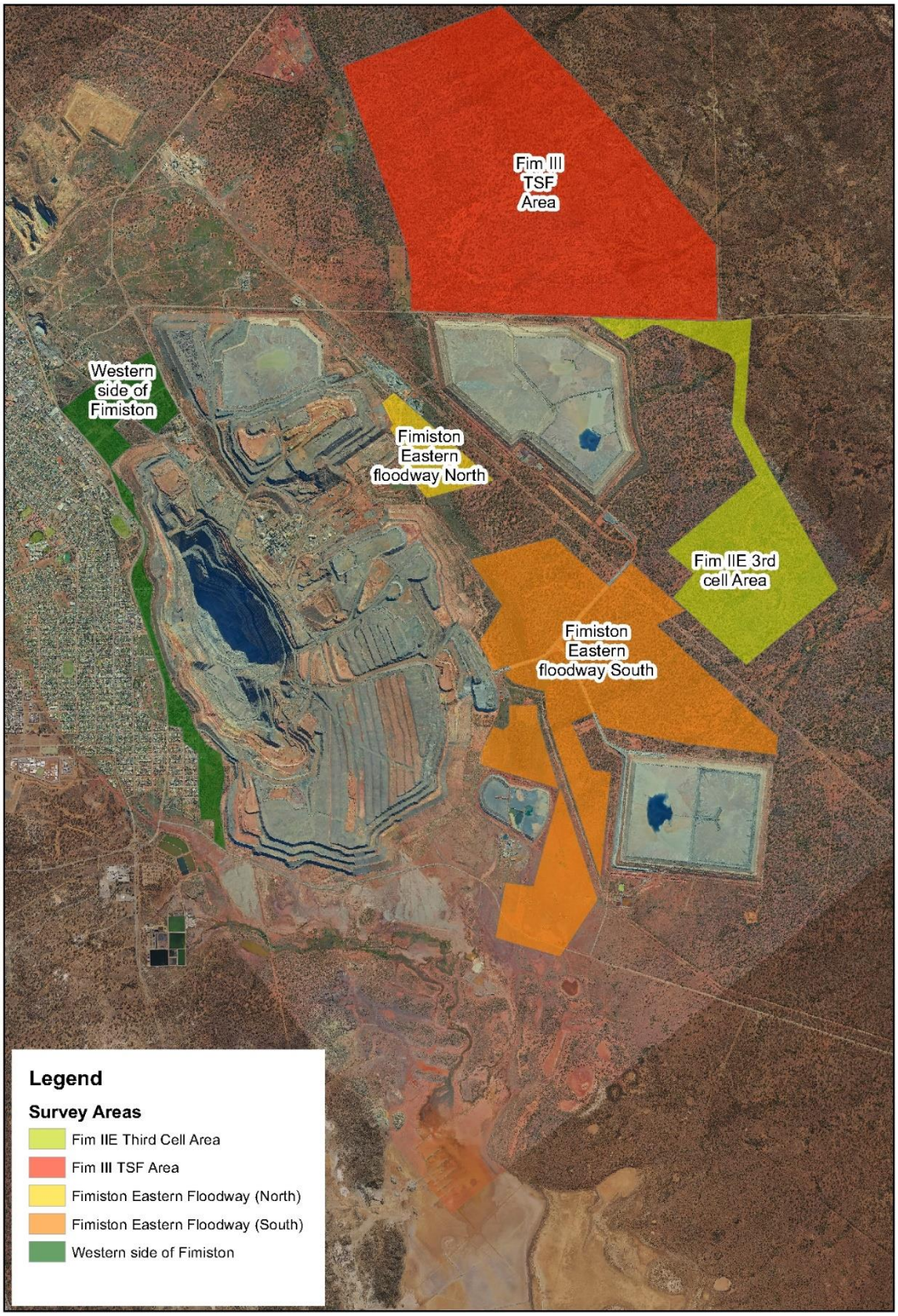

Figure 1: Fimiston proposed impact areas

4 Background

4.1 Species and Habitat Information

4.1.1 Biology

Malleefowl are a stocky ground-dwelling bird belonging to the family Megopodiidae. This species builds large distinctive on ground mounds to incubate their eggs. Breeding season usually begins in September when egg laying begins and ends in late January. Chicks typically begin hatching in November, with most chicks emerging from mounds by January, however it has been noted that in some seasons hatching may continue until March (Benshemesh 2007).

4.1.2 Distribution and Habitat

Historically, Malleefowl have been found in semi-arid mallee shrublands and woodlands across southern Australia (Department of Parks and Wildlife 2016b), but their range has been greatly reduced, mostly attributed to extensive land clearing for agriculture (Department of Parks and Wildlife 2016b).

Several environmental factors contribute to habitat critical for successful Malleefowl breeding, of which those attributes facilitating construction of suitable nesting mounds are essential. Less critical habitat in surrounding areas may be used for foraging (Benshemesh 2007).

In Western Australia, Malleefowl habitat commonly consists of acacia-dominated shrublands and woodlands dominated by mallee eucalypts. Malleefowl require a sandy substrate and abundance of leaf litter for construction of mounds (Department of Parks and Wildlife 2016a). Deep sandy loam or loamy sand soils appear highly desirable for Malleefowl nesting mounds. Soils with higher clay content or sandy soils over heavier soils were generally avoided; or attempts to establish nesting mounds in heavier soils were found to have failed in other habitat surveys within the Goldfields Region, by Alexander Holm & Associates (2022b).

Habitats characterised by numerous food plants (especially leguminous shrubs and herbs), a dense canopy cover and open ground layer are generally associated with high breeding densities of this species. While Malleefowl also prefer long unburnt country, traditional patch burning practices are recommended to stimulate regeneration in spinifex habitats in which the birds feed (Benshemesh 2007).

Stenhouse (2022), in a study of factors affecting Malleefowl distribution on the Eyre Peninsular in South Australia, identified total vegetation cover as the most important determinant of breeding activity. Herbs, shrubs and their seeds make up a large part of Malleefowl diet and vegetation cover also provides habitat for invertebrate food sources that Malleefowl eat. While published work suggests Malleefowl movement patterns are partially driven by food availability. Stenhouse (2022) found the influence of food plants on habitat use was small and possibly reflects that Malleefowl have a highly variable diet and opportunistically feed on what is available within their surroundings.

While definitive habitat preferences were not defined, Stenhouse (2022) found Malleefowl movement was positively influenced by availability of litter and taller canopy cover, possibly for heat or predator avoidance.

4.1.3 Conservation Status

Malleefowl is a Threatened fauna species listed as Vulnerable under the State *Biodiversity Conservation Act 2016* and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

4.1.4 Nesting Mound Characterisation

The National Malleefowl Monitoring Manual defines 'active' nesting mounds as "Currently being used by Malleefowl as an incubator for their eggs, and is likely to contain eggs" (National Malleefowl Recovery Team 2019).

Three other categories are proposed for this report:

- 'Inactive recent': Potentially used within the last 5 years. Mound well-formed, litter often still present, no evidence of inner crusting or growth of annual herbs or grasses.
- 'Inactive abandoned': Likely unused for more than 5-10 years and possibly abandoned. Mound somewhat degraded, often crusted, annual herbs or grasses may be present.
- 'Long unused': Evidence of an extended period of inactivity such as shrubs or trees growing from hollow or mound very degraded/poorly formed. Highly unlikely to become active in the future.

4.2 Environmental Information

4.2.1 Climate

The Goldfields region is classified as arid to semi-arid with average annual rainfall decreasing from about 250mm in the south-west to 200mm in the north-east. The area experiences hot summers and mild winters with cold nights. Rainfall varies widely between years and droughts are common. Remnants of tropical cyclones occasionally bring heavy summer rain and can cause localised short-term flooding. The area transitions between desert summer and winter dominated rainfall and desert: non-seasonal bioclimatic (Beard 1990).

Kalgoorlie rainfall has averaged 250mm a year since 1980 with 40%, generally falling during summer months of January to March. Rainfall since 2018 has been below average with records showing only 143mm falling in 2019 (one of the driest years in 84 years of records[1]); 171mm in 2020 and 185mm in 2022. Over 300mm was recorded in 2021 of which over 100mm fell during summer with little effect on vegetation (Figure 1).

