

Terrestrial Ecology Assessment for the Vulcan Complex Project

For Vitrinite Pty Ltd.

September 2020



VITRINITE
BRIGHTER COAL

METSERVE
Mining & Energy Technical Services Pty Ltd

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1 EXECUTIVE SUMMARY

Vitrinite Pty. Ltd., owner of Qld Coal Aust No.1 Pty. Ltd. and Queensland Coking Coal Pty. Ltd. (Vitrinite) proposes to develop a small open-cut coal mine on a proposed Mining Lease (ML) within its exploration tenements EPC 1234 and 1732, midway between Dysart and Moranbah, Queensland. This proposed mine forms the Vulcan Complex Project. As the Project qualifies as an environmentally relevant activity, an Environmental Authority (EA) will be required. An ecological impact assessment (this report) has been prepared to inform the EA application.

This ecological impact assessment is based on a combination of field surveys and a review of past records of matters of environmental significance from the general region. Field surveys were undertaken in 2018-2019, spanned multiple seasons, and covered a much broader region (6,566.5 ha) than the mining lease application (MLA) area for the Project (407.3 ha).

Fauna was surveyed at 127 locations. Techniques included pitfall traps, funnel traps, Elliott traps, cage traps, remote-sensory cameras, ultrasonic bat recorders, targeted searches and spotlighting.

Flora was surveyed at 466 locations, allowing the production of a field-verified regional ecosystem map, which corrects errors contained within regulated vegetation mapping, as well as provides a finer scale of information. This revised vegetation map was used in conjunction with known habitat preferences of wildlife (based on published records and field data) to infer the distribution of matters of State and National environmental significance in and near the footprint of the Project.

Field surveys detected 40 species of mammal, 133 species of bird, 35 species of reptile, 14 species of frog and 423 species of vascular plants across the region containing the Project. Species accumulation curves fitted to the data estimated that the surveys successfully detected 83% of the plants, 100% of reptiles, 97% of amphibians, 100% of birds, 92% of non-bat mammals and 100% of the bats present within the survey area that could potentially have been detected using the methodology employed. This represents a thorough knowledge of the region's ecology.

In accordance with best practice, the Project has been strategically positioned to avoid disturbance to as many matters of State and/or National environmental significance as practicable. No protected conservation estates, wetlands or watercourses of high ecological significance, secured offset areas, environmentally sensitive areas (category A, B or C), threatened ecological communities or remnant vegetation containing endangered or of concern regional ecosystems will be disturbed by the Project activities.

The Project is located within land almost entirely previously cleared for grazing. The project footprint contains only 4.3 ha of remnant vegetation, and this is listed as a least concern regional ecosystem. An additional 71.2 ha of regrowth vegetation will be cleared, and all of this is also listed as least concern regional ecosystems. The majority of the disturbance footprint comprises cleared pastures (149 ha).

Two matters of State environmental significance could be affected by the Project: "threatened and special least concern wildlife" and "regulated vegetation".

Two types of regulated vegetation will be removed by the project:

- 15.2 ha of category R regrowth (non-remnant vegetation within 50 m of watercourses); and
- 17.7 ha of category B (remnant vegetation), C (high-value regrowth) or R areas that are located within a defined distance from the defining banks of a relevant watercourse.

Note that the latter mostly consists of the former, and that vegetation extent is based on field-verified mapping rather than the regulated vegetation map, as the regulated map is based on erroneous regional ecosystem mapping.

Forty-one species of plants and animals listed as matters of State environmental significance were flagged by database searches as being potentially present in the region. Of these, two species were recorded within the Project's MLA, and an additional five species were considered likely to occur within

the MLA. Seven additional species were classed as possibly occurring within the MLA. Of the species known to be or potentially occurring on site, the following impacts are predicted:

- Loss of 66.3 ha of marginal foraging habitat (regrowth containing secondary food tree species) and 2.6 ha of secondary foraging habitat (regrowth containing primary food tree species) for the vulnerable Koala (2.2% of the Koala habitat contained within the survey area, and the lowest quality);
- Loss of 73.1 ha of primary habitat and 15.6 ha of secondary habitat for the vulnerable Squatter Pigeon (3.0% of the Squatter Pigeon habitat contained within the survey area); and
- Loss of 224.5 ha of potential habitat for the special least concern Short-beaked Echidna (3.4% of the echidna habitat contained within the survey area).

Due to the low quality of habitat for Koalas within the disturbance footprint, this habitat loss is unlikely to qualify as a significant residual impact in accordance with the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline*. However, disturbance to Squatter Pigeon and Short-beaked Echidna habitat may constitute a significant residual impact due to the fact that feeding and/or breeding sites ("ecologically significant locations", according to the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline*) are likely to be affected. Nevertheless, the scale of this impact is small, with 96% or more of the habitat for both species being retained in the local landscape. Consequently, there are no anticipated impacts on either species' local populations, despite the Project's potential classification as a significant impact under the relevant guideline.

The Koala and Squatter Pigeon also qualify as Matters of National Environmental Significance (MNES). No other matters of national environmental significance are considered likely to experience a significant impact as a result of the Project. A significant residual impact under the *Environment Protection and Biodiversity Conservation Act 1999* is defined differently than for Matters of State Environmental Significance. According to the *Matters of National Environmental Significance Significant Impact Guidelines*, both the Koala and Squatter Pigeon are likely to experience a significant residual impact as a result of the Project, despite the small scale of disturbance.

As impacts to five matters of State environmental significance (category R vegetation, watercourse vegetation, Koala, Squatter Pigeon and Short-beaked Echidna) and two matters of national environmental significance (Koala and Squatter Pigeon) are likely, the significance of these impacts should be assessed by the Queensland and Federal Governments, respectively. These assessments will determine whether offsets are required under the *Environmental Offsets Act 2014* or the *EPBC Act Environmental Offsets Policy 2012.*

2 INTRODUCTION

Vitrinite Pty. Ltd., owner of Qld Coal Aust No.1 Pty. Ltd. and Queensland Coking Coal Pty. Ltd. (Vitrinite) has been investigating the development potential of coal reserves contained within the Exploration Permit Coal (EPC) tenements 1233, 1234 and 1732. As part of its investigations, Vitrinite Pty Ltd engaged Mining and Energy Technical Services Pty Ltd (METServe) to undertake baseline terrestrial ecological surveys across large parts of its three EPC tenements. These surveys spanned the wet and dry seasons of 2018-2019.

Based on its investigations, Vitrinite Pty Ltd proposes to develop a small-scale coal-mining project (named the Vulcan Complex Project (the Project)) on EPC 1732 and the far east of EPC 1234. This is a much smaller area than that surveyed because, at the time ecology surveys commenced, the scale of the project was unknown. Nevertheless, the findings of all surveys—not just those within the project footprint—are presented in this report for two reasons. Firstly, it is valuable to place the ecological values of the project area into a broader regional context. Secondly, species recorded outside the project footprint, but in habitats that are also present within the project footprint, could be impacted by the project.

This report presents the findings of ecological surveys across 6,552 hectares (ha) spanning the three tenements. It then assesses the potential impacts of the Project (occupying 407.3 ha in the far north of the survey area) on local environmental values pertaining to terrestrial ecology. The Project will require assessment and approval by the Queensland and Commonwealth Governments, and this report is intended to provide supporting information for a site-specific application for a new environmental authority.

2.1 LOCATION

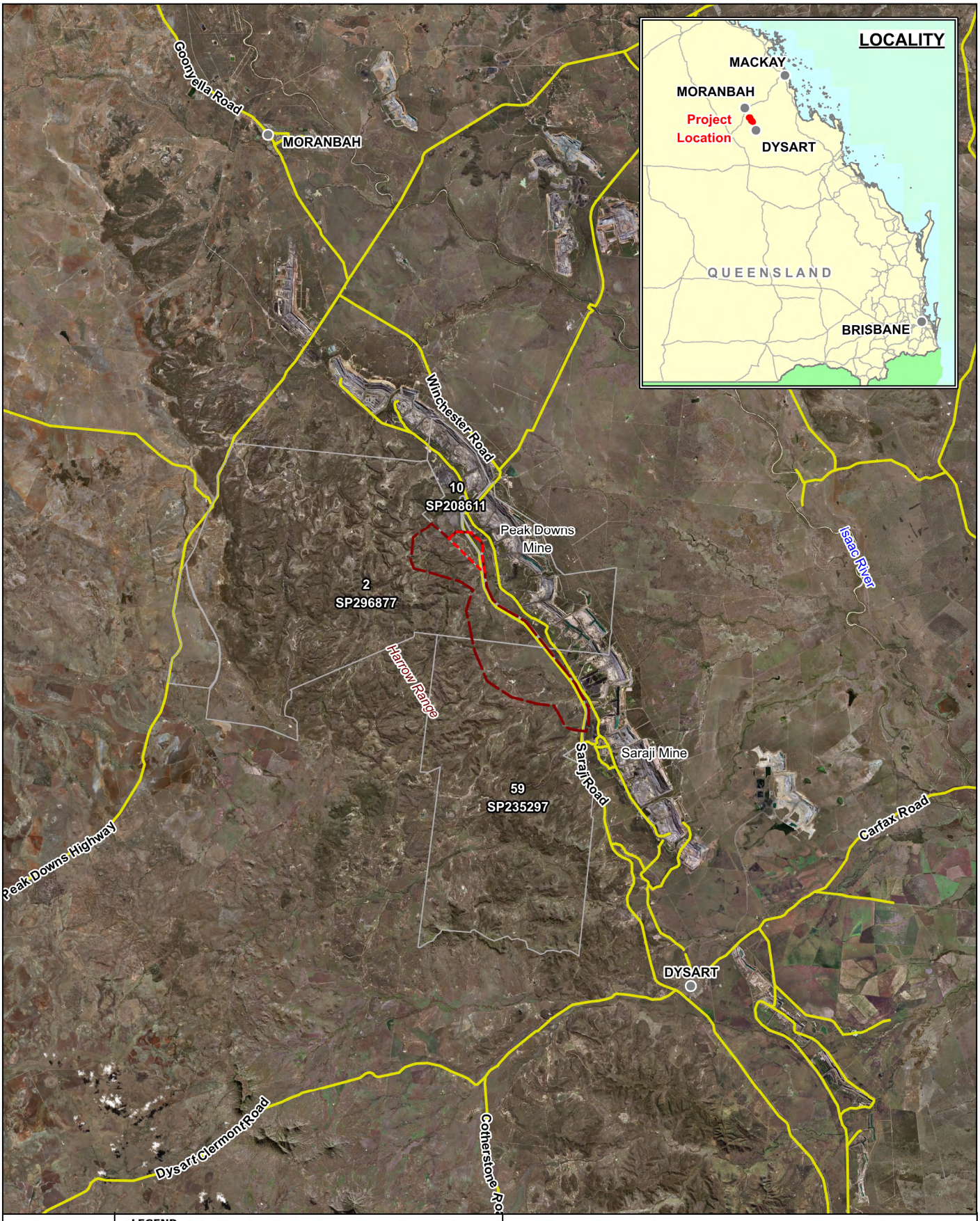
Throughout this report, the "survey area" refers to the 6,552-ha area in which ecological surveys were undertaken. The "project area" refers to the MLA containing the Vulcan Complex Project. The project area therefore forms a part of the survey area.

The survey area is located midway between Moranbah and Dysart, in the Bowen Basin of central Queensland (**Figure 2-1**). The Project falls within the jurisdiction of the Isaac Regional Council. It lies immediately south and west of the existing Peak Downs Mines, alongside the Saraji Road. The project area is contained within Lot 10 on Plan SP208611, while the survey area also encompasses portions of Lot 2 on Plan SP296877 and Lot 59 on Plan SP235297.

The survey area falls within the Northern Bowen Basin subregion of the Brigalow Belt North bioregion, according to the Interim Biogeographic Regionalisation for Australia.

2.2 EXISTING LAND-USE

The survey area is located on leasehold land that is used primarily for cattle grazing. There is also an existing machinery-storage depot located in the project area, which serves nearby mining operations. The survey area is bounded to the north and east by existing coal mining operations. Saraji Road, a sealed highway, runs along the eastern boundary of the survey area.



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LEGEND

- Town
- Road
- Vulcan Complex Survey Area
- Project Area
- Property Boundary

Data Source: Town, Road - Geoscience Australia (2016); Survey Boundary, Bulk Sample Pit - Vitrinite (2019); Property Boundary - QLD Government (2019); Imagery - ESRI, DigitalGlobe, GeoEye, Esarthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Vitrinite

Vulcan Complex Project Location

5 0 5 10
Kilometres
Scale: 1:400,000 (A4)

21/02/2020

Datum: GDA94
Projection: MGA55

FIGURE 2-1

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fig2-1_ProjectLocation_RevB.WOR

2.3 PROPOSED ACTIVITIES

The Vulcan Complex Project is a small-scale coal mine that will operate for approximately 4 years and will extract approximately 6 Mt of hard coking coal at a rate of up to 1.95 Million tonness per annum (Mtpa). Coal extraction will occur via a single open-cut pit. Truck and shovel mining operations will be employed to develop the pit. The coal will be hauled to a run-of-mine pad and processed using a dry crushing and screening mobile plant (including Sorterra screening). Once crushed and screened, coal will be placed on the run-of-mine stockpile for haulage. Rejects from the crushing and screening process will be stockpiled separately and placed within the relevant active dump. There are no coal-washing activities, facilities or storage of processed wastes proposed as part of the Project. Coal will be trucked off site for toll washing at a nearby facility between Moranbah and Coppabella on the Peak Downs Highway. Each truck will transport approximately 70 tonnes (t) of coal, with an anticipated average of 80 truck movements per 24 hours each way. Haulage will operate 24 hours a day on a 7-day roster.

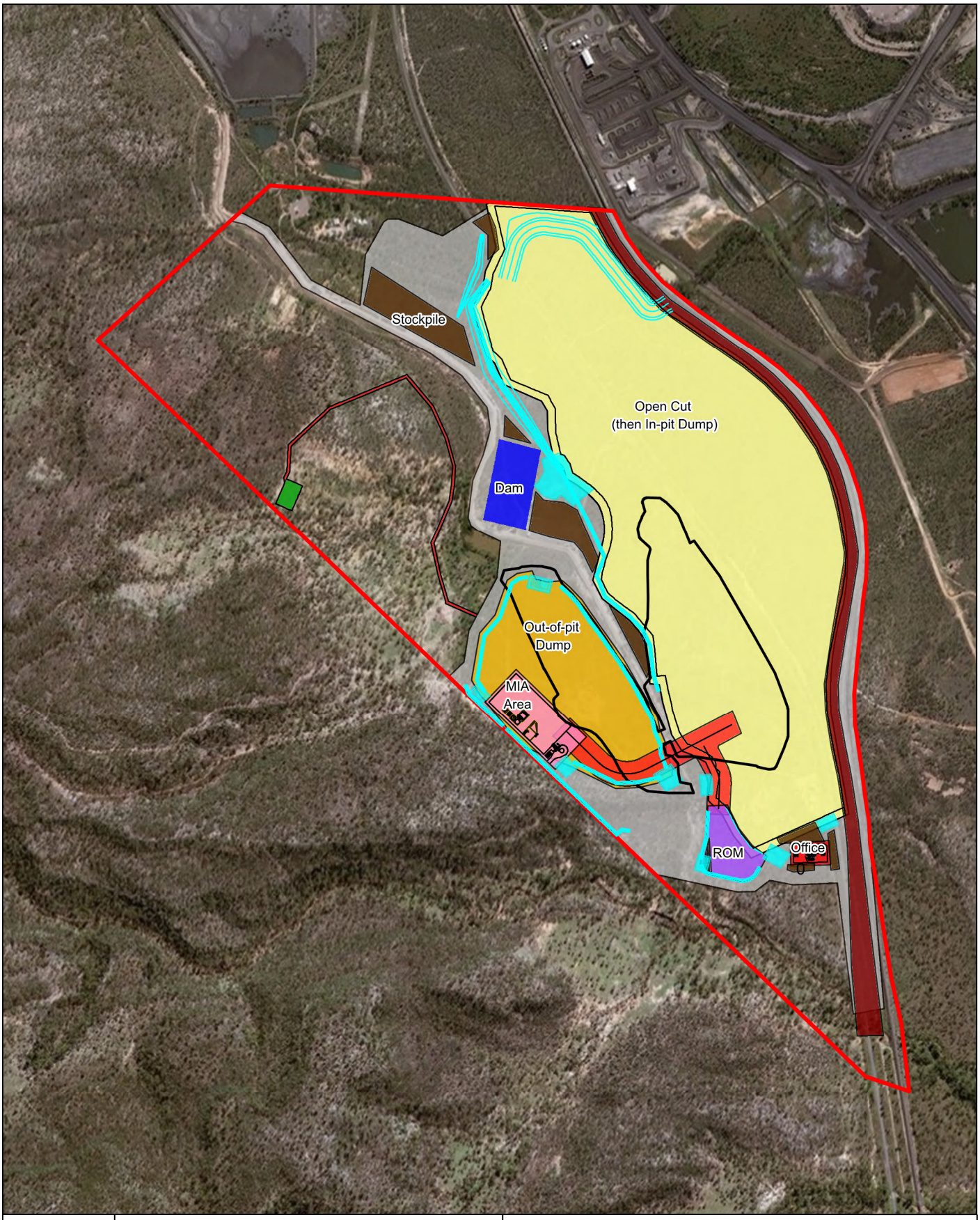
A small out-of-pit waste-rock dump will be established prior to commencing in-pit dumping activities that will continue for the life of the operation. Ancillary infrastructure, including a run-of-mine pad, Mine Infrastructure Area (MIA), offices, roads and surface water management infrastructure will be established to the west and south of the open cut. The MIA will include heavy vehicle workshops and park-up, equipment laydown areas and project offices and facilities. An explosives magazine will be established to the North-West of the out-of-pit dump, away from operational areas and critical infrastructure. This will be accessed via an existing track from the northern end of the out-of-pit dump.

Surface water management infrastructure will be established progressively to divert clean water around operational areas and to manage runoff from disturbed areas. A mine water dam will be constructed as a water supply dam for dust suppression. This will also receive any accumulated pit water that requires dewatering. A series of drains and bunds will be established to direct runoff to sediment control structures.

The realignment of the existing Saraji Road and services infrastructure to the eastern boundary of the proposed MLA area, adjacent to the existing rail easement, is also proposed (**Figure 2-2**). The re-alignment will occur within the lease; however, the connection back to the existing alignment of Saraji Road to the north will extend off the lease and will be subject to a separate approvals process.

In-pit dumping will fill the majority of the pit during operations with the remaining final void to be backfilled upon cessation of mining, resulting in the establishment a low waste rock dump landform over the former pit area. The initial ex-pit waste rock dump will be rehabilitated in-situ.

Vitrinite has been granted an Environmental Authority (EA0002054) and a Mineral Development Licence (MDL3039) to permit extraction of a bulk sample of coal from the target seams. This approved bulk sample is located within the proposed footprint of the Vulcan Complex Project. Prior to commencement of the Project, Vitrinite will extract up to 600 kilotonnes (kt) of high-quality coking coal from the bulk sample pit for testing by a number of international coal consumers. To access the coking coal within the bulk sample area, up to an additional 150 kt of weathered thermal coal lying above the coking coal, will also be extracted incidentally. The bulk sample does not form part of the Project, but its features are assumed to form part of baseline conditions for the purposes of environmental assessment of the Project. It is Vitrinite's intention, subject to favourable testing of the bulk sample coal and the successful approval of the Project, to retain part of the bulk sample void to facilitate Project will be developed as an extension of the bulk sample Ex-pit dump. The bulk sample is planned to commence in 2020 and to run for 9-12 months while the Vulcan Complex Project is subject to environmental authority and mining lease application processes.



LEGEND

- Bulk Sample Maximum Disturbance
- Vulcan Complex Maximum Disturbance
- Mining Lease Application Area
- Office Complex
- MIA
- ROM
- Stockpile
- Drainline
- Sediment Dam
- Water Dam
- Saraji Rd Realignment
- Internal Roads
- Magazine
- In-pit Dump
- Out-of-pit Dump

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Vulcan Complex Project
Proposed Layout

0 350 700

Metres

Scale: 1:18,000 (A4)

Data Source: Drainage Lines, ML Application Area, Infrastructure, Aerial Imagery - Vitrinite (2019).

17/09/2020

Datum: GDA94
Projection: MGA55

FIGURE 1-16

S:\Projects\V1010_Vulcan Complex Project_Jupiter section\MapInfo\Workspaces\PRC Plan\V1010_Fig1-14_Project_Layout_Proposed_RevA.wor

Due to the swelling of re-deposited overburden, the in-pit dump will extend approximately 15 meters (m) above the surrounding ground level, and batters will have a slope of 15%. A central plateau will drain to the west.

An assessment of waste rock geochemistry has concluded that the waste rock does not propose a significant risk of generating saline or metalliferous drainage, and no selective handling and treatment measures are proposed.

The peak operational workforce is anticipated to comprise 116 positions. It is anticipated that less than a quarter (approximately) of this workforce would be present on site at any one time due to shift and roster arrangements and the inclusion of off-site haulage positions in this total. It is assumed that approximately half of the workforce will commute daily from Moranbah, while the other half will commute daily from Dysart. There would be two 12-hour shifts per day, with crews operating on a 7-days-on, 7-days-off roster.

2.4 RELEVANT LEGISLATION

2.4.1 Queensland

Environmental Protection Act 1994

The *Environmental Protection Act 1994* (EP Act) regulates environmental management and aims to achieve ecologically sustainable development. The EP Act outlines legal obligations and the duty of care all persons have to the environment and directions for preparing environmental protection policies.

Nature Conservation Act 1992

The *Nature Conservation Act 1992* (NC Act) regulates native flora, fauna and habitat conservation within Queensland.

Nature Conservation (Wildlife) Regulation 2006

The *Nature Conservation (Wildlife) Regulation 2006* prescribes the conservation status of Queensland wildlife, following provisions of the NC Act.

Vegetation Management Act 1999

The *Vegetation Management Act 1999* (VM Act) provides a planning framework for the management of native vegetation across Queensland. It regulates clearing of vegetation and aims to conserve Queensland's biodiversity through vegetation management.

Environmental Offsets Act 2014

The *Environmental Offsets Act 2014* (EO Act) provides for environmental offsets to counterbalance significant residual impacts of activities on particular matters of State or local environmental significance.

Biosecurity Act 2014

The *Biosecurity Act 2014* lists weeds and pest animals that constitute prohibited or restricted matters, and obligations pertaining to these matters.

2.4.2 Commonwealth

Environmental Protection and Biodiversity Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*) provides for the identification and management of matters of national environmental significance, including threatened flora and fauna species, ecological communities, migratory species protected under international

treaties, internationally recognised significant wetlands and critical habitat areas. Under the *EPBC Act*, an action will require approval from the Federal Environment Minister if the action has, will have, or is likely to have a significant impact on a Matter of National Environmental Significance.

EPBC Act Environmental Offsets Policy 2012

The *EPBC Act Environmental Offsets Policy* (EOP) provides guidance on how the Federal Government considers the suitability of a proposed offset, when there are residual impacts of a project on matters of national environmental significance.

3 METHODS

3.1 LITERATURE REVIEW

A desktop-based assessment was undertaken using publicly available databases to determine the ecological values potentially occurring in the vicinity of the Project. The following databases were consulted:

1) Queensland Government's Wildlife Online search tool (records within a 20 km buffer from the central point –22.3678, 148.2352);
2) Department of Environment and Energy's Protected Matters Search Tool (records within a 20 km buffer from central point: -22.3678, 148.2352);
3) Atlas of Living Australia;
4) eBird;
5) the Australasian Virtual Herbarium Search tool; and
6) the Department of Environment and Science's regulated vegetation management mapping.

For each species flagged during the literature review, but not recorded on site during field surveys, an assessment of the likelihoods of their presence within the survey area and project area was undertaken based on the reliability and recentness of the record(s) and whether suitable habitat—as described by the Australian Government's Species Profiles and Threats Database, species recovery plans, referral guidelines, and/or primary scientific literature—is present.

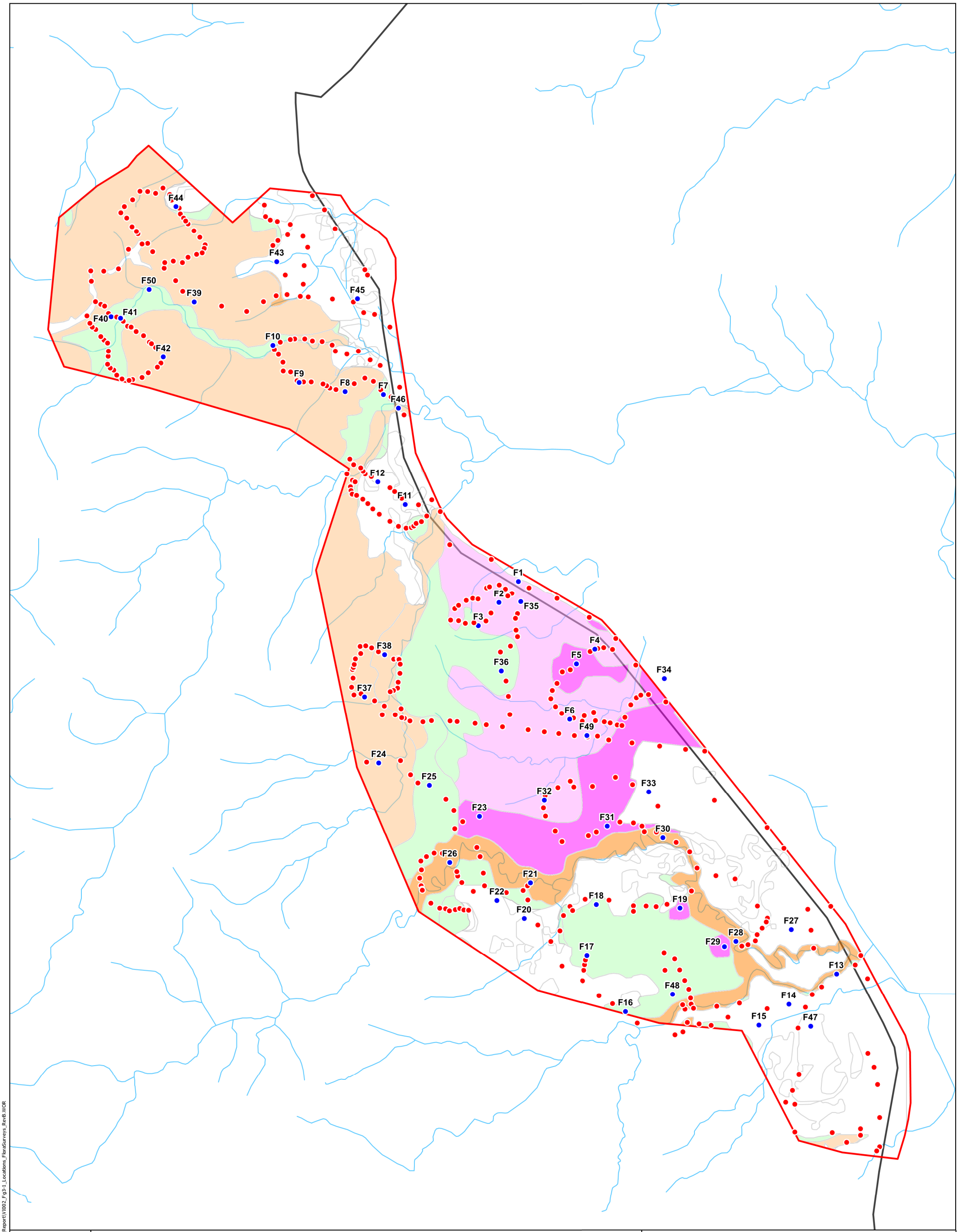
3.2 FIELD SURVEYS

3.2.1 Flora

The principal flora survey was undertaken between 4 February and 15 February 2019 by Dr Chris Wiley (Principal Consultant – Ecology) and Jacob Rolley (Consultant – Ecology). The approach taken followed that prescribed by Neldner *et al*. (2019) in *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland, Version 5.0*. Survey timing coincided with maximum plant growth in the mid- to late-wet season, and was optimal for detecting threatened species as well as describing overall diversity.

Additional surveys for supplementary vegetation mapping were undertaken on 1-2 October 2019 in the far south of the survey area. These took place in a small area of non-remnant vegetation added to the survey area subsequent to the February 2019 survey. Due to October being a sub-optimal month for flora surveys (dry conditions mean that most grasses and herbs are dormant), this survey aimed primarily to assess the spatial extent of vegetation units rather than comprehensively document the species present within these.

For all flora surveys, the survey area was traversed by car and (mostly) on foot, and routes were pre-selected to maximise coverage of the site and the number of mapped vegetation units visited. The aim of the field surveys was to ground-truth a sufficient sample of sites to enable interpolation of regional ecosystems across the survey area using detailed satellite imagery. In total, 466 sites were ground-truthed across the survey area (**Figure 3-1**). These comprised 416 quaternary sites and 50 secondary sites, as per Neldner *et al*. (2019). Secondary sites are detailed floristic and structural assessments of the vegetation communities present. These were only assessed during optimal conditions in February 2019. Quaternary sites are simple descriptions of the dominant species present and their corresponding regional ecosystem. A small subset (3.6%) of quaternary sites was assessed in October 2019, while the remainder were assessed under optimal conditions in February 2019. Field data were then used in conjunction with satellite imagery to produce a field-verified regional ecosystem map of the entire survey area. This field-verified map corrects numerous errors in certified mapping, as well as provides greater resolution due to its finer scale.



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LEGEND

Survey Sites
- Quaternary
- Secondary
- Saraji Road
- Watercourse
- Survey Area

Certified Regional Ecosystem Mapping
- Endangered (dominant)
- Endangered (sub-dominant)
- Least concern
- Non-remnant
- Of concern (dominant)
- Of concern (sub-dominant)

Data Source: Road, Watercourse, RE Mapping - QLD Gov. (2018-2019); Survey Boundary - Vitrinite (Jan 2019); Survey Sites - METServe (Jan 2019).

Vitrinite

Location of Flora Surveys

1 0 1 2
Kilometres

Scale: 1:55,000 (A3)

16/10/2019

Datum: GDA94
Projection: MGA55

FIGURE 3-1

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Neldner *et al*. (2019) recommend sampling a minimum of three secondary sites per regional ecosystem. An average of 2.9 secondary sites per regional ecosystem was sampled during field surveys. One quarter of the regional ecosystems present on site were represented by single, small patches less than 10 ha in extent, preventing them being sampled over three sites. The remaining regional ecosystems were sampled at an average of 4.1 secondary sites, surpassing guideline requirements.

In addition to plant lists generated at each secondary site, additional plant species were noted during timed meander searches while walking between sites. These searches had the primary goal of targeting species of conservation significance in accordance with the *Flora Survey Guidelines – Protected Plants version 2.01*. They also allowed for a comprehensive inventory of floral diversity across the survey area.

3.2.2 Fauna

3.2.2.1 Seasonal Conditions

The following fauna surveys were undertaken across the survey area in order to encompass seasonal variation in faunal movements and detectability:

1) 24 October 2018 to 2 November 2018;
2) 4 February 2019 to 15 February 2019 (bird surveys and spotlighting were undertaken during the flora survey);
3) 25 March 2019 to 29 March 2019 (abandoned prematurely due to heavy rain);
4) 8 April 2019 to 17 April 2019;
5) 1 May 2019 to 9 May 2019; and
6) 23 September to 4 October 2019.

All of the above surveys fell within the two seasons recommended by the *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland version 3.0* (Eyre *et al*. 2018) for the Brigalow Belt bioregion.

Heavy rain events (>100 mm within 24 h) occurred during the first and third surveys, leading to flash-flooding of creeks and the filling of temporary pools and gilgais. This provided optimal conditions for the detection of frogs and burrowing snakes. Light rain events (~15 mm) also occurred during the second and fourth surveys, stimulating moderate frog activity. A light shower (<5 mm) during the sixth survey was the first rain received by the site in many months and also stimulated moderate frog activity.

The mean maximum temperature across all surveys was 33.4°C (range = 24.3°C–41.4°C). The mean minimum temperature across all surveyed was 16.8°C (range = 6.6°C–22.9°C). With the possible exception of three nights that fell below 10°C in May 2019, conditions were optimal for detecting ectothermic fauna.

3.2.2.2 General Approach

In accordance with the *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland version 3.0* (Eyre *et al*. 2018), the entire survey area was divided into assessment units based on broad vegetation groups and age (remnant versus regrowth). These guidelines stipulate that each assessment unit is to be sampled at a minimum of three trap sites. This sampling intensity was achieved for most of the broad vegetation groups present on site, and all broad vegetation groups contained within the project area (**Table 3-1**). Two of the broad vegetation groups present on site (7a and 34d) were not amenable to sampling via traps; 7a was too small, rocky and remote, while 34d was primarily open water. These were sampled via targeted searches (day and night), instead. A remote-sensory camera was also installed in broad vegetation group 7a. Where broad vegetation groups were represented on site by both remnant vegetation and high-value regrowth, sampling effort was focused on the former, but the latter was also sampled if it comprised more than 5% of the total area of the broad vegetation group. In total, 34 comprehensive trap sites were sampled. A list of sites and photographs of each are provided in **Appendix A**.