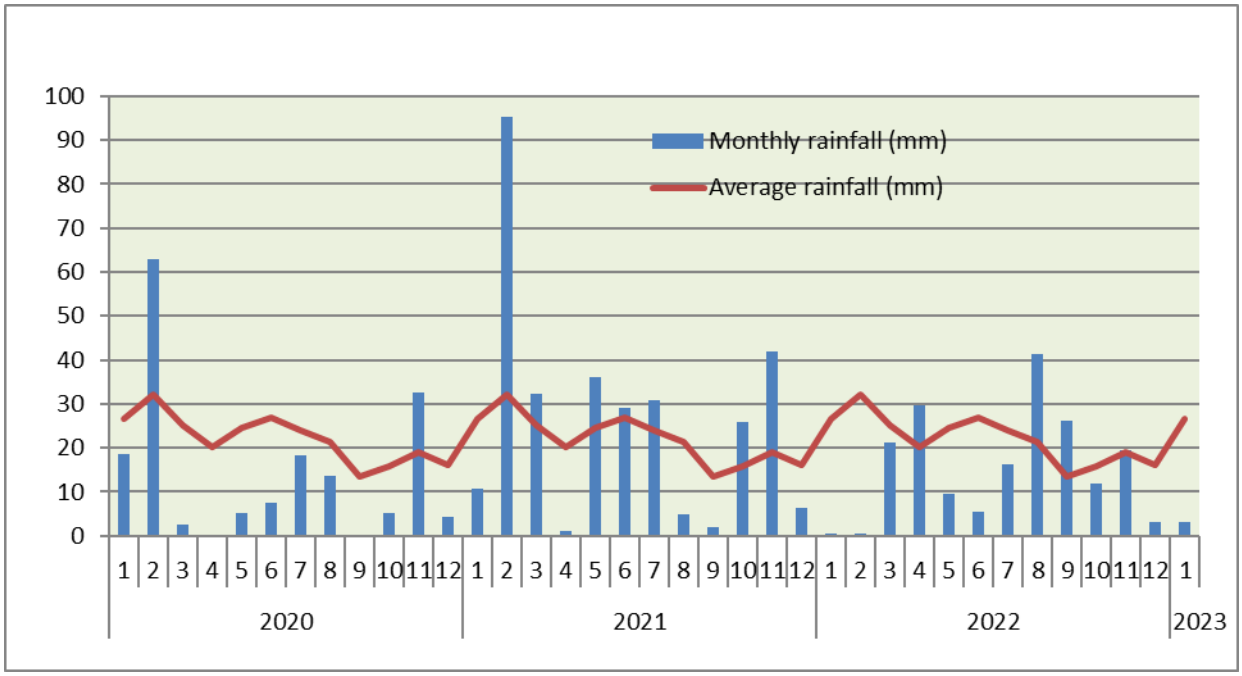

Figure 2: Kalgoorlie monthly rainfall

[1] Monthly Rainfall - 012038 - Bureau of Meteorology (bom.gov.au)

4.2.2 Vegetation and Soil

The region lies within the Eremaean botanical province, mainly in the Austin botanical district, with the eastern edge approaching the Helms botanical district (Beard, 1976). Lake Ballard/Lake Rebecca form a major vegetation divide with characteristic *Acacia aneura* (mulga) low woodlands associated with red loams over siliceous hardpan to the north and low woodlands of mixed mulga and Casuarina (black oak) and *Eucalyptus* species on alkaline and calcareous soils to the south. Spinifex hummock grassland with eucalypt overstorey on sand plain is common. Halophytic vegetation occurs throughout the region on palaeo-drainage systems, breakaways and on some stony and alluvial plains.

Landloch Pty Ltd were commissioned by KCGM to classify and map soils within the Fimiston III TSF and Fimiston IIE third cell areas. Sodic clay soils consisting of loamy topsoils over sodic clay soils; Gradational soils consisting of loamy topsoils often grading to silty clay loams at depth and Acidic gradational soils consisting of loamy topsoils grading to clay loams and light clays at depth occupied most of the area being lower in the overall landscape. Soils in restricted higher sections in the east consisted of Shallow rocky soils of loams over rocky material.

4.3 Previous Surveys

In June 2015, G. Harwood on behalf of Botanica Consulting completed and reported on a Level 2 fauna survey which covered 3,260ha associated with a proposed tailings storge facility (TSF), which encompassed the 1177ha Fimiston III TSF and 355ha Fimiston IIE third cell areas within the DE covered in this report.

Harwood reported “no evidence of malleefowl using the study area and in particular no evidence of breeding (i.e. nest mounds recent or old) were observed despite numerous traverses across the study area during the fauna and botanical surveys. This supports the conclusion that the area is not a site of significance for the species despite the fact that transient individuals may occasionally frequent the area” (Harwood 2015).

Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by KCGM in 2021 to undertake a gap analysis of biological values at the Fimiston Operational Area, and to conduct a botanical survey in areas identified as data deficient. Phoenix identified 20 remnant vegetation types within areas partially covered by this report, none of which were considered regionally significant or representative of a listed Threatened or Priority Ecological Community (Phoenix Environmental Sciences 2022a).

In September 2021, Phoenix was commissioned by KCGM to undertake a basic terrestrial fauna survey within the Fimiston Operational Area to map habitat and record evidence of Malleefowl. Three broad fauna habitats were mapped in the study area: 1) Open woodland, 2) Shrubland and 3) Rehabilitation. These habitat types, identified within a southern section of the DE covered in this report, were extrapolated across the un-surveyed northern section.

While Malleefowl were not found within the southern study area in 2021 it was inferred they may potentially use the majority of the DE for dispersal and foraging but were unlikely to depend on the area for breeding (Phoenix Environmental Sciences 2022b). In their review Phoenix identified Malleefowl sightings approximately 7 to 10km from the current survey area.

5 Methods

5.1 Personnel

The habitat assessment was conducted by Alexander Holm and Geoffrey Eliot.

Dr Holm is an ecologist with over 35 years' experience in arid environments and Goldfield regions. He has conducted Malleefowl surveys and habitat assessments in the Goldfields region since 2010. He is an accredited environmental consultant with the Environmental Consultants Association of Western Australia.

Mr Geoffrey Eliot was soil and landscape technician for the Western Australian Department of Agriculture's rangeland surveys and has over 20 years' experience in Western Australian arid regions. He has assisted Alexander Holm & Associates in conducting several Malleefowl surveys and habitat assessments within the Goldfields region.

The 2023 Malleefowl targeted species search for nesting mounds and activity was conducted by Holm, Eliot and Philip Smyth from Alexander Holm & Associates, with assistance of up to nine KCGM personnel. Mr Smyth has assisted Alexander Holm & Assistants in previous Malleefowl surveys in this region.

This report was prepared by Dr Holm (Alexander Holm & Associates).

5.2 Timing of Survey

The Malleefowl habitat mapping was conducted from March 6 to March 9, 2023; while the targeted Malleefowl activity and mound searches were completed from March 10 to 15, 2023. All proposed impact areas within the DE were inspected and assessed during this time.

5.3 Survey Area

Habitat suitability for Malleefowl was assessed within the following areas as shown in Figure 1 on page 3:

- Fimiston III TSF – 1171ha north of Bulong Road
- Fimiston IIE Third Cell – 355ha South of Bulong Road
- Fimiston Eastern floodway North – 77.9ha – West of the Trans Australia Railway
- Fimiston Eastern floodway South – 777ha – Southwest of the Trans Australia Railway
- Western side of Fimiston – 174ha – between Boulder townsite and the KCGM Superpit.

5.4 Targeted Malleefowl Search and Activity Survey

5.4.1 Survey Techniques

Three approaches were utilised to assess Malleefowl activity according to the likelihood of activity within each assessment area.

1) Intensive grid line searches for areas a) well connected to extensive areas of suitable surrounding habitat and b) that may contain suitable habitat:
    - Fimiston III TSF.
    - Fimiston IIE Third Cell.
2) Controlled foot traverses in areas identified as a) poorly connected to areas of suitable surrounding habitat and b) that may contain suitable habitat. This included:
    - Fimiston Eastern floodway South (eastern and northern sections).

3) Vehicle traverse in fragmented areas, isolated and not connected to areas of suitable surrounding habitat, this included:
    - Fimiston Eastern floodway North.
    - Western side of Fimiston.

5.4.2 Intensive Gridline Searches

In accordance with the National Malleefowl Monitoring Manual (2019) operators searched Fimiston III TSF and Fimiston IIE Third cell areas along tracklines 20m apart using GPS devices to maintain position (Figure 3). A total of 880km was traversed along tracklines which took over 290 person hours to complete thereby meeting the survey guidelines for Australia's threatened birds (2017) which recommends 10 hours/50ha for such searches in semi-arid zones.

Operators searched for nesting mound/s to be photographed, measured and evidence of Malleefowl activity noted in accordance with the procedures outlined in the *National Malleefowl Monitoring Manual* referenced at item 9a (National Malleefowl Recovery Team 2019). Additionally, operators looked for other evidence of Malleefowl activity (disturbance of litter, tracks and sightings) during traverse activities. Visible evidence of predators and livestock was also noted.

It is considered, that search procedures were sufficient to ensure any active nesting mounds or evidence of recent Malleefowl activity would have been found/intercepted.

5.4.3 Controlled Foot Traverse

Presence of Malleefowl in the north and east sections of Fimiston Eastern Floodway South, a 162ha area west of the Railway (Figure 1), was assessed by GPS controlled searches 500m apart (Figure 3). by Holm, Eliot and Smyth according to Survey guidelines for Australia's threatened birds (2017) Operators looked for evidence of Malleefowl activity (disturbance of litter, tracks and sightings) during traverse.

A total of 10.2km were traversed over 4 hours well in excess of 166ha/hour recommended in 'Survey guidelines for Australia's threatened birds' (2017).

5.4.4 Vehicle Traverse

Fimiston Eastern Floodway North and the Western Fimiston east of Boulder (Figure 1) are heavily impacted and constrained by mining activity, urban development, transport and power corridors and mining infrastructure. These areas, previously surveyed by Phoenix (2022a), and characterised as 'Rehabilitated' of 'Disturbed' were traversed as far as possible by vehicle and habitat suitability assessed visually.