Table 3-1 Summary of sampling effort per broad vegetation group (BVG)

BVG	Constituent regional ecosystems	Short description	Area (hectares)		$N_{trap\ sites}$	
			Remnant	Regrowth	Remnant	Regrowth
10a	11.10.1	*Corymbia citriodora* woodland on hilly terrain.	225.8	0	3	0
12a	11.10.7, 11.10.13	Ironbark (*Eucalyptus* spp.) and/or bloodwood (*Corymbia* spp.) woodland on scarps and sandstone tablelands.	672.2	59.8	3	2
16a/9e*	11.3.25/11.3.7	*E. camaldulensis* forest fringing drainage lines/*Corymbia* spp. woodland on alluvial terraces	148.1/86.4	5.3/0	3	0
17a	11.3.2, 11.5.3	*Eucalyptus populnea* woodland on sandplains or alluvium.	407.5	386.8	3	1
17b	11.9.2	*Eucalyptus orgadophila* woodland on fine-grained sedimentary rocks.	326.4	0	3	0
18b	11.5.9	*Eucalyptus crebra* woodland on flat to undulating plains.	880.3	269.8	3	2
24a	11.10.3	*Acacia shirleyi* or *A. rhodoxylon* open forest on residual surfaces.	1,402.5	69	3	1
25a	11.3.1, 11.4.8, 11.4.9	*Acacia harpophylla* woodland to open forest on clay soils	145.7	4	3	0
34d	11.3.27c, 11.3.27e	Freshwater swamps and billabongs on floodplains.	8.5	0	0	0
7a	11.10.8	Semi-evergreen vine thicket in sheltered habitats on medium to coarse-grained sedimentary rocks.	1.3	0	0	0
Non-remnant pasture		Cleared pasture, +/- scattered trees or young regrowth	1,452.7		4	

*Broad vegetation groups 16a and 9e occur as parallel, narrow bands along waterways. Due to the narrow width of these vegetation units relative to the area of the standard trapping array, trap sites placed on creek banks invariably spanned both broad vegetation groups. For this reason, they were treated as a single assessment unit.

3.2.2.3 Comprehensive Trap Sites

Each of 34 comprehensive trap sites were sampled using methodology described in the *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland version 3.0* (Eyre *et al*. 2018). The following traps were installed and monitored twice daily over four days and nights per site:

1) 45 m of 40-cm-high aluminium fly-screen drift fence was installed flush with the ground in a T-arrangement (**Figure 3-2**);
2) four 20-L buckets were installed as pitfall traps beneath this drift fence;
3) three pairs of funnel traps were installed along the drift fence;
4) 20 Elliott traps (baited with an oat-and-peanut-butter mix) were placed at 10-m spacing parallel to the drift fence; and
5) one Reconyx HC550 Hyperfire White Flash remote-sensory camera (baited with an oat-and-peanut-butter mix) was installed approximately 50 m from the drift fence.

The entire trap array spanned approximately 120 m × 50 m. Note that the survey guidelines suggest the use of one cage trap per site, instead of the camera. This recommended approach was adopted during the October 2018 survey, but abandoned in favour of cameras in all other survey rounds. Remote-sensory cameras are able to detect all species potentially caught by a cage trap, but have several advantages. They are (i) easier to transport, (ii) able to 'catch' more than one individual/species per night, and (iii) able to detect a broader range of species that are too large (macropods, dingos, pigs) or small (birds, rodents) to be caught in a cage trap.

In addition to the four days of trapping, each trap site was also subjected to the following targeted surveys:

1) 40 person-minutes of spotlighting;
2) 40 person-minutes of diurnal active searches;
3) 80 minutes of bird surveys (10 minutes during each check of the traps); and
4) one night of recording with an AnaBat Express bat-call detector.

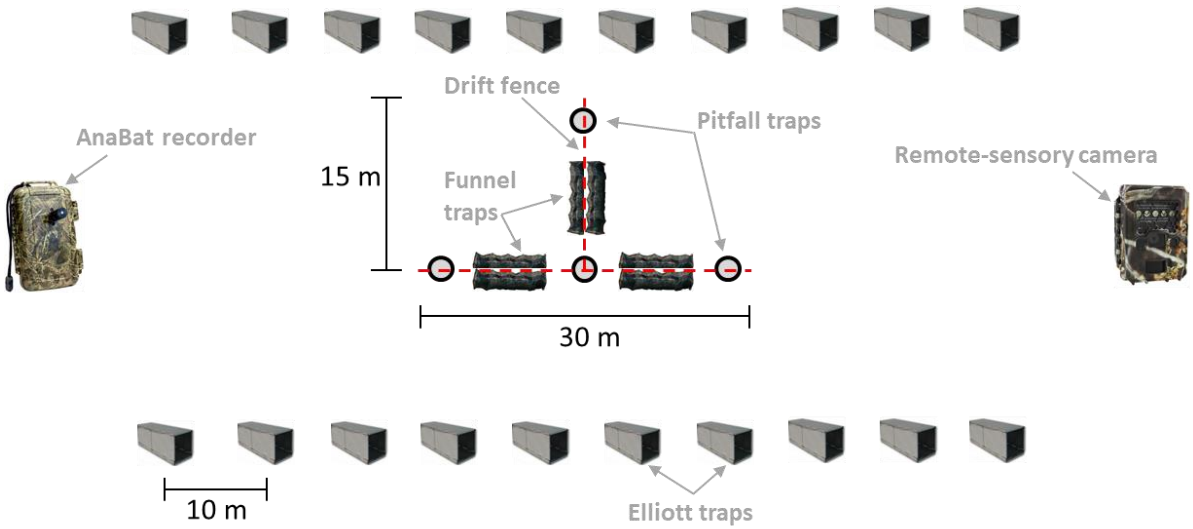


Figure 3-2 Schematic diagram of the trapping array at each comprehensive trap site

3.2.2.4 Supplementary Targeted Surveys

In addition to the sampling at comprehensive trap sites, further targeted searches were undertaken in a range of habitats that are difficult to sample using conventional trapping (e.g., rock outcrops, dams, wetlands, wood piles). Furthermore, targeted searches were undertaken to fill spatial gaps in assessment units that were very extensive and/or spatially heterogenous.

The following surveys were undertaken at additional sites away from the comprehensive trap sites:

1) Diurnal active searches of at least 40 person-minutes' duration were undertaken at 28 sites. This involved turning over logs and rocks, raking through leaf litter, searching for signs of Koalas, and recording all birds seen or heard;
2) Spotlighting for at least 40 person-minutes was undertaken at 28 sites;
3) Bird surveys of at least 20 minutes' duration were undertaken at 24 sites, in addition to diurnal active search sites. All birds heard or seen during flora surveys (10 days of survey effort in February 2019) were also recorded;
4) AnaBat recordings were carried out at 10 sites that represented likely flyways for bats: tracks through forest, creek lines and around dams. Recordings were made across a single night (12 hours) per site; and
5) Remote-sensory cameras were installed at three sites (a total of 12 trap-nights) along creeklines, which are favoured movement pathways for fauna.

3.2.2.5 Total Survey Effort

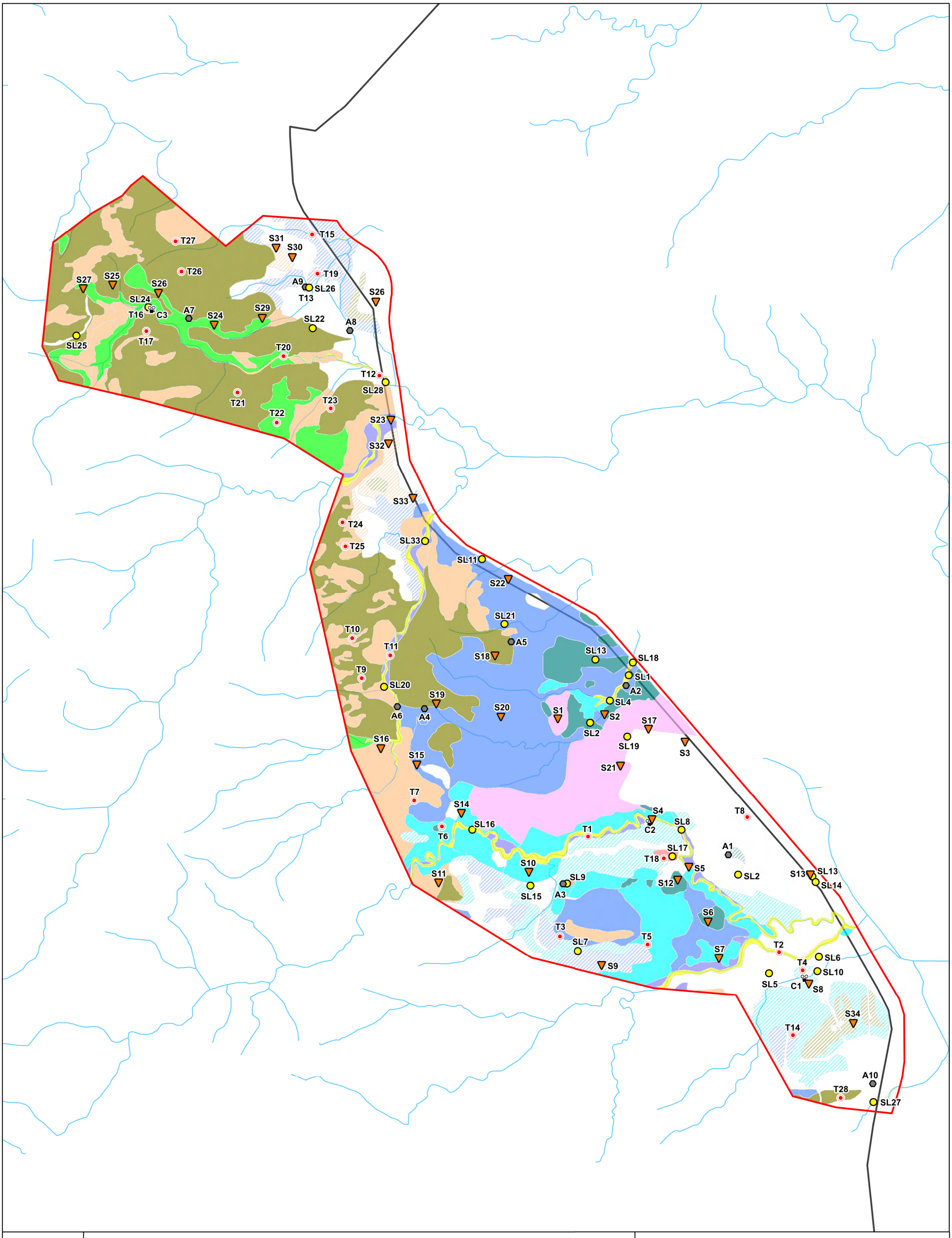
The total amount of survey effort expended for faunal surveys of the Vulcan Complex Project area is summarised in **Table 3-2** and the locations of surveys are shown on **Figure 3-3**.

Table 3-2 Fauna survey effort across the survey area between October 2018 and October 2019

Survey Method	Targeted Species	Potential EVNT Species*	Total Effort†	Unit
Pitfall trap	Frogs, small reptiles, small mammals	Ornamental Snake, Common Death Adder, Dunmall's Snake, Allan's Lerista	588	Trap-nights
Funnel trap	Lizards, snakes	Ornamental Snake, Common Death Adder, Yakka Skink, Dunmall's Snake, Allan's Lerista	882	Trap-nights
Elliott trap	Small mammals	n/a	2,860	Trap-nights
Cage trap	Medium-sized mammals	Northern Quoll	31	Trap-nights
Remote-sensory camera	Mammals, birds	Short-beaked Echidna, Northern Quoll, Squatter Pigeon	122	Trap-nights
AnaBat	Microchiropteran bats	Ghost Bat, Large Pied Bat	45	AnaBat-nights
Bird survey	Birds	Squatter Pigeon, Red Goshawk, Painted Honeyeater, Australian Painted-snipe, Black-throated Finch, migratory birds	288	Person-hours
Diurnal targeted search	Reptiles, larger mammals	Allan's Lerista, Yakka Skink, Dunmall's Snake, Common Death Adder, Short-beaked Echidna, Koala	45.3	Person-hours
Spotlighting	Frogs, reptiles, mammals, birds	Ornamental Snake, Common Death Adder, Short-beaked Echidna, Greater Glider, Koala	52.5	Person-hours

*Potential EVNT species are those listed as endangered, vulnerable, near threatened or special least concern within Queensland and/or nationally that have been historically recorded within the region.

†Note that not all sites were surveyed over four nights, as heavy rain necessitated the early closure of five sites. Four of these were re-surveyed on a later date, resulting in >4 survey nights for these sites.


T27
S31
T15
S30
T26
T19
S27
S25
S26
A9
SL26
T13
SL24
T16
C3
A7
S24
S29
SL22
A8
S26
SL25
T17
T20
T12
SL28
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SL16
SL8
T6
T1
C2
SL17
A1
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S10
S5
S11
SL9
SL2
S13
SL13
SL15
A3
S12
SL14
S6
T3
T5
SL7
T2
S7
SL6
S9
T4
SL10
SL5
C1
S8
S34
T14
A10
T28
SL27
LEGEND
Fauna Survey Site
Trap Site
Camera Site
AnaBat
Spotlight
Targeted Survey
Saraji Road
Watercourse
Field-verified Broad Vegetation Group
10a
12a
16a
17a
17b
18b
24a
25a
34d
7a
9e
Solid indicates remnant vegetation;
hatched indicates high value regrowth
Data Source: Property Boundary, RE Mapping - QLD Gov. (2018-2019); Survey Boundary - Vitrinite (Jan 2019); Survey Sites - METServe (Jan 2019).
METSERVE
Mining & Energy Technical Services Pty Ltd
Vitrinite
Location of Fauna Surveys
1 0 1 2
Kilometres
Scale: 1:55,000 (A3)
21/02/2020
Datum: GDA94
Projection: MGA55
FIGURE 3-3
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3.3 GROUNDWATER-DEPENDENT ECOSYSTEMS

The Queensland Government has undertaken mapping of groundwater-dependent ecosystems (GDEs) across most of the State (Department of Science, Information Technology and Innovation 2015). The survey area has, however, not been mapped in the most recent version (version 1.5) of this GDE mapping.

Instead, the *National Atlas of Groundwater Dependent Ecosystems* (BOM 2019) was consulted to identify locations where there is a moderate to high potential for vegetation communities to be dependent on groundwater. This dataset was compared to the field-verified regional ecosystem mapping undertaken as per **Section 3.2.1**. Regional ecosystems present within areas mapped as potentially groundwater-dependent ecosystems were assessed for their likelihood of groundwater dependence by examining:

1) Published literature on the ecology of the dominant tree species in each regional ecosystem;
2) landscape position;
3) water-holding capacity of the soil; and
4) site-specific data on the depth to groundwater.

For regional ecosystems considered likely to be groundwater-dependent, their mapped boundaries were taken from field-verified regional ecosystem mapping, rather than the coarser-scale *National Atlas of Groundwater Dependent Ecosystems.* This integration of GDE mapping with regional ecosystem mapping is a core principle of the Queensland GDE Mapping Project (Department of Science, Information Technology and Innovation 2015).

4 ENVIRONMENTAL VALUES

4.1 OVERVIEW OF THE REGION'S ECOLOGY

4.1.1 Habitat Features

The survey area contains a variety of remnant, regrowth and cleared habitats. The western half of the survey area is dominated by low sandstone ridges and escarpments of the Harrow Range. These escarpments rise 100-170 m above the surrounding plains, and mostly support remnant vegetation. Dominant tree species across the Harrow Range include *Corymbia citriodora, Corymbia aureola, Eucalyptus crebra, Corymbia trachyphloia, Eucalyptus melanophloia* and *Acacia shirleyi.* The sandstone escarpments contain an abundance of boulders and rock outcrops (**Figure 4-1**), which provide shelter for reptiles and rock-wallabies. Rock overhangs and small caves are also present, primarily in the northwest, and these provide potential shelter sites for bats and other fauna.

The eastern half of the survey area, which includes the project area, predominantly comprises a sand plain supporting woodlands of *Eucalyptus crebra, Eucalyptus melanophloia, Eucalyptus populnea* and/or *Corymbia clarksoniana* (**Figure 4-1**). This plain also contains sections of heavy clay, supporting *Acacia harpophylla, Casuarina cristata* and/or *Eucalyptus cambageana.* These heavier soils have mostly been cleared of their remnant vegetation, although small fragments still remain, especially near Saraji Road. The clay soils support minor gilgai formation. These gilgais tended to be less than 30 cm deep, and held water for less than one month after heavy rain. They provide marginal breeding habitat for frogs, and frog densities tended to be low, even after heavy rain.

A low (~10 m above the surrounding plain) clay rise running northeast-southwest through the southern half of the survey area supported open woodland of *Eucalyptus orgadophila*. The cracking clay soil provided potential shelter for some reptiles and mammals; however, the understorey had been markedly affected by prolonged heavy grazing by livestock. This understorey was dominated by the exotic pasture grass, *Bothriochloa pertusa*, which was grazed to a lawn during dry periods, affording little protection for ground-dwelling fauna.

Heavy grazing pressure was also a notable feature of the sand plains across the survey area. This manifested through the altered composition of the understorey vegetation (Fensham *et al.* 1999; Walker *et al.* 2006). Native perennial grasses, an important food source for a variety of granivorous animals (Lewis 2007; Crowley 2008), were scarce, while introduced pasture grasses (especially *Cenchrus ciliaris, Bothriochloa pertusa, Melinis repens* and *Urochloa mosambicensis*) and native annual species (e.g., *Alloteropsis cimicina, Setaria surgens, Dactyloctenium radulans, Perotis rara*) dominated all remnant and non-remnant habitats away from the sandstone ridges.

The survey area is bisected by numerous first- to fourth-order watercourses that flow in an easterly direction. All of these are tributaries of the Isaac River. All watercourses on site are ephemeral, and sustain flows for short periods (less than one week) following heavy rain. Sub-surface flows (beneath the sandy creek beds) occur for longer periods, and third- and fourth-order watercourses support a dense fringe of *Eucalyptus camaldulensis, Melaleuca leucadendra* and/or *Melaleuca fluviatilis,* trees that can access this water supply. These sandy-bedded watercourses do not provide an important water source for fauna, due to a lack of pools and the short duration of surface flows. The only watercourse on site that retained pooled water for extended periods (i.e., months) after rain was North Creek, but only in its upper reaches. Where it passes through gorges within sandstone escarpments, the boulder-strewn bed of North Creek (**Figure 4-1**) contains numerous small pools, which provide a drinking source for fauna. These pools were dry in the late dry season (September-October).

Other surface water features that provide important water sources for fauna include farm dams and natural wetlands. The latter are represented on site by two billabongs formed in the former channel of Hughes Creek (**Figure 4-1; Figure 4-2**). Both of these billabongs had heavily grazed margins and supported few waterfowl. Among the farm dams, two areas provided particularly important habitat for waterfowl and other aquatic wildlife: 1) a chain of dams in the far southeast of the survey area, and 2) a large dam beside cattle yards in the southwest of the survey area. Both sites supported a

diversity of sedges and rushes, providing refuge for waterfowl and other fauna. A smaller, but equally well vegetated dam occurred in the northeast of the survey area, within the project area (**Figure 4-1; Figure 4-2**).

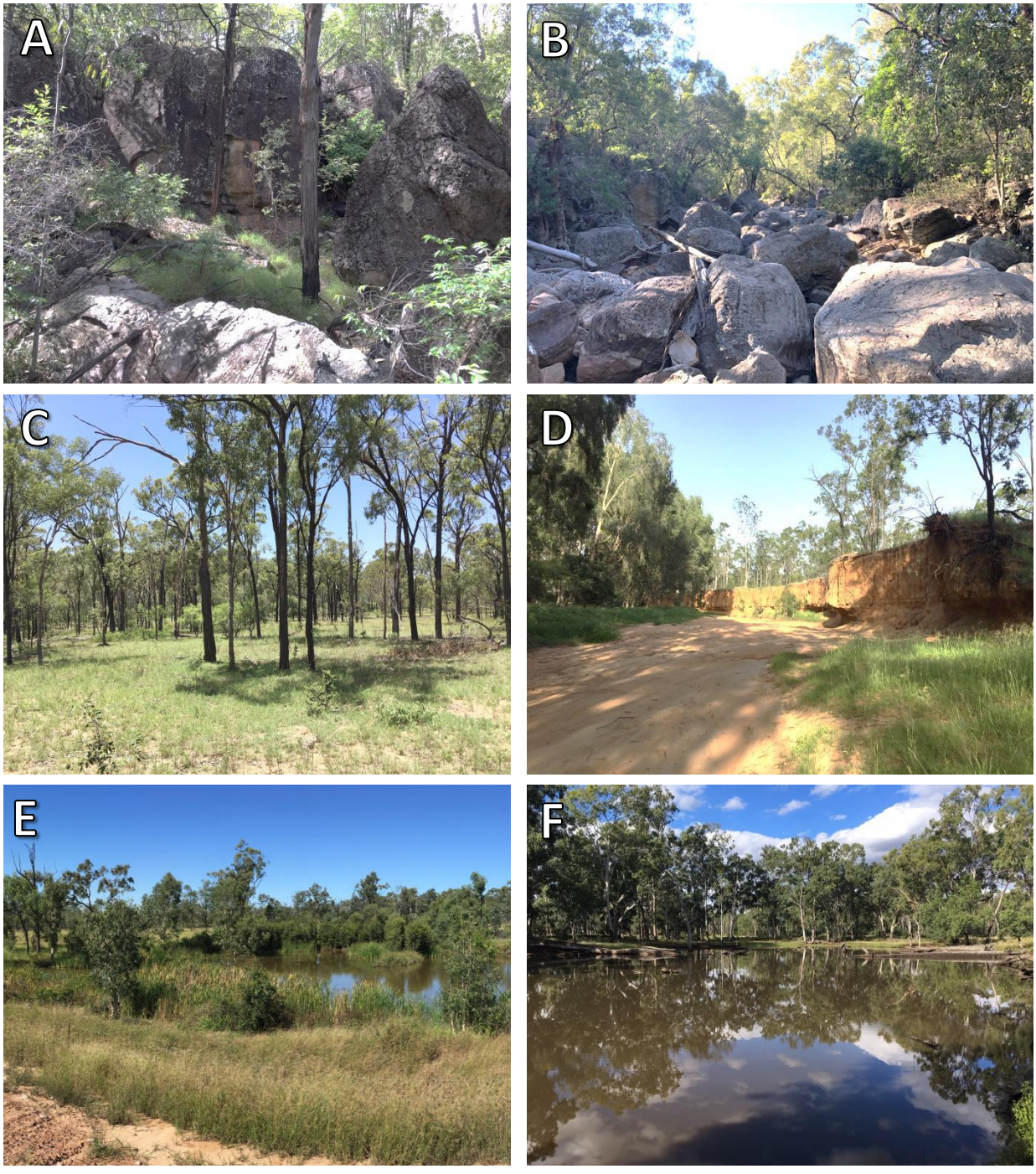
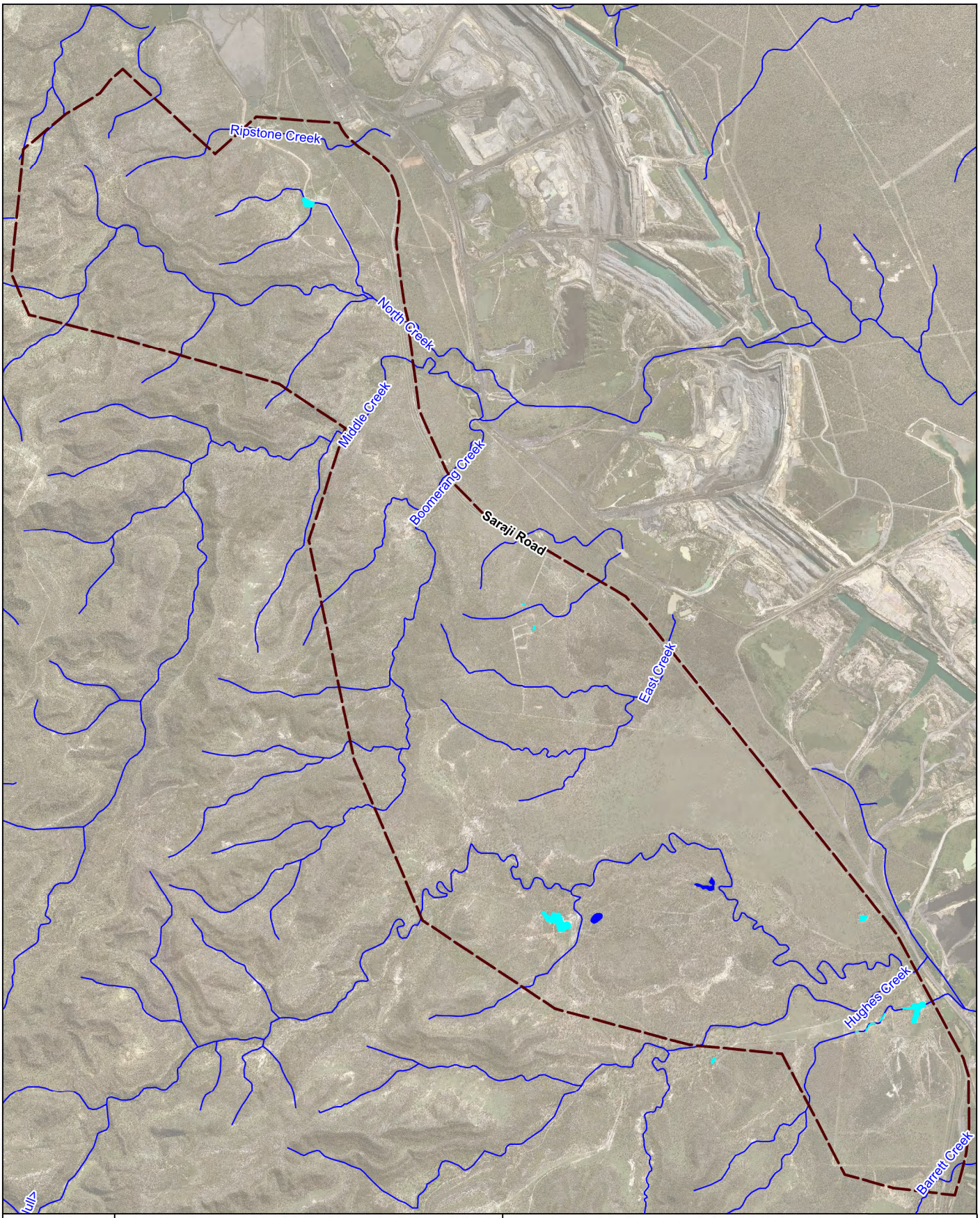


Figure 4-1 **Habitat features of the survey area:** A) sandstone outcrops, B) headwaters of North Creek (-22.28918, 148.15744), C) sand plain woodland dominated by *Eucalyptus crebra* (RE 11.5.9, -22.3411, 148.1925), D) middle reaches of Hughes Creek showing a sandy watercourse bed (-22.38601, 148.24998), E) dam in the project area, from which cattle are excluded (-22.28563, 148.18171), and F) a natural billabong beside Hughes Creek (-22.34021, 148.21326).



LEGEND

- Watercourse
- Vulcan Project Survey Area
- Dam
- Natural Wetland

Data Source: Watercourse - QLD Government (2018); Survey Boundary - Vitrinite (2019); Imagery - ESRI, DigitalGlobe, GeoEye, Easrthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

METSERVE Mining & Energy Technical Services Pty Ltd

Vitrinite

Vulcan Project Water Features

1 0 1 2 3

Kilometres

Scale: 1:75,000 (A4)

09/03/2020

Datum: GDA94
Projection: MGA55

FIGURE 4-2

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fig4-2_WaterFeatures_RevB.WOR

4.1.2 Vegetation Communities

Sixteen regional ecosystems were recorded within the survey area (**Table 4-1, Figure 4-3**). Of these, four were present within the project area. Field surveys revealed widespread errors in the regulated vegetation map of the site (for the regulated vegetation map, refer to **Figure 4-8**):

1) A large unit located in the centre of the survey area is erroneously mapped as the endangered regional ecosystem 11.4.8. Field surveys revealed that this entire unit contains the least concern regional ecosystem 11.9.2. This is supported by secondary sites 6, 23 and 31 (**Appendix B**).
2) The dominant unit in the western part of the survey area is mapped as a mixed mosaic containing 11.10.1, 11.10.3 and 11.10.8. While 11.10.3 was widespread in this unit, 11.10.1 was scarce and highly localised. Furthermore, 11.10.8 was confined to a single, tiny patch (secondary site 50). A fourth unmapped regional ecosystem, dominated by the tree *Corymbia aureola*, formed a major part of this mosaic. While no described regional ecosystems within Queensland are dominated by this species, the vegetation closely resembles 11.10.13, in particular the subtype 11.10.13b, dominated by the closely related *Corymbia leichhardtii.* We therefore map this regional ecosystem as 11.10.13. Secondary sites assessing this regional ecosystem include 3, 24, 37 and 44 (**Appendix B**).
3) Large parts of the survey area are mapped as the regional ecosystem 11.5.9b. These areas are better described as 11.5.9, due to the absence of *Eucalyptus tenuipes* and *Lysicarpus angustifolius*, and the frequent dominance of *Eucalyptus melanophloia, Alphitonia excelsa, Acacia* spp. and *Melaleuca nervosa*. This is supported by secondary sites 2, 17, 25 and 32 (**Appendix B**). In some places (e.g., secondary sites 1, 4 and 35), the *Eucalyptus* stratum is missing, resulting in a dense shrub layer of *Melaleuca nervosa, Acacia burdekensis* and/or *Allocasuarina leuhmannii*. Presumably this occurs where drainage is impeded by shallow bedrock or texture contrast soils. Due to a lack of suitable alternatives for these communities, they are retained as subtypes of 11.5.9, despite the localised absence of *E. crebra* and *E. melanophloia.*
4) Extensive areas mapped as regional ecosystem 11.5.9b were located on the foot slopes of sandstone outcrops. In many instances, there was substantial outcropping of sandstone present. Based on gully erosion present at some of these sites, the sandy layer was only approximately 0.5 m thick above sandstone. These areas were more appropriately considered 11.10.7, which is the equivalent *E. crebra* and/or *E. melanophloia* community on land zone 10. This is supported by secondary sites 7, 38 and 40 (**Appendix B**).
5) The extent of land zone 3 (alluvium) tended to be over-estimated by certified regional ecosystem mapping. Often, there were relatively flat terraces on the sandstone slopes close to waterways that resembled alluvial plains on aerial imagery. However, field surveys revealed steep boulder-strewn slopes (land zone 10) between these terraces and the banks of the waterway, indicating that these terraces are not alluvial. Furthermore, where land zone 5 (sand plain) abutted waterways, there was often no detectable drop in elevation as one approached the waterway, consistent with a shift to land zone 3. In some cases, the terrain actually rose slightly from the neighbouring plain to the banks of the watercourse (with a very steep bank present on one side of the watercourse). Such cases are more appropriately considered land zone 5 up to the watercourse bank.
6) Certified regional ecosystem mapping is undertaken at a broad scale, and contains numerous units composed of a mosaic of multiple regional ecosystems. The fine scale of our mapping has allowed us, in most cases, to re-map each regional ecosystem separately.

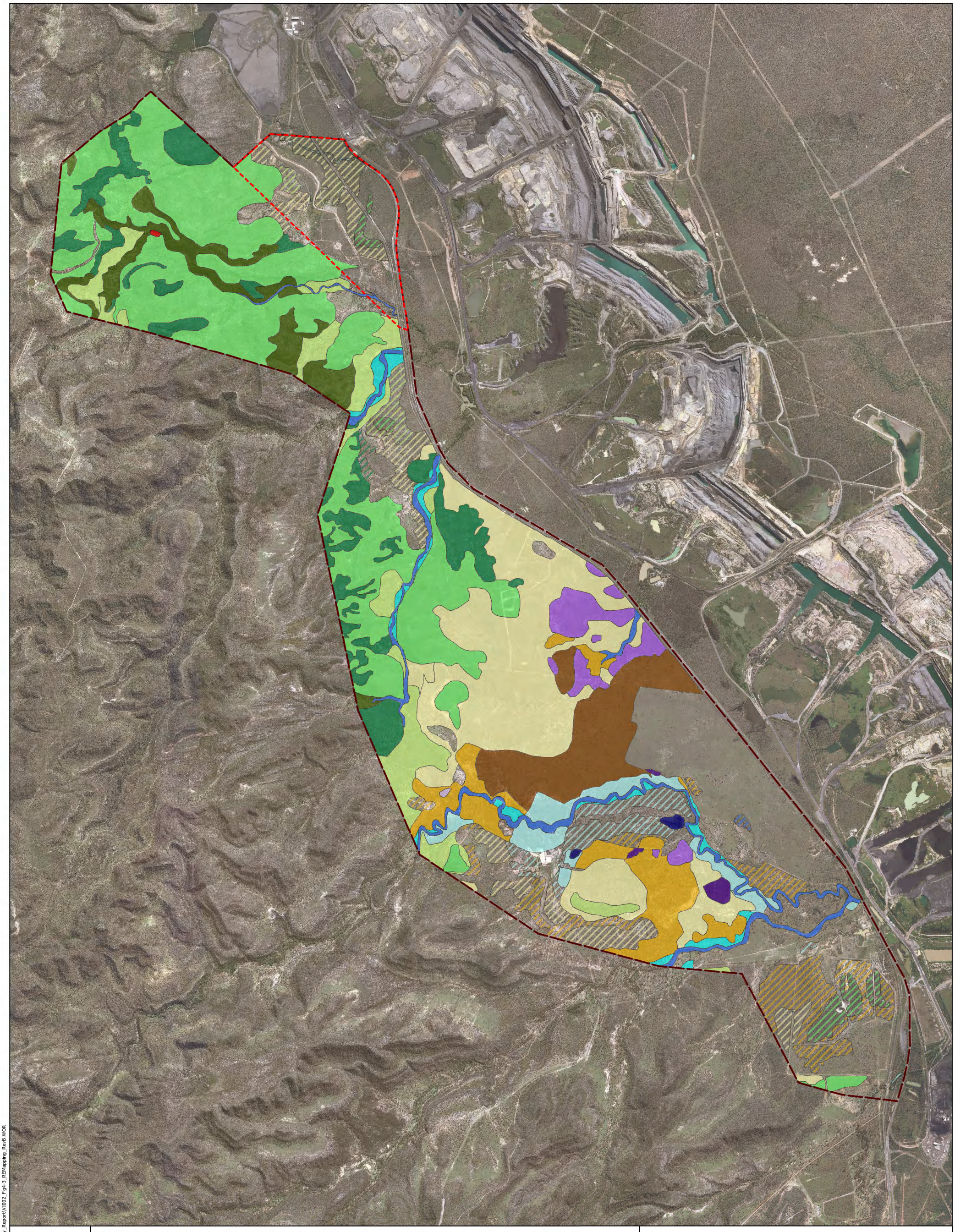
Table 4-1 Regional ecosystems recorded in the survey and project areas

Regional Ecosystem	BVG*	Short description	VM class†	Biodiv. Status‡	Hectares within survey area		Hectares within project area	
					Remnant	Regrowth	Remnant	Regrowth
11.3.1	25a	*Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains	E	E	1.6	0	0	0
11.3.2	17a	*Eucalyptus populnea* woodland on alluvial plains	OC	OC	128.0	148.6	0	0
11.3.7	9e	*Corymbia* spp. woodland on alluvial terraces	LC	OC	86.4	0	0	0
11.3.25	16a	*E. camaldulensis* forest fringing drainage lines.	LC	OC	148.1	5.3	2.1	2.6
11.3.27c	34d	Mixed sedgeland in freshwater wetland	LC	OC	2.0	0	0	0
11.3.27e	34d	Open water freshwater wetland with fringing trees	LC	OC	6.5	0	0	0
11.4.8	25a	*Eucalyptus cambageana* woodland to open forest with *Acacia harpophylla* on Cainozoic clay plains.	E	E	127.8	4.0	0	0
11.4.9	25a	*Acacia harpophylla* shrubby woodland with *Terminalia oblongata* on Cainozoic clay plains.	E	E	16.3	0	0	0
11.5.3	17a	*Eucalyptus populnea* woodland on Cainozoic sand plains and/or remnant surfaces.	LC	NC	279.5	238.1	0	0
11.5.9	18b	*Eucalyptus crebra* and other *Eucalyptus* spp. and *Corymbia* spp. woodland on Cainozoic sand plains and/or remnant surfaces.	LC	NC	880.3	272.2	0	103.7
11.9.2	17b	*Eucalyptus orgadophila* woodland on fine-grained sedimentary rocks.	LC	NC	326.4	0	0	0
11.10.1	10a	*Corymbia citriodora* woodland on coarse-grained sedimentary rocks.	LC	NC	225.8	0	0	0
11.10.3	24a	*Acacia shirleyi* open forest on coarse-grained sedimentary rocks. Crests and scarps.	LC	NC	1,405.2	66.7	32.3	14.2
11.10.7	12a	*Eucalyptus crebra* woodland on coarse-grained sedimentary rocks.	LC	NC	284.8	39.2	0.9	9.2
11.10.8	7a	Semi-evergreen vine thicket in sheltered habitats on medium to coarse-grained sedimentary rocks.	OC	OC	1.3	0	0	0
11.10.13	12a	*Eucalyptus* spp. and/or *Corymbia* spp. open forest on scarps and sandstone tablelands.	LC	NC	396.6	11.3	0	0
Non-remnant	-	Cleared pasture, +/- scattered trees or young regrowth	-	-	1,464.5		242.3	

*BVG = broad vegetation group

†VM class = classification under the *Vegetation Management Act 1999*: E = endangered, OC = of concern. LC = least concern.

‡Biodiversity status relates to environmentally sensitive areas under the *Environmental Protection Act 1994*: E = endangered, OC = of concern, NC = no concern at present.



LEGEND

Regional Ecosystem Mapping

11.3.1	11.5.3	HVR 11.3.2
11.3.2	11.5.9	HVR 11.3.25
11.3.7	11.9.2	HVR 11.4.8
11.3.25	11.10.1	HVR 11.5.3
11.3.27c	11.10.3	HVR 11.5.9
11.3.27e	11.10.7	HVR 11.10.3
11.4.8	11.10.8	HVR 11.10.7
11.4.9	11.10.13	HVR 11.10.13

Vulcan Complex Survey Area

Project Area

Data Source: Drainage Line, Road - QLD Gov. (2018); Field-verified RE Mapping, Habitat, Species Sites - METServe (2019); Survey Boundary, Bulk Sample Footprint - Vitrinite (2019).

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Vitrinite

Vulcan Complex Project
Field-verified Regional Ecosystem Map

1 0 1 2
Kilometres

Scale: 1:55,000 (A3)

21/02/2020

Datum: GDA94
Projection: MGA55

FIGURE 4-3

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fg4-3_REMapping_RevB.WOR

4.1.3 Groundwater-dependent Ecosystems

There are three main categories of groundwater-dependent ecosystems (Department of Science, Information Technology and Innovation 2015):

1) Vegetation that accesses sub-surface groundwater through its roots;
2) wetlands that receive groundwater discharge (e.g., springs); and
3) subterranean aquatic ecosystems, and marine systems that receive sub-marine discharge of groundwater.

Of these, categories 2 and 3 are aquatic ecosystems assessed elsewhere through an aquatic ecological assessment. Category 1, however, refers to terrestrial ecosystems that are dependent on access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services.

For vegetation to access groundwater in the subsurface, the roots must be able to reach the capillary zone above the water table and the water quality of groundwater must be adequate. In order to assess and map potential terrestrial groundwater-dependent ecosystems across the survey area, the following data sources were considered:

- *National Atlas of Groundwater Dependent Ecosystems version 2.0* (BOM 2019);
- published literature on root depths and groundwater usage among local vegetation types;
- depth-to-groundwater mapping of the project area (provided by hydrogeologist.com.au); and
- groundwater quality (hydrogeologist.com.au 2020).

4.1.3.1 Review of Groundwater Use by Terrestrial Vegetation

There has been much recent worldwide research into groundwater-dependent ecosystems, combining tools such as stable isotope analysis, measurement of pre-dawn leaf water potential, and seasonal tracking of transpiration rates and "greenness" indices. One of the key findings of this research is that the use of groundwater by terrestrial vegetation depends greatly on the depth of this groundwater, and the influence of depth is largely consistent across continents and vegetation communities:

- In arid regions of China, groundwater up to 4–10 m below the surface is used by vegetation (Jin *et al.* 2011; Lv *et al*. 2012; Liu *et al*. 2017).
- In California, groundwater up to a depth of 6–8 m is used by vegetation (McLendon *et al*. 2008).
- Various studies in Australia have identified lower limits to the root extraction of groundwater of 7.5 m (Benyon *et al*. 2006), 5–11 m (O'Grady *et al*. 2006b), 8–10 m (Robinson *et al*. 2006), and 9 m (Zolfaghar *et al*. 2017).

Despite these relatively consistent average patterns, not all tree species access groundwater equally. For example, based on spatial patterns in declining canopy conditions during drought, Kath *et al.* (2014) inferred that *Eucalyptus populnea* (a species native to the survey area) regularly accessed groundwater to a depth of 13 m and, to far lesser extent, up to 26 m. To explore this variation between species in their propensity to access groundwater, published data on local vegetation types were reviewed and summarised in **Table 4-2**. Note that this assessment is limited to regional ecosystems within the MLA area, as the accuracy of depth-to-groundwater mapping far beyond this is limited by a lack of survey data.

Where data is lacking, it is practical to use the widely adopted rule-of-thumb (e.g., Eamus *et al*. 2006a; Department of Natural Resources, Mines and Energy (DNRME) 2019a), that vegetation is likely to use groundwater where it is up to a depth of 10 m, may possibly use groundwater at depths of 10-20 m, but is unlikely to access water deeper than 20 m.

Table 4-2 Published groundwater usage by local tree species

Regional Ecosystem	Rooting depths of dominant species	Depth-to-groundwater within the project area: mean (range)*	Likelihood of groundwater-dependence
11.3.25	*Eucalyptus camaldulensis* is often dependent on shallow aquifers and watercourses (Bacon *et al*. 1993). Isotope studies indicate that *E. camaldulensis* accesses groundwater up to a depth of 9.4–11.2 m, but not deeper (Rumman *et al.* 2018).A similar finding—that *E. camaldulensis* commonly accesses groundwater to a depth of 12.5 m—was revealed by studies of tree condition (Kath *et al.* 2014). The latter study revealed that groundwater may also be accessed to a limited extent up to 20 m, but not deeper. *Melaleuca leucadendra* and other riparian *Melaleuca* spp. are reliant on river water and/or shallow groundwater, up to 9 m deep (O'Grady *et al.* 2005, 2006a, 2006b).	9.2 m (2.6 m to 14.5 m)	**High:** Water tables are within reach of this vegetation, and the constituent species are regularly groundwater-dependent elsewhere.
11.5.9	Ironbarks (*Eucalyptus crebra* and *E. melanophloia*) are sensitive to die-back during drought and exhibit xylem flows and root depths consistent with a lack of access to groundwater (Rice *et al*. 2004; Fensham and Fairfax 2007). *Corymbia clarksoniana* is highly dependent on groundwater between 6.5 and 10 m deep during the dry season (Cook and O'Grady 2006; O'Grady *et al*. 2006b). Gow *et al*. (2016) found that *Eucalyptus crebra*, *E. decorticans* and *Corymbia* spp. woodlands on rocky hill slopes exhibited temperature radiation patterns consistent with the use of deep soil water. As the water table was generally between 10 m and 60 m, the authors hypothesised that most of the water used was intercepted while draining through the unsaturated zones of the soil profile, rather than originating from groundwater per se.	13.6 m (1.2 m to 41.9 m)	**Moderate:** In places where the water table is within 10 m of the ground surface, sub-dominant components of this RE are likely to be groundwater-dependent.
11.10.3	There are no published data on the groundwater-dependence or rooting depths of *Acacia shirleyi* or *Acacia rhodoxylon*. However, other *Acacia* spp. that grow on similar rocky substrates (e.g., *A. aneura, A. aptaneura* and *A. kempeana*) do not access groundwater, but instead have reinforced xylem vessels that are able to cope with strong water deficiencies (Anderson and Hodgkinson 1997; Nolan *et al*. 2017).	14.8 m (4.7 m to 31.1 m)	**Low:** Dominant species are unlikely to utilise groundwater.
11.10.7	Ironbarks (*Eucalyptus crebra* and *E. melanophloia*) are sensitive to die-back during drought and exhibit xylem flows and root depths consistent with a lack of access to groundwater (Rice *et al*. 2004; Fensham and Fairfax 2007). Gow *et al*. (2016) found that *Eucalyptus crebra*, *E. decorticans* and *Corymbia* spp. woodlands on rocky hill slopes exhibited temperature radiation patterns consistent with the use of deep soil water. As the water table was generally between 10 m and 60 m, the authors hypothesised that most of the water used was intercepted while draining through the unsaturated zones of the soil profile, rather than originating from groundwater per se.	10.0 m (6.2m to 18.2 m)	**Low:** Dominant species are unlikely to utilise groundwater.

*Depth-to-groundwater data for the survey area was sourced from hydrogeologist.com.au as per **Section 4.1.3.2**.

4.1.3.2 Depth to Groundwater

Hydrogeologist.com.au (2020) developed a calibrated, numerical groundwater model of all relevant aquifers within the vicinity of the Vulcan Complex Project. This was based on a range of data sources, including an on-site groundwater monitoring network, groundwater assessments from nearby mines, and the *Queensland Groundwater and Surface Water Monitoring* database (DNRME 2019b).

An aquifer is generally defined as a geological unit that can transmit and store significant quantities of groundwater. In the vicinity of the project area, some geological units yield low volumes of groundwater and would not typically be classified as aquifers in most hydrogeological settings. However, as these could provide a small and/or temporary source of groundwater for vegetation, they are referred to as aquifers for the purposes of this assessment.

Groundwater may be stored, even if only temporarily, in three hydro-stratigraphic units present on site:

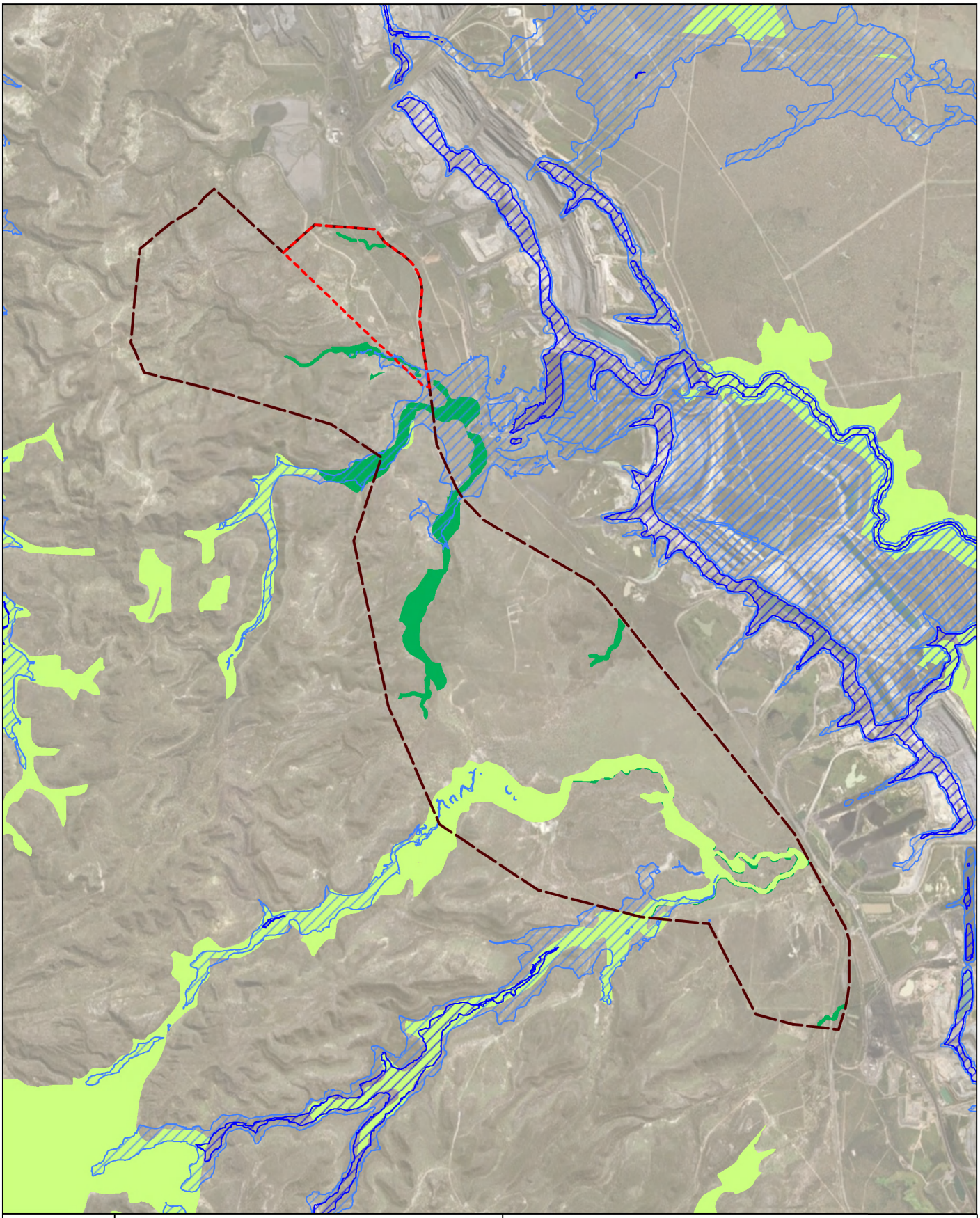
1) Quaternary Alluvium: The silted-up stream channels of ephemeral creeks support small, localised, temporary unconfined "aquifers". The alluvium saturates following flow events within the creeks. As the watercourses are highly ephemeral, some component of sub-surface flow through the alluvium persists after the surface water flow ceases.
2) Tertiary Sediments: This is a mix of Tertiary sediments (lenses of palaeochannel gravels and sands separated by dry, densely compacted sandy silts, sandy clays and clays) and weathered Permian regolith. These aquifers tend to be of limited lateral and vertical extent and consequently have low hydraulic conductivity. This layer was generally unsaturated in the survey area.
3) Permian Coal Measures: The coal seam aquifers are generally confined above and below by the low-permeability inter- and overburden. The coal seam aquifers present on site are regarded as poor aquifers because of their limited thickness and the presence of low-permeability interburden. Across most of the survey area, these aquifers represent the shallowest source of groundwater for vegetation.

Although Quaternary alluvium can provide a temporary source of shallow, fresh groundwater for terrestrial vegetation, this is recharged exclusively via rain and surface flows, and is therefore unaffected by any drawdown that may result from the Vulcan Complex Project. For most of the suvey area, the Permian Coal Measures, and occasionally the Tertiary Sediments, contain the uppermost groundwater.

A map of composite groundwater elevation contours was developed by Hydrogeologist.com.au (2020). This was converted to a depth-to-groundwater map based on surface topography obtained from aerial LiDAR data. This map revealed that in much of the project area water tables were within 20 m of the ground surface (**Figure 4-4**), and were therefore potentially within reach of vegetation. In some areas, the groundwater is within 10 m, or even 5 m, of the ground surface, where it is likely to be utilised by vegetation. Chief locations were this occurs are along North Creek and in the far north of the project area.

4.1.3.3 National Atlas of Groundwater Dependent Ecosystems

According to the *National Atlas of Groundwater Dependent Ecosystems*, there is a high potential for terrestrial groundwater-dependent ecosystems along the lower reaches of Boomerang Creek and its larger tributaries, including North Creek (**Figure 4-4**). The un-named tributary in the far north of the project area is also mapped as having a high potential for terrestrial groundwater-dependent ecosystems.



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LEGEND

- Vulcan Project Survey Area
- Project area

National Groundwater Dependent Ecosystems Atlas

- High potential Terrestrial GDE
- Moderate potential Terrestrial GDE

Depth to Water

- 0-10 m
- 10-20 m

Data Source: Survey Boundary - Vitrinite (2019); GDE Atlas V2 - BOM (2017); Depth to Water - Oasis Hydrogeology (2019); Imagery - ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Vitrinite

Vulcan Complex Project Depth to Groundwater in Relation to the GDE Atlas

2 0 2 4
Kilometres

Scale: 1:100,000 (A4)

21/02/2020

Datum: GDA94
Projection: MGA55

FIGURE 4-4

S:\Projects\V1005 Vulcan Project_MapInfo\Workspaces\Groundwater_Dependent_Ecosystems\V1005_Fig4-4_GDE_Mapping_Depth_to_GW_RevA.WOR

There was reasonable accordance between the *National Atlas of Groundwater Dependent Ecosystems* and depth-to-groundwater mapping. Areas mapped as likely GDEs along North Creek had a depth to groundwater of less than 10 m. Likewise, riparian vegetation along the northern unnamed tributary is within 6-14 m of groundwater, which it is likely to utilise. However, there were large additional parts of the project area (not mapped as GDEs) where the groundwater was 10-20 m beneath the ground's surface. Such depths can be reached by some species of tree. Given that the vegetation communities present in these areas are dominated by species (e.g., *Eucalyptus melanophloia, Eucalyptus crebra, Corymbia clarksoniana* and *Acacia shirleyi*) that do not typically access groundwater as such depth, it is assumed that these communities are unlikely to represent GDEs. An exception is regional ecosystem 11.5.9, where this occurs in the far north of the MLA area, where groundwater is less than 10 m below the ground surface. This regional ecosystem is likely to be partly groundwater-dependent; that is, dominant species (e.g., *E. crebra* and *E. melanophloia*) are unlikely to utilise groundwater but sub-dominant species (e.g., *C. clarksoniana* and *Melaleuca viridiflora*) are likely to.

4.1.3.4 Water Quality

All groundwater sampled to date within the survey area is brackish to highly saline. Electrical conductivity ranges between 2.5 and 22.8 dS/m, with a mean value of 9.0 dS/m (Hydrogeologist.com.au 2020). For context, sea water has an electrical conductivity of approximately 50 dS/m, while drinking water has 0.05–0.5 dS/m. The pH of groundwater on site is generally close to neutral (Hydrogeologist.com.au 2020). Electrical conductivity greater than 3–4 dS/m inhibits the growth of most plants (Katerji *et al.* 2003), although tolerance to salt varies between species. As the water table within the project area is beyond the reach of most local plant communities, the most relevant plant species are those inhabiting regional ecosystems 11.3.25 and 11.5.9.

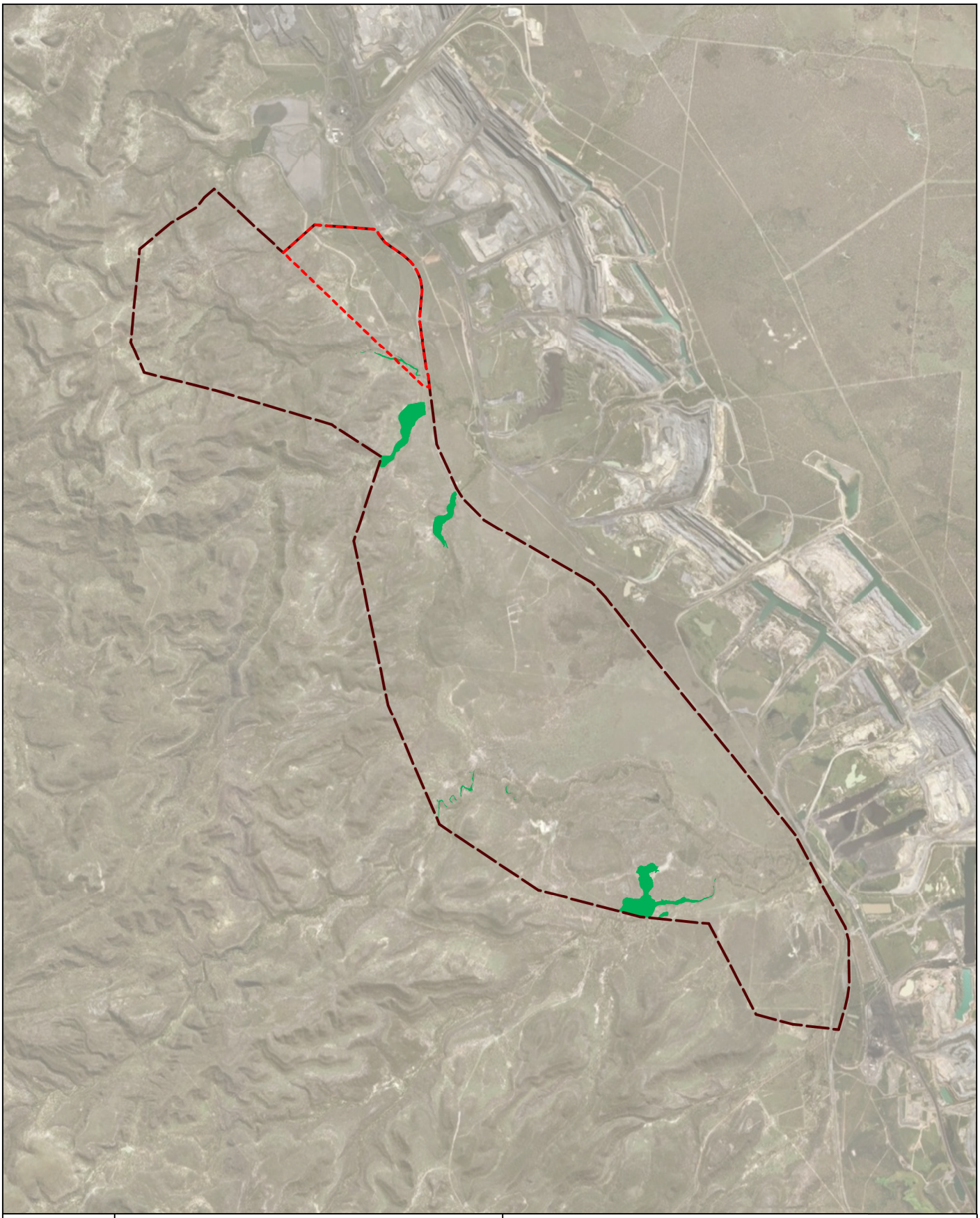
Some local tree species are known to utilise groundwater with salinity that would preclude its use by most plants. *Eucalyptus camaldulensis*, a dominant tree along local waterways (RE 11.3.25), is one such salt-tolerant species. Salinity comparable to the lower levels recorded onsite impairs the growth of *E. camaldulensis* seedlings, but has no effect on survival (Sun and Dickinson 1995; Farrell *et al.* 1996). Furthermore, isotope analyses have confirmed that adult trees growing above a 2–3 m deep, highly saline (30–50 dS/m) water table were able to use this groundwater, despite experiencing substantial water stress as a result (Mensforth *et al.* 1994). While saline groundwater can potentially sustain *E. camaldulensis* during dry periods, most growth occurs in response to saturation of the upper soil profile with freshwater during floods. These intermittent flooding events provide half to two-thirds of the water requirements of the species and are vital for maintaining their health (Eamus *et al.* 2006b; Wen *et al.* 2009).

Melaleuca leucadendra, the other dominant riparian species in regional ecosystem 11.3.25, is known to be variously salt-sensitive (van der Moezel *et al.* 1991) to salt-tolerant (Sun and Dickinson 1995). This species may be able to use groundwater at the lower end of local salinity levels (equivalent to electrical conductivity up to 5 dS/m), even though such concentrations of salt greatly impair growth (Nguyen *et al.* 2009). *Eucalyptus crebra,* a dominant species in RE 11.5.9 and subdominant in 11.3.25, has moderate salt tolerance only (Gill and Abrol 1991; Sun and Dickinson 1993; Hoy *et al.* 1994). This species is unlikely to be able to utilise most groundwater on site.

In summary, regional ecosystem 11.3.25 is capable of using saline groundwater within the reach of roots; however, the quality of the groundwater within the project area is near the limits of tolerance of RE 11.5.9.

4.1.3.5 Potential Groundwater-dependent Ecosystems

Based on literature reviews (see **Section 4.1.3.1**), depth-to-groundwater data (see **Section 4.1.3.2**), and water quality data (see **Section 4.1.3.4**), there are likely to be some GDEs contained within the project area. The locations of these likely GDEs closely match that mapped within the *National Atlas of Groundwater Dependent Ecosystems*. An additional partly groundwater-dependent ecosystem is located in the far north of the project area. The location of these GDEs, based on depth-to-groundwater and field-verified regional ecosystem mapping, is presented in **Figure 4-5**.



LEGEND

- Vulcan Project Survey Area
- Project area
- Possible Groundwater-dependent Terrestrial Ecosystems

Data Source: Survey Boundary - Vitrinite (2019);
GDE Terrestrial Ecosystems (Field-verified RE Mapping) - METServe (2019); Imagery - ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

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Vulcan Complex Project
Possible Groundwater-dependent Terrestrial Ecosystems

2 0 2 4
Kilometres

Scale: 1:100,000 (A4)

21/02/2020

Datum: GDA94
Projection: MGA55

FIGURE 4-5

S:\Projects\V1005 Vulcan Project_MapInfo\Workspaces\Groundwater_Dependent_Ecosystems\V1005_Fig4-5_GDE_Mapping_Terrestrial_Rev8.WOR

4.1.4 Biodiversity

Field surveys detected 40 species of mammal, 133 species of bird, 35 species of reptile, 14 species of frog and 423 species of vascular plants (**Appendix C**). Not all bat calls could be identified to unique species, and unresolved calls may have arisen from an additional species of bat not included in the above tally (**Appendix D**).

4.1.4.1 Thoroughness of Surveys

The nature of ecological surveys means that it is inevitable that some species present remain undetected. To estimate the extent to which this occurred, species accumulation curves were fitted to the fauna and flora data using EstimateS 9.1.0. The total numbers of species that occur within the survey area were estimated using the Chao2 richness estimator. These analyses suggested that, of the species that could have been detected using the methodology employed, the surveys to date have detected:

1) 83% of the floral diversity;
2) 100% of reptiles;
3) 97% of amphibians;
4) 100% of birds;
5) 92% of non-bat mammals; and
6) 100% of bats.

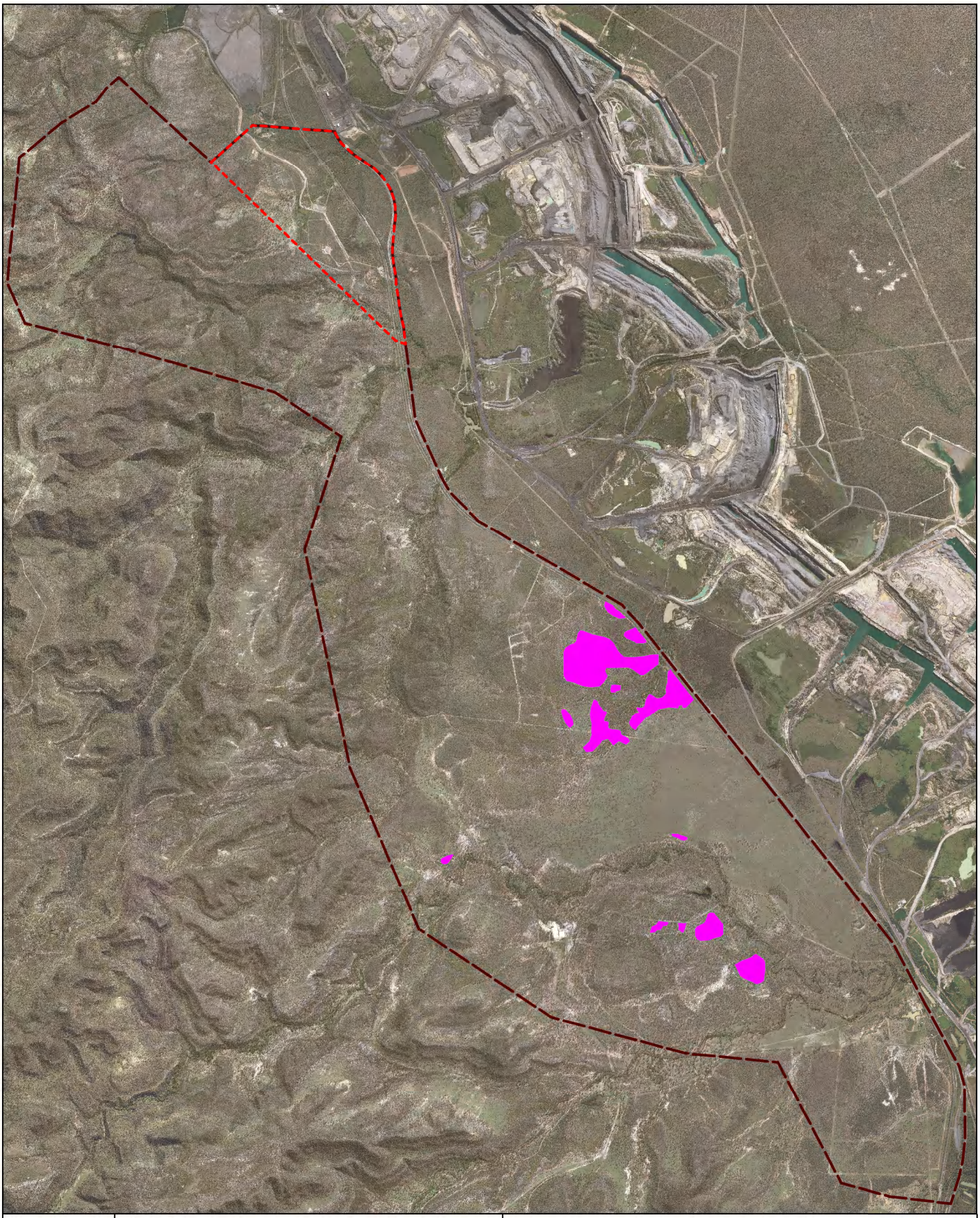
Note that the above are estimates generated from a statistical analysis of the detection rate per sampling unit (e.g., per trap site). It only takes into account species that *could* be detected by the surveys. Species that were inactive at the time of surveys, or which are visitors that do not occur during the sampling periods are not incorporated into these estimates. Sampling across a broad range of seasons and climatic conditions, as was done for this study, limits the number of species considered undetectable. Nevertheless, it is possible that even for taxonomic groups with total detection, additional species could be detected with additional effort. Still, the number missed is expected to be very low. Overall, the species accumulation curves indicate that the data gathered on the area's ecology is relatively thorough. The incomplete knowledge of mammals reflects the cryptic behaviour (shy, difficult to trap) and low density of many species. The incomplete knowledge of amphibians is due to the highly patchy distribution of populations and the narrow windows of time (immediately after heavy rain) that these are detectable. The incomplete knowledge of plants in part owes to the high diversity present (over 420 species already recorded), and the observation that many are restricted to patchily distributed micro-habitats within the sandstone ridges and gorges, to the west of the project area.

4.2 ENVIRONMENTALLY SENSITIVE AREAS

Category A and B environmentally sensitive areas are defined under Schedule 12 of the *Environmental Protection Regulation 2008*, while category C environmentally sensitive areas are defined in the *Eligibility Criteria and Standard Conditions for Mining Lease Activities* (Department of Environment and Heritage Protection 2016).

No category A or C environmentally sensitive areas occur in or near the survey area.

The only category B environmentally sensitive areas within the survey area are "endangered regional ecosystems identified in the database known as the 'Regional ecosystem description database'". Field-verified regional ecosystem mapping revealed a total of 145.7 ha of endangered regional ecosystems within the survey area. The locations of these category B environmentally sensitive areas are shown in **Figure 4-6**. No category B environmentally sensitive areas are contained in or within 500 m of the project area.



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Vulcan Complex Survey Area

Project Area

Category B Environmentally Sensitive Areas

Endangered Regional Ecosystem

Data Source: Field-verified RE Mapping - METServe (2019); Survey Boundary - Vitrinite (2019); Imagery - ESRI, DigitalGlobe, GeoEye, Easrthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Vitrinite

Vulcan Complex Project
Environmentally Sensitive Areas

1 0 1 2 3

Kilometres

Scale: 1:75,000 (A4)

21/02/2020

Datum: GDA94
Projection: MGA55

FIGURE 4-6

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fig4-4_EnvironmentallySensitiveAreas_RevB.WOR

4.3 MATTERS OF STATE ENVIRONMENTAL SIGNIFICANCE

Matters of State environmental significance are defined in the *State Planning Policy 2017.* Each of these are summarised below, with respect to the Project.

4.3.1 Protected Areas

No national parks, conservation parks, resource reserves, special wildlife reserves, nature refuges or coordinated conservation areas are located in or near the survey area.

4.3.2 Marine Matters

No marine parks, marine plants or fish habitat protected under the *Fisheries Act 1994*, *Fisheries Regulation 2008* or the *Marine Parks Act 2004* is contained in the survey area.

4.3.3 Designated Precinct in Strategic Environmental Areas

No strategic environmental areas are listed for the Isaac Regional Council area.

4.3.4 Wetlands and Watercourses

No wetlands or watercourses of high ecological significance are located within the survey area.

4.3.5 Secured Offset Areas

No legally secured offset areas from other projects are located in or near the survey area.