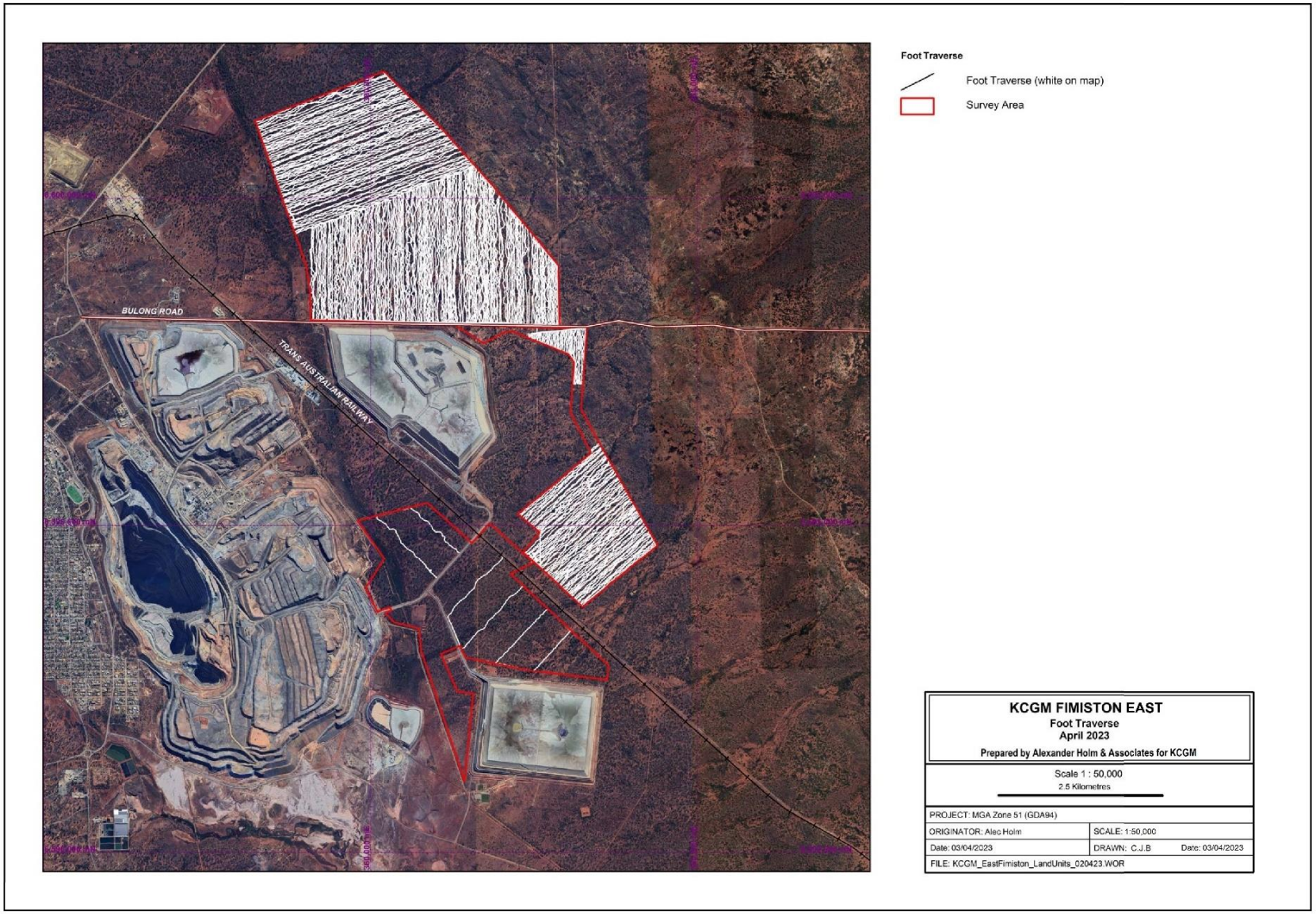

Figure 3: Malleefowl targeted survey showing foot traverse in March 2023.

5.5 Habitat Assessment

5.5.1 Habitat Mapping and Description

The underlying basis for habitat assessment was spatially-described information within land units, each occupying a similar topographic position, vegetation and soil type (Christian and Stewart 1953). As such land units are analogous with habitat types.

Prior to the March 2023 survey being completed by Alexander Holm & Associates, readily identified common landform patterns were provisionally marked out on high-resolution aerial images covering the DE. This was assisted by comparisons of underlying geology, vegetation type maps and descriptions by Phoenix (2022a) and consistent with habitat mapping guidance by EPA (2020).

Again, before survey 44 inventory sites were selected within these provisionally demarcated images to a) provide replicate samples of each landform polygon, b) provide systematic coverage of the survey area, and c) encompass variations in pattern within each land unit.

During field survey each inventory site was located by GPS and the following information recorded:

- Digital photographs.
- Foliage cover and dominant flora within upper, mid and lower stratum.
- Vegetation condition visually estimated using rating scales of Keighery (1994).
- Vegetation community and land unit descriptions using terminology from Payne et al. (1998).
- Landform, slope and relief, (Anon, 2009).
- Litter abundance (nil, minimal, moderate, abundant).
- Disturbances (fire, human, grazing) and access and isolation constraints noted.
- Soil characteristics (texture, reaction to acid and coarse fragment characteristics) to maximum of 30cm (Anon, 2009).
- Depth to intractable soil layer (unable to be dug by hand) or depth to siliceous hardpan or parent material.

5.6 Malleefowl Habitat Assessment

5.6.1 Breeding Habitat Assessment

Critical Malleefowl breeding habitat was assessed from field survey information collected during the March 2023 survey using a set of environmental variables, as informed by the National Malleefowl Recovery Plan (Benshemesh 2007), which consisted of an analysis of i) site suitability, ii) site context and iii) Malleefowl activity.

Site Suitability

Malleefowl habitat characteristics were assessed using an unweighted sum of values from inventory site ratings, including:

- Loamy sand or sandy loam soil type.
- Depth to intractable soil layer, hardpan or parent material (>30cm).
- Litter abundance (nil:0; minimal: 0.25; moderate: 0.5; abundant: 1.0).
- Upper and mid-storey canopy cover (>25%).
- Level ground (<1.5% slope).

- Presence of mallee, mulga type trees or spinifex.
- Vegetation condition (totally degraded: 0 – pristine: 1)

These criteria were rated for each land unit with factor scores expressed as a proportion of inventory sites sampled within each land unit with the desired character.

Site Context

Site context refers to the freedom and ability to support Malleefowl to breed, forage and disperse. Factors assessed during survey were:

- Disturbances (vehicle tacks, livestock grazing, clearing).
- Constraints to movement to and from surrounding habitat suitable for Malleefowl (mining infrastructure, roads, rail lines, fences).

Connectivity and constraints to movement are severely affected by the Trans Australian Railway and separate ratings for this factor are provided for Fimiston Eastern Floodway South impact area west of the railway (Figure 1).

Malleefowl Activity

Information collected during the intensive gridline and transect searches for evidence of Malleefowl present activity (tracks and active or recently active nesting mounds) and past activity (abandoned nesting mounds), were ranked from nil (no evidence of present or past activity) to 1 (presence of active or recently active nesting mounds).

Assessment

Composite indexes were then summed to provide a summary index for each land unit. This was expressed on a scale of 0 to 10 where scores above 5 are considered marginal habitat for breeding and survival, whilst scores of above 7 considered critical habitat for breeding and survival of Malleefowl.

5.6.2 Forage and Dispersal Habitat Assessment

Factors, considered relevant for assessment of habitat suitability for forage and dispersal were derived from information within the National Malleefowl Recovery Plan (Benshemesh 2007), the PhD thesis of Stenhouse (2022) and observations from earlier surveys (e.g. Alexander Holm & Associates 2022a). Factor scores are expressed as a proportion of inventory sites sampled within each land unit with the desired character. Factors assessed during survey were:

- Observations of Malleefowl activity.
- Upper and mid-storey canopy cover exceeding 25%.
- Litter abundance.
- Presence of mallee, mulga type trees or spinifex.
- Disturbances (vehicle tacks, livestock grazing, clearing).
- Constraints to movement to and from surrounding habitat suitable for Malleefowl (mining infrastructure, roads, rail lines, fences).

Assessment

Composite indexes were then summed to provide a summary index for each land unit expressed on a scale of 0 to 10 where scores above 5 are considered suitable habitat for foraging and dispersal.

5.6.3 Fimiston Eastern Floodway North and Western Fimiston areas

Fimiston Eastern Floodway North and the Western Fimiston, east of Boulder are heavily impacted and constrained by mining activities and infrastructure, urban development, transport and power corridors. These areas were traversed by vehicle and habitat suitability visually assessed according to:

- Connectivity with and/or isolation from surrounding suitable habitat for Malleefowl.
- Disturbances and threats.
- Fragmentation.

6 Results

6.1 Malleefowl Activity Survey

No evidence of recent Malleefowl activity was found in any of the proposed impact areas. There were no Malleefowl tracks, no litter disturbance and no recently used nesting mounds identified or located.

One definite 'long unused' nesting mound (FM02) was located and documented during the survey. The presence of shrubs and a tree within the nest perimeter indicates the nest had not been used for many decades. The mound was within the 'Low rounded hillocks and gentle footslopes' of land unit 1f. Nearby and further afield localised soil disturbances of warrens by long-departed burrowing animals (possibly burrowing bettong *Bettongia lesueur)* were indicative of micro-habitats of suitable soil for construction of a nesting mounds within this land unit but no other Malleefowl nesting mounds were found.

Other ill-defined ground disturbances were noted during survey. One of these (FIM01), a shallow, irregularly shaped disturbance on clay soils, occurred in very sparse eucalypt woodland within land unit 4a (Broad plains with salmon gum overstoreys). These factors strongly suggest this disturbance is not a Malleefowl nesting mound or at best is a long-ago failed attempt to construct a mound.