4.3.6 Regulated Vegetation

The following regulated vegetation under the *Vegetation Management Act 1999* is classed as a matter of State environmental significance in the *State Planning Policy 2017*:

(i) category B areas (regional ecosystems) on the regulated vegetation management map that are 'endangered' and 'of concern' regional ecosystems;

(ii) category C areas (regrowth) on the regulated vegetation management map that are 'endangered' and 'of concern' regional ecosystems;

(iii) category R areas (non-remnant vegetation within 50 m of watercourses) on the regulated vegetation management map;

(iv) areas of essential habitat on the essential habitat map for wildlife prescribed as 'endangered wildlife' or 'vulnerable wildlife' under the *Nature Conservation Act 1992*;

(v) category A, B, C or R areas on the regulated vegetation management map that are located within a defined distance from the defining banks of a relevant watercourse identified on the vegetation management watercourse and drainage feature map; and

(vi) category A, B, C or R areas on the regulated vegetation management map that are located within a wetland or within 100 metres from the defining bank of a wetland identified on the vegetation management wetlands map.

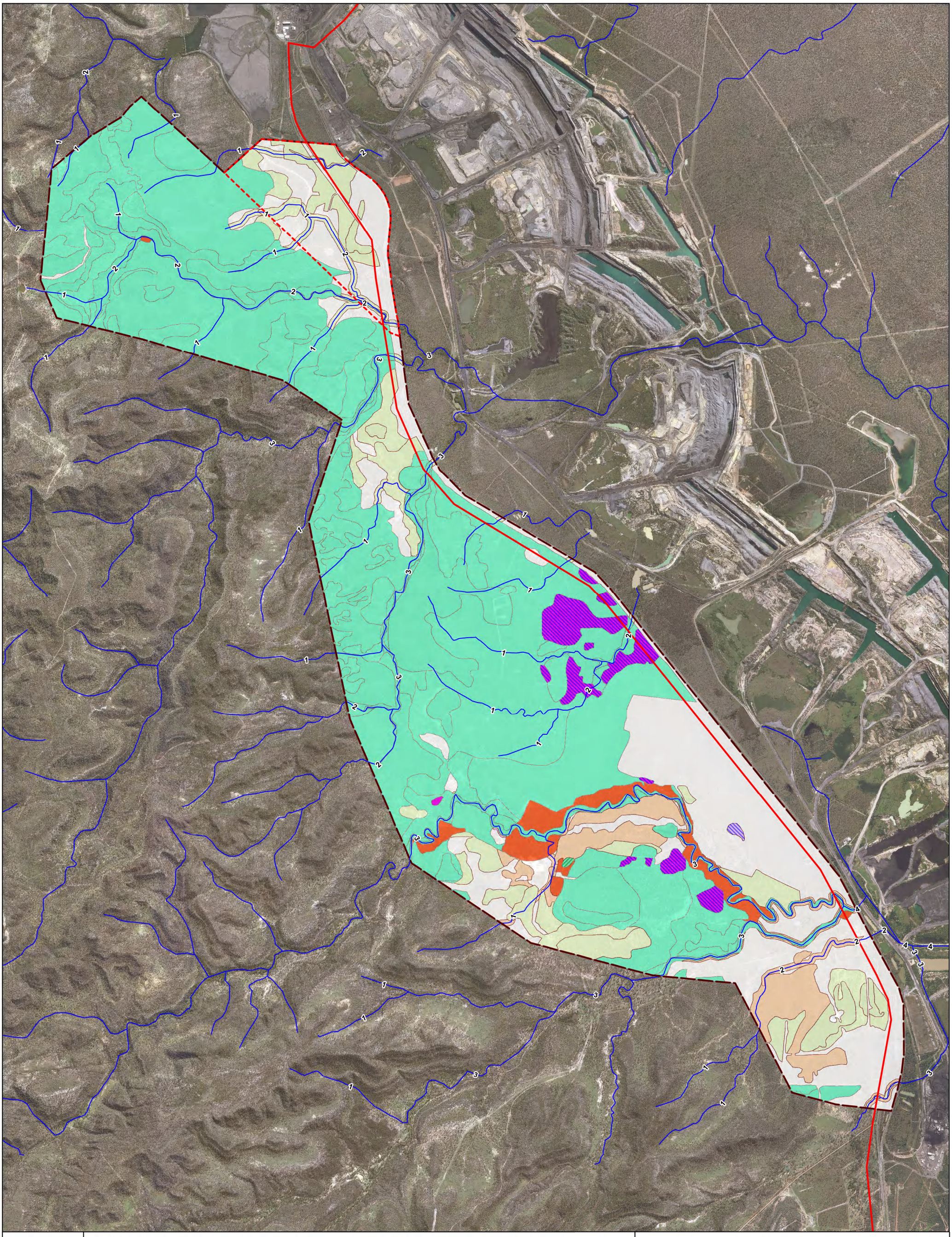
The regulated vegetation management map and essential habitat map, referred to in the definitions of many of the above matters, are based on erroneous regional ecosystem mapping. This mapping can be corrected by applying for a property map of assessable vegetation (PMAV), but this requires consent of the current landholders, which was not granted. In light of the discrepancies between the legally defined extent of regulated vegetation and the actual extent of vegetation, both are reported here (**Table 4-3**). It is anticipated that, should the Vulcan Complex Project proceed as proposed, Vitrinite Pty Ltd can apply for a PMAV after acquiring the land containing the project. As such, it is expected that the field-verified data constitutes the principal mapping on which impacts are to be assessed. Mapping of regulated vegetation derived from the field-verified regional ecosystem map is presented in **Figure 4-7** and the regulated vegetation management map is shown in **Figure 4-8.**

Table 4-3 Regulated vegetation constituting MSES

Vegetation Type	Constituent REs	Field-verified Data		Regulated Vegetation Map	
		Total Area within the Survey Area	Total Area within the Project Area	Total Area within the Survey Area	Total Area within the Project Area
Endangered and of concern regional ecosystems	11.3.1 (endangered)	1.6 ha	0 ha	0 ha	0 ha
	11.3.2 (of concern)	128.0 ha	0 ha	482.8 ha	0 ha
	11.4.8 (endangered)	127.8 ha	0 ha	317.6 ha	0 ha
	11.4.9 (endangered)	16.3 ha	0 ha	843.9 ha	0 ha
	11.10.8 (of concern)	1.3 ha	0 ha	1,602.2 ha	2.1 ha
	Total	**275.0 ha**	**0 ha**	**3,246.4 ha**	**2.1 ha**
Endangered and of concern regrowth	11.3.2 (of concern)	148.6 ha	0 ha	16.8 ha	4.5 ha
	11.4.8 (endangered)	4.0 ha	0 ha	0 ha	0 ha
	11.4.9 (endangered)	0 ha	0 ha	34.2 ha	0.1 ha
	11.10.8 (of concern)	0 ha	0 ha	2.0 ha	0.1 ha
	Total	**152.6 ha**	**0 ha**	**53.2 ha**	**4.7 ha**
Non-remnant vegetation along watercourses (Category R)	n/a	111.5 ha	34.6 ha	45.5 ha	30.5 ha
Essential habitat for threatened wildlife (Ornamental Snake)	11.4.8, 11.4.9, HVR 11.4.9	148.1 ha	0 ha	1,193.9 ha	0.1 ha
Category A, B, C or R areas that occur within 100 m of a wetland	11.3.2 (category B)	3.3 ha	0 ha	0 ha	0 ha
	11.3.27c (category B)	2.0 ha	0 ha	0 ha	0 ha
	11.5.3 (category B)	2.0 ha	0 ha	3.9 ha	0 ha
	11.5.9 (category B)	0 ha	0 ha	3.9 ha	0 ha
	HVR 11.3.2 (category C)	3.4 ha	0 ha	0 ha	0 ha
	Non-remnant (category R)	0.2 ha	0 ha	3.0 ha	0 ha
	Total	**11.1 ha**	**0 ha**	**10.8 ha**	**0 ha**
Category A, B, C or R areas that are located within a defined distance from the defining banks of a relevant watercourse*	11.3.2 (category B)	28.2 ha	0 ha	100.4 ha	0 ha
	11.3.7 (category B)	41.5 ha	0 ha	69.2 ha	0 ha
	11.3.25 (category B)	142.2 ha	2.1 ha	85.2 ha	0 ha
	11.3.27e (category B)	0.3 ha	0 ha	0 ha	0 ha
	11.4.8 (category B)	1.9 ha	0 ha	0.7 ha	0 ha
	11.4.8 (category B)	0 ha	0 ha	12.1 ha	0 ha
	11.5.3 (category B)	16.1 ha	0 ha	1.4 ha	0 ha
	11.5.9 (category B)	54.6 ha	0 ha	58.1 ha	0 ha
	11.9.2 (category B)	1.4 ha	0 ha	0 ha	0 ha
	11.10.1 (category B)	28.0 ha	0 ha	46.3 ha	0 ha
	11.10.3 (category B)	61.5 ha	0 ha	42.6 ha	0 ha
	11.10.7 (category B)	23.8 ha	0.4 ha	0 ha	0 ha
	11.10.8 (category B)	0.7 ha	0 ha	7.6 ha	0 ha
	11.10.13 (category B)	14.8 ha	0 ha	0 ha	0 ha
	HVR 11.3.2 (category C)	8.6 ha	0 ha	4.2 ha	3.3 ha
	HVR 11.3.7 (category C)	0 ha	0 ha	0.3 ha	0 ha
	HVR 11.3.25 (category C)	4.8 ha	2.1 ha	12.6 ha	4.7 ha
	HVR 11.4.9 (category C)	0 ha	0 ha	0.2 ha	0.03 ha
	HVR 11.5.3 (category C)	11.2 ha	0 ha	3.3 ha	0 ha
	HVR 11.5.9 (category C)	12.6 ha	7.8 ha	32.0 ha	23.4 ha
	HVR11.10.1 (category C)	0 ha	0 ha	0.2 ha	0 ha
	HVR 11.10.3 (category C)	0 ha	0 ha	4.2 ha	4.2 ha
	Non-remnant (category R)	111.4 ha	34.6 ha	29.7 ha	18.3 ha
	Total	**563.6 ha**	**47.0 ha**	**510.6 ha**	**54.1 ha**

*The defined distance is listed by DEHP (2017) as 25 m for a first- or second-order stream and 50 m for a third- or fourth-order stream. The certified vegetation management watercourse map shows the centreline of relevant watercourses, but not the exact locations of their banks. Bank location was estimated based on the average width of watercourses in the Vulcan Complex survey area. Watercourse widths (distance between banks) were estimated to be 5 m for first-order streams, 10 m for second-

order streams, 15 m for third-order streams and 20 m for fourth-order streams. Buffers around the watercourse centreline were enlarged beyond the "defined distance" to account for these stream widths.



LEGEND

Revised Vegetation Management Map

- Category A or B area containing endangered regional ecosystems
- Category A or B area containing of concern regional ecosystems
- Category A or B area that is a least concern regional ecosystem
- Category C or R area containing endangered regional ecosystems
- Category C or R area containing of concern regional ecosystems
- Category C or R area that is a least concern regional ecosystem
- Category X area
- Essential Habitat
- Wetland

- Watercourses and drainage features on the vegetation management watercourse and drainage features map (stream order shown as black number against stream where available)
- Roads
- Vulcan Complex Survey Area
- Project area

Data Source: Drainage Line, Road - QLD Gov. (2018); Field-verified RE Mapping - METServe (2019); Survey Boundary - Vitrinite (2019).

METSERVE Mining & Energy Technical Services Pty Ltd

Vitrinite

Vulcan Complex Project
Vegetation Management Map
Based on Field-verified Data

1 0 1 2
Kilometres

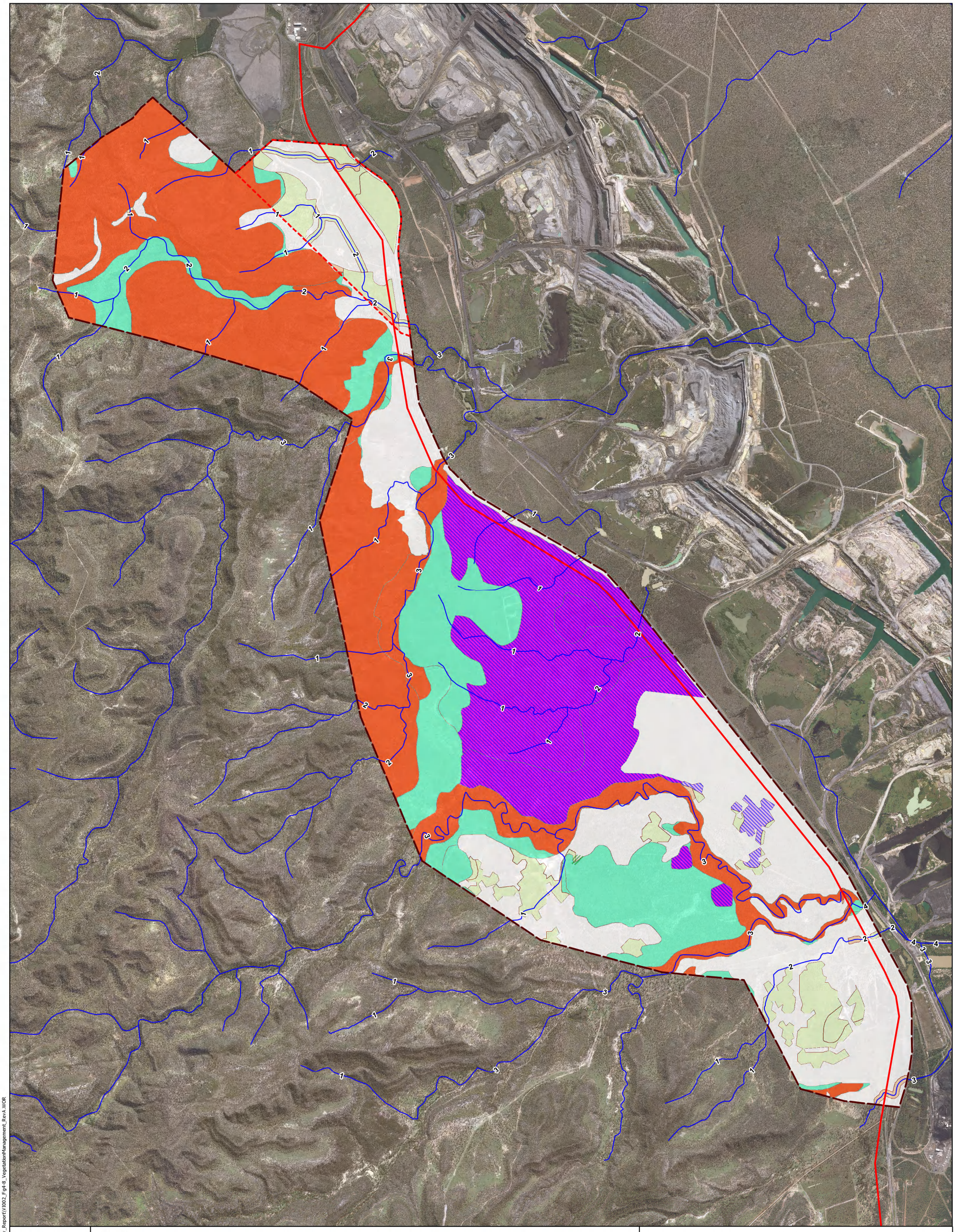
Scale: 1:55,000 (A3)

21/02/2020

Datum: GDA94
Projection: MGA55

FIGURE 4-7

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LEGEND

Revised Vegetation Management Map

- Category A or B area containing endangered regional ecosystems
- Category A or B area containing of concern regional ecosystems
- Category A or B area that is a least concern regional ecosystem
- Category C or R area containing endangered regional ecosystems
- Category C or R area containing of concern regional ecosystems
- Category C or R area that is a least concern regional ecosystem
- Category X area
- Essential Habitat
- Wetland

- Watercourses and drainage features on the vegetation management watercourse and drainage features map (stream order shown as black number against stream where available)
- Roads
- Vulcan Complex Survey Area
- Project area

Data Source: Drainage Line, Road - QLD Gov. (2018); Field-verified RE Mapping - METServe (2019); Survey Boundary - Vitrinite (2019).

METSERVE Mining & Energy Technical Services Pty Ltd

Vitrinite

Vulcan Complex Project
Regulated Vegetation Management Map

1 0 1 2
Kilometres

Scale: 1:55,000 (A3)

26/02/2020

Datum: GDA94
Projection: MGA55

FIGURE 4-8

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Overall, the only regulated vegetation that field-verified mapping revealed to be present within the project area is category R vegetation (non-remnant areas within 50 m of watercourses) and category B, C and R areas that are located within a defined distance from the defining banks of a relevant watercourse.

4.3.7 Threatened and Special Least Concern Wildlife

Forty-one species of plants and animals listed as matters of State significance were flagged by database searches as being potentially present in the region. Field surveys confirmed that five of these (Koala, Greater Glider, Squatter Pigeon, Short-beaked Echidna and Rufous Fantail) were present within the survey area (**Figure 4-9**). No threatened species of plants were detected within the survey area.

The likelihoods that the remaining species occur within the survey area were assessed by considering the proximity and recentness of records, as well as availability of potential habitat (**Table 4-4**). An additional 18 species were considered likely or possibly occurring within the vicinity of the Project. A detailed description of the habitat requirements of each of the above 23 species is provided in the following subsections.

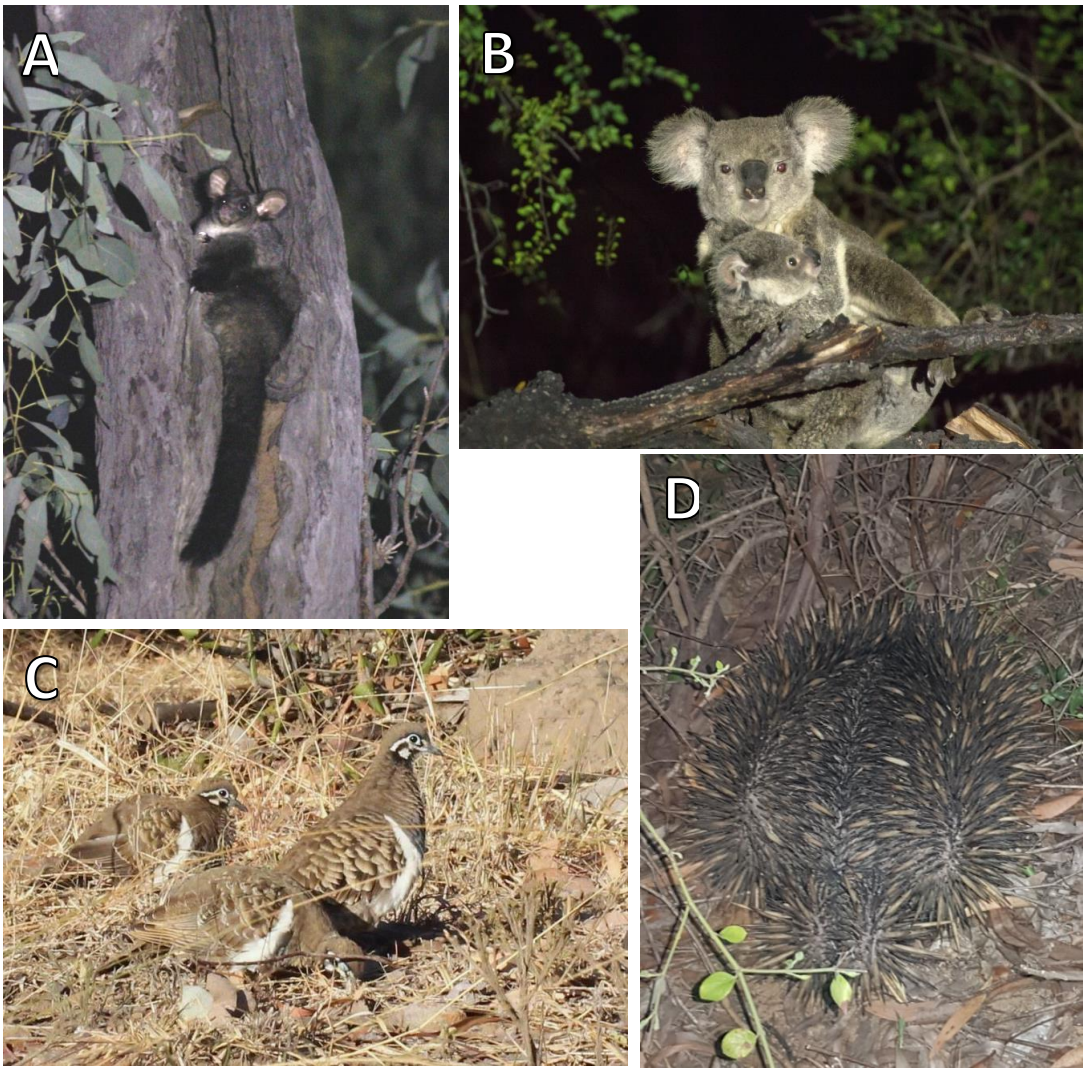


Figure 4-9 **Photographs of threatened and special least concern wildlife taken during surveys:** A) Greater Glider (-22.30611, 148.19281), B) Koala (-22.34550, 148.23138), C) Squatter Pigeons (-22.29018, 148.17957), D) Short-beaked Echidna (-22.34720, 148.23051).

Table 4-4 Species of State environmental significance flagged by databases as being potentially present in the local region

Taxon	Species	Common Name	EPBC status*	NC status†	Habitat requirements	Presence in survey area#	Presence in project area#
Bird	*Geophaps scripta scripta*	Squatter Pigeon	V	V	Open grassy woodland with areas of bare ground, on land zones 3, 5 and 7.	C	C
Mammal	*Tachyglossus aculeatus*	Short-beaked Echidna	-	SL	Cosmopolitan habitat usage; anywhere termites can be found.	C	C
Mammal	*Phascolarctos cinereus*	Koala	V	V	Vegetation communities containing large food trees (*Eucalyptus* spp.), especially near watercourses.	C	L
Mammal	*Petauroides volans*	Greater Glider	V	V	Tall, old-growth eucalypt forest with tree hollows.	C	L
Bird	*Rhipidura rufifrons*	Rufous Fantail	M	SL	Dense woody vegetation, including vine thickets, paperbark forests and rainforest.	C	L
Bird	*Apus pacificus*	Fork-tailed Swift	M	SL	Almost exclusively aerial, foraging on flying insects above all habitat types.	L	L
Bird	*Gallinago hardwickii*	Latham's Snipe	M	SL	Freshwater wetlands with well-vegetated muddy edges.	L	L
Reptile	*Acanthophis antarcticus*	Common Death Adder	-	V	Forested areas with deep leaf litter and/or abundant rocks.	L	P
Reptile	*Denisonia maculata*	Ornamental Snake	V	V	Gilgais on heavy clay soil, especially where *Acacia harpophylla* grows.	L	P
Bird	*Cuculus optatus*	Oriental Cuckoo	M	SL	Primarily coastal forest and woodland. Rarely moves inland west of the coastal ranges.	P	P
Reptile	*Egernia rugosa*	Yakka Skink	V	V	Potentially any vegetated habitat with fallen timber or rocks. There are no nearby records, but habitat is available locally.	P	P
Bird	*Rostratula australis*	Australian Painted-snipe	E	V	Freshwater wetlands with well-vegetated muddy edges.	P	P
Bird	*Monarcha melanopsis*	Black-faced Monarch	M	SL	Typically associated with rainforest. Migrating individuals may utilise dense riparian vegetation in a transient capacity.	P	P
Bird	*Myiagra cyanoleuca*	Satin Flycatcher	M	SL	Tall wet forests of the coast and nearby ranges. Vagrant individuals may occasionally occur inland, where they are most likely in denser forests (e.g., along waterways).	P	P
Bird	*Plegadis falcinellus*	Glossy Ibis	M	SL	Shallow, marshy edges of large freshwater wetlands.	P	P
Bird	*Erythrotriorchis radiatus*	Red Goshawk	V	E	Large tracts of undisturbed forest, especially near the ecotone between rainforests, melaleuca swamps and open eucalypt woodlands. Within the survey area, it is most likely in densely forested riparian habitats.	P	U

Taxon	Species	Common Name	EPBC status*	NC status†	Habitat requirements	Presence in survey area#	Presence in project area#
Grass	*Aristida annua*	Annual Wiregrass	V	V	Open eucalypt woodlands and pastures on basalt-derived clay. The survey area lies outside the known distribution of the species; the most northern record is 35 km south.	P	U
Bird	*Calidris acuminata*	Sharp-tailed Sandpiper	M	SL	Estuarine and freshwater wetlands with extensive shallow, muddy margins.	P	U
Bird	*Gelochelidon nilotica*	Gull-billed Tern	M	SL	Primarily a coastal species. Can occur over inland lakes.	P	U
Mammal	*Macroderma gigas*	Ghost Bat	V	E	Primarily coastal ranges, where large cave systems occur near extensive forests. The nearest record is 85 km northeast.	P	U
Reptile	*Furina dunmalli*	Dunmall's Snake	V	V	Associated with *Acacia harpophylla* and eucalypt forests. The survey area is outside the known distribution of the species.	P	U
Reptile	*Lerista allanae*	Allan's Lerista	E	E	Inhabits root systems of grass tussocks growing on black clay soils.	P	U
Grass	*Dicanthium queenslandicum*	King Blue-grass	E	V	Grasslands or open woodland on clay soils, with low grazing pressure. Favourable soils within the survey area were subject to high grazing pressure.	P	U
Bird	*Actitis hypoleucos*	Common Sandpiper	M	SL	Inhabits primarily tidal rivers and rocky foreshores. Transient individuals occasionally use the edges of inland wetlands.	U	U
Bird	*Calidris ferruginea*	Curlew Sandpiper	CE/M	E	Primarily coastal mudflats, but occasionally also uses the muddy margins of large freshwater wetlands.	U	U
Bird	*Calidris melanotos*	Pectoral Sandpiper	M	SL	Estuarine and freshwater wetlands with extensive shallow, muddy margins.	U	U
Bird	*Grantiella picta*	Painted Honeyeater	V	V	Open woodlands, especially dominated by *Acacia harpophylla* or other *Acacia* species. The species is dependent on an abundance of mistletoe, a resource that was scarce in the survey area.	U	U
Bird	*Motacilla flava*	Yellow Wagtail	M	SL	The shallow, muddy edges of wetlands. Primarily a coastal species.	U	U
Bird	*Neochmia ruficauda ruficauda*	Star Finch	E	E	Probably extinct in the Bowen Basin. Formerly inhabited grassy edges of rivers and wetlands.	U	U
Bird	*Pandion haliaetus*	Osprey	M	SL	Restricted to coastlines, estuaries and large inland rivers/lakes.	U	U
Bird	*Phaethon rubricauda*	Red-tailed Tropicbird	M	SL	A marine species that has only been recorded near the survey area following a cyclone.	U	U
Bird	*Poephila cincta cincta*	Southern Black-throated Finch	E	E	Grassy eucalypt forests, especially near water, where the understorey of native perennial grasses has not been compromised by grazing. No records within 100 km.	U	U
Bird	*Tringa nebularia*	Common Greenshank	M	SL	Primarily coastal mudflats, but occasionally also uses the muddy margins of large freshwater wetlands.	U	U

Taxon	Species	Common Name	EPBC status*	NC status†	Habitat requirements	Presence in survey area‡	Presence in project area‡
Bird	*Tringa stagnatilis*	Marsh Sandpiper	M	SL	Muddy margins of shallow fresh or brackish water.	U	U
Mammal	*Nyctophilus corbeni*	Corben's Long-eared Bat	V	V	Only known from three cave systems, all south of Bundaberg. The survey area lies well outside the known distribution of the species.	U	U
Reptile	*Elseya albagula*	Southern Snapping Turtle	CE	E	Large permanent to semi-permanent river systems. The survey area lies outside the known distribution of the species, and suitable habitat is lacking.	U	U
Reptile	*Rheodytes leukops*	Fitzroy River Turtle	V	V	Inhabits deep pools with fallen timber in rivers with fast-flowing water. Suitable habitat is absent from the survey area.	U	U
Fish	*Maccullochella peelii*	Murray Cod	V	-	Clear, rocky streams, slow-flowing or turbid lowland rivers and billabongs. The survey area lies well outside the natural range of the species.	U	U
Cycad	*Cycas ophiolitica*	Marlborough Blue Cycad	E	E	Grows on steep slopes and hill tops in coastal areas over 100 km east of the survey area.	U	U
Tree	*Cadellia pentastylis*	Ooline	V	V	Edges of sandstone or basalt escarpments within *Acacia harpophylla*, vine-thicket, poplar box and bendee vegetation communities. The survey area lies outside the known distribution of the species. A very small amount of suitable habitat for the species exists on site, and this was thoroughly surveyed.	U	U
Tree	*Samadera bidwillii*	Quassia	V	V	Occurs in lowland rainforest 120 km east of the survey area.	U	U

*Status under the *Environment Protection and Biodiversity Conservation Act 1999*: CE = critically endangered, E = endangered, V = vulnerable, M = migratory.
†Status under the *Nature Conservation Act 1992*: E = endangered, V = vulnerable, LC = least concern, SL = special least concern.
‡Presence within survey area in which the Project is contained: C = presence confirmed, L = likely to be present, P = possibly present, U = unlikely to be present.

4.3.7.1 Koala

Koala habitat is defined by the Department of Environment and Energy (2019a) as any forest or woodland containing species that are known Koala food trees, or shrubland with emergent food trees. Koalas have been recorded feeding on a broad range of tree species within the family Myrtaceae (including *Eucalyptus, Corymbia, Lophostemon, Melaleuca* and others). However, within any particular region of Australia, only a few *Eucalyptus* species are preferentially used, while other species are utilised opportunistically for food, social purposes or shelter (Australian Koala Foundation 2015). While Koalas often spend the day sheltering in dense shade trees (e.g., *Melaleuca* and *Acacia* spp.), these species are almost never eaten (Ellis *et al.* 2002). For Koalas, the major factor defining habitat quality is the presence of preferred food trees. Tree size is also important (Callaghan *et al*. 2011; Smith *et al*. 2013); trees less than 30 cm trunk diameter are used 20-25% less frequently than larger trees (Callaghan *et al*. 2011). Geology is also of some importance, with trees growing on more fertile and/or wetter soils producing more nutritious leaves with higher water content (Munks *et al.* 1996).

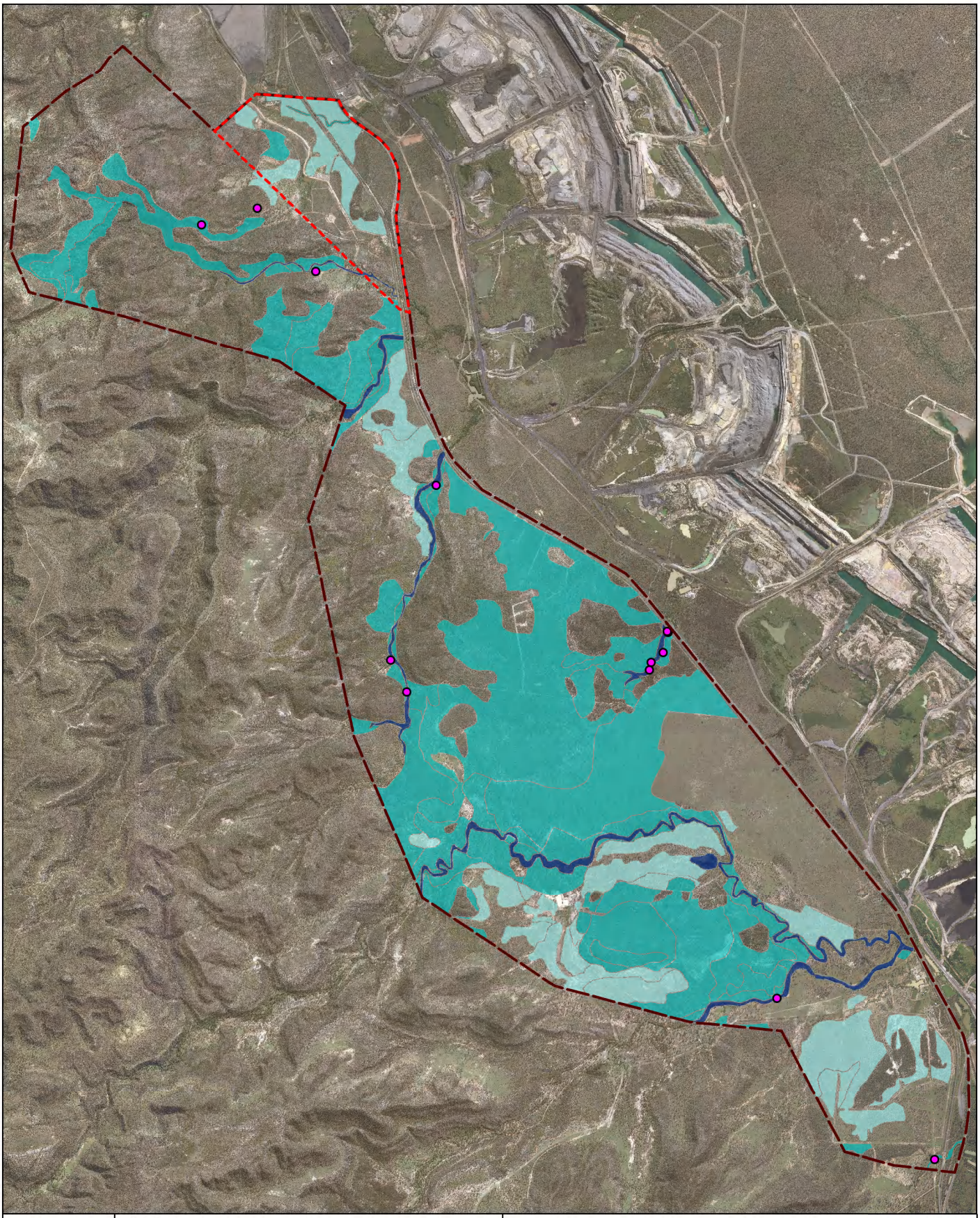
Using field-verified regional ecosystem mapping, Koala habitat was mapped using an approach similar to that of McAlpine *et al*. (2007) and Callaghan *et al*. (2011). Local *Eucalyptus* species were categorised into primary and secondary food trees based on the database maintained by the Australian Koala Foundation (2015). This database lists primary and secondary food species used by Koalas within the Isaac Regional Council area. Next, habitat quality was inferred by whether the regional ecosystems present were dominated by primary and/or secondary food tree species. As tree size is also an important second-order factor influencing koala habitat quality (e.g., Callaghan *et al*. 2011; Smith *et al*. 2013), remnant habitats were mapped as one category higher quality than regrowth habitats. This approach generated four categories of habitat quality as defined in **Table 4-5.** The distribution of these habitats across the region is shown in **Figure 4-10.**

Table 4-5 Categories of Koala habitat contained within the survey area

Habitat Type	Regional Ecosystems	Justification
Primary Habitat	Remnant 11.3.25 or 11.3.27e	Dominated by primary food trees*; abundant large trees; high subsoil moisture; abundant shady *Melaleuca* for shelter.
Secondary Habitat	Regrowth 11.3.25	As for primary habitat, but trees are less favoured due to their smaller size.
	Remnant 11.3.2, 11.3.7, 11.5.3, 11.5.9, 11.9.2, 11.10.1 or 11.10.7.	Dominated by secondary food trees†; moderate density of large trees
Marginal Habitat	Regrowth 11.3.2, 11.3.7, 11.5.3, 11.5.9, 11.9.2, 11.10.1 or 11.10.7.	Dominated by secondary food trees†; large trees (>30 cm dbh) are absent.
Non-habitat	Remnant or regrowth 11.3.1, 11.3.27c, 11.4.8, 11.4.9, 11.10.3, 11.10.8 or 11.10.13.	Primary food trees* absent. Secondary food trees† comprise less than 10% of the canopy.

*Primary food trees in the Isaac Regional Council, as described by the Australian Koala Foundation (2015), are *Eucalyptus camaldulensis* and *E. tereticornis*.

†Secondary food trees in the Isaac Regional Council, as described by the Australian Koala Foundation (2015), are *Eucalyptus brownii*, *E. coolabah*, *E. ochrophloia*, *E. orgadophila* and *E. populnea*. *Eucalyptus crebra* is also considered to be a secondary species as it is often eaten by Koalas at nearby sites (Ellis *et al.* 2002; Melzer *et al.* 2014) and the Australian Koala Foundation (2015) acknowledges that it can constitute a secondary food species in localised areas with better soils and nutrient availability.



LEGEND

- Koala Sighting
- Vulcan Complex Survey Area
- Project Area

Koala Habitat

- Primary
- Secondary
- Marginal

Data Source: Drainage Line, Road - QLD Gov. (2018); Field-verified RE Mapping, Habitat, Species Sites - METServe (2019); Survey Boundary, Bulk Sample Footprint - Vitrinite (2019).

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Vitrinite

Vulcan Complex Project
Koala Habitat

1 0 1 2 3
Kilometres
Scale: 1:75,000 (A4)

21/02/2020

Datum: GDA94
Projection: MGA55

FIGURE 4-10

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Data gathered during surveys supported the above habitat quality mapping. A total of 13 Koalas were recorded during surveys, and these were distributed as follows:

- 77% of Koalas were recorded in primary habitat, despite this comprising only 2.4% of the survey area;
- 15% of Koalas were recorded in secondary habitat, while this comprised 33.7% of the survey area;
- No Koalas were recorded in marginal habitat, despite this comprising 10.6% of the survey area;
- One Koala was recorded in non-habitat, which comprised 53.2% of the survey area. However, despite being located in a vegetation unit mapped as 11.10.3, this individual was actually within a tiny patch of RE 11.10.1 (secondary habitat, surrounded by a matrix of non-habitat) that was too small to be mapped. This likely represented a transient visitor from nearby secondary habitat, located less than 200 m away.

The survey area contains 154.6 ha of primary habitat, 2,216.5 ha of secondary habitat and 698.1 ha of marginal habitat for the Koala, while the project area contains 2.1 ha of primary habitat, 3.5 ha of secondary habitat and 112.9 ha of marginal habitat.

4.3.7.2 Greater Glider

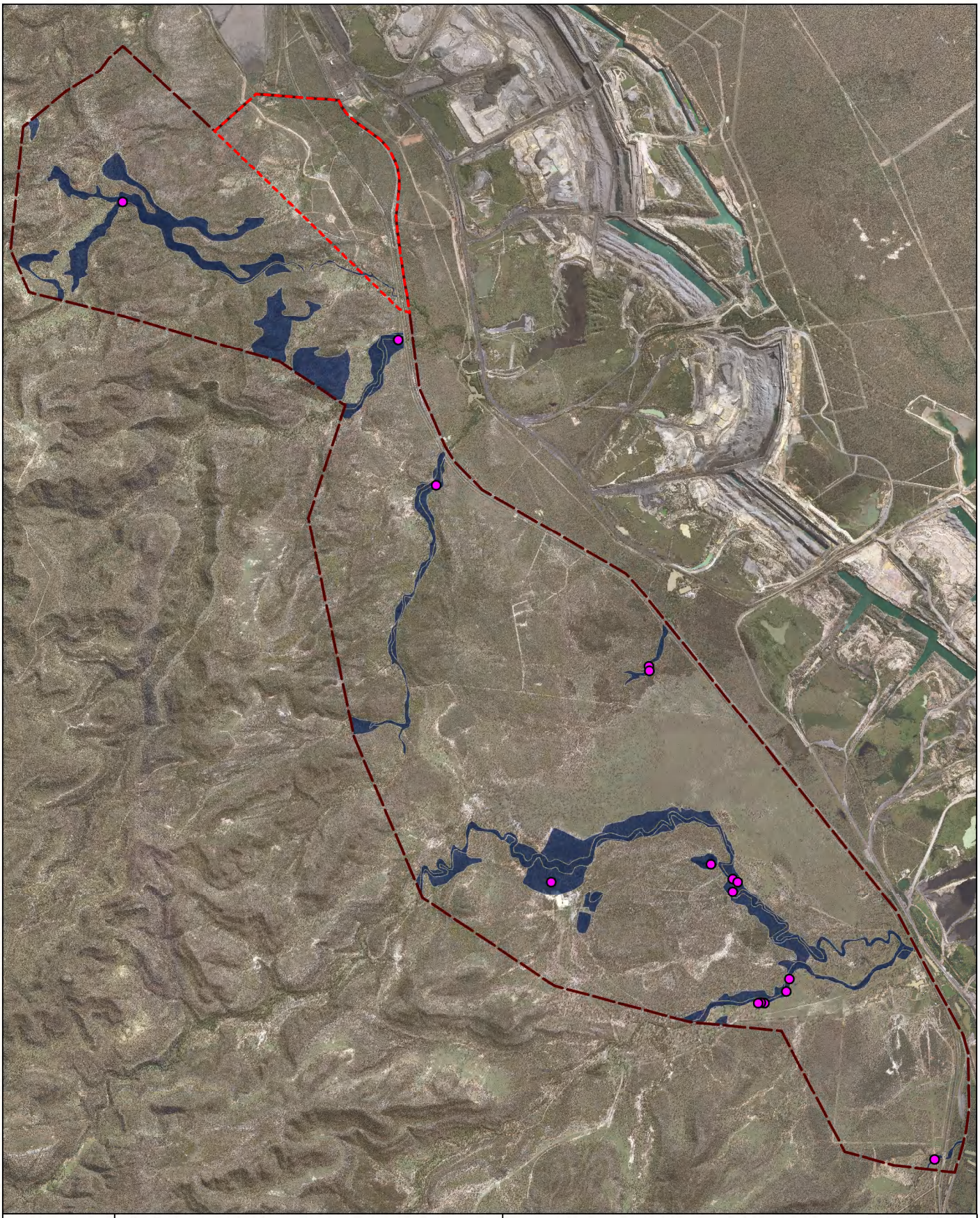
Greater Gliders inhabit a broad range of eucalypt forests across eastern Australia, with a preference for tall, montane, moist eucalypt forests with abundant hollows and a diversity of tree species present (TSSC 2016). They feed on the young leaves of eucalypts, and shelter in large hollow branches.

The Project lies near the western edge of the distribution of the northern subspecies, *P. volans minor* (Kearney *et al.* 2010). Water availability limits the distribution of the northern subspecies (Kearney *et al.* 2010). Local populations are largely restricted to riparian environments, where subsoil moisture supports suitable food trees.

A second limitation of local forests away from riparian zones is that they rarely contain a sufficient density of large hollows to support Greater Gliders. Each individual requires many large, hollow-bearing trees within its home range of 1-4 ha (Comport *et al*. 1996; Lindenmayer *et al*. 2004). Trees larger than 50 cm (diameter of trunk at breast height) are generally required in temperate climates (Kehl and Borsboom 1984), and even larger trees may be required in tropical environments, in order for hollows to be buffered against extreme daytime temperatures (Kearney *et al.* 2010). During ecological surveys of the survey area, high densities of trees of this size were very rarely encountered away from riparian zones. Nevertheless, large, hollow *Corymbia citriodora* occasionally grew in sheltered, south-facing slopes of gorges within the Harrow Range. One Greater Glider was recorded within such habitat during surveys. For this reason, regional ecosystem 11.10.1 was also considered potential habitat for Greater Gliders within the Vulcan survey area.

Non-remnant habitats (e.g. regrowth) are unlikely to be utilised by Greater Gliders, due to an absence of hollows for shelter. An exception is where many large, hollow trees were retained during clearing. The only part of the survey area where this was observed was in the far south, along Barrett Creek. Here, a pair of Greater Gliders was observed to emerge from one of the retained hollow dead trees. Riparian vegetation along Barrett Creek was therefore mapped as habitat, while regrowth elsewhere within the survey area was considered to be unsuitable for Greater Gliders.

A total of 20 individual Greater Gliders were recorded across the survey area (**Figure 4-11**). With the exception of a single record in regional ecosystem 11.10.1, all of these records were in riparian environments (regional ecosystems 11.3.25, 11.3.7, 11.3.27e and regrowth 11.3.25 with many retained large trees), despite these habitats comprising only 3.7% of the survey area. This is clear evidence for the importance of riparian habitats for local populations of the Greater Glider. In total, 469.4 ha of Greater Glider habitat are present within the survey area. Habitat for the Greater Glider is mostly lacking from the project area, although 2.1 ha is present along North Creek, in the far south of the project area.



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LEGEND

- Greater Glider Sighting
- Greater Glider Habitat
- Vulcan Complex Survey Area
- Project Area

Data Source: Drainage Line, Road - QLD Gov. (2018); Field-verified RE Mapping, Habitat, Species Sites - METServe (2019); Survey Boundary, Bulk Sample Footprint - Vitrinite (2019).

Vitrinite

Vulcan Complex Project
Greater Glider Habitat

1 0 1 2 3
Kilometres
Scale: 1:75,000 (A4)

21/02/2020

Datum: GDA94
Projection: MGA55

FIGURE 4-11

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VI002_Fig4-8_Greater Glider_RevC.pdf

Figure 4-11 Greater Glider Habitat

4.3.7.3 Squatter Pigeon

Squatter Pigeons inhabit open forests to sparse open woodlands and scrub that are dominated by *Eucalyptus, Corymbia, Acacia* or *Callitris* species, and occur within 3 km of water (Department of Environment and Energy 2019b). Foraging and breeding occurs primarily on sandy or gravelly soils (land zones 3, 5 and 7), supporting a patchy understorey of grasses and herbs, punctuated with areas of bare ground (Department of Environment and Energy 2019b).

Squatter Pigeons are not dependent on remnant vegetation communities and often favour thinned habitats where grazing cattle create favourable open patches of ground for foraging. Some introduced pastures also provide a valuable food source for the species (Crome 1976). A moderate amount of land modification probably benefits the species, reflected by long-term population increases (between 1934 and 1999) in grazing properties elsewhere in the Brigalow Belt (Woinarski and Catterall 2004). This is also supported by data comparing undisturbed woodlands near Townsville with areas disturbed by grazing or military activities; the latter two land uses supported ten times more Squatter Pigeons (Woinarski and Ash 2002).

Some degree of retained tree cover is required by Squatter Pigeons, and the Department of Environment and Energy (2019b) suggest that 100 m spacing between remnant trees is sufficient. This degree of clearing would disqualify land as remnant or regrowth under the *Vegetation Management Act 1999*. Consequently, rather than rely on regional ecosystem mapping for assessing the local distribution of Squatter Pigeon habitat, a combination of land zone and vegetation density (inferred using the Normalised Differential Vegetation Index) was used to generate a map of potential habitat. This involved the following approach:

1) The entire survey area was divided into 1-ha cells.
2) Any cells containing remnant vegetation on heavy clay (REs 11.3.1, 11.4.8, 11.4.9 and 11.9.2) or rugged sandstone ridges (REs 11.10.1, 11.10.3, 11.10.8 and 11.10.13) were considered non-habitat, due to the absence of suitable foraging substrate. Note that RE 11.10.7 was included as potential habitat, despite falling on land zone 10, due to the fact it generally occurs on the gentle lower slopes of sandstone ranges, where it approaches land zone 5 in its attributes.
3) The habitat value of the remaining cells (remnant, regrowth or cleared vegetation) was inferred by calculating the mean Normalised Difference Vegetation Index (NDVI) for each cell. NDVI is an index of the extent of live, green vegetation present. By using Landsat imagery captured following a prolonged dry spell (i.e., August 2018), when the grass was dry, the NDVI reflects the density of woody vegetation cover.
4) A total of 60 Squatter Pigeons were recorded in 28 cells during ecological surveys, and these extensive records were used to infer the range of NDVI values favoured by the species. Cells with more extreme NDVI values than the range in which Squatter Pigeons were recorded were considered non-habitat. This included both open paddocks lacking sufficient tree cover, as well as dense forest/shrubland in which Squatter Pigeons tended to be replaced by the related Common Bronzewing (*Phaps chalcoptera*). Cells with NDVI values lower than the 10th percentile of Squatter Pigeon records, and cells with a higher NVDI than the 90th percentile of Squatter Pigeon records, were classed as secondary habitat, while the NDVI values spanning the middle 80% of Squatter Pigeon records were classed as primary habitat (**Figure 4-12**).

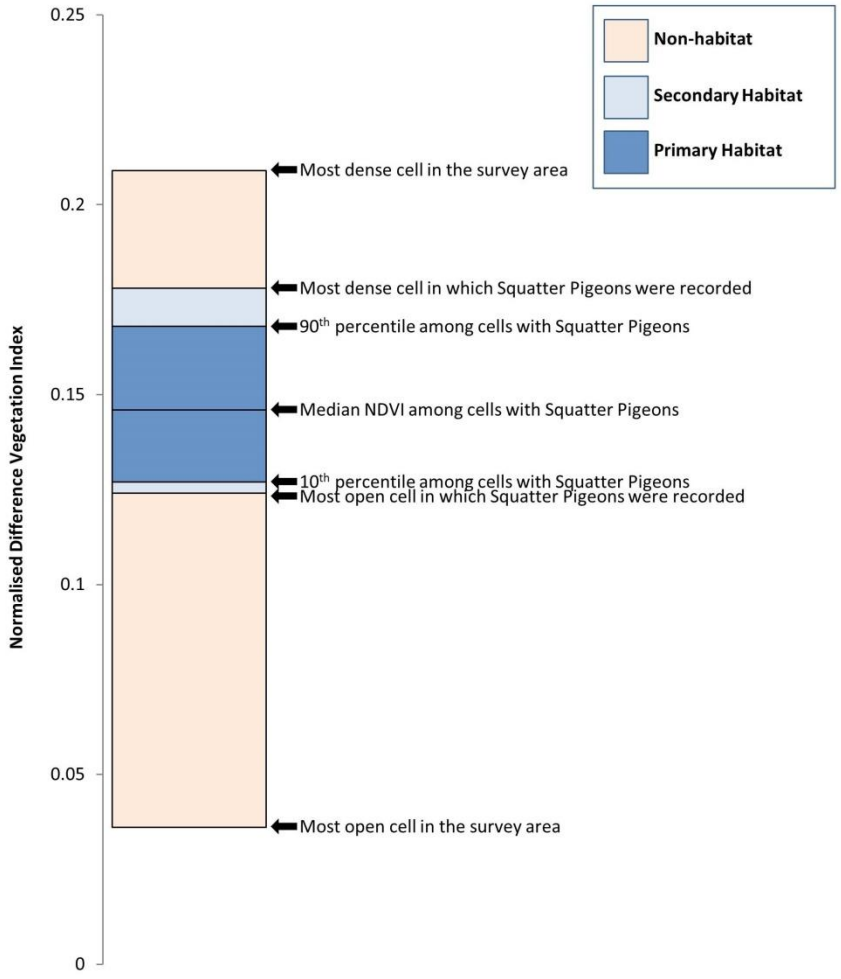
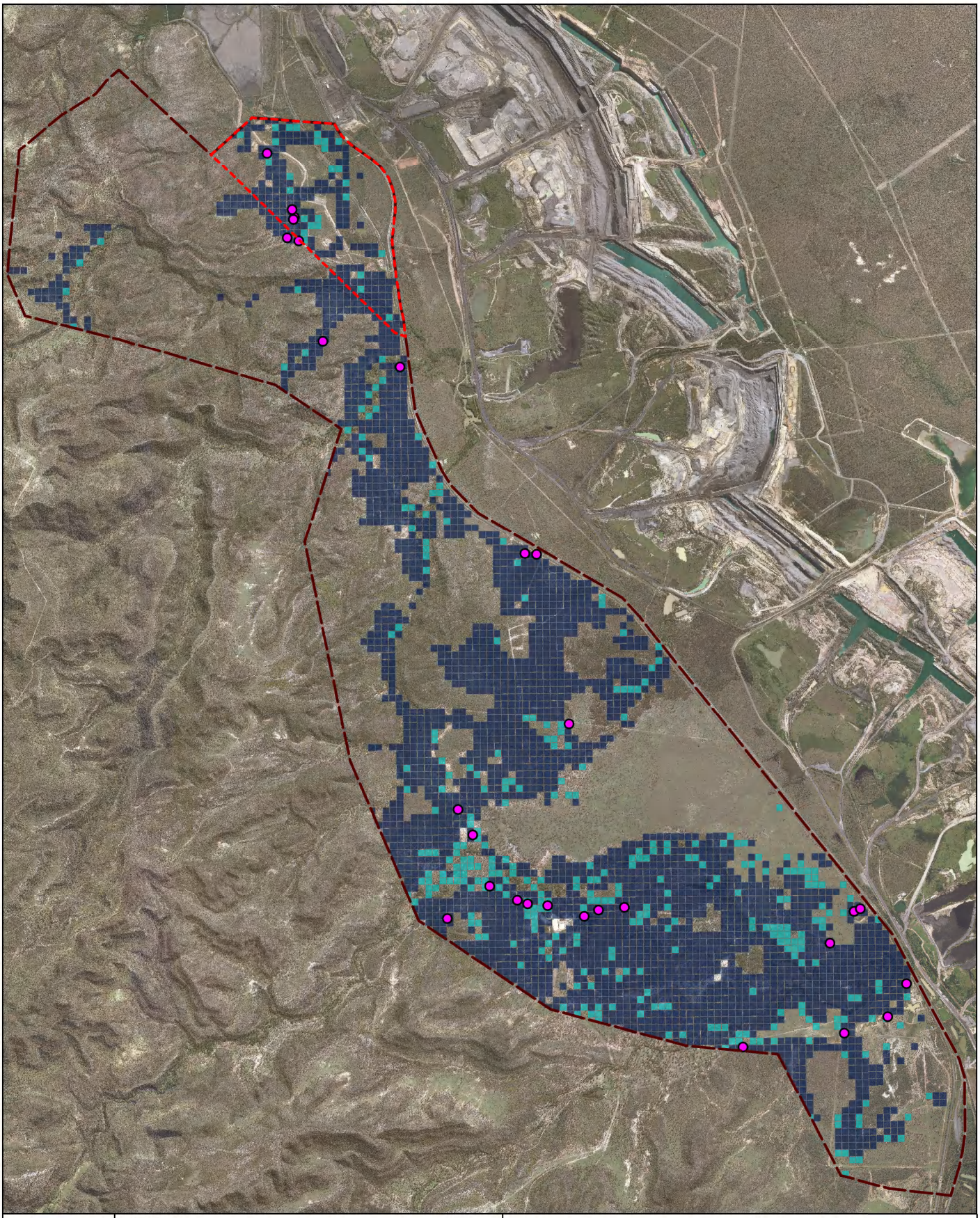


Figure 4-12 Squatter Pigeon habitat classification according to the normalised difference vegetation index

The distribution of Squatter Pigeon habitat across the survey area is shown in **Figure 4-13.** Note that proximity to water was not considered when assessing habitat quality, because the entire survey area lies within 3 km of a water source. Water is therefore unlikely to be limiting the local distribution of Squatter Pigeons.

The chief advantage of the above approach is that habitat quality was informed by local Squatter Pigeon records, rather than arbitrary classes of vegetation age or density (e.g., "regrowth" versus "non-remnant"). This is important in light of multiple local records of the species in some types of highly modified/cleared vegetation.

In total, 2,562.7 ha of primary habitat and 351.2 ha of secondary habitat are present within the survey area. Of these, 177.0 ha of primary habitat and 28.1 ha of secondary habitat are present within the project area.



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LEGEND

- Squatter Pigeon Sighting
- Vulcan Complex Survey Are
- Project Area

Squatter Pigeon Habitat

- Primary
- Secondary

Data Source: Drainage Line, Road - QLD Gov. (2018); Field-verified RE Mapping, Habitat, Species Sites - METServe (2019); Survey Boundary, Bulk Sample Footprint - Vitrinite (2019).

Vitrinite

Vulcan Complex Project
Squatter Pigeon Habitat

1 0 1 2 3
Kilometres
Scale: 1:75,000 (A4)

21/02/2020

Datum: GDA94
Projection: MGA55

FIGURE 4-13

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fig4-10_SquatterPigeon_RevB.WOR

4.3.7.4 Short-beaked Echidna

The Short-beaked Echidna is the most widespread native mammal in Australia. It is listed as Special Least Concern under the *Nature Conservation (Wildlife) Regulation 2006*. It has no particular habitat requirements other than potential den sites (beneath rocks or fallen timber) and a supply of ants and termites, on which it feeds (Augee 2008). Short-beaked Echidnas, or their scats or excavations, were recorded on seven occasions during ecological surveys. These included within remnant and non-remnant vegetation. As echidnas utilise a broad diversity of natural and modified habitats, and have very large home ranges spanning up to 100 ha (Nichol *et al.* 2011), the entire survey area (6,566.5 ha) comprises potential habitat for the Short-beaked Echidna.

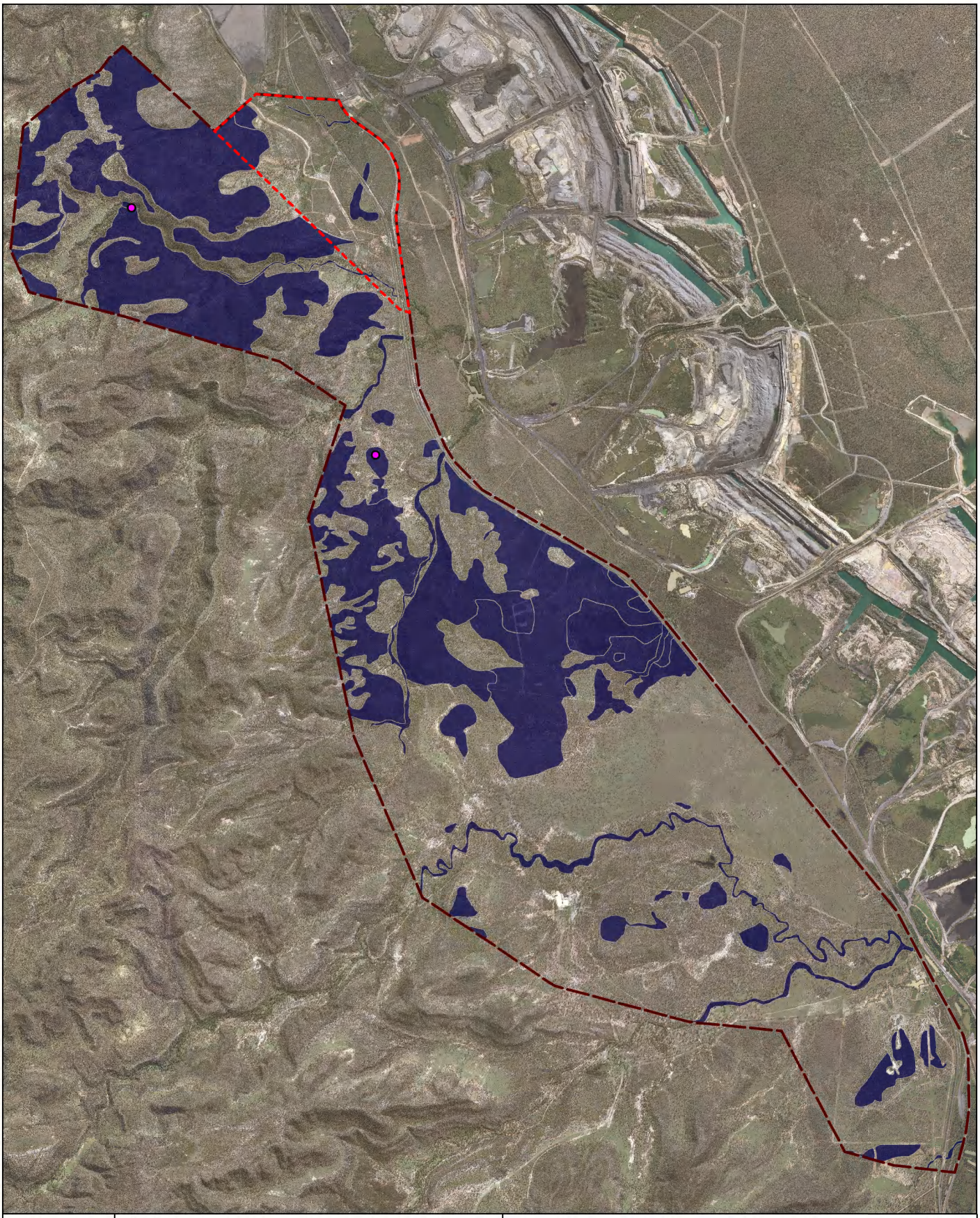
4.3.7.5 Rufous Fantail

Rufous Fantails are migratory birds that likely pass through the project area during transit in spring and autumn. They are listed as Special Least Concern under the *Nature Conservation (Wildlife) Regulation 2006*. Rufous Fantails live primarily along the east coast and nearby ranges in rainforest and wet eucalypt forests with a dense, shrubby midstorey. During migration, they can inhabit drier woodlands further west. Two individuals were recorded on site in September-October 2019: one within vine-thicket and the other within dense *Acacia* regrowth (**Figure 4-14**). It is likely that small numbers (5 to 10) pass through the survey area during each northward or southward migration. Within the survey area, habitats possessing a dense midstorey of *Acacia, Melaleuca* or vine-thicket species are most likely to be used (**Figure 4-14**). In total, 2,269.7 ha of such habitat exist within the survey area. A total of 594.3 ha of potential habitat occur within the project area.

The survey area is of marginal significance for the Rufous Fantail, given that most of the population migrates through more coastal habitats further east (based on eBird and Atlas of Living Australia records). Breeding has never been recorded in dry habitats west of the coastal ranges in central Queensland (Barrett *et al.* 2003), and is not likely within the survey area.

4.3.7.6 Fork-tailed Swift

Fork-tailed Swifts are migratory birds that visit Australia during their non-breeding season (the austral summer). They are listed as Special Least Concern under the *Nature Conservation (Wildlife) Regulation 2006*. They are exclusively aerial, foraging for flying insects in airspace above most habitats, including cleared farmland. Flocks of Fork-tailed Swifts are highly mobile and don't remain long in any one location. While no Fork-tailed Swifts were recorded during ecological surveys, it is likely that passing flocks utilise the survey area briefly and intermittently during summer.



LEGEND

- Rufous Fantail Sighting
- Rufous Fantail Habitat
- Vulcan Complex Survey Are
- Project Area

Data Source: Drainage Line, Road - QLD Gov. (2018); Field-verified RE Mapping, Habitat, Species Sites - METServe (2019); Survey Boundary, Bulk Sample Foootprint - Vitrinite (2019).

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Vitrinite

Vulcan Complex Project
Rufous Fantail Habitat

1 0 1 2 3
Kilometres
Scale: 1:75,000 (A4)

21/02/2020

Datum: GDA94
Projection: MGA55

FIGURE 4-14

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fig4-11_RufousFantailHabitat_RevA.WOR

4.3.7.7 Ornamental Snake

Ornamental Snakes feed on frogs and favour habitats supporting the temporary pooling of water where frogs breed (Department of Environment and Energy 2019c). Ornamental Snakes primarily inhabit gilgai (melon-hole) mounds and depressions in land zone 4 (deep-cracking clay plains), but also lake margins and wetlands (Department of Environment and Energy 2019c). Locally, such habitats tend to support vegetation communities dominated by *Acacia harpophylla* (broad vegetation group 25a). Areas with a diversity of gilgai sizes and depths provide optimal habitat (Department of Environment and Energy 2019c). An abundance of fallen timber is also important for shelter (Department of Environment and Energy 2019c). Cleared grasslands may also be utilised, provided that gilgais are present and some debris remains for shelter.

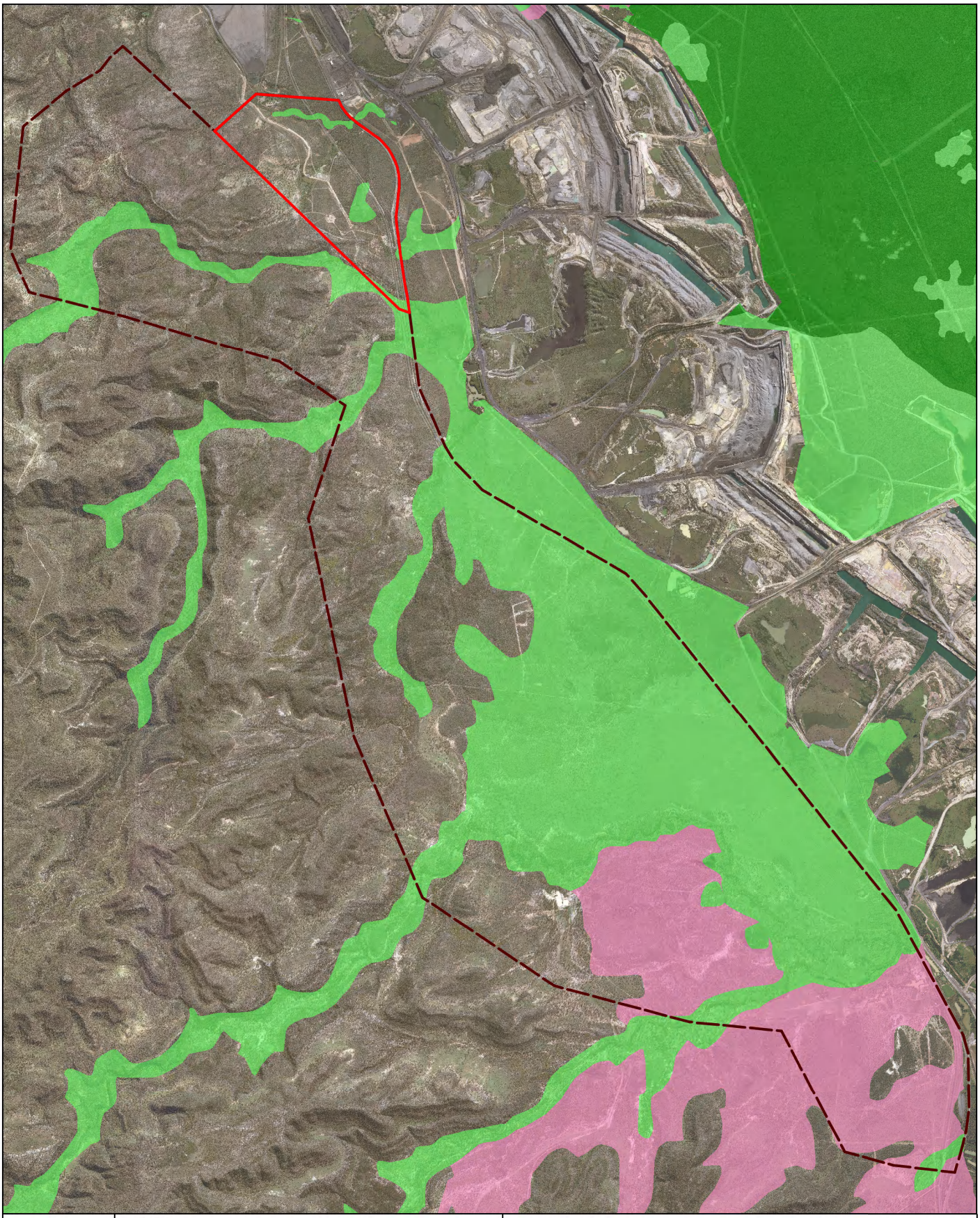
Ornamental Snakes are active, and therefore detectable, only when frogs are active (i.e., following heavy rainfall events). For the remainder of the year, most local frogs (especially the genera *Cyclorana, Platyplectrum* and *Limnodynastes*) remain buried underground, and Ornamental Snakes are similarly inactive. At optimal times of the year, Ornamental Snakes are readily detectable by spotlighting around flooded gilgais where frogs are active, or via funnel and pitfall traps installed in favourable habitats (Department of Environment and Energy 2019c).

Most of the fauna surveys undertaken on site coincided with ideal conditions for detecting Ornamental Snakes. Heavy rain events occurred midway through the October 2018 and March 2019 surveys, resulting in widespread flash-flooding and the pooling of surface water in gilgais and other depressions. Spotlighting on the nights following these rain events targeted 10 locations potentially supporting Ornamental Snakes (flooded gilgais, dams and billabongs). A total of 8 person-hours were spent spotlighting in possible habitat under optimal conditions. This represented a disproportionate search effort for this species; it equates to 18.5% of the total spotlighting effort on site, despite potential Ornamental Snake habitats constituting only 2.3% of the survey area. In addition, there were three trap sites installed in broad vegetation group 25a, and rain fell midway through the sampling of each of these. Two other trap sites were installed in *Eucalyptus populnea* woodland close to dams with potential to support Ornamental Snakes. Despite all the above search effort, no Ornamental Snakes were recorded on site.