Table 1: Malleefowl mound and other disturbances located during survey in March 2023

Details	Comment	Photo
FIM01 Record date: 14/03/2023 Indeterminate dimensions. Location: 121.53319E -30.72835S	Highly degraded. No clear mound construction. Shrubs growing on rim	
FIM02 Record date: 14/03/2023 Outer rim: 450cm Inner rim: 260cm Depth: 40cm Location: 121.57226E -30.76502S	Well-formed MF mound. Shrubs and trees growing on rim suggest >50years since used	

6.2 Habitat Assessment

6.2.1 Habitat Mapping

Vegetation communities, landform and soil profile descriptions of the six land units within this survey are described with representative photographs in Table 2 and are shown spatially in Figure 4.

- Gently inclined to near-level plains characterised by Salmon gum (*Eucalyptus salmonophloia*) and with light clays or sandy clay loams over light clay soils of land unit 4a occupy 40% of the mapped areas within the DE.
- Flood-prone broad drainage tracts (land unit 4b) with intractable light clays at shallow depths occupying 16% pass from higher land in the east down slope towards mining infrastructure in the west.
- Rocky low hills and footslopes of land unit 1f (and minor components of land unit 2a), rising to a maximum of 40m, occupy 19% along eastern fringes of the DE. Lower slopes have moderately deep, usually calcareous, sandy clay loams with abundant calcrete nodules at depth with small highly restricted pockets of more tractable soils.
- Broad gently inclined plains, commonly with abundant ferruginous fine gravel mantles and intractable light clays at shallow depths (land unit 2a) occupy 12%.
- The remaining 12% represents two land units in the lowest part of the DE; occupied by saline plains (land unit 5) and a densely vegetated drainage system (land unit 6) both with light clay soil.

Western Fimiston impact area was previously mapped by Phoenix (2022a) as ‘Rehabilitated’ or ‘Degraded’ and their mapping has been incorporated in Figure 4.

Table 2: Land unit descriptions of landform soil and vegetation characteristics.

Land unit	Landform and soil type	Vegetation community
1f. Low rounded hillocks and gentle footslopes		
	Low rises to 20m, commonly on felsic geology with slopes to 5%. Often with abundant surface mantles of gravel and cobbles. Surface sheet flow often with accelerated soil erosion. Upper slopes with variable depth, often skeletal, sandy clay loams. Lower slopes with moderately deep, usually calcareous, sandy clay loams with abundant calcrete nodules at depth. Depth to non-tractable soil or parent material: 15 to >30cm	Very sparse to sparse shrublands, often with abundant re-colonizing shrubs, and isolated *Eucalyptus* spp and *Casuarina pauper.* *Foliar cover (>1m)*: 5-30% Ave 17% *Litter:* Nil -minimal 60%; moderate 40% *Vegetation condition*: 50% structure intact; 50% structure altered to significantly altered.
2a. Gently inclined plains with ferruginous gravel mantles		
	Broad gently inclined plains (slopes 1.5 to 3%) commonly with 100% ferruginous fine gravel mantles. Occassional ironstone hillocks to 40m. Diffuse overland sheet flow. Mostly calcareous sandy clay loams to light clays occassionally over ferruginous hardpan. Depth to non-tractable soil or hardpan: 10-25cm	Very sparse to sparse shrublands often with spinifex with isolated *Eucalyptus* spp and *Casuarina pauper*. *Foliar cover (>1m):* 2-30% Ave 17% *Litter:* Nil to minimal 87%; moderate 13% *Vegetation condition:* 33% structure intact; 67% structure altered to significantly altered.

Land unit	Landform and soil type	Vegetation community
4a. Broad plains with salmon gum overstoreys. 	Level to gently inclined plains (slopes 0 to 1.5%) often with abundant ferruginous fine gravel strews. Diffuse overland sheet flows. Deep, often calcareous light clays or sandy clay loams over light clay. Depth to non-tractable soil: 10 to >30cm	Very sparse eucalypt woodland typically *E. salmonophloia* over sparse shrubland or sparse to very sparse shrubland with isolated or patchy eucalpt overstorey. *Foliar cover (>1m):* 15-48% Ave 23% *Litter:* Moderate to abundant: 87% *Vegetation condition:* 20% structure intact; 80% structure altered to significantly altered.
4b. Broad drainage tracts with chenopod shrublands 	Broad gently inclined drainage tracts (slopes <1 to 1.5%) with mostly diffuse overland sheet flow and minor incised gutters. Mostly deep light clays or sandy clay loams over light clay. Depth to non-tractable soil: 5-20cm	Sparse often patchy chenopod shrublands with re-colonizing shrubs and isolated *Eucalpytus* spp. In some areas re-colonizing shrubs completely dominate forming mid-dense shrublands. *Foliar cover (>1m)* 5-50% Ave 22% *Litter:* Highly variable from nil to moderate. *Vegetation condition:* 33% structure altered; 67% structure significantly altered.

Land unit	Landform and soil type	Vegetation community
5. Saline plains 	Level saline plains adjoining nearby saltlake. Deep saline clacareous light clays. Depth to non-tractable soil : 30cm	Sparse degraded halophytic shrublands with numerous to abundant re-colonizing shrubs. *Foliar cover (>1m)* 20% *Litter:* Nil. *Vegetation condition:* 100% structure significantly altered.
6 Drainage system with acacia shrubland 	Interupted drainage tract. Deep light clay. Depth to non-tractable soil : 30cm	Closed mid-height shrubland dominated by re-colonizing acacia shrubs. *Foliar cover (>1m)* 20-80% Ave 50% *Litter:* Nil to moderate. *Vegetation condition:* 100% structure severely altered/impacted.

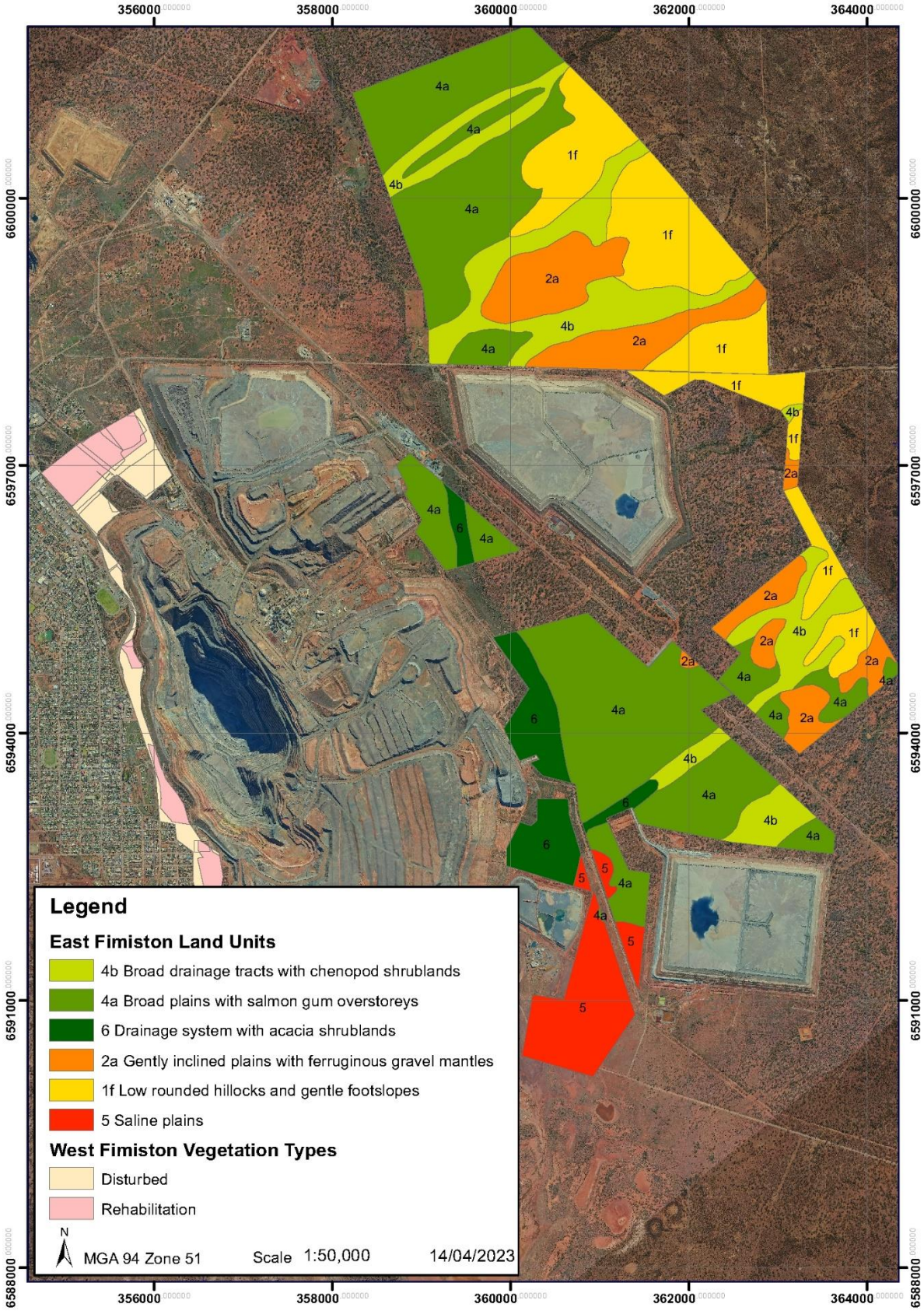

Figure 4: Fimiston land units

6.2.2 Critical Habitat for Breeding

The factors considered within this assessment of the presence of critical habitat for breeding: Malleefowl activity, Site suitability and Site context, as listed in Section 5.6.1 and based on information from a) intensive search for Malleefowl activity and b) data from inventory sites during the habitat survey, are summarised in Table 3.