According to the Wildnet database, Ornamental Snakes have been recorded at the adjacent Peak Downs Mine and Saraji Mine (both located immediately east of the survey area) on numerous occasions since 2000. Despite the close proximity, there are several differences between the habitat in the survey area and that present east of Saraji Road. Firstly, certified regional ecosystem mapping indicates that land zone 4 is far more widespread to the east. Within the survey area, it was confined to small, isolated patches mostly less than 5 ha in extent. Secondly, most of land zone 4 within the survey area has very minor to no gilgai development. Where gilgais occurred, these tended to be less than 30 cm deep, and held water for less than one month after heavy rain. Consequently, frog diversity and density was very low in gilgais on site. In contrast, extensive ponds and wetlands (many of which are constructed as part of water management at neighbouring mines) occur to the east of Saraji Road, and many frogs were heard calling from this direction.

Nevertheless, given that the survey area is adjacent to known populations of Ornamental Snakes, and some potential habitat occurs on site, it is likely that small numbers of Ornamental Snakes utilise the survey area. Failure to detect the species despite optimal survey conditions, combined with the poor quality of habitat present, suggests that the survey area is of marginal importance to the Ornamental Snake.

The Queensland Department of Environment and Science published a habitat suitability model for the Ornamental Snake in January 2019. This model shows that small areas of preferred habitat possibly occur within the project area, and extensive areas possibly occur within the southern half of the survey area (**Figure 4-15**).



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LEGEND

Vulcan Project Survey Area
Project Area

Ornamental Snake Habitat Value
Preferred Habitat Known
Preferred Habitat Possible
General Habitat Known
General Habitat Possible

Data Source: Vulcan survey area - Vitrinite (2019);
Ornamental Snake Data - QLD Gov, Imagery - ESRI, DigitalGlobe, GeoEye, Easrthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Vitrinite

Ornamental Snake Habitat Suitability Model Predictions (Department of Environment and Science)

0 1.5 3
Kilometres
Scale: 1:75,000 (A4)

09/06/2020

Datum: GDA94
Projection: MGA55

Figure 4-15

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fig5-6_OrnamentalSnakeHabitat_ProjectFootprint_RevA.WOR

However, there are several reasons why the mapping generated by this model was not reliable with respect to the survey area. These include:

1) The model was based on certified regional ecosystem mapping, which contained widespread errors with regards to the local distribution of *Acacia harpophylla* communities important to Ornamental Snakes;
2) The model assumed that riparian areas represented non-core habitat; however, all watercourses within the survey area had sandy beds with no surface water pools. No breeding habitat for frogs (and therefore Ornamental Snakes) was present along these watercourses; and
3) Some gilgais and well-vegetated dams occurred in areas mapped as non-remnant, which were excluded from the models. Given the high frog densities recorded at such sites, it is appropriate to include these locations as potential habitat for the Ornamental Snake.

Possible habitat mapped by the model within the project area fell into two categories:

1) sandy watercourses that did not provide habitat for frogs or Ornamental Snakes; and

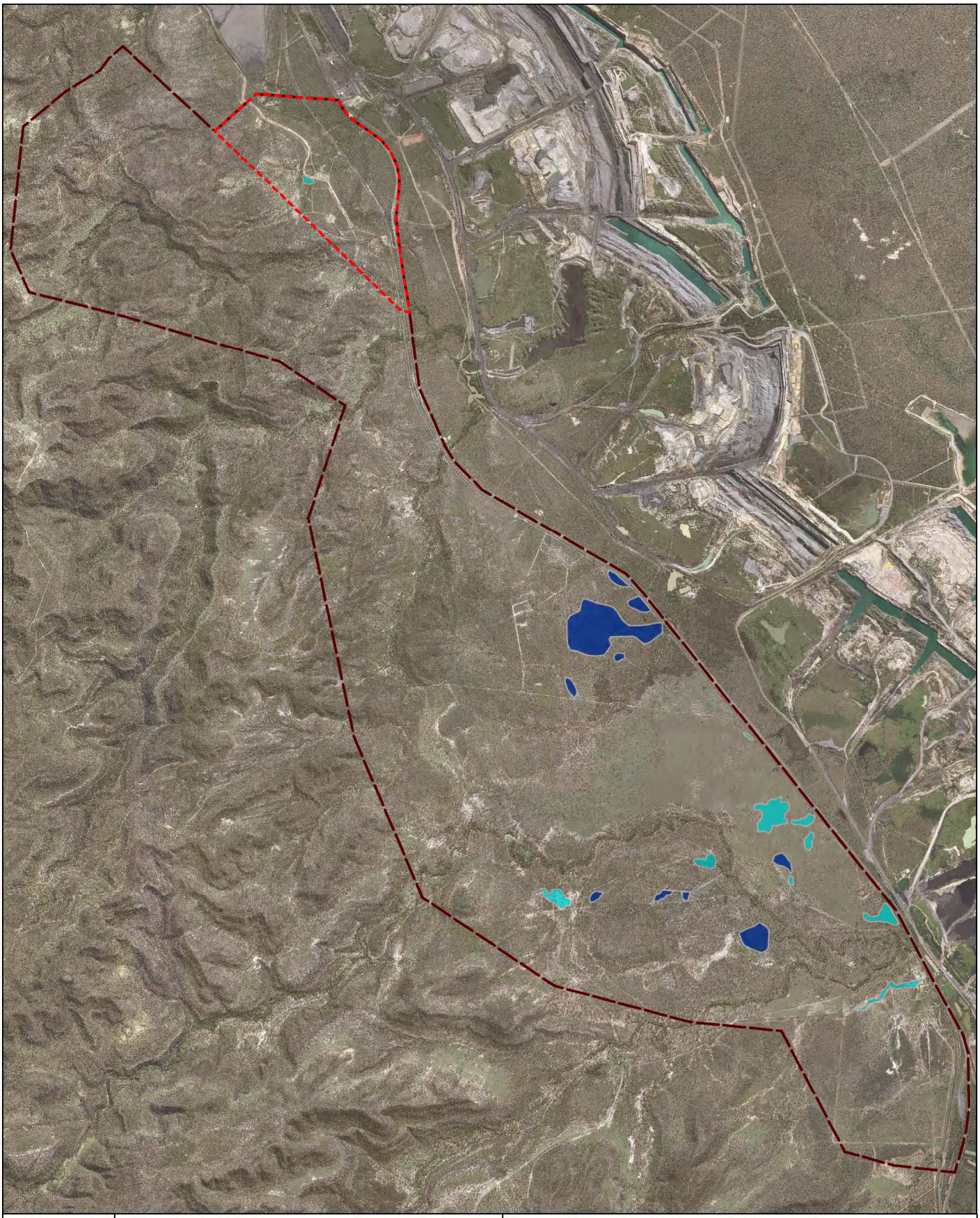
2) a patch of *Acacia shirleyi* growing on a low sandstone hill, which was misinterpreted from aerial imagery as a brigalow community (*A. harpophylla*).

Field surveys confirmed that neither of these habitats was suitable for Ornamental Snakes. However, based on field surveys, a small dam (not mapped as habitat by the model) was considered possible habitat for the species, albeit lacking the preferred clay soil and connectivity to other habitats.

For the above reasons, potential habitat for the Ornamental Snake was re-mapped based on the following principles:

1) Any patches of broad vegetation group 25a (remnant and regrowth forms of brigalow) were assumed to be primary habitat, unless field surveys confirmed that gilgais were lacking;
2) any natural wetlands with a dense cover of aquatic vegetation were assumed to be primary habitat;
3) permanent dams supporting a fringe of aquatic vegetation were considered secondary habitat;
4) gilgais within cleared pasture were considered secondary habitat; and
5) dams lacking vegetated margins, and all other locations where surface water did not pool after rain (including all creeks on site), were considered non-habitat.

The resulting habitat map (**Figure 4-16**) revealed 93.1 ha of primary habitat and 48.3 ha of secondary habitat contained within the survey area. Of this, only 1.3 ha of secondary habitat (associated with a small dam) is contained within the project area. The lack of clay soil at this dam, and its isolation from other patches of potential habitat mean that it is unlikely to support Ornamental Snakes.



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LEGEND

- Vulcan Complex Survey Area
- Project Area

Potential Ornamental Snake Habitat

- Primary
- Secondary

Data Source: Fieled-verified RE Mapping - MetServe (2019); Survey Boundary, Bulk Sample Pit Footprint - Vitrinite (2019); Imagery - ESRI, DigitalGlobe, GeoEye, Easrthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Vitrinite

Vulcan Complex Project
Potential Ornamental Snake Habitat

1 0 1 2 3
Kilometres
Scale: 1:75,000 (A4)

21/02/2020

Datum: GDA94
Projection: MGA55

Figure 4-16

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fig4-12_OrnamentalSnakeHabitat_RevB.WOR

4.3.7.8 Latham's Snipe and Australian Painted-snipe

Latham's Snipe and Australian Painted-snipe are shorebirds with similar ecological requirements. Both inhabit the muddy edges of freshwater and brackish wetlands where there exists abundant low, dense vegetation for shelter. Latham's Snipe is listed by the *Nature Conservation (Wildlife) Regulation 2006* as a special least concern species, while Australian Painted-snipe is a vulnerable species.

Neither species was recorded during ecological surveys, although both are highly mobile and behave cryptically. This makes them rarely detected during surveys. Potential habitat for both species was recorded at natural and artificial (dams) wetlands in the southern third of the survey area (**Figure 4-17**). In addition, a small dam in the northeast of the survey area (within the project area) possessed margins vegetated with suitable sedges and rushes, but the steep banks lacking areas of shallow mud limit the suitability of this habitat for Latham's Snipe and Australian Painted-snipe.

4.3.7.9 Common Death Adder

The Common Death Adder is a snake that inhabits a broad range of habitats across eastern Australia. Its chief habitat requirement is abundant shelter in the form of leaf litter, woody debris and/or rocks. A low density of Cane Toads (*Rhinella marina*) is important, as ingested toads cause lethal poisoning (Phillips *et al.* 2009). Habitats well away from permanent water (where toads congregate and breed) are therefore likely to be most important for the species.

No Common Death Adders were recorded during ecological surveys. However, the species was recently recorded (in 2012) 25 km northeast of the Project, and it is possible that populations persist on site despite high densities of Cane Toads. Within the survey area, the sandstone ridges in the western half probably contain the most valuable habitat for the species. Such habitats have the highest density of shelter sites and lowest densities of toads.

4.3.7.10 Red Goshawk

The Red Goshawk formerly had a wide distribution across northern and eastern Australia, occupying a variety of forested environments, but favouring the ecotone between dense forest and open woodland, especially near rivers and wetlands. In partly cleared parts of eastern Queensland it is associated with gorge and escarpment country (TSSC 2015). Within the last two decades, it has largely disappeared from the southern half of its former distribution. Since 2000, there have been very few (possibly no) confirmed records within New South Wales, where it is listed as critically endangered (NSW Scientific Committee 2008). Likewise, over the past 20 years in Queensland there are very few records of the species south of Townsville. The Birdata database lists a single record (from Main Range, southeast Queensland, in 2000), while the eBird database contains a single record (from Maryborough, in 2005). Neither record is supported by photographic evidence. A total of 10 Queensland records south of Townsville since 2000 are listed within the Wildnet database, without details to assess their validity. Given the propensity for misidentification of the species (Department of Environment and Resource Management 2012), it is likely that many of these records are erroneous. Some of the records (especially those older than ten years) are undoubtedly authentic, given that at least three nests were known in southeast Queensland between 2001 and 2003 (Czechura *et al.* 2010). However, extensive targeted surveys at the same locations between 2013 and 2014 failed to find any Red Goshawks (Seaton 2014).

The survey area occurs within the historical distribution of the Red Goshawk. Potential habitat for the species occurs on site, although it is not of high quality; escarpments and nearby waterways mostly lack surface water, and the surrounding landscape is highly modified through mining and clearing for grazing. The Red Goshawk rarely breeds in areas with fragmented native vegetation (TSSC 2015), and never more than 1 km from water. The project area, in particular, mostly contains low-quality, cleared habitats.

While it is considered possible that dispersing Red Goshawks may occasionally use the survey area, the importance of the site to the species is considered to be low.



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LEGEND

- Watercourse
- Vulcan Complex Survey Area
- Project Area
- Potential Habitat

Data Source: Survey Boundary - Vitrinite (2019); Habitat - MetServe (2019); Imagery - ESRI, DigitalGlobe, GeoEye, Easrthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Vitrinite

Vulcan Complex Project
Potential Habitat for Australian Painted-snipe and Latham's Snipe

1 0 1 2 3
Kilometres
Scale: 1:75,000 (A4)

21/02/2020

Datum: GDA94
Projection: MGA55

Figure 4-17

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fig4-13_SnipesHabitat_RevB.WOR

4.3.7.11 Yakka Skink

Yakka Skinks are large, gregarious lizards that inhabit a broad range of woodland and forest communities across sub-coastal and semi-arid Queensland (Department of Environment and Energy 2019d). Yakka Skinks live in colonies within cavities under and between partly buried rocks, logs or tree stumps, root cavities and abandoned animal burrows (Department of Environment and Energy 2019d). They remain in close proximity to their burrows, and are only active for brief periods at dawn and dusk (Department of Environment and Energy 2019d). This, combined with their low density, makes them difficult to detect.

No Yakka Skinks were recorded during surveys on site. Detectability is greatest during warm, humid conditions (Department of Environment and Energy 2019d), and the surveys were therefore under optimal conditions. Nevertheless, given the large size of the survey area, it was not practical to inspect every possible burrow location within it.

Despite numerous surveys undertaken across the northern Bowen Basin (Dysart-Moranbah-Collinsville) as part of various mining projects, Yakka Skinks have never been recorded there. The nearest record (a Queensland Museum specimen) of this species is from the vicinity of Blackwater, 130 km to the south. Nevertheless, there are scattered records of Yakka Skinks as far north as Cape York, and there remains a slight possibility that the species occurs within the survey area.

If present, they may occur in any wooded habitat (remnant and regrowth), as all contain some degree of rock outcropping or woody debris, which can provide structural support for a burrow.

4.3.7.12 Annual Wiregrass

The Annual Wiregrass is thought to be restricted to the black clay soils of central Queensland (Simon 1984), which is where almost all herbarium specimens have been collected. These soils are mostly derived from basalt and support native grasslands or open woodlands dominated by *Eucalyptus orgadophila, Eucalyptus crebra* or *Eucalyptus melanophloia*. One specimen (held at the Queensland Herbarium) was anomalously collected by D. Osten "on a ridge...[with] sandy red loam". However, according to regional ecosystem mapping, the collection location falls within land zone 8 (clay soil derived from basalt), and the habitat reported is probably erroneous.

No basalt-derived soil exists within the survey area, but black clay soils derived from fine-grained sedimentary rock occur on site and support similar vegetation communities (regional ecosystem 11.9.2). However, these areas were heavily degraded by grazing, with the exotic pasture grass *Bothriochloa pertusa* comprising more than 90% of the vegetation cover. No areas dominated by native grasses were observed on clay soil.

No Annual Wiregrass was recorded during flora surveys. Elsewhere in central Queensland, the species has been collected in flower (when easiest to detect and identify) between February and June. The survey period coincided with the start of this period. Given the early start to the 2018-2019 growing season (e.g., heavy rain commenced in October 2018), and the abundance of flowering annual grasses of other species recorded in February 2019, it is expected that, if present, Annual Wiregrass would have been flowering and readily detectable at the time of survey.

The survey area lies outside the known distribution of Annual Wiregrass; however, the nearest record is only 35 km southwest. Given that potential habitat for this threatened grass exists within the survey area, its occurrence on site is considered possible. However, based on the highly degraded nature of the habitat present, the survey area is likely to be of negligible importance to the species. No habitat for the species exists within the project area.

4.3.7.13 Ghost Bat

Ghost Bats are large, carnivorous bats whose distribution is primarily limited by suitable roost sites. Ghost bats roost and breed in caves that comprise a small entrance hole and a large chamber, where conditions remain warm and humid year-round (Toop 1985; Armstrong and Anstee 2000). Roost sites are often 30-50 m deep within the cave, where conditions are most stable (Armstrong and Anstee

2000). However, smaller caves may be used transiently (Armstrong and Anstee 2000). Ghost Bats move between a number of caves seasonally or as dictated by weather conditions, and require a range of cave sites. Ghost Bats also colonise disused mines, especially those that are deep and complex, with an isothermal zone (Armstrong and Anstee 2000).

Ghost Bats forage in a wide range of native vegetation types. Foraging areas average 61 ha in size, and are generally within 1-10 km of roost sites (Tideman *et al.* 1985; Diete *et al.* 2016).

Suitable roost sites are scarce across eastern Queensland. There are only two known breeding colonies of Ghost Bats in central eastern Queensland: at Rockhampton and Cape Hillsborough. Genetic studies indicate that these populations are isolated from other populations and each other (Worthington Wilmer *et al*. 1999). This suggests a general lack of suitable breeding habitat elsewhere in central eastern Queensland (Worthington Wilmer *et al*. 1999). Ghost Bats may disperse in winter 20-50 km from the maternity roosts (Toop 1985), and the closest record of a dispersing individual (presumably from Cape Hillsborough) is at the Clarke Range (80 km northeast of the survey area).

The survey area is well outside the known winter dispersal and foraging zones of the two central Queensland populations of Ghost Bats. However, given that the existence of unknown breeding sites is possible, and the proliferation of mining across the Bowen Basin may have inadvertently created new roosting habitats (in disused mines), it is considered possible that the survey area may be used intermittently by Ghost Bats. This use would solely be in a foraging capacity, as none of the sandstone ridges on site supported caves of a size and structure suitable as a roost site. No Ghost Bats were recorded during surveys.

4.3.7.14 Dunmall's Snake

The Dunmall's Snake is poorly known and rarely recorded. The species inhabits a variety of wooded habitats, ranging from *Acacia harpophylla* on cracking clay soil to *Eucalyptus citriodora, Eucalyptus crebra* and *Eucalyptus melanophloia* open forest on sandstone-derived soil (Department of Environment and Energy 2019e). In the *Draft Referral Guidelines for the Nationally Listed Brigalow Belt Reptiles*, important habitat for the species is defined as any forest or woodland "within the 'Known/Likely to occur' modelled distribution of the species…and any habitat corridors in between" (Department of Sustainability, Environment, Water, Population and Communities 2011). Despite containing potential habitat for the species, the survey area lies outside the known/likely distribution of the Dunmall's Snake, as modelled in the *Draft Referral Guidelines for the Nationally Listed Brigalow Belt Reptiles*. It is, therefore, not considered "important habitat" for the species. Nevertheless, the survey area lies within the modelled "may occur" zone, and given the difficulty associated with detecting this highly cryptic species, its presence on site is considered possible. No Dunmall's Snakes were detected during surveys. The nearest record is from Clermont, 80 km southwest of the survey area.

4.3.7.15 Allan's Lerista

Allan's Lerista is a skink that is confined to black soil downs (undulating plains formed primarily on basalt) in the vicinity of Clermont. It burrows within the upper profile of heavy clay soil under tussocks of grass (Department of the Environment and Energy 2019f). It is typically recorded from *Eucalyptus orgadophila* and *Corymbia erythrophloia* open woodlands (Department of the Environment and Energy 2019f).

No Allan's Leristas were found during surveys. The nearest known population to the survey area is 30 km west. However, it is separated from the survey area by a 130-km long sandstone ridge, which likely constitutes an important barrier to dispersal. The species has never been recorded east of this ridge.

The *Draft Referral Guidelines for the Nationally Listed Brigalow Belt Reptiles* (Department of Sustainability, Environment, Water, Population and Communities 2011) defines suitable habitat for the species as being regional ecosystems 11.8.5 and 11.8.11, both of which are lacking from the survey area. Nevertheless, regional ecosystem 11.9.2 (*E. orgadophila* open woodland on soil derived from

fine-grained sedimentary rock) occurs on site, and closely resembles 11.8.5 in its floristics and soil attributes. Furthermore, models within the *Draft Referral Guidelines for the Nationally Listed Brigalow Belt Reptiles* indicate that the species may occur within the survey area, despite the site being outside the modelled "known/likely to occur" zone. Taken together, it remains possible that the Allan's Lerista occurs within the survey area, but based on current knowledge the survey area does not contain important habitat for the species. No potential habitat for the species exists within the project area.

4.3.7.16 Special Least Concern Birds

In addition to the Rufous Fantail, Latham's Snipe and Fork-tailed Swift—birds known or considered likely to utilise the survey area transiently—six other special least concern bird species may be possible visitors. Three of these (Oriental Cuckoo, Black-faced Monarch and Satin Flycatcher) are migrants inhabiting rainforest, tall open forest and riparian corridors near the coast and nearby ranges. All three occasionally stray further inland, where they are most likely to utilise denser vegetation along watercourses. The survey area, and project area within it, may occasionally be visited by all three species, but only in a transient capacity. As the survey area is west of their primary migration routes, it does not constitute important habitat for the Oriental Cuckoo, Black-faced Monarch or Satin Flycatcher.

The remaining three species (Sharp-tailed Sandpiper, Gull-billed Tern and Glossy Ibis) are waterbirds that normally inhabit extensive lakes and wetlands. Sharp-tailed Sandpipers and Glossy Ibis depend on wetlands with shallow, muddy margins and short, damp vegetation. Gull-billed Terns require large, open expanses of water in which to fish. The natural wetlands present on site are too small and/or are too heavily treed to provide favourable habitat for these three species. However, two dams constitute marginal habitat that may be used briefly under optimal weather conditions (i.e., when retreating water levels expose muddy banks). Both of these dams are located in the southern half of the survey area, outside the project area. None of the habitat present within the survey area is considered important for any of these three special least concern waterbirds.

4.3.7.17 King Blue-grass

King Blue-grass inhabits native grasslands and open woodlands on black cracking clay soil derived from basalt. The species also colonises pastures established following the clearance of *Acacia harpophylla* and other dense vegetation communities growing on heavy clay soil. King Blue-grass cannot tolerate continual heavy stocking regimes, and is outcompeted by exotic grass species and weeds, which tend to dominate heavily grazed pastures (Fensham 1999). For this reason, most extant populations are confined to road reserves and other sites semi-protected from grazing livestock.

Heavy clay soils supporting grasses are represented within the survey area by remnant regional ecosystem 11.9.2 and cleared pastures that formerly supported regional ecosystem 11.4.8. Both habitats have been subjected to long periods of heavy grazing. This has led to the almost complete replacement of native perennial grasses with the exotic *Bothriochloa pertusa.* Road verges protected from grazing livestock were dominated by other weed grasses, such as *Cenchrus ciliaris, Megathyrsus maximus, Chloris* spp. and *Hyparrhenia rufa*. Nowhere within the survey area were clay soils observed to support a native grassland community. No clay soils are present within the project area.

The nearest recorded King Blue-grass is in the vicinity of Moranbah Airport, 30 km north of the survey area. While the species possibly once inhabited the survey area, its continued existence is unlikely under current grazing regimes.

4.4 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

Matters of national environmental significance are those protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). These include:

1. World heritage places;
2. National heritage places;
3. Wetlands of international importance;
4. Listed threatened species and ecological communities;

5. Migratory species protected under international agreements;
6. Commonwealth marine areas;
7. The Great Barrier Reef Marine Park;
8. Nuclear actions; and
9. A water resource, in relation to coal seam gas development and large coal mining development.

The last two matters on the list are not ecological matters, and are assessed elsewhere. Of the remainder, the only matters of national environmental significance present in the vicinity of the Project are 4 and 5.

4.4.1 Threatened Ecological Communities

One threatened ecological community was confirmed to be present within the survey area. Two other vegetation communities present on site possessed attributes similar to listed threatened ecological communities, but did not meet the criteria for these listed communities. Each of these three ecological communities is discussed below.

4.4.1.1 Brigalow

A total of 149.7 ha of the threatened ecological community listed as "Brigalow (*Acacia harpophylla* dominant and co-dominant)" are contained within the survey area. This includes remnants and high-quality regrowth of the constituent regional ecosystems, 11.3.1, 11.4.8 and 11.4.9 (see **Figure 4-3**) (Department of the Environment 2013b). None of this occurred within the project area.

4.4.1.2 Poplar Box Woodland on Alluvium

The ecological community listed under the EPBC Act as "Poplar Box Grassy Woodland on Alluvial Plains" broadly corresponds to remnant and high-value regrowth forms of regional ecosystem 11.3.2, among others not found on site. A total of 128 ha of remnant 11.3.2 and 148.6 ha of regrowth 11.3.2 occur within the survey area, mostly along Hughes Creek. No 11.3.2 occurred within the project area.

According to the draft conservation advice for this ecological community, in order to be considered a Matter of National Environmental Significance, areas of the ecological community must meet key diagnostic characteristics and condition thresholds. One key diagnostic characteristic listed by the draft conservation advice is a "ground layer (<1 m) mostly dominated across a patch by native grasses, other herbs and occasionally chenopods". Dominance is defined as "accounting for more than 50% of the cover". None of the regional ecosystem 11.3.2 within the survey area met this criterion. Weeds (non-native species) comprised 91.8% and 92.9% of the ground layer at the two secondary sites sampled in remnant 11.3.2. These two sites were in the largest, best-quality examples of the community available. This high weed density was typical of ecosystems on alluvial soils in general; weeds made up an average of 82.2% of the ground layer in 11.3.25.

Within the survey area, *Eucalyptus populnea* (Poplar Box) also formed ecological communities on sand plains. Here, three out of seven secondary sites sampled met the criterion of being dominated by native ground layer species. These sites were on very sandy, leached soils unfavourable for weed establishment. These soil conditions are characteristic of non-alluvial sites, which do not form part of the Poplar Box Grassy Woodland on Alluvial Plains.

Given the dominance of weeds across alluvium within the survey area, none of the *E. populnea* woodlands occurring there qualify as a threatened ecological community under the EPBC Act.

4.4.1.3 Semi-evergreen Vine Thicket

A small area (1.3 ha) of semi-evergreen vine thicket is located in a gorge in the upper reaches of North Creek. Floristically, this resembles the threatened ecological community listed under the EPBC Act as "Semi-evergreen Vine Thickets of the Brigalow Belt (North and South) and Nandewar Bioregions". However, the particular regional ecosystem assigned to this vine thicket (11.10.8) is not included in the listed threatened ecological community, on the grounds that it occurs on coarse-grained sedimentary rock (Department of Environment and Energy 2019g).

4.4.2 Threatened Species

Of the matters of State environmental significance potentially found within the survey area (see **Table 4-4**), three confirmed species, one likely species and eight possible species are also threatened under the EPBC Act:

- Koala (vulnerable);
- Greater Glider (vulnerable);
- Squatter Pigeon (vulnerable);
- Ornamental Snake (vulnerable);
- Australian Painted-snipe (endangered);
- Red Goshawk (vulnerable);
- Yakka Skink (vulnerable);
- Annual Wiregass (vulnerable);
- Ghost Bat (vulnerable);
- Dunmall's Snake (vulnerable);
- Allan's Lerista (endangered); and
- King Blue-grass (endangered).

For an assessment of potential habitat for each of these, refer to **Section 4.3.7**. Three species flagged by the literature review as being potentially present within the region constitute matters of national, but not State, significance (**Table 4-6**). Two of these (Northern Quoll and Hairy Bluegrass) are considered possible inhabitants of the survey area.

Table 4-6 Matters of national environmental significance that are not matters of State significance

Taxon	Species	Common Name	EPBC status*	NC status†	Habitat requirements	Presence in survey area‡
Mammal	*Dasyurus hallucatus*	Northern Quoll	E	LC	Rugged escarpments in wetter forested areas.	P
Grass	*Dicanthium setosum*	Hairy Bluegrass	V	LC	Grasslands or open woodland on clay soils, with low grazing pressure.	P
Mammal	*Pteropus poliocephalus*	Grey-headed Flying-fox	V	LC	Rainforests and wet eucalypt forests well south and east of the survey area. No records within 100 km.	U

*Status under the *Environment Protection and Biodiversity Conservation Act 1999*: E = endangered, V = vulnerable.
†Status under the *Nature Conservation Act 1992*: LC = least concern.
‡Presence within the Project area and the broader survey area in which the Project is contained: C = presence confirmed, L = likely to be present, P = possibly present, U = unlikely to be present.

4.4.2.1 Northern Quoll

The Northern Quoll inhabits a broad range of habitats across eastern and northern Australia. The *EPBC Act Referral Guideline for the Endangered Northern Quoll* (Department of the Environment 2016) defines critical habitat as "habitat within the modelled distribution of the northern quoll which provides shelter for breeding, and refuge from fire, predation and potential poisoning from Cane Toads". These can include rocky habitats, treed creek lines and structurally diverse forest with large trees, termite mounds and hollow logs (Department of the Environment 2016). The survey area occurs within the modelled distribution of the Northern Quoll (Department of the Environment 2016). Within the survey area, critical habitats were found on land zones 3 and 10. Land zone 10, particularly in the northwest of the survey area, contained boulder-strewn escarpments and gorges, which are potentially important for Northern Quolls (Pollock 1999; Woinarski *et al.* 2008; Hill and Ward 2010).

Den sites close to (within 300 m of) permanent fresh water are preferred by the species (Pollock 1999); such sites were very scarce within the survey area (**Figure 4-18**).

The two major threats to Northern Quolls (Feral Cats and Cane Toads: Hill and Ward 2010) were common and widespread across the survey area.

The *EPBC Act Referral Guideline for the Endangered Northern Quoll* (Department of the Environment 2016) recommends a minimum of ten baited remote-sensory cameras to be deployed for four nights each (total of 40 camera-nights). The current survey included 122 camera-nights of sampling, in addition to 31 trap-nights of cage trapping. These surveys failed to detect any Northern Quolls.

In recent decades, the Queensland distribution of the Northern Quoll has contracted towards the most rugged habitats close to the coast (Braithwaite and Griffiths 1994; Woinarski *et al.* 2008). The nearest recent (post-2000) records of the Northern Quoll are from the Clarke Range, 100 km northeast of the survey area. No Northern Quolls have ever been detected at neighbouring mines within the Bowen Basin.

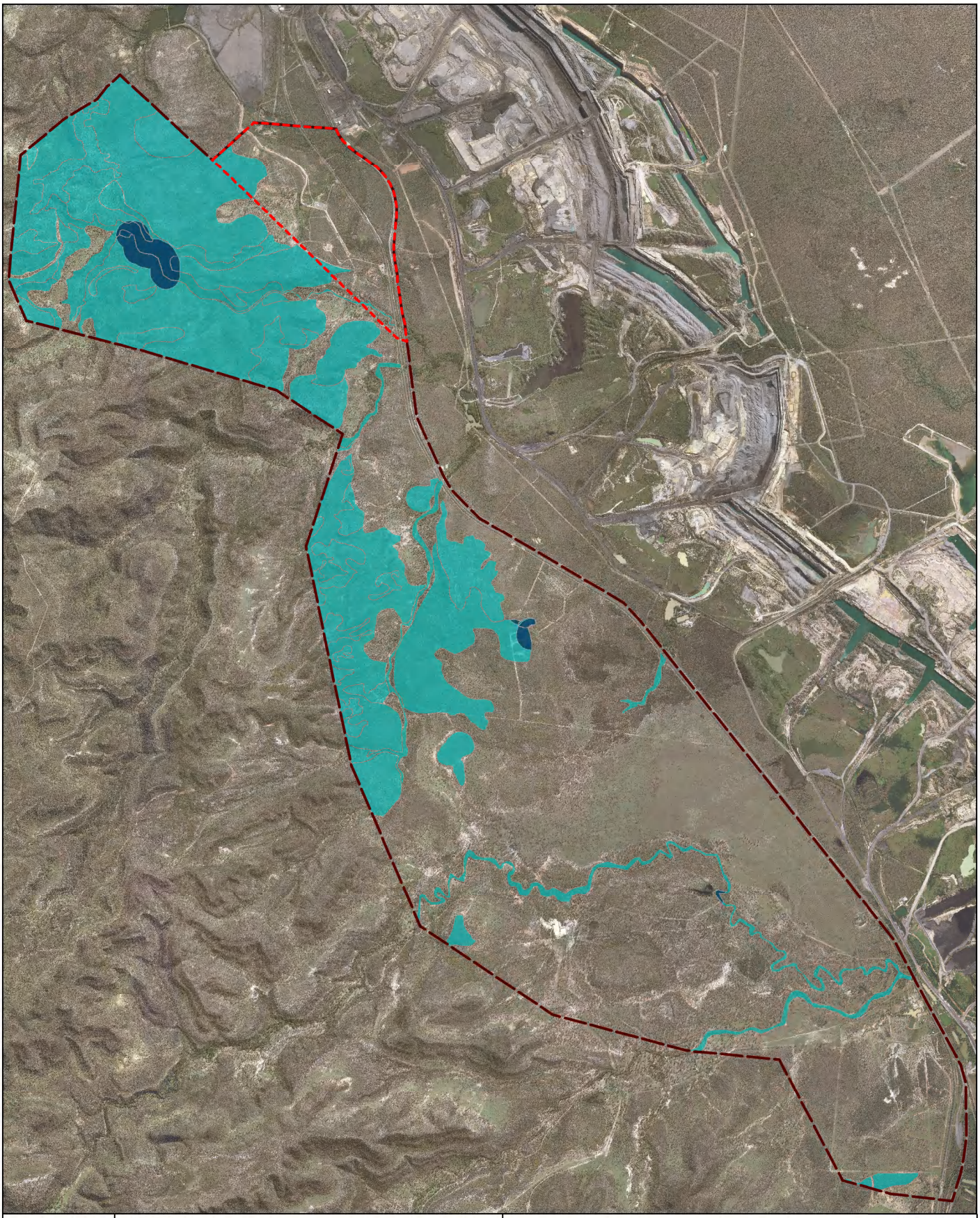
The lack of nearby records despite extensive ecological surveys undertaken in the Moranbah region in recent decades may suggest that the Northern Quoll is extinct in the region. Nevertheless, as the habitat present on site meets the criteria specified in the *EPBC Act Referral Guideline for the Endangered Northern Quoll*, the presence of the species within the survey area remains a possibility. If present, the local population is expected to be of very low density, given the lack of detection, abundance of toads and cats, and the relative paucity of surface water in rocky areas.