Malleefowl Activity

No evidence of recent Malleefowl activity was found in any of the assessment areas. There were no Malleefowl tracks, no litter disturbance and no recently used nesting mounds. Only one positively identified mound was found in the footslopes of land unit 1f. Shrubs and a tree within the nest perimeter indicated the nest had not been used for many decades.

Site Suitability

Vegetation within the DE has been structurally altered presumably from historical stock grazing and tree felling during early mining development. Re-colonizing shrubs, predominately *Eremophila scoparia*, *Senna artemisioides* subsp*. filifolia* and *Acacia hemeteles*, are widespread and are frequently the dominant species. Vegetation condition at 33% of the inventory sites is severely or significantly altered by disturbance and 44% show obvious signs of disturbance (Table 2).

There are no sandy substrate soils (preferred for nest construction), with all soils testing sandy clay loam or heavier and considered unsuitable for successful mound construction. Nesting mound construction is also constrained by depth to the intractable layer in all except small pockets of more tractable soils within footslopes of land unit 1f.

Litter is generally scarce in all except the Broad plains with salmon gum overstoreys of land unit 4a.

Most areas supported sparse to very sparse shrublands and isolated eucalyptus with canopy cover generally less than 40%, except for restricted sections of Broad drainage tracts of land unit 4b and within the drainage system of land unit 6. However, Melaleuca, mulga-type acacia and Mallee species favoured by Malleefowl, are not present. Malleefowl are known to feed in spinifex habitats which is a minor and spatially limited component of land unit 2a.

Site Context

Connectivity of land units within the DE and surrounding country is highly constrained in all areas west of the Railway and partially constrained east of the Railway by roads, hobby farms and mining infrastructure except for land unit 1f which adjoins open country along the eastern boundaries of the DE. Networks of off-road vehicle tracks and trails fragment all areas.

When indices for Malleefowl activity, Site suitability and Site context, are combined and expressed on a scale of 0 to 10, habitat ratings for land units range from about 2 to 3 for Fimiston II/III and less than 2 for all land units in Eastern Floodway South (Table 3).

Given these ratings, where scores above 5 are considered marginal habitat and above 7 critical habitat for breeding and survival, Fimiston II/III and Eastern Floodway South contain no critical or marginal habitat for breeding and survival.

6.2.3 Foraging/Dispersal Habitat

The factors considered in the assessment of habitat suitable for Malleefowl foraging and dispersal, as listed in Section 5.6.2 and based on information from a) intensive search for Malleefowl activity and b) data from inventory sites during the habitat survey, are summarised in Table 4.

When factor scores are combined and expressed on a scale of 0 to 10, habitat ratings for land units range from 2.6 (land unit 4a) to 5.1 (land unit 1f) for Fimiston II/III and from 1.5 (land unit 4a) to 3.1 (land unit 6) for Eastern Floodway South.

Given these ratings, where scores above 5 are considered suitable habitat for Malleefowl foraging and dispersal, only the low rolling hillocks and footslopes of land unit 1f within Fimiston II/III are considered suitable habitat for foraging and dispersal and are shown in Figure 5.

6.2.4 Fimiston Eastern Floodway North and Western areas

Fimiston Eastern Floodway North and Western areas were visually assessed and rated according to factors listed in section 5.6.3 and are summarised in Table 5.

Both these areas are highly constrained by mining infrastructure, the Transline which passes to the east of Eastern Floodway North and urban development to the west of the Western area. Active rock crushing and vehicle movements adjacent to Floodway North and immediate access to threats from domestic animals pose significant threats.

Neither the Eastern Floodway North nor the Western area provide suitable habitat for Malleefowl use.

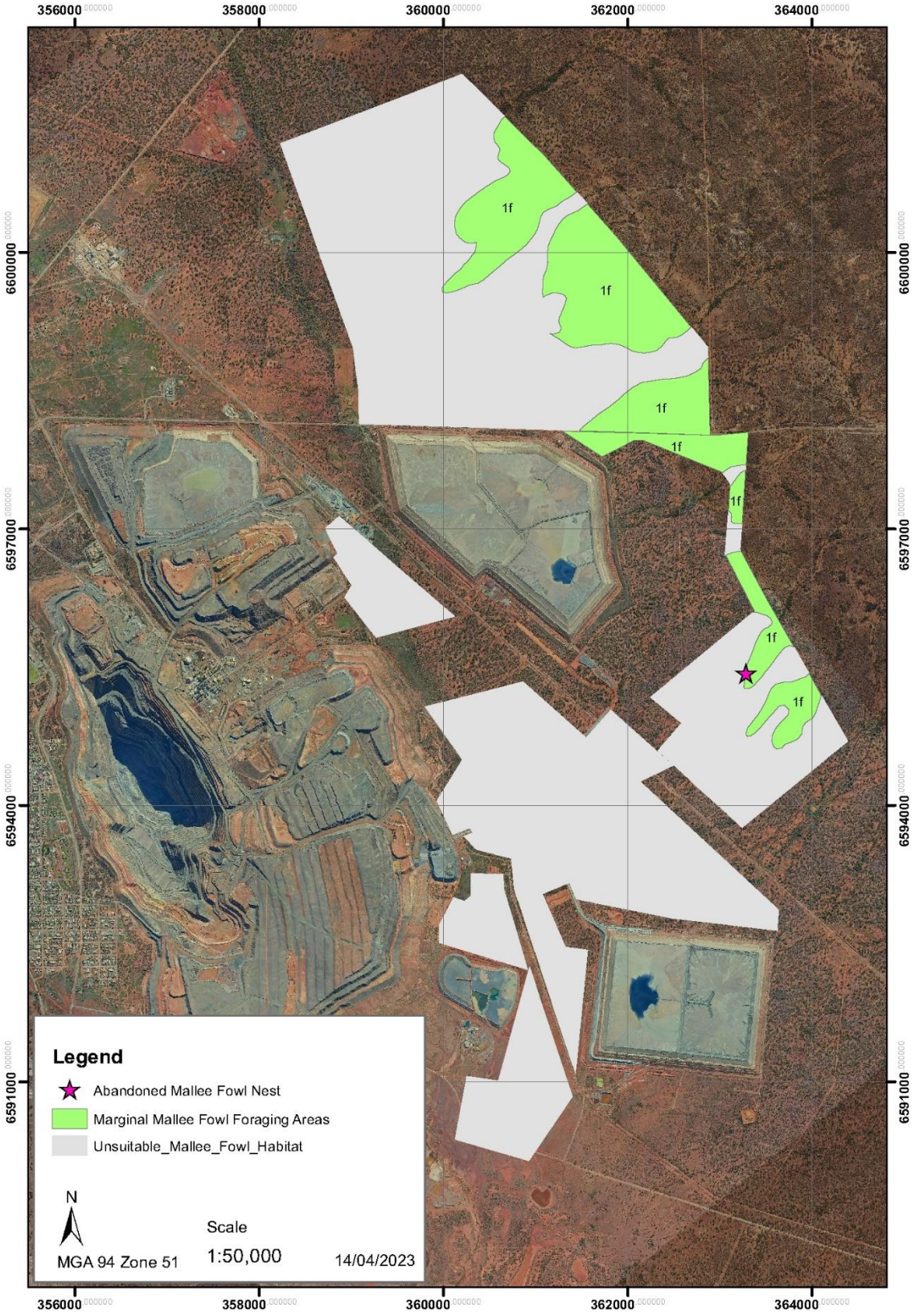

Figure 5: Assessment of habitat for Malleefowl within proposed impact areas of the DE.

Table 3: Habitat calculation worksheet for assessment of suitability of land units for Malleefowl breeding

Factor	Condition	1f	2a	4a	4b	5	6
Number of sites		10	8	15	8	1	2
Site suitability							
Sandy soil	Loamy sand or sandy loam soil type	0.10	0	0	0	0	0
Soil depth	>30cm to intractable soil layer, hardpan or parent material	0.30	0.13	0.53	0.50	0	0
Litter abundance	Nil:0; minimal: 0.25; moderate: 0.5; abundant: 1.0	0.55	0.22	0.53	0.25	0	0.38
Upper/mid canopy cover	Cover >25%	0.20	0.50	0.33	0.38	0	0.50
Level ground	<1.5% slope	0.10	0.63	1.00	1.00	1.00	0.50
Favourable vegetation	Presence of mallee, mulga type trees or spinifex	0	0.13	0	0	0	0
Vegetation condition	Totally degraded: 0 – pristine: 1	0.62	0.58	0.61	0.45	0.60	0.30
Habitat suitability score	**Adjusted score out of 3**	**0.80**	**0.93**	**1.29**	**1.10**	**0.69**	**0.72**
Site context							
Disturbances	Vehicle tacks, livestock grazing, clearing	0.40	0.25	0	0.50	1.00	1.00
Constraints to movement	Mining infrastructure, roads, rail lines, fences						
Fimiston II/III		0.90	0.88	0.67	0.88	0	0
Fimiston Eastern Floodway South		NA*	NA	0	0	0	0
Habitat context score Fim II/III	**Adjusted score out of 3**	**1.30**	**1.13**	**0.67**	**1.38**		
Habitat context score Fim EFS	**Adjusted score out of 3**			**0**	**0.50**	**1.00**	**1.00**
Activity							
Active or recently active	Nesting mounds present (1)	0	0	0	0	0	0
Recent activity	Malleefowl tracks and litter disturbance (0.75)	0	0	0	0	0	0
Inactive nesting mounds	Inactive mounds present (0.5)	0	0	0	0	0	0
Long abandoned nesting mounds	Long abandoned nesting mounds present (0.25)	0.25	0	0	0	0	0
No evidence of Malleefowl	No nesting mounds, tracks or litter disturbance (0)		0	0	0	0	0
Habitat activity score	**Adjusted score out of 4**	**1.00**	**0**	**0**	**0**	**0**	**0**
Combined habitat score Fim II/III	**Score out of 10**	**3.10**	**2.05**	**1.96**	**2.48**	**NP**	**NP**
Combined habitat score Fim EFS	**Score out of 10**	**NP**	**NP**	**1.29**	**1.60**	**1.69**	**1.72**

*NP: Land unit not present in this proposed impact area

Table 4: Habitat calculation worksheet for assessment of suitability of land units for Malleefowl foraging and dispersal.