4.4.2.2 Hairy Bluegrass

Hairy Bluegrass is associated with heavy basaltic black soils and red-brown loams with clay subsoil (Department of the Environment and Energy 2019h). It is tolerant of a moderate amount of disturbance, but excessive grazing and invasion of exotic grasses threatens the species (Department of the Environment and Energy 2019h). All clay soils within the survey area were dominated by the exotic pasture grass *Bothriochloa pertusa*. No native grass communities were observed on clay within the survey area. Furthermore, no clay soils occurred within the project area.

Hairy Bluegrass has a patchy distribution across subcoastal eastern Australia. Based on herbarium records, there appears to be a 280 km gap between known populations at Springsure and Glenden. The survey area occurs within this gap; the nearest known record is 95 km to the north.

Despite the survey area being within the known distribution of the species, and potential habitat occurring on site, the lack of local records and the heavily degraded nature of the available habitat suggest that the survey area is not important for the Hairy Bluegrass. No potential habitat for the species occurs within the project area.



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Vulcan Complex Survey Area
Project Area

Potential Northern Quoll Habitat

Habitat within 300 m of Water
Potential Habitat (Landzone 3 and 10)

Data Source: Field-verified RE Mapping, Habitat - METServe (2019); Survey Boundary - Vitrinite (2019); Imagery - ESRI, DigitalGlobe, GeoEye, Easrthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Vitrinite

Vulcan Complex Project
Potential Northern Quoll Habitat

1 0 1 2 3
Kilometres
Scale: 1:75,000 (A4)

21/02/2020

Datum: GDA94
Projection: MGA55

Figure 4-18

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fig4-14_NorthernQuollHabitat_RevB.WOR

4.4.3 Migratory Species

Migratory species listed in the following international agreements are protected under the EPBC Act as matters of national environmental significance:

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

One listed migratory species, the Rufous Fantail, was detected within the survey area. Two additional species (Fork-tailed Swift and Latham's Snipe) are likely visitors, and an additional six species (Sharp-tailed Sandpiper, Oriental Cuckoo, Gull-billed Tern, Black-faced Monarch, Satin Flycatcher, Glossy Ibis) are possible visitors. All of these are listed as special least concern species under the *Nature Conservation (Wildlife) Regulation 2006*, and are discussed in **Sections 4.3.7.5, 4.3.7.6**, **4.3.7.8** and **4.3.7.16**.

For no migratory species does the survey area contain "important habitat" that supports an "ecologically significant proportion of the population", as defined by the *Matters of National Environmental Significance: Significant Impact Guidelines 1.1* (Department of the Environment 2013a), *Referral Guidelines for 14 Birds Listed as Migratory Species under the EPBC Act* (Department of the Environment 2015) and *Industry Guidelines for Avoiding, Assessing and Mitigating Impacts on EPBC Act Listed Migratory Shorebird Species* (Department of Environment and Energy 2017).

4.5 WEEDS AND PEST ANIMALS

A total of 56 species of non-native plants were recorded within the survey area. Of these, the following weeds were most widespread, occurring at 30% or more of sampling sites:

- *Bothriochloa pertusa* (Indian Couch);
- *Sida spinosa* (Spiked Sida);
- *Cenchrus ciliaris* (Buffel Grass);
- *Melinis repens* (Natal Grass);
- *Portulaca pilosa* (Hairy Portulaca);
- *Stylosanthes scabra* (Shrubby Stylo); and
- *Urochloa mosambicensis* (Sabi Grass).

Seven species of weeds present within the survey area are category 3 restricted matters under the *Biosecurity Act 2014*, which prohibits their sale, trade or spread. These restricted weeds are:

- *Cryptostegia grandiflora* (Rubber Vine);
- *Harrisia martinii* (Harrisia Cactus);
- *Hymenachne amplexicaulis* (Olive Hymenachne);
- *Jatropha gossypiifolia* (Bellyache Bush);
- *Opuntia stricta* (Prickly Pear);
- *Opuntia tomentosa* (Velvet Pear); and
- *Parthenium hysterophorus* (Parthenium).

All of the above, except *H. martini*, are also classed as Weeds of National Significance. While this classification does not introduce additional restrictions, it acts to coordinate management across states.

The following eight species of non-native animals were recorded within the survey area:

- Feral Cat (*Felis catus*)*;
- Red Fox (*Vulpes vulpes*)*;
- Dingo (*Canis lupus dingo*)*;
- European Rabbit (*Oryctolagus cuniculus*)*;
- House Mouse (*Mus musculus*);
- Feral Pig (*Sus scrofa*)*;

- Cane Toad (*Rhinella marina*); and
- Common Myna (*Acridotheres tristis*).

Species marked with an asterisk are category 3, 4 and 6 restricted matters under the *Biosecurity Act 2014*. The Red Fox, Dingo and European Rabbit are also category 5 restricted matters under the *Biosecurity Act 2014.* Category 3 restricted matters must not be distributed or released, category 4 restricted matters must not be moved, category 5 restricted matters must not be kept, and category 6 restricted matters must not be fed.

5 ECOLOGICAL IMPACTS OF PROPOSED ACTIVITIES

5.1 GENERAL IMPACTS

5.1.1 Clearing

The clearing of vegetation to accommodate the pits, overburden stockpiles and infrastructure is the principal ecological impact of the Project. The extent of this impact has been minimised to the greatest extent practicable by:

- Primarily disturbing non-remnant vegetation (pastures and regrowth);
- locating amenable infrastructure (of which location is not constrained by resource distribution) in non-remnant pastures with low ecological value; and
- utilising in-pit dumping of overburden, to reduce the overall size of the disturbance footprint.

A total of 4.3 ha of remnant vegetation (category B regulated vegetation), 71.2 ha of high-value regrowth (category C regulated vegetation) and 149.0 ha of cleared pasture is contained within the footprint of the Vulcan Complex Project. The composition of this vegetation is listed in **Table 5-1**. Clearing of this vegetation constitutes the main loss of habitat that will result from the Project. How this habitat loss affects matters of State and National environmental significance are assessed in **Section 5.3**.

Table 5-1 Vegetation to be cleared for the Vulcan Complex Project

Regional Ecosystem	Description	Amount to be cleared (ha)
11.10.3	*Acacia shirleyi* open forest on coarse-grained sedimentary rocks. Crests and scarps.	4.3
High-value regrowth 11.3.25	*Eucalyptus camaldulensis* forest fringing drainage lines.	2.6
High-value regrowth 11.5.9	*Eucalyptus crebra* and other *Eucalyptus* spp. and *Corymbia* spp. woodland on Cainozoic sand plains and/or remnant surfaces.	66.0
High-value regrowth 11.10.3	*Acacia shirleyi* open forest on coarse-grained sedimentary rocks. Crests and scarps.	2.3
High-value regrowth 11.10.7	*Eucalyptus crebra* woodland on coarse-grained sedimentary rocks.	0.3
Non-remnant	Cleared pasture and young regrowth.	149.0
Total footprint		224.5

The habitats present within the disturbance footprint were not unique in a local context. All vegetation to be disturbed is represented by extensive areas of remnant vegetation within the broader survey area (see **Table 4-1** and **Figure 4-3**). Furthermore, all flora and fauna recorded within or near the disturbance footprint were widespread within similar habitats across the survey area, with the following exceptions:

- the weed *Jatropha gossypiifolia* (Bellyache Bush) was recorded at a single site within the disturbance footprint, but not elsewhere within the survey area;
- Two reptiles (the Common Dwarf Skink *Menetia greyii*, and Coral Snake *Brachyurophis australis*) were recorded at a trap site within heavily grazed regrowth (site S30: see **Appendix A**), which was within the project area, but just outside the disturbance footprint. Despite not being recorded elsewhere within the survey area, these species are geographically widespread and common (both are listed as Least Concern under the NC Act). They are likely to occur widely within the survey area, but the highly degraded habitats they were recorded within were not a focus of survey effort.
- Several species not recorded elsewhere within the survey area were recorded in riparian vegetation around the small dam within the project area (Water Rat *Hydromys chrysogaster*,

Green Tree Snake *Dendrelaphis punctulatus*, and Chestnut-breasted Mannikin *Lonchura castaneothorax*). This dam will not be disturbed by the project. These three species are geographically widespread and common (all are listed as Least Concern under the NC Act), and are highly mobile. They almost certainly utilise riparian habitats around dams, natural wetlands and creeks across the survey area and broader region.

No locally unique ecological values will be disturbed by the proposed clearing of (mostly) regrowth and already-cleared pastures.

5.1.2 Habitat Fragmentation

The Project is located immediately south and west of a large existing mine, which already interrupts west-east movement of wildlife. The Project will not introduce new barriers to the movement of wildlife.

5.1.3 Edge Effects

Forest edges are associated with altered microclimate, invasion of weeds and disturbance to wildlife. The Project will not increase the total length of edges in remnant or regrowth habitats, as most of the project area currently contains a patchy mosaic of remnant, regrowth, cleared areas and roads with a high total edge length.

5.1.4 Direct Mortality

Nocturnal fauna that shelter during the day (when clearing is undertaken) in hollow trees and under rocks and fallen timber are susceptible to injury or death during the clearing process. However, most of the vegetation to be cleared for the Project is regrowth or pasture, where hollows are absent, and fallen debris is relatively sparsely distributed compared with nearby remnant vegetation.

5.1.5 Vehicle Collisions

The Vulcan Complex Project will not introduce any new major roads to the region. It will involve the relocation of Saraji Road 500 m to the east. The proposed new location of Saraji Road is further from remnant vegetation than the current road, and the new road will be bounded by disturbed habitat on both sides, reducing the frequency of fauna attempting to cross.

The Vulcan Complex Project will, however, increase road traffic on existing roads in two ways, which will slightly increase the risk of collisions with wildlife crossing roads:

- Haulage of coal material is via Type 2 road train (triple) to a train load-out facility at the Isaac Plain Mine, 51 km from the Vulcan Complex. A traffic impact assessment (GTA Consultants 2020) found that haulage will increase traffic rates on these roads by up to 4.8% over current levels; and
- The daily commute of workers to/from accommodation in Moranbah and/or Dysart will increase traffic on these roads by up to 3.4% (GTA Consultants 2020).

Impacts of increased traffic will be largely limited to the extraction phase of the mine (years 2-4). Outside this period, only negligible increases (<2.5%) in total traffic over baseline levels are expected.

5.1.6 Dust

Dust can impact nearby vegetation by blocking photosynthesis and increasing leaf temperature; both impacts can reduce drought tolerance (Farmer 1993). Dust that is severe enough to inhibit plant growth is only likely where vegetation is close to (within 100 m of) the source (roads, operational areas). Any effects of dust are expected to be short-term (maximum of four years), as any effects will cease immediately upon cessation of the adjacent operations.

No threatened plant species or communities are located within 2 km of the Project.

5.1.7 Groundwater Drawdown

Open-cut mining can lead to the drawdown of groundwater, potentially harming groundwater-dependent ecosystems. Groundwater modelling of the survey area suggests that any drawdown is highly localised and unlikely to occur in the vicinity of groundwater-dependent ecosystems. For further details, refer to **Section 5.3.2.**

5.1.8 Noise and Vibration

Noise from traffic and industrial sources can have significant detrimental impacts on fauna (Shannon *et al.* 2016; Cunnington and Fahrig 2010; Barber *et al*. 2010). The Project is located on a busy highway (Saraji Road), immediately west of a large mining operation. The increase in noise resulting from the Project is expected to be negligible relative to existing background noise. Nevertheless, there may be localised disturbance from noise where operational areas are close to (e.g., within 100 m of) habitats for threatened fauna (e.g., Greater Gliders, Koalas).

5.1.9 Artificial Lighting

The Project will operate 24 hours per day, which will require flood-lighting around operational areas. Artificial lighting can impact fauna through interfering with the navigation of nocturnal species (Howell *et al.* 1954; Salmon *et al.* 1995; Poot *et al.* 2008; Longcore *et al.* 2012), interrupting natural patterns of sleep and cell repair (Ben-Shlomo and Kyriacou 2010), exposing nocturnal prey to elevated predation risks (Baker and Richardson 2006; Rotics *et al*. 2011; Davies *et al*. 2012), disturbing the timing of daily activities (Miller 2006; Kempenaers *et al*. 2010), and leading to long-term declines in insect populations (Conrad *et al*. 2006). Artificial lighting may also interfere with photosynthesis (Roman *et al*. 2000) and flower development in plants (Wang *et al*. 2003). The Project is located immediately west of a large and strongly lit mining operation. Considering these background light levels, it is expected that any impacts of the Project due to lighting will be small and highly localised (to within 500 m of operational areas).

5.1.10 Waste

Waste produced by mining operations (e.g., runoff from stockpiles) can have long-term detrimental effects on the surrounding ecology, if allowed to enter waterways. Sediment-collecting infrastructure has been incorporated into the Project design, and no down-stream impacts are anticipated. Inappropriate storage of food waste generated by mine workers can also attract feral animals (Black Rats, Feral Cats, Red Foxes), which impact threatened wildlife.

5.1.11 Weeds and Pest Animals

Land disturbance and the movement of soils, vehicles and people between areas can promote weed invasion. The risk that the Project could encourage invasion by the seven restricted weeds recorded on site (see **Section 4.5**) is assessed in **Table 5-2**. Controls must be in place to manage the risks posed by Harrisia Cactus, Bellyache Bush, Velvet Pear and Parthenium in order for the Project to avoid being in violation of the *Biosecurity Act 2014.*

The project will have negligible effects on pest animal populations. There will be a temporary cessation of current pig- and dingo-hunting in the vicinity of the project during operations. However, this is countered by the deterring effects of lights, noise and vegetation clearance associated with operations.

Table 5-2 Inherent Risk (without controls) that the Project could spread restricted weeds

Species	Inherent Risk	Justification
Cryptostegia grandiflora (Rubber Vine)	Low	Rubber Vine was confined to creek banks well away from the Project (i.e., Middle and Boomerang Creeks).
Harrisia martinii (Harrisia Cactus)	High	While not in high density, this cactus was recorded in numerous locations within the proposed disturbance footprint. As it can spread via stem

		fragments, new infestations could establish in soil stockpiles.
Hymenachne amplexicaulis (Olive Hymenachne)	Nil	Olive Hymenachne is an aquatic weed recorded 9 km south of the project footprint. Potential habitat for the species is present within the project area, but is not to be disturbed by the Project.
Jatropha gossypiifolia (Bellyache Bush)	Moderate	A small infestation (<10 plants) of this weed within the project area was the only record of the species across the survey area. If not controlled prior to soil disturbance, seeds may be spread to new areas (e.g., soil stockpiles, tracks).
Opuntia stricta (Prickly Pear)	Low	This cactus was only recorded once within the entire survey area, 1.8 km south of the proposed footprint. As the Project will not result in any soil movement between the infestation and uninfested areas, there is a low risk of impact.
Opuntia tomentosa (Velvet Pear)	High	This cactus occurred widely, in low densities, across most of the survey area, including within the disturbance footprint. As it can spread via stem fragments, there is a risk that new infestations could establish in soil stockpiles.
Parthenium hysterophorus (Parthenium)	Moderate	Parthenium was abundant on clay soils and alluvial areas (sites with moisture-retentive soil). While disturbance to clay soil is avoided, there will be minor disturbance to riparian areas.

5.1.12 Cumulative Impacts

The small scale of the Project relative to large existing mines in close proximity, and its minimal impact on remnant vegetation, means that the Project is unlikely to contribute significantly towards cumulative impacts of mining within the region.

5.1.13 Summary

Clearing of 71.2 ha of regrowth vegetation and 4.3 ha of remnant vegetation is the principal impact of the Project on ecological matters. Artificial lighting and weeds are additional risks that require management.

5.2 Recommended Mitigation Measures

As part of a site-specific application for a new environmental authority for a resource activity, supporting information must include "strategies for avoiding, mitigating or managing the predicted impacts on the environmental values". A list of recommended measures for reducing each of the impacts listed in **Section 5.1** is shown in **Table 5-3**.

Table 5-3 Recommended impact mitigation measures

Potential Impact	Recommended mitigation measures
Clearing	1) Vitrinite employees and contractors are to be made aware of environmental obligations and compliance requirements through a site induction program. 2) The edges of the project footprint are to be marked out, to prevent unnecessary accidental clearing of neighbouring habitats. 3) Overburden is mostly to be returned to the mined pits, to limit the total disturbance footprint of the project. 4) Topsoil removed from each site in preparation for mining is to be stored and managed in accordance with a Progressive Rehabilitation and Closure Plan, to protect a favourable growing medium for vegetation post-mining. 5) Post-mine rehabilitation should aim for a post-mine land use with similar environmental values to those being lost (see the Progressive Rehabilitation and Closure Plan).
Habitat fragmentation	Not applicable
Edge effects	Not applicable

Potential Impact	Recommended mitigation measures
Direct mortality	1) Clearing should occur in stages, to allow fauna the opportunity to exit the area. 2) Injured fauna is to be taken to the nearest wildlife carer or veterinarian. 3) Any injury and/or mortality is to be communicated to the Department of Environment and Science within 24 hours. 4) Vitrinite employees and contractors will be made aware of environmental obligations and compliance requirements through the site induction program.
Vehicle collisions	1) Buses will transport ~80% of workers daily from accommodation to site, to reduce the total number of vehicles using the roads. 2) Road trucks used to transport coal are to be of the largest size safely driven on the relevant roads, to reduce the total number of trips required.
Dust	1) Mitigation measures for managing dust are described elsewhere in the Air Quality Assessment Report. No threatened plant species or communities are located within close proxmity to dust-generating operations, and any dust management measures in place for human health will be sufficient for managing risks of dust to environmental values.
Groundwater drawdown	Not applicable.
Noise and vibration	1) Mitigation measures for managing noise and vibration are described elsewhere in the Noise Assessment Report.
Artificial lighting	1) The following lighting designs should be used, where appropriate, in operational areas within 500 m of remnant vegetation: i. Artificial lighting used in operational areas is to be angled away from habitats supporting sensitive species (e.g., riparian areas supporting Koalas and Greater Gliders). ii. Floodlights with "low glare" louvres/attachments are recommended to limit lateral transmission of light. Note that newer LED-type flood lights may have glare-reduction technology built-in. iii. Any street lights used are recommended to be of the "aeroscreen" type (flat glass lenses), to reduce sideways glare. iv. Light fittings should be positioned as close to horizontally as possible.
Waste	1) Food wastes are to be stored in sealed containers and disposed off-site. 2) Mitigation measures for managing mine-affected water are described elsewhere in the Geochemical Assessment Report.
Weeds and pest animals	1) Putrescible waste is to be stored in animal-proof containers and removed from site. 2) All vehicles that will enter undisturbed parts of the site are to be washed and certified prior to arrival at the project site, to restrict the introduction of new weeds. Weed management activities will control weeds in high traffic areas. 3) Light vehicles used for commuting between the project area and nearby towns (where they may be exposed to weeds) are to be parked in the visitor carpark. 4) Operational areas and the visitor carpark are to be inspected regularly (at least biannually) to identify new infestations of restricted weeds. These should be treated soon after detection, with follow-up treatment required until populations are eradicated. 5) Any weeds germinating on topsoil stockpiles should be treated and eradicated to maintain a source of weed-free growing medium for use post-mining. 6) Only native species, or species with low weed risk, are to be included within seed mixes applied to rehabilited sites.
Cumulative impacts	Not applicable.

5.3 RESIDUAL IMPACTS ON PROTECTED MATTERS

The residual impacts of the Vulcan Complex Project are summarised in a risk assessment contained in **Appendix E**. These are discussed in detail in the following subsections.

5.3.1 Regulated Vegetation

As it is a resource activity under the *Environmental Protection Act 1994,* section 107, the Project represents exempt clearing work under the *Vegetation Management Act 1999*. Nevertheless, any disturbance to vegetation classed as a matter of State environmental significance is subject to offsets.

The vegetation to be disturbed for the Vulcan Complex Project is listed in **Table 5-4**. The only vegetation category to be disturbed that qualifies as a matter of State environmental significance is category R, which occurs within 50 m of watercourses.

Table 5-4 Regulated vegetation to be disturbed by the Vulcan Complex Project

Regulated Vegetation Category	Description	Area to be disturbed (ha)		Total area within survey area (ha)
		Field-verified Map	Regulated Vegetation Map	
A	**Declared area, offset area or other protected vegetation***	0	0	0
B	**Remnant vegetation: Endangered***	0	0	145.7
	Remnant vegetation: Of Concern*	0	0.5	129.3
	Remnant vegetation: Least Concern	4.3	0.3	4,041.6
C	**High-value regrowth: Endangered***	0	0.1	4.0
	High-value regrowth: Of Concern*	0	10.5	148.6
	High-value regrowth: Least Concern	71.2	99.8	632.8
R	**Non-remnant vegetation within 50 m of a watercourse***	15.2	17.9	111.5
X	Already-cleared areas or other exempt areas not regulated by vegetation management laws	133.8	95.4	1,353.0
Total		224.5	224.5	6,566.5

*Vegetation categories in bold are classed as matters of State environmental significance, and therefore subject to offsets.

While the above vegetation categories not shown in bold do not individually constitute matters of State environmental significance, they are classed as significant if they occur "within a defined distance from the defining banks of a relevant watercourse". Such watercourse vegetation will be disturbed for the Vulcan Complex Project, as listed in

Table 5-5 Area of each vegetation category contained within a defined distance of the defining banks of relevant watercourses

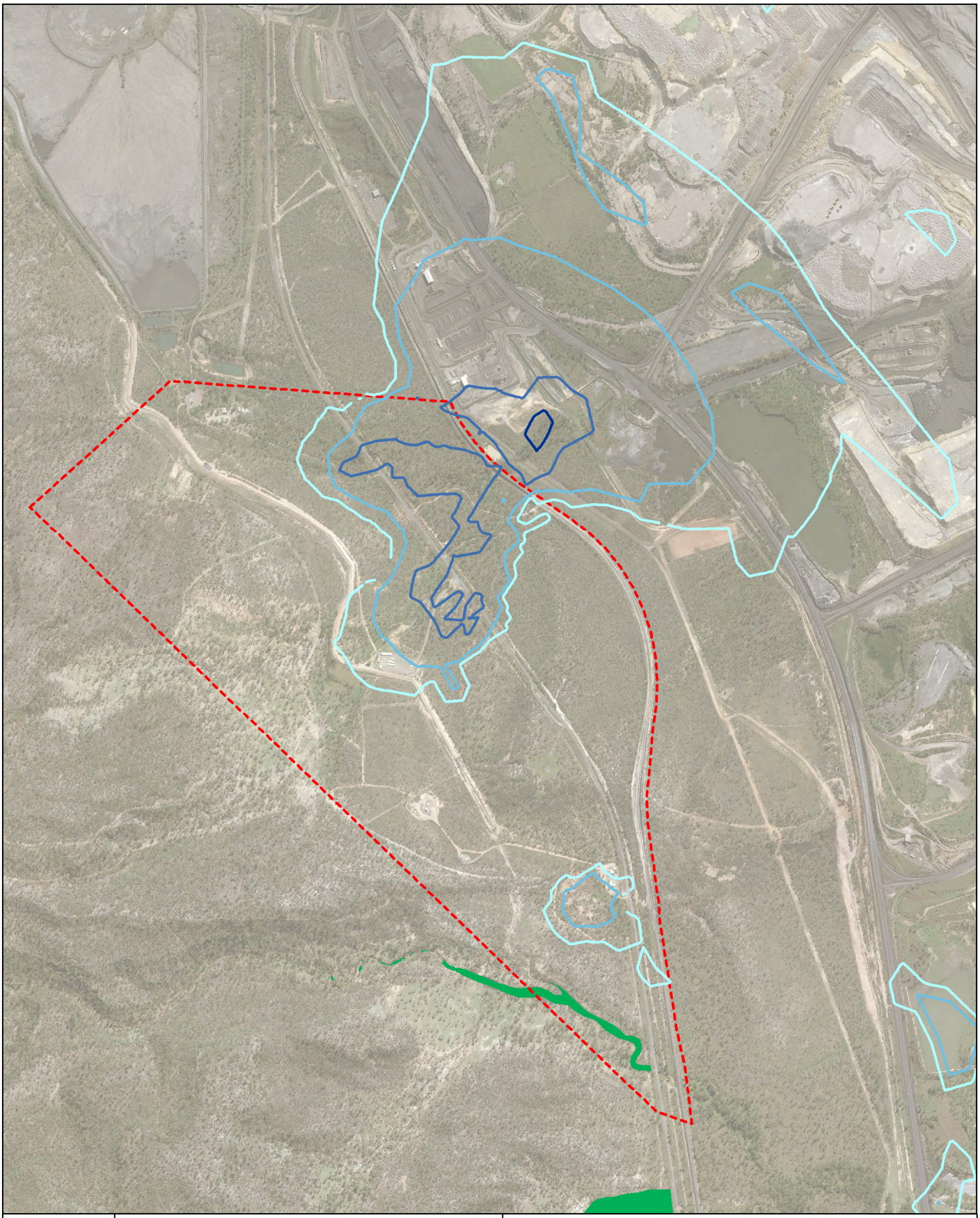
Regulated Vegetation Category	Description	Area to be disturbed (ha)		Total area within survey area (ha)
		Field-verified Map	Regulated Vegetation Map	
A	Declared area, offset area or other protected vegetation	0	0	0
B	Remnant vegetation: Endangered	0	0	1.9
	Remnant vegetation: Of Concern	0	0	28.9
	Remnant vegetation: Least Concern	0	0	384.2
C	High-value regrowth: Endangered	0	0.04	0
	High-value regrowth: Of Concern	0	1.8	8.6
	High-value regrowth: Least Concern	6.3	15.9	28.6
R	Non-remnant vegetation within 50 m of a watercourse	11.4	12.4	111.4
Total		**17.7**	**30.1**	**563.6**

Overall, the only Regulated Vegetation that is a matter of State environmental significance to be disturbed by the Vulcan Complex Project is 15.2 ha of category R vegetation and 17.7 ha of category B, C or R areas on the regulated vegetation management map that are located within a defined distance from the defining banks of a relevant watercourse. Note that the latter includes most of the former. The Vulcan Complex Project is a resource activity under the *Environmental Protection Act 1994,* section 107, and therefore represents exempt clearing work under the *Vegetation Management Act 1999*. However, a significant impact to vegetation that is a matter of State environmental significance is subject to offsets.

5.3.2 Groundwater-dependent Ecosystems

Hydrogeologist.com.au (2020) has developed a numerical groundwater flow model of the survey area and broader region to predict the effects of the Vulcan Complex Project on local groundwater levels. The drawdown predicted from the project is limited in geographic extent (up to 3,000 m to the northeast toward existing mining) and magnitude (up to 10 m). The zone of drawdown does contain some GDEs, but only within the clearing footprint. No remnant vegetation outside the clearing footprint is found within the zone of drawdown. Furthermore, any non-remnant vegetation within this zone is highly disturbed by existing mining operations associated with the Peak Downs Mine (**Figure 5-1**). The groundwater quality is unlikely to be significantly altered by the Vulcan Complex Project and, even if it were, all local potentially groundwater-dependent ecosystems occur upgradient (in terms of groundwater flow) of potential effects.

In summary, negligible impacts to GDEs are predicted to result from the Vulcan Complex Project, beyond that which will occur due to vegetation clearing.



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LEGEND

Predicted Drawdown
- 1 m
- 2 m
- 5 m
- 10 m

Mining Lease Application Area

Possible Groundwater-dependent Terrestrial Ecosystems

Data Source: Survey Boundary - Vitrinite (2019);
GDE Terrestrial Ecosystems (Field-verified RE Mapping) - METServe (2019); Imagery - ESRI, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Vitrinite

Vulcan Complex Project Maximum drawdown of groundwater predicted

2 0 2 4
Kilometres

Scale: 1:22,000 (A4)

Datum: GDA94
Projection: MGA55

FIGURE 5-1

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fig5-1_GDE_Mapping_Terrestrial_RevA.WOR

5.3.3 Matters of State Environmental Significance

5.3.3.1 Koala

No primary habitat for Koalas will be removed as a result of the Vulcan Complex Project (**Figure 5-2**). All primary habitat is located further than 100 m from the project. However, a small amount of primary habitat is located within 200 m from the main operational areas (mine pit, waste rock dumps and offices) and may experience minor disturbance from lighting or noise.

A total of 2.6 ha of secondary habitat and 66.3 ha of marginal habitat for Koalas will be removed to accommodate the mine pits and infrastructure. This represents a loss of 0.1% and 9.5%, respectively, of the secondary habitat and marginal habitat located within the survey area, and 74.3% and 58.7% of the secondary and marginal habitat contained within the project area. This impact will last until mature food trees have been re-established in rehabilitated areas post-mining. It is expected to take 15 years post-planting for trees to be large enough to be used by Koalas. Re-colonisation of rehabilitated sites after 6 years has been recorded in wetter climates in south-east Queensland (Critescu *et al.* 2013), but a more conservative estimate is adopted here due to the drier climate and slower growth rates expected. As the final blocks of disturbed land can only commence rehabilitation at the cessation of mining activities (four years after the commencement of the project), the duration of disturbance is estimated to be 19 years. Viable populations of Koalas are expected to be maintained in extensive neighbouring undisturbed habitats (100% of primary habitat and 99.9% of secondary habitat is retained in the broader landscape) throughout this disturbance period, providing a source of recruitment to rehabilitated areas in the future.

The location of this disturbance adjacent to existent mining operations means that no new barriers to dispersal are anticipated to arise as a result of the project. An additional 10.3 ha of marginal habitat is located within 100 m of the main operational areas (mine pit, waste rock dumps and offices) and therefore may experience some disturbance from lighting, noise and dust. This disturbance is short-term, lasting only for the duration of the adjacent operations (four years).

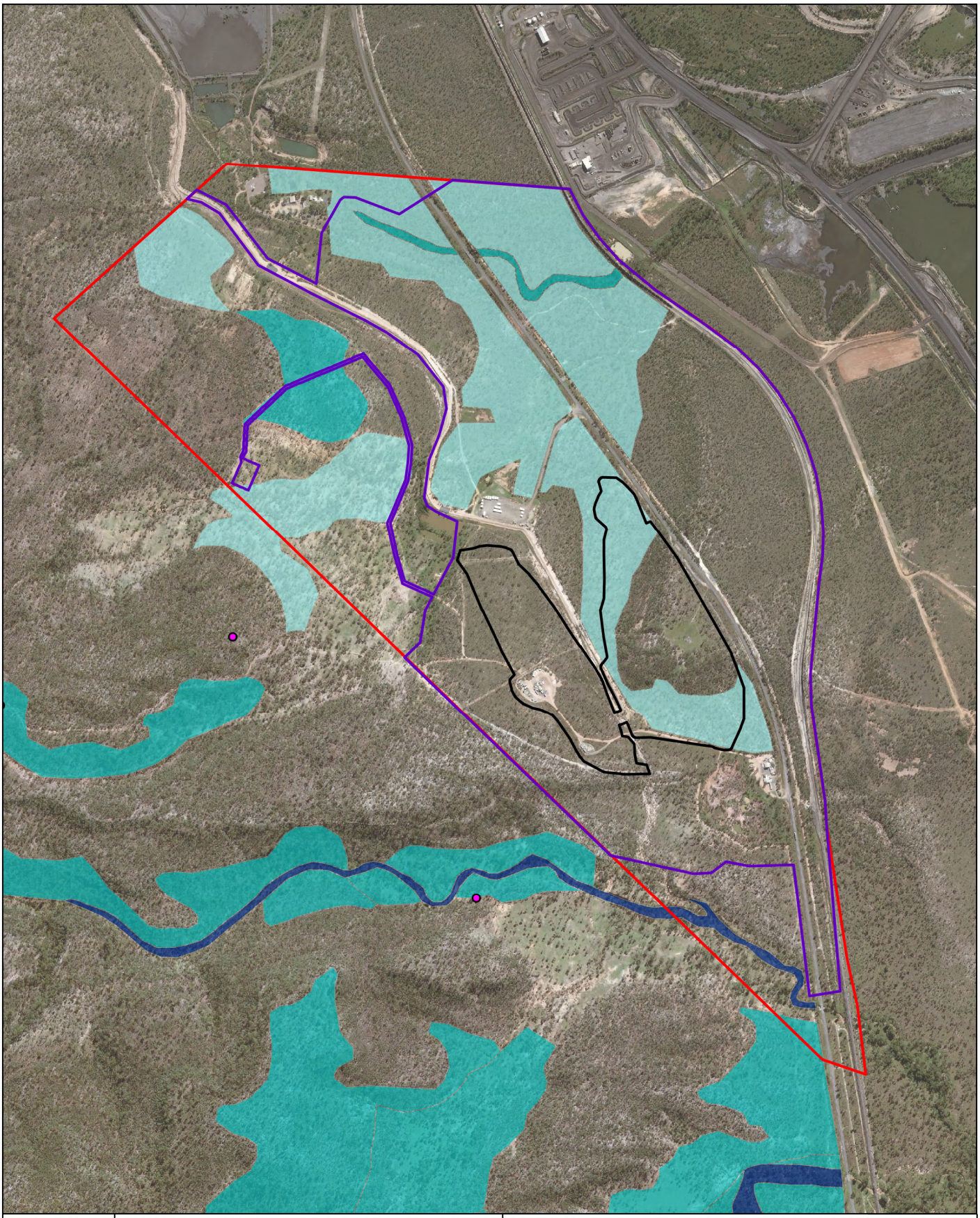
Realignment of the Saraji Road will have a net positive effect on the Koala. The road's new position will be further from primary and secondary habitats than the current road, and its location between the Vulcan Complex Project and the Peak Downs Mine means that Koalas are unlikely to occur in its vicinity. This will reduce risk of collisions with vehicles.

The removal of secondary and marginal habitat may qualify as a significant residual impact under the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (Department of Environment and Heritage Protection 2014), as the extent of occurrence of the species will be locally reduced (at least for 19 years, until habitat is rehabilitated post-mining), and ecologically significant locations (feeding and resting sites) will be disturbed over an estimated 19-year period. The habitat to be removed also qualifies as "habitat critical to the survival of the koala" under the EPBC Act (see **Section 5.3.4.3**).