Factor	Condition	1f	2a	4a	4b	5	6
Number of sites		10	8	15	8	1	2
Malleefowl activity	Some evidence of past activity: 1	1.00					
	No evidence of present or past activity: 0		0	0	0	0	0
Upper/mid canopy cover	Cover >25%	0.20	0.50	0.33	0.38	0.00	0.50
Litter abundance	Nil:0; minimal: 0.25; moderate: 0.5; abundant: 1.0	0.55	0.22	0.53	0.25	0.00	0.38
Favourable vegetation	Presence of mallee, mulga type trees or spinifex	0.00	0.13	0.00	0.00	0.00	0.00
Disturbances	Vehicle tacks, livestock grazing, clearing	0.40	0.25	0.00	0.50	1.00	1.00
Constraints to movement	Mining infrastructure, roads, rail lines, fences						
Fimiston II/III		0.90	0.88	0.67	0.88	0.00	0.00
Fimiston Eastern Floodway South		NA*	NA	0.00	0.00	0.00	0.00
Forage habitat score Fim II/III	**Score out of 10**	**5.09**	**3.30**	**2.56**	**3.34**	**NP**	**NP**
Forage habitat score Fim EFS	**Score out of 10**	**NP**	**NP**	**1.45**	**1.88**	**1.67**	**3.13**

*NP: land unit not present in this proposed impact area.

Table 5: Habitat assessment for Malleefowl breeding and foraging within Fimiston Eastern Floodway North and Fimiston West.

Factor	Fimiston Eastern Floodway North	Fimiston West
Area (ha)	77.9	174
Connectivity with and isolation from surrounding suitable habitat for Malleefowl.	Highly constrained by mining infrastructure to the north, west and east. The Transline passes to the east.	Highly constrained by urban development along western edge and to the north. Mining infrastructure prevents access to the east. 2.4m chain wire fencing on large sections.
Disturbances and threats.	Active rock crushing with frequent vehicle movements in the northeast. Vehicle tracks crisscross the area.	Proximity to Boulder and town cats and dogs. Off-road trail bikes and 4wd vehicles. Unfenced areas are a maze of vehicle tracks.
Fragmentation	Tailings discharge pipelines bisect the area	Area divided into a 5km long narrow southern section and a fragmented northern section separated by roads and fences.
Habitat assessment	**Unsuitable**	**Unsuitable**

6.3 Survey Limitations

The limitations of the targeted Malleefowl activity survey and habitat assessment were considered in accordance with EPA's Technical Guidance: Terrestrial fauna surveys (2020) (Table 6).

No major limitations were identified.

Table 6: Survey limitations

Limitation	Limitation for this survey?	Comments
Availability of contextual information at a regional and local scale	No	Previous biological and soil surveys for KCGM together with geological maps provided excellent local scale information. Regional scale information from Land System mapping assisted land unit/habitat description
Competency/experience of the team carrying out the survey, including experience in the bioregion surveyed	No	Alexander Holm, who managed the survey and prepared the report, has many years experience in WA arid environments and has worked specifically in the Goldfields since 2005. Holm and his team have conducted Malleefowl search and habitat assessments since 2010.
Any identification issues	Partial	Recent Malleefowl nests are large and distinctive and unlikely to be missed. Highly degraded nests may be missed.
Was the appropriate area fully surveyed (effort and extent)	No	Intensity of sampling effort was proportional to the likelihood of Malleefowl and met or exceeded sampling intensity recommended in Survey guidelines for Australia's threatened birds' (2017).
Access restrictions within the survey area	No	All areas were accessible by vehicle or on foot.
Survey timing, rainfall, season of survey	No	The search for Malleefowl activity was in March optimal for nesting activity or chick emergence. Good rainfall from a few weeks before survey ensured optimal conditions for recent footprint identification.
Disturbance that may have affected the results of survey	No	No disturbance affected conduct of the survey. As indicated in the report, proximity of the DE to Kalgoorlie Boulder and mining activity has most probably significantly diminished the likelihood of Malleefowl using this area.

7 Discussion and conclusions

Following the completion of extensive field surveys conducted in March 2023 and the post survey data analysis on behalf of KCGM, Alexander Holm & Associates have concluded the following regarding suitability of habitat for Malleefowl within proposed impact areas adjacent to Fimiston Gold Mine Operations Kalgoorlie Boulder:

- None of the proposed impact areas contain critical or marginal habitat for breeding and survival.
- The low rolling hillocks and footslopes of land unit 1f occupying 451ha within Fimiston II/III are rated as suitable habitat for foraging and dispersal.
- Fimiston Eastern Floodway North and Western proposed impact areas are not suitable for Malleefowl.

No evidence of recent Malleefowl use was found. There were no active or recent nesting mounds, no Malleefowl footprints and no litter disturbance indicative of foraging activity.

Only one definite Malleefowl nesting mound was found in the 2303ha DE. This long-unused mound was in highly restricted micro-habitats within the low rounded hills and footslopes of land unit 1f where local soil conditions were favourable for mound construction. For most of this land unit, slopes exceeded 2% and soils are skeletal sandy clay loams to light clays, conditions generally unsuitable for mound construction.

Elsewhere, soil types and depth to intractable layers are universally unsuitable for mound construction. One long abandoned nesting mound indicates Malleefowl may have used parts of these areas many decades ago and probably before major mining expansion and urban development in Kalgoorlie Boulder. Proximity to this major urban centre together with numerous tracks and trails encourages off-road vehicle activity and this combined with town dogs, whose tracks were noted throughout, are major deterrents to present-day Malleefowl use of these areas.

These limitations, together with limited cover and other factors important for successful Malleefowl breeding, render all land units unsuitable for breeding. A conclusion also reached by Phoenix (2022a) and Harwood (2015).

The low rolling hillocks and footslopes of land unit 1f occupying 451ha within Fimiston II/III are rated suitable habitat for foraging and dispersal. This land unit occurs in the eastern margins of the DE and has unrestricted access to habitat to the east. Malleefowl have been found 7km to the east and are known at times to range over one to several square kilometres for forage (Benshemesh 2007). While it is possible that Malleefowl from these distant populations may travel to the edges of the DE, and while Harwood (2015) considered that transient individuals may occasionally frequent the area, it is likely that even transient individuals will be deterred by off-road vehicle activity and urban-based predators.

The overall habitat rating for foraging and dispersal was 5 out of a maximum of 10 for land unit 1f. As such, when impacts of off-road vehicle activity and urban-based predators are taken into consideration, this land unit is considered marginally suitable for foraging and dispersal.

8 References

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Disclaimer

Appendix 1: Vegetation details at inventory sites arranged in land unit (LU) order.

Site	Date	LU	Upper storey cover				Mid storey cover				Lower story cover			UMC	TPC	Lit	VC*	Vegetation description
			%	Sp 1	Sp2	Sp3	%	Sp 1	Sp2	Sp3	%	Sp 1	Sp2	%	%			
FIM05	6/03/2023	1f	3	caspau	eucgrif		15	snnfil	ereold	acabur	2	olemue	ptiobo	18	20	2	3	Mixed-height very sparse shrubland with isolated caspau and eucgrif mostly on upper slopes
FIM06	6/03/2023	1f	3	eucsalm	eucsalub	eucspp	5	snnfil	ereold	ereopp	7	maised	atrbun	8	15	2	3	Very sparse chenopod shrubland with scattered mid-height shrubs and isolated euc and caspau
FIM07	6/03/2023	1f	10	eucles	eucole	caspau	5	eresco	snnfil	ereint	25	cracon	erepar	15	40	2	2	Sparse mixed-height shrubland with very sparse euc overstory and isolated caspau
FIM16	7/03/2023	1f	2	eucgrif	eucsalm	caspau	20	snnfil	eresco	ereold	5	erepar	atrspp	22	27	1	4	Sparse mid-height shrubland with isolated eucs
FIM17	7/03/2023	1f	1	caspau	eucles	eucgrif	20	snnfil	acanys	ereold	5	erepar	scvspi	20	25	0	2	Very sparse shrubland with isolated caspau and eucs
FIM18	7/03/2023	1f	1	eucles	caspau		25	snnfil	eresco	ereopp	5	maised	atrspp	25	30	1	4	Sparse chenopod shrubland with abundant re-colonizing shrubs and isolated caspau and eucs
FIM23	7/03/2023	1f	5	eucles			10	snnfil	eresco	ereint	5	atrnum	erepar	15	20	2	3	Very sparse chenopod shrubland with re-colonizing shrubs and isolated eucs
FIM24	7/03/2023	1f	1	eucles			30	acabur	snnfil	dodlob	5	proalf	atrnum	30	35	1	2	Sparse mid-height shrubland with very isolated to patchy eucs
FIM26	8/03/2023	1f	3	eucles	eucgrif	caspau	5	eresco	ereold		12	atrnum	atrves	8	20	2	4	Very sparse chenopod and other shrubs shrubland with isolated eucs and caspau
FIM29	8/03/2023	1f	3	eucles	caspau		2	snnfil	ereint		20	cracon	erepar	5	25	1	2	Sparse low shrubland with isolated eucs
FIM11	6/03/2023	2a	3	eucsalm	eucrav		5	eresco	ereion	acanys	5	atrves	ptiobo	8	13	1	4	Very sparse chenopod shrubland with re-colonizing shrubs and isolated eucs
FIM20	7/03/2023	2a	2	caspau	eucgrif	eucsalm	28	acahem	acatet	ereopp	<1	olemue	triodia	30	30	1	3	Sparse acacia shrubland and very isolated caspau and eucs

Site	Date	LU	Upper storey cover				Mid storey cover				Lower story cover			UMC	TPC	Lit	VC*	Vegetation description
			%	Sp 1	Sp2	Sp3	%	Sp 1	Sp2	Sp3	%	Sp 1	Sp2	%	%			
FIM21	7/03/2023	2a	1	eucsalm			24	acahem	snnfil	acatet	3	maitrip	maised	25	28	1	3	Very sparse mid-height shrubland with remaining maised and isolated salmon gum overstory.
FIM25	8/03/2023	2a	2	eucspp			13	acccoo?	ereold		5	scvspi	grespp	15	20	0	2	Very sparse mixed-height shrubland with isolated eucs
FIM27	8/03/2023	2a	1	caspau	eucgrif		23	acahem	acabur	snnfil	1	scvspi	ptiobo	24	25	1	3	Sparse shrubland with very isolated caspau and eucs
FIM30	8/03/2023	2a	2	eucsalm			15	acahem	snnfil	ereopp	3	scvspi	erepar	17	20	1	2	Very sparse shrubland with isolated eucs
FIM32	8/03/2023	2a	<1	eucsalm	eucyil		2	eresco	acahem		<1	atrnum	maipyr	2	2	0	5	Very sparse shrubland - mostly degraded chenopod shrubland with very isolated eucs
FIM33	8/03/2023	2a	5	eucspp	eucgrif		10	snnfil	acahem		10	spinfex	wesrig	15	25	2	3	Sparse shrubland with small spinifex patches and very sparse eucs
FIM01	6/03/2023	4a	2	eucsalm			20	acahem	snnfil	acanys	5	maitrip	ptiobo	22	27	1	3	Very sparse mid-height shrubland with patchy isolated salmon gum overstory.
FIM02	6/03/2023	4a	2	eucsalm			30	eresco	snnfil	acahem	<1	maitrip	maised	32	32	2	3	Sparse mid-height shrubland with scattered salmon gum overstory
FIM04	6/03/2023	4a	2	eucsalm	euctrans		15	snnfil	acahem	eresco	5	atrbun	maitrip	17	22	3	2	Very sparse chenopod shrubland with numerous re-colonizing shrubs and isolated eucs
FIM12	6/03/2023	4a	5	eucsalm	eucles		25	snnfil	eresco	exoaph	5	olemue	erepar	30	35	2	3	Very sparse euc woodland over very sparse mixed-height shrubland
FIM13	7/03/2023	4a	<1	caspau	eucsalm		25	acahem	acanys	snnfil	2	ptiobo	maitrip	25	27	1	4	Sparse acacia shrubland of re-colonizing shrubs and very isolated caspau and salmon gums
FIM14	7/03/2023	4a	8	eucrav	eucsalm		40	snnfil	eresco		5	erepar	scvspi	48	50	3	3	Very sparse euc woodland over sparse re-colonizing shrubland with maised remnants
FIM15	7/03/2023	4a	2	eucsalm			15	snnfil	acahem	eresco	5	maised	maitrip	17	20	2	3	Very sparse degraded chenopod shrubland with re-colonizing shrubs and isolated salmon gums

Site	Date	LU	Upper storey cover				Mid storey cover				Lower story cover			UMC	TPC	Lit	VC*	Vegetation description
			%	Sp 1	Sp2	Sp3	%	Sp 1	Sp2	Sp3	%	Sp 1	Sp2	%	%			
FIM22	7/03/2023	4a	3	eucles	eucsalm	eucrav	25	eresco	snnfil	acahem	2	olemue	erepar	28	30	2	3	Sparse mid-height shrubland with isolated eucs
FIM31	8/03/2023	4a	5	eucles	eucsalm		5	eresco	snnfil		10	cracon	erepar	10	20	2	3	Very sparse shrubland with isolated and patchy eucs
FIM34	8/03/2023	4a	10	eucsalm	euctrans		5	snnfil	eresco		10	maised	atrves	15	25	2	4	Degraded very sparse chenopod shrubland with re-colonizing shrubs and sparse, patch euc overstory
FIM35	8/03/2023	4a	10	eucsalm	euctrans	eucles	10	snnfil	eresco	acahem	10	cracon	maised	20	30	2	3	Very sparse eucalypt woodland with sparse shrubland understorey
FIM36	8/03/2023	4a	10	eucsalm			10	snnfil	eresco	acahem	10	cracon	erepar	20	30	2	2	Very sparse eucalypt woodland with sparse shrubland understorey
FIM38	9/03/2023	4a	8	eucspp	eucsalm		15	snnfil	eresco	acahem	7	erepar	cracon	23	30	2	2	Very sparse eucalypt woodland with sparse shrubland understorey
FIM42	9/03/2023	4a	5	eucsalm			15	snnfil	acahem	eresco	5	cracon	erepar	20	30	2	3	Very sparse eucalypt woodland with sparse shrubland understorey
FIM44	9/03/2023	4a	7	eucsalm			13	snnfil	eresco	exoaph	15	cracon	erepar	20	35	2	3	Spars shrubland with numerous re-colonizing shrubs and very spars eucalypt overstory
FIM03	6/03/2023	4b	1	caspau	eucsalm		50	acahem	acanys	erespp	1	ptiobo	rhadru	50	50	2	3	Mid-dense mixed acacia eremophila shrubland with isolated caspau and salmon gums
FIM08	6/03/2023	4b	2	eucsalm	eucrav	eucole	5	eresco	acatet	ereold	25	atrves	maipyr	7	27	0	4	Patchy chenopod shrubland, some bare areas and patchy mixed height shrubs and isolated eucs
FIM09	6/03/2023	4b	1	eucsalm	eucrav		10	eresco	snnfil	acatet	20	maipyr	atrves	10	30	0	4	Patchy chenopod shrubland with re-colonizing shrubs and isolated eucs
FIM10	6/03/2023	4b	1	eucrav	eucsalm		5	eresco	ereion		5	maipyr	atrbun	6	11	1	4	Patchy very sparse chenopod shrubland with re-colonizing shrubs and isolated eucs
FIM19	7/03/2023	4b	<1	eucsalm	eucrav		5	eresco			40	maipyr	atrves	5	45	0	3	Mid-dense chenopod shrubland with taller shrubs mostly in concentrated flow zones and very isolated eucs

Site	Date	LU	Upper storey cover				Mid storey cover				Lower story cover			UMC	TPC	Lit	VC*	Vegetation description
			%	Sp 1	Sp2	Sp3	%	Sp 1	Sp2	Sp3	%	Sp 1	Sp2	%	%			
FIM28	8/03/2023	4b	5	eucrav	eucgrif	caspau	10	eresco	snnfil	ereint	5	atrves	atrnum	15	20	2	4	Very sparse chenopod and other shrubs shrubland with isolated to patchy eucs and caspau
FIM37	9/03/2023	4b	2	eucsalm	eucyil	eucrav	50	eresco	ereion	acahem	10	ptiobo	maised	50	60	1	4	Mid-dense shrubland with mostly re-colonizing shrubs and isolated eucs
FIM39	9/03/2023	4b	5	eucsalm	eucspp		30	snnfil	ereion	acahem				35	35	2	4	Mid-dense shrubland with mostly re-colonizing shrubs and isolated eucs
FIM40	9/03/2023	5					20	eresco	snnfil	exoaph	10	maised	cracon	20	30	0	3	Low sparse halophytic shrubland with numerous re-colonizing shrubs
FIM41	9/03/2023	6					20	snnfil	acahem		30	atrsti	atrbun	20	50	1	4	Sparse degraded chenopod shrubland with abundant re-colonizing shrubs
FIM43	9/03/2023	6					80	acahem	acatet		2	rhadru	atrnum	80	80	2	5	Closed mid-height shrubland dominated by re-colonizing acacia shrubs

UMC: Upper and mid storey cover;

TPC: Total perennial canopy cover

Lit: Litter abundance (0: nil; 1: minimal; 2: moderate; 3: abundant)

VC: Vegetation condition (1: Pristine; 2: structure intact; 3: structure altered; 4: structure significantly altered; 5: structure severely impacted)

Appendix 2: Landscape and soil details at inventory sites arranged in land unit (LU) order.

Site	LU	Slope	Relief	Landform	Disturbance	Landform description	Depth	Texture.		Frag.	Cem.	Soil description
		(%)	(m)				(cm)	A	B	(%)	(cm)	
FIM05	1f	3	3	Mid slope	Nil	Felsic low rise with minor outcropping and abundant mantle of coarse gravel and cobbles	15	SCL		15	15	Variable depth often skeletal sandy clay loam over felsic parent material
FIM06	1f	2	1	Lower slope	Vehicle tracks	Lower slope with overland flow and abundant mantle of ironstone and basic gravel	15	SCL	LC	20	15	Deep highly calcareous gradational soil over very hard light clay with abundant calcrete nodules
FIM07	1f	3	1	Lower slope	Vehicle tracks	Lower felsic slope with patchy gravelly mantles	>30	SCL		20		Deep highly calcareous sandy clay loam
FIM16	1f	2	3	Mid slope		Gently inclined mid-slope with active sheet erosion	15	SCL		50	15	Shallow non-calcareous sandy clay loam over felsic parent material
FIM17	1f	5	20	Hillock		Gently rounded hillock with abundant mantles of gravel and cobbles	15	SCL		80	15	Shallow often skeletal sandy clay loam over calcrete
FIM18	1f	1.5	2	Lower slope	Vehicle tracks	Slightly inclined lower slope with some accelerated soil erosion	20	SCL	LC	20	20	Deep calcareous gradational from scl to lc
FIM23	1f	5	10	Upper slope	Vehicle tracks	Gently rounded hillock with minor outcrops	>30	SCL		70		Moderately deep highly calcareous sandy clay loam
FIM24	1f	5	15	Upper slope	Vehicle tracks/main road	Gently rounded hillock to 15m	10	SCL		80		Moderately deep highly calcareous sandy clay loam with abundant calcrete inclusions
FIM26	1f	3	10	Mid slope	Clearing	Mid slope with significant water erosion	>30	LC		0	1	Deep fine textured light clay
FIM29	1f	4	15	Hillock		Low rounded felsic hillock	15	SL	SCL	10-50		Deep calcareous gradational from sl to scl with abundant calcrete nodules at depth
FIM11	2a	1.5	2	Lower slope	Vehicle tracks	Broad gently inclined plain with diffuse overland flow and occasional concentrated flow paths with 100% fine gravel mantle	10	LC	LC	10	20	Deep calcareous light clay

Site	LU	Slope	Relief	Landform	Disturbance	Landform description	Depth	Texture.		Frag.	Cem.	Soil description
		(%)	(m)				(cm)	A	B	(%)	(cm)	
FIM20	2a	1.5	0	Lower slope	Vehicle tracks/main road	Broad gently inclined lower slope with diffuse sheet flow	25	LC		10	25	Shallow light clay over ferruginous hard pan
FIM21	2a	1.5	2	Flat	Vehicle tracks	Broad gently inclined plain with 100% ironstone gravel mantle	10	SCL	LC	15		Deep calcareous gradational from slc to lc with abundant calcrete gravels
FIM25	2a	6	40	Upper slope	Vehicle tracks clearing	Ironstone/laterite rise to ~40m with gently slopes and 100% ironstone gravel mantles	10	SCL	LC	30	10	Deep calcareous gradational from slc to lc
FIM27	2a	3	10	Mid slope		Extensive gently inclined slope with abundant mostly ironstone gravel mantle	25	SCL		10-50	25	Shallow variable depth sandy clay loam over calcrete with abundant calcrete nodules at depth
FIM30	2a	1.5		Mid slope	Cattle pads/vehicle tracks	Broad gently inclined plain with 100% ironstone gravel mantle	15	SL	LC	10-30	15	Deep calcareous gradational from sl to scl
FIM32	2a	1.5		Lower slope	Cattle pads/vehicle tracks	Broad gently inclined plain with diffuse sheet flow and 100% gravel mantle	20	LC	LC	10	20	Deep calcareous light clay
FIM33	2a	2	5	Upper slope		Broad gently inclined plain with diffuse sheet flow and 75% ironstone gravel mantle	>30	SCL		10-40		Deep highly calcareous sandy clay loam with increasing gravels with depth
FIM01	4a	<1	0	Flat	Vehicle tracks	Broad plain with diffuse overland flow.	>30	SCL		40	10	Deep non-calcareous sandy clay loam with friable surface over very hard
FIM02	4a	<1	0	Flat	Nil	Broad plain with diffuse overland flow.	>30	SCL		20		Deep non-calcareous sandy clay loam
FIM04	4a	1	0	Flat	Nil	Broad plain with diffuse overland flow.	15	SCL	LC	20		Deep calcareous gradational from scl to lc
FIM12	4a	0	0	Flat	Vehicle tracks	Broad near-level plain with diffuse overland flow	>30	SCL		20		Deep highly calcareous sandy clay loam
FIM13	4a	1	0	Flat	Vehicle tracks	Broad plain with diffuse overland flow.	10	SCL		10	10	Shallow non-calcareous sandy clay loam over ferruginous hardpan

Site	LU	Slope	Relief	Landform	Disturbance	Landform description	Depth	Texture.		Frag.	Cem.	Soil description
		(%)	(m)				(cm)	A	B	(%)	(cm)	
FIM14	4a	<1	0	Flat	Vehicle tracks	Broad near-level plain with diffuse overland flow	15	SCL	LC	15	15	Deep calcareous gradational from scl to lc
FIM15	4a	<1	0	Flat	Vehicle tracks	Broad near-level plain with diffuse overland flow	20	SCL	LC	10	20	Deep calcareous gradational from scl to lc
FIM22	4a	1	0	Flat	Vehicle tracks/main road	Broad gently inclined plain with diffuse overland flow	15	SCL	LC	10		Deep calcareous gradational from slc to lc
FIM31	4a	1.5		Lower slope	Stock pad/vehicle tracks	Broad gently inclined plain with diffuse sheet flow	10	SL	SCL	10-30	10	Deep calcareous gradational from sl to scl with calcrete nodules at depth
FIM34	4a	1.5		Lower slope	Vehicle tracks	Broad gently inclined plain with diffuse sheet flow and some water erosion	10	SCL	LC	10	10	Deep highly calcareous gradational soil from scl to lc
FIM35	4a	1		Lower slope	Vehicle tracks/fence	Broad gently inclined plain with mostly diffuse sheet flow.	>30	LC		10		Deep highly calcareous light clay
FIM36	4a	1		Lower slope	Vehicle tracks/power line	Broad gently inclined plain with diffuse sheet flow	>30	LC		15		Deep highly calcareous light clay
FIM38	4a	<1		Flat	Cattle pads/vehicle tracks	Broad near-level plain with diffuse overland flow	>30	SCL		10		Deep calcareous sandy clay loam
FIM42	4a	1		Flat	Vehicle/rail/roads	Broad near-level plain with diffuse overland flow and minor incised drainage channels	>30	LC		5		Deep slightly calcareous light clay
FIM44	4a	<1		Flat	Roads/md	Broad near-level plain with diffuse sheet flow	>30	LC		10		Deep highly calcareous light clay with calcrete nodules at depth
FIM03	4b	<1	0	Flat	Nil	Broad wash slightly lower in landscape	>30	LC		10	5	Deep non-calcareous light clay
FIM08	4b	1	0	Lower slope	Nil	Broad flow line with minor incised gutters	>30	LC		0	10	Deep non-calcareous light clay
FIM09	4b	1	0	Drainage tract	Vehicle tracks	Broad drainage tract with minor incised gutters	5	SCL	LC	0	5	Deep gradational non-calcareous from scl to lc
FIM10	4b	1	0	Flat	Vehicle tracks	Broad flow line with minor incised gutters	15	SCL	LC	10	15	Deep calcareous gradational from scl to lc

Site	LU	Slope	Relief	Landform	Disturbance	Landform description	Depth	Texture.		Frag.	Cem.	Soil description
		(%)	(m)				(cm)	A	B	(%)	(cm)	
FIM19	4b	1.5	0	Drainage tract		Broad drainage tract with minor incised gutters and mostly sheet flow	5	LC	LMC	10	20	Deep calcareous gradational from lc to lmc
FIM28	4b	1.5		Lower slope		Broad drainage tract with significant water erosion and concentrated flow zones	15	SCL	LC	20-40	15	Deep calcareous gradational from slc to lc
FIM37	4b	1.5		Flat	Cattle pads	Broad flow line with concentrated flow zones	>30	LC		0	15	Deep non-calcareous light clay
FIM39	4b	<1		Flat	Vehicle track haulroad	Broad near-level drainage tract with some incised drainage channels	>30	LC		10	20	Deep highly calcareous light clay
FIM40	5	0		Flat	Roads/md	Saline plain	>30	LC		10	30	Deep saline calcareous light clay
FIM41	6	0		Flat	Roads/md	Level saline plain	>30	LC		5	30	Deep saline non-calcareous light clay
FIM43	6	<1		Drainage tract	Vehicle/md	Interrupted drainage tract	>30	LC			30	Deep slightly calcareous light clay

Depth: Depth of A horizon

Texture: SCL: Sandy clay loam; LC: Light clay; LMC: Light to medium clay.

Frag: Fragments (gravels, cobbles etc)

Cem. Depth to cemented layer (intractable clay, hardpan, parent material).