5.3.3.2 Greater Glider

No habitat for Greater Gliders is expected to be removed as a result of the Vulcan Complex project (**Figure 5-3**). The Vulcan Complex project will not introduce any new barriers to dispersal for the Greater Glider, as continuous tracts of riparian habitat remain connected along all waterways in the survey area.

A small amount of habitat (0.9 ha) is located less than 200 m, but further than 100 m, from the main operational areas (mine pit, waste rock dumps and offices) of the project and may therefore be affected by lighting or noise emanating from the project. Any impacts to the species are likely to be negligible.



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LEGEND

- Koala Sighting

Koala Habitat

- Primary
- Secondary
- Marginal

- Bulk Sample Maximum Disturbance
- Vulcan Complex Maximum Disturbance
- Mining Lease Application Area

Data Source: Drainage Line, Road - QLD Gov. (2018); Field-verified RE Mapping, Habitat, Species Sites - METServe (2019); Survey Boundary, Bulk Sample Footprint - Vitrinite (2019).

Vitrinite

Vulcan Complex Project
Koala Habitat

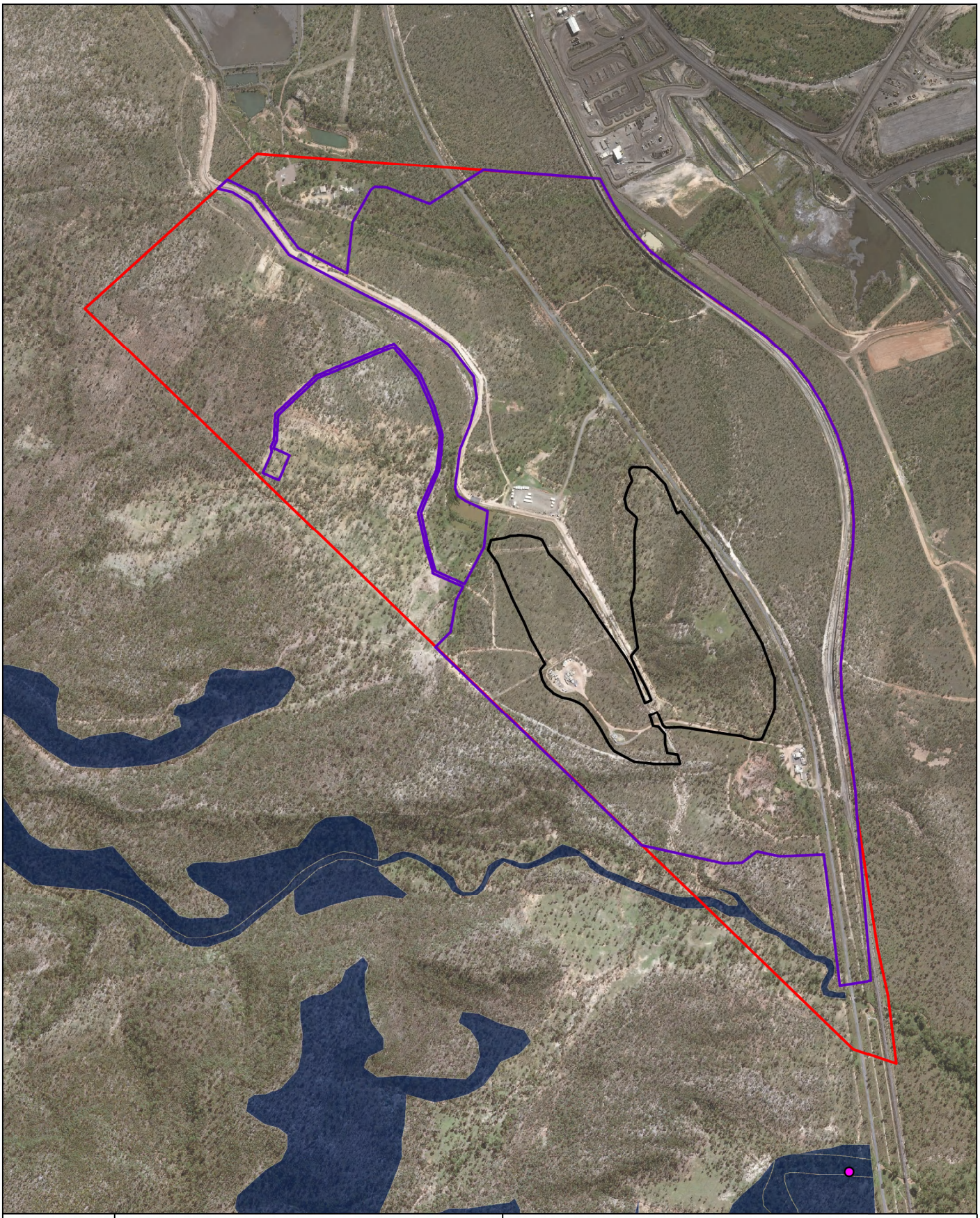
1 0 1 2 3
Kilometres
Scale: 1:18,000 (A4)

26/02/2020

Datum: GDA94
Projection: MGA55

FIGURE 5-2

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fig4-7_KoalaHabitat_ProjectFootprint_RevA.WOR



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LEGEND

- Greater Glider Sighting
- Greater Glider Habitat
- Bulk Sample Maximum Disturbance
- Vulcan Complex Maximum Disturbance
- Mining Lease Application Area

Data Source: Drainage Line, Road - QLD Gov. (2018); Field-verified RE Mapping, Habitat, Species Sites - METServe (2019); Survey Boundary, Bulk Sample Footprint - Vitrinite (2019).

Vitrinite

Vulcan Complex Project
Greater Glider Habitat

1 0 1 2 3
Kilometres
Scale: 1:18,000 (A4)

26/02/2020

Datum: GDA94
Projection: MGA55

FIGURE 5-3

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fig5-3_GreaterGlider_ProjectFootprint_RevA.WOR

5.3.3.3 Squatter Pigeon

While attempts were made to position infrastructure away from habitat for the Squatter Pigeon, due to the large scale of this habitat across the local region, disturbance of this habitat could not be completely avoided. The project footprint was designed to avoid disturbing a dam that the species uses for drinking. Furthermore, the overall footprint of the project was minimised by utilising in-pit dumping of overburden. This negates the need for constructing large out-of-pit waste rock dumps, and means that no void will remain after mining. Not only does this reduce the overall disturbance footprint, but it results in a relatively flat post-mining landform that is conducive to recreating habitat for the Squatter Pigeon. Squatter Pigeon habitat values have been incorporated into rehabilitation completion criteria within the Progressive Rehabilitation and Closure Plan.

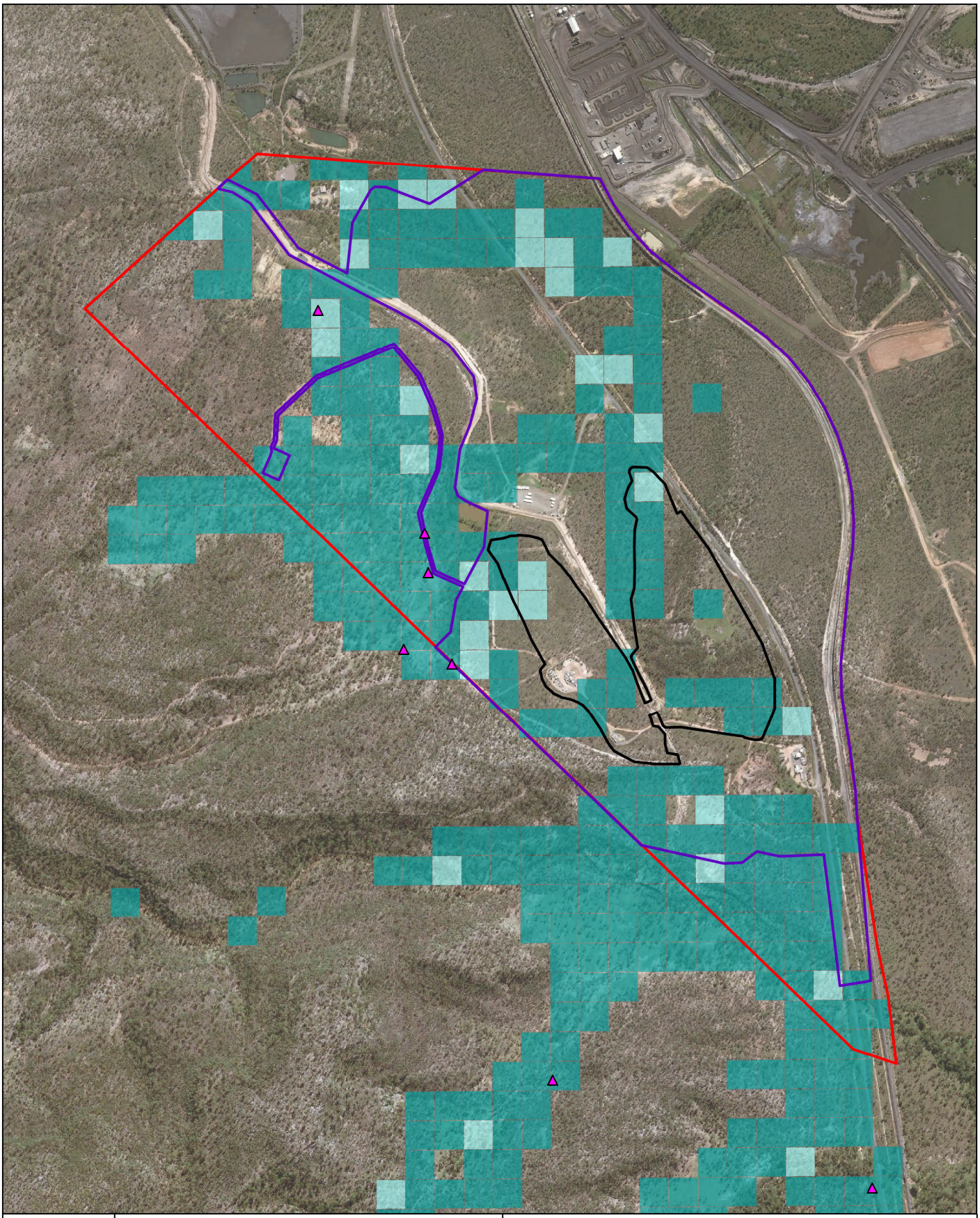
The clearing of 73.1 ha of primary habitat and 15.6 ha of secondary habitat is the principal anticipated impact of the Project on the Squatter Pigeon (**Figure 5-4**). No sources of water used by Squatter Pigeons are expected to be removed by the Project.

The size of the average home range of a pair of Squatter Pigeons is not known, but the related Partridge Pigeon (*Geophaps smithii*) is thought to occupy a home range of approximately 8 ha (Fraser *et al.* 2003). Assuming Squatter Pigeons are similar—a likely scenario, given their similar biology—the Project could impact up to 11 pairs of Squatter Pigeons.

The habitat to be removed constitutes 3% of the total habitat contained within the survey area. Assuming all potential habitat mapped within the survey area is occupied by Squatter Pigeons, and each pair occupies 8 ha, up to 364 pairs of Squatter Pigeons could inhabit the survey area. This is very likely to be an over-estimate, and occupancy rates of 50% within potential habitat are more consistent with rates of detection in the field. In this scenario, approximately 182 pairs of Squatter Pigeons are predicted to inhabit the survey area. This local population is likely to extend west and south of the survey area. With respect to the overall population, the Project is unlikely to have a significant impact on the overall size of the local population.

The impacts of habitat clearance will persist at least for the short- to medium-term, until vegetation is re-established on mined land. Being a ground-dwelling bird, they are not dependent on old trees, and rehabilitated sites are expected to meet their requirements for a low, protective tree cover within 15 years post-rehabilitation (Ngugi and Neldner 2015). It is unknown whether the relatively simple understorey vegetation communities that typically establish on rehabilitated sites (Grigg *et al.* 2000; Ngugi and Neldner 2015) will meet the ecological needs of Squatter Pigeons. Their readiness to feed on introduced pasture species such as *Urochloa mosambicensis* and *Stylosanthes* spp. (Crome 1976; C.Wiley pers. obs. 2019) suggests that re-establishing appropriate food plants is likely to be achievable. Consequently, it is estimated that the duration of impacts will be approximately 19 years, although this estimate has low confidence, given the lack of data on the dietary requirements of the species.

Ecologically significant locations for threatened species in Queensland are defined by the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (Department of Environment and Heritage Protection 2014) as "breeding, feeding, nesting, migration or resting sites". As habitat mapped for Squatter Pigeons can contain sites used for feeding and nesting, any disruption to this habitat could constitute a significant impact to the species, according to this guideline. The scale of this disruption is, however, very small relative to the total extent of "ecologically significant locations" available for the species locally. As discussed, 97% of ecologically significant habitat will be retained within the immediate landscape.



LEGEND

- Squatter Pigeon Sighting
- Bulk Sample Maximum Disturbance
- Vulcan Complex Maximum Disturbance
- Mining Lease Application Area

Squatter Pigeon Habitat

- Primary
- Secondary

Data Source: Drainage Line, Road - QLD Gov. (2018); Field-verified RE Mapping, Habitat, Species Sites - METServe (2019); Survey Boundary, Bulk Sample Footprint - Vitrinite (2019).

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Vulcan Complex Project
Squatter Pigeon Habitat

1 0 1 2 3
Kilometres
Scale: 1:18,000 (A4)

Datum: GDA94
Projection: MGA55

FIGURE 5-4

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fig5-4_SquatterPigeon_ProjectFootprint_RevA.WOR

5.3.3.4 Short-beaked Echidna

Short-beaked Echidnas occupy home ranges of 50-100 ha (Nichol *et al*. 2011), and the prescribed actions (removal of 224.5 ha of potential habitat) therefore amount to a loss of 2–5 territories. Given the extensive and continuous matrix of potential habitat to the west and south of the Vulcan Complex Project, these prescribed actions will have a negligible effect on local populations. As the habitat being removed could be used for feeding and breeding, it qualifies as an ecologically significant location according to the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (Department of Environment and Heritage Protection 2014). Nevertheless, there are no habitat features of the Project footprint that make it locally significant, and extensive tracts of habitat will be retained to the west. This retained habitat is of higher quality than that being removed, because much of it is remnant vegetation and thus contains an abundance of fallen timber, important for denning and providing termites. Sandstone areas to the west also contain an abundance of boulders, which provide den sites.

5.3.3.5 Rufous Fantail

A total of 9.2 ha of potential habitat for transient Rufous Fantails will be removed to accommodate the Vulcan Complex project (**Figure 5-5**). This represents 0.4% of the available habitat contained within the survey area.

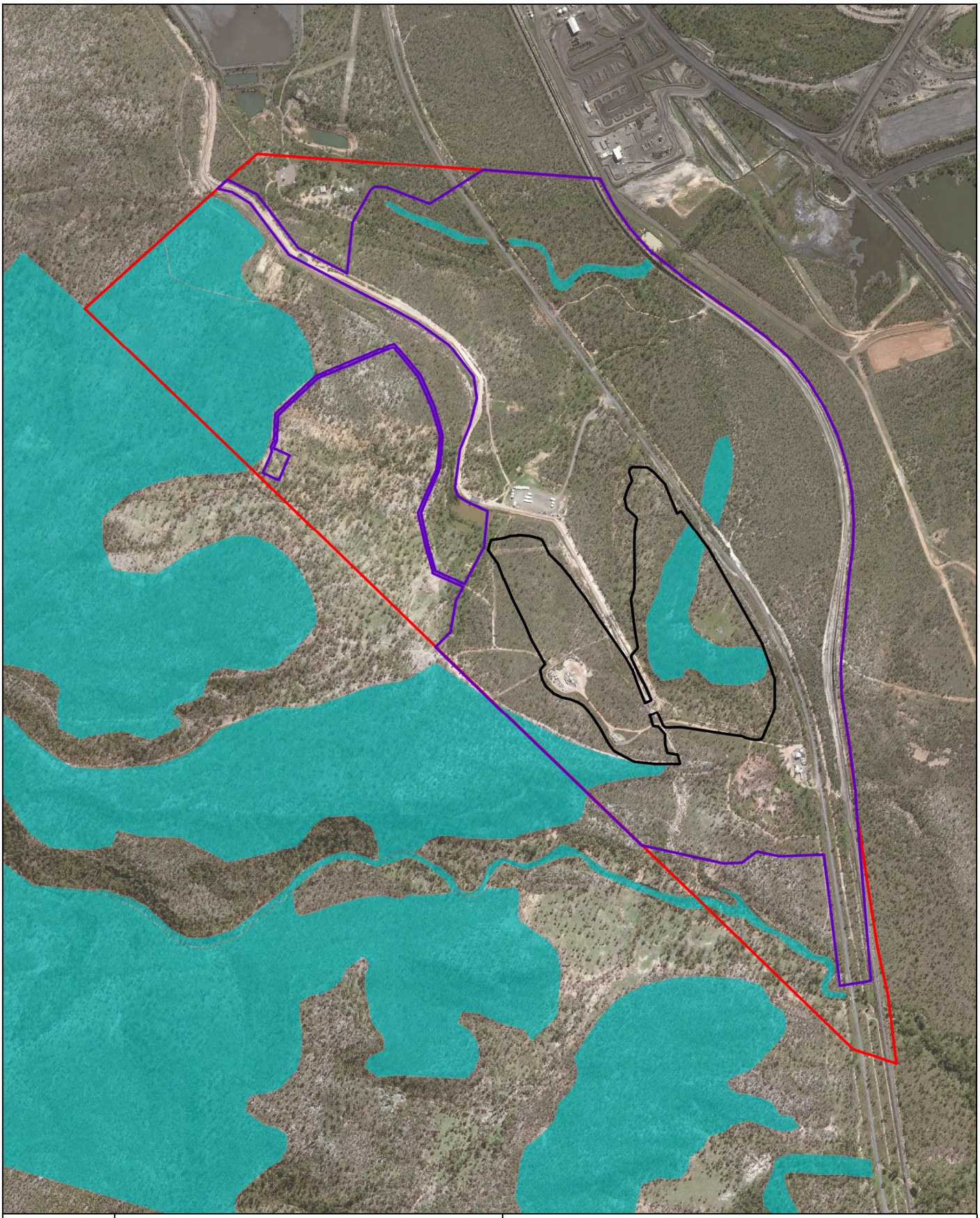
An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of the species. A nationally significant proportion of the southern Rufous Fantail (the subspecies that is most likely to migrate through the project area in small numbers) is defined by the Department of the Environment (2015) as 1,100 individuals (0.1% of the total population). The Vulcan Complex Project lies near the western edge of the species' migration route and contains marginal habitat for this inhabitant of rainforest. It is expected that fewer than 10 individuals probably migrate through the survey area on an annual basis, which does not constitute a nationally significant number. Consequently, significant impacts on this species are not likely to result from the Vulcan Complex Project.

5.3.3.6 Fork-tailed Swift

As the Project will not interfere with the above airspace, there are no anticipated impacts of the Project on the Fork-tailed Swift.

5.3.3.7 Ornamental Snake

No potential habitat for Ornamental Snakes will be removed for the Vulcan Complex Project. A small dam, which constitutes secondary habitat of marginal significance (i.e., is unlikely to be inhabited by the species) is located less than 100 m from a proposed waste rock dump, and may be affected by light and noise (**Figure 5-6**). The former may expose Ornamental Snakes, if present, to elevated predation risk. Any disturbance would be of short duration (maximum of four years), as the impacts of light will cease once extraction is complete. Overall, the impacts of the Vulcan Complex Project on the Ornamental Snake are considered to be negligible.



LEGEND

- Rufous Fantail Sighting
- Rufous Fantail Habitat
- Bulk Sample Maximum Disturbance
- Vulcan Complex Maximum Disturbance
- Mining Lease Application Area

Data Source: Drainage Line, Road - QLD Gov. (2018); Field-verified RE Mapping, Habitat, Species Sites - METServe (2019); Survey Boundary, Bulk Sample Footprint - Vitrinite (2019).

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Vulcan Complex Project
Rufous Fantail Habitat

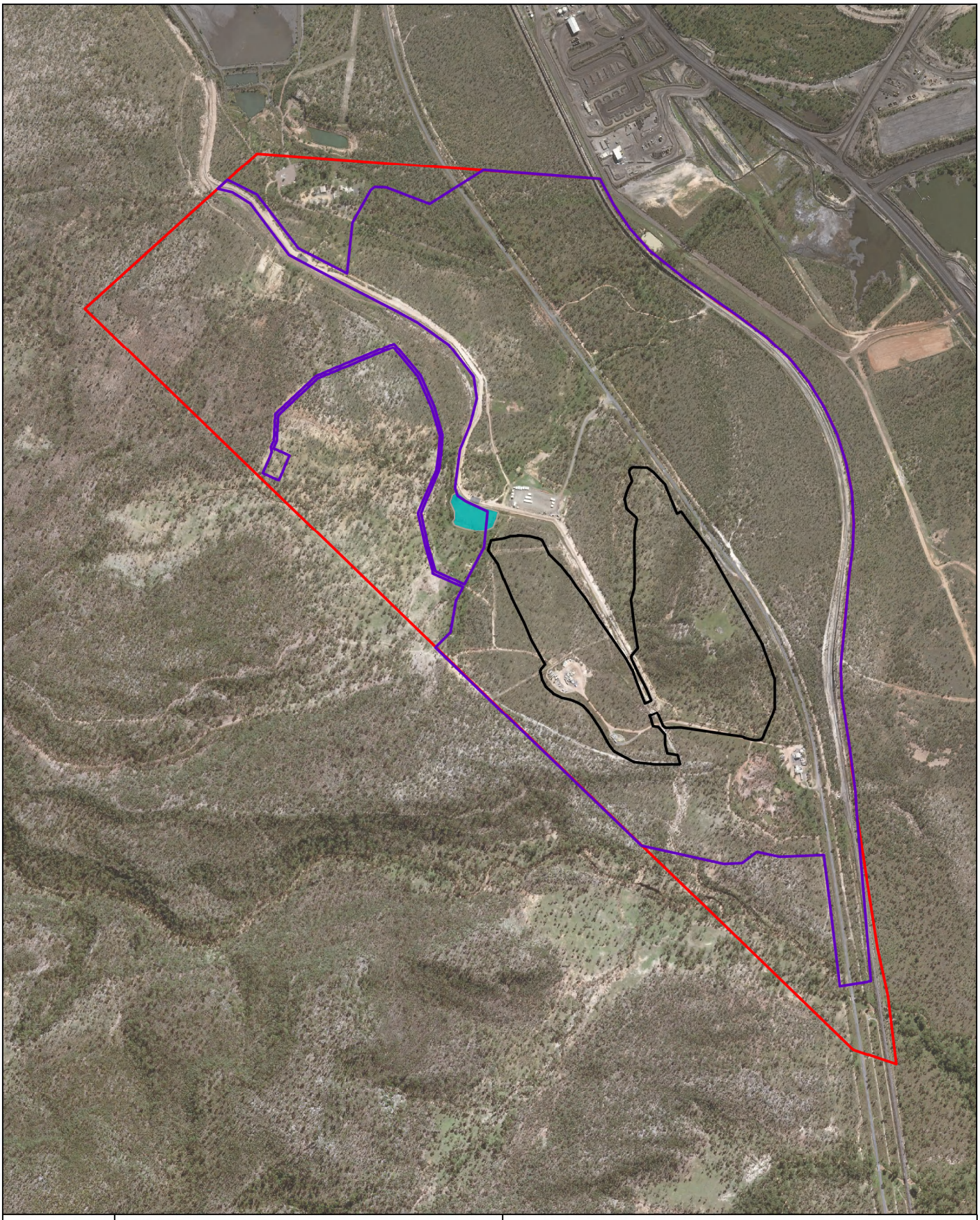
1 0 1 2 3
Kilometres
Scale: 1:18,000 (A4)

26/02/2020

Datum: GDA94
Projection: MGA55

FIGURE 5-5

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fig5-5_RufousFantailHabitat_ProjectFootprint_RevA.WOR



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LEGEND

Potential Ornamental Snake Habitat
- Primary
- Secondary

- BSP Maximum Disturbance Area
- VCP Maximum Disturbance
- Mining Lease Application Area

Data Source: Fieled-verified RE Mapping - MetServe (2019); Survey Boundary, Bulk Sample Pit Footprint - Vitrinite (2019); Imagery - ESRI, DigitalGlobe, GeoEye, Easrthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Vitrinite

Vulcan Complex Project
Potential Ornamental Snake Habitat

1 0 1 2 3
Kilometres
Scale: 1:18,000 (A4)

26/02/2020

Datum: GDA94
Projection: MGA55

FIGURE 5-6

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fig5-6_OrnamentalSnakeHabitat_ProjectFootprint_RevA.WOR

5.3.3.8 Latham's Snipe and Australian Painted-snipe

The footprint of the Vulcan Complex project avoids all dams and natural wetlands within the survey area. However, a small dam comprising potential habitat for these two shorebirds is located less than 100 m from a proposed waste rock dump (**Figure 5-7**). Light and noise emanating from these operations constitute a potential disturbance to Latham's Snipe and Australia Painted-snipe.

Important habitat for Latham's Snipe is defined as supporting at least 18 individuals of the species (Department of the Environment and Energy 2017). No Latham's Snipe were observed during field surveys of the Vulcan Complex area, despite almost all field trips coinciding with times of year when the species is most likely to be present (September to April). It is, therefore, highly unlikely that the survey area contains important habitat for the species. Instead, it is most likely that small numbers (fewer than five individuals) utilise the dam to be disturbed, and only when conditions (water levels, vegetation cover) are favourable, which depends on weather patterns (favourable habitat may not be present in every year).

The Australian Painted-Snipe is even less likely than Latham's Snipe to utilise the dam to be disturbed, as it is a much less numerous species.

The minor disturbance to habitat for these two shorebirds as a result of the Vulcan Complex Project is of short duration, and will cease once extraction is complete (within four years). This disturbance is not expected to constitute a significant residual impact under the EPBC Act or the NC Act.

5.3.3.9 Common Death Adder

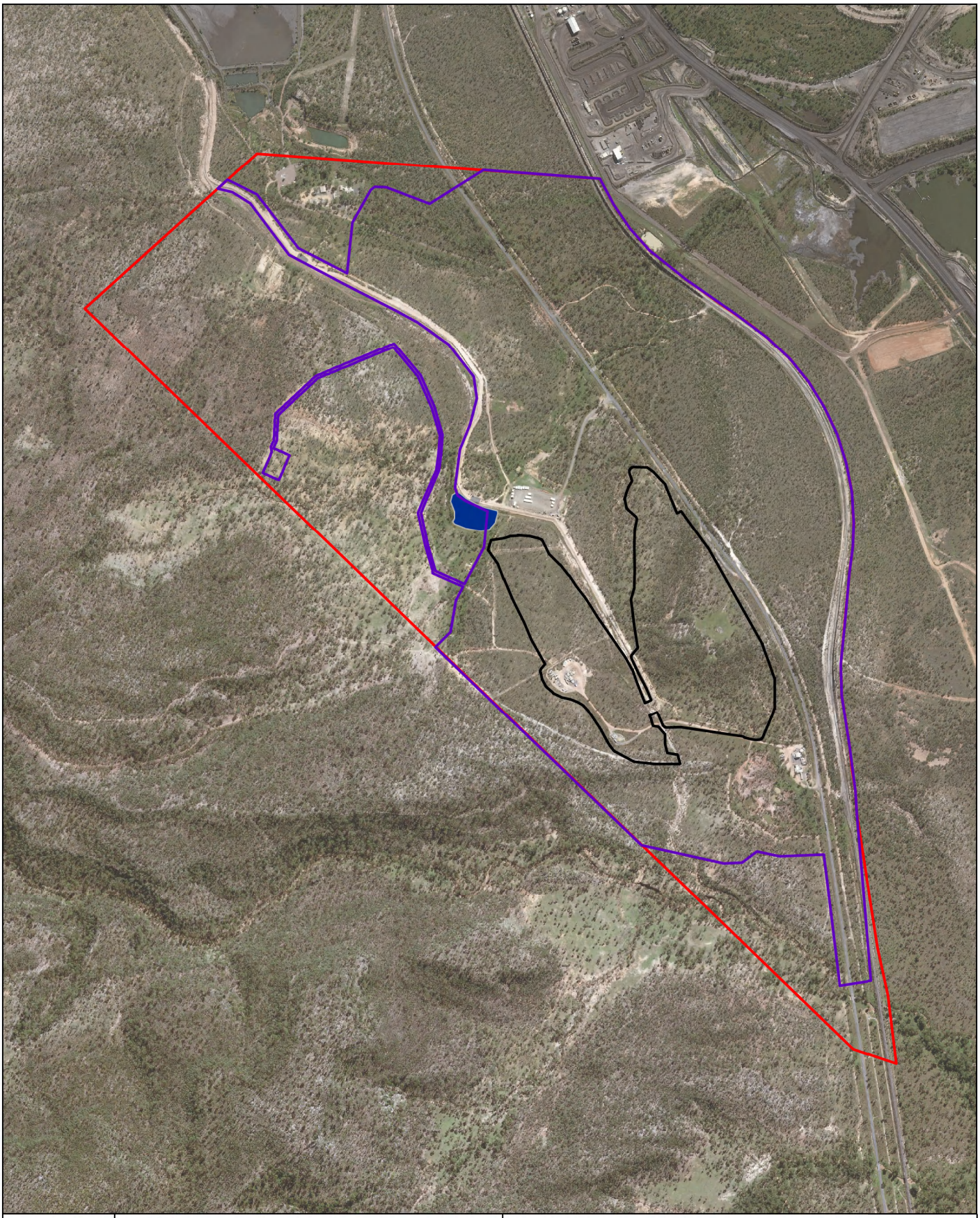
Primary habitat for the Common Death Adder within the Harrow Range (remnant vegetation with sandstone boulders) will not be disturbed by the Vulcan Complex Project. Nevertheless, the species could potentially utilise any vegetated habitats (remnant and regrowth) on site, and 75.5 ha of marginal habitat (lowland areas with an abundance of Cane Toads and few rocks) will be removed for the proposed mine and associated infrastructure.

The entire disturbance footprint already supports high densities of Cane Toads, a major threat to Common Death Adders. The installation of sediment ponds and drainage infrastructure may cause temporary pooling of surface runoff, in which toads may breed. Given the close proximity of existing surface water to the project, and the short duration that drainage infrastructure will be in place, the Vulcan Complex Project is likely to have a negligible impact on local toad populations.

Overall, it is anticipated that the project will have a negligible effect on local populations of the Common Death Adder.

5.3.3.10 Red Goshawk

Red Goshawks are probably extinct in the local region. Potential habitat for the species that occurs on site is of poor quality; escarpments and nearby waterways mostly lack surface water, and the surrounding landscape is already highly modified through mining and clearing for grazing. The Red Goshawk rarely breeds in areas with fragmented native vegetation (TSSC 2015), and never more than 1 km from water. Consequently, the importance of the region to the species is considered to be low. The loss of 75.5 ha of local habitat for the species is, therefore, considered inconsequential for its long-term conservation.



LEGEND

- Potential Habitat
- Bulk Sample Maximum Disturbance
- Vulcan Complex Maximum Disturbance
- Mining Lease Application Area

Data Source: Survey Boundary - Vitrinite (2019); Habitat - MetServe (2019); Imagery - ESRI, DigitalGlobe, GeoEye, Easrthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

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Vitrinite

Vulcan Complex Project
Potential Habitat for Australian Painted-snipe and Latham's Snipe

1 0 1 2 3
Kilometres
Scale: 1:18,000 (A4)

26/02/2020

Datum: GDA94
Projection: MGA55

FIGURE 5-7

S:\Projects\V1002 Saraji West_MapInfo\Workspaces\Vulcan_Ecology_Report\V1002_Fig4-13_SnipesHabitat_RevB.WOR

5.3.3.11 Yakka Skink

The *Draft Referral Guidelines for the Nationally Listed Brigalow Belt Reptiles* define important habitat for the Yakka Skink as "any contiguous patch of suitable habitat, particularly remnant vegetation, where a colony is known or identified…[or] any microhabitat where colonies are likely to be found". The survey area does not contain habitat connected to known populations of the Yakka Skink. Furthermore, as no colonies have ever been recorded in the northern Bowen Basin, despite extensive ecological surveys undertaken across Dysart-Moranbah-Collinsville as part of various mining projects, colonies are not "likely to be found" in the vicinity of the Vulcan Complex project. Consequently, no "important habitat" is located within the survey area, and no significant residual impacts to the Yakka Skink are anticipated.

5.3.3.12 Annual Wiregrass

No habitat for the Annual Wiregrass is present within the vicinity of the Vulcan Complex Project. There are no anticipated impacts of the project on the Annual Wiregrass.

5.3.3.13 Ghost Bat

The project will not disturb any roosts for Ghost Bats or remove foraging habitat within 1-10 km of known roost sites. It is unlikely that the disturbance footprint is used in any capacity by the species, and no residual impacts on Ghost Bats are anticipated.

5.3.3.14 Dunmall's Snake

In the *Draft Referral Guidelines for the Nationally Listed Brigalow Belt Reptiles*, important habitat for the Dunmall's Snake is defined as any forest or woodland "within the 'Known/Likely to occur' modelled distribution of the species…and any habitat corridors in between" (Department of Sustainability, Environment, Water, Population and Communities 2011). As the Vulcan Complex Project area lies outside the known/likely distribution of the Dunmall's Snake, as modelled in the *Draft Referral Guidelines for the Nationally Listed Brigalow Belt Reptiles*, no significant impacts to the species are anticipated.

5.3.3.15 Allan's Lerista

The *Draft Referral Guidelines for the Nationally Listed Brigalow Belt Reptiles* (Department of Sustainability, Environment, Water, Population and Communities 2011) defines important habitat for the species as being "vegetation occurring on mid to dark-brown-coloured, non-cracking clay soils in Queensland regional ecosystems 11.8.5 and 11.8.11/11.8.5 and grassy open-woodland mapped as cleared but where the above regional ecosystems formerly occurred". The survey area does not contain important habitat for the species, and no significant residual impacts of the Vulcan Complex project are anticipated.

5.3.3.16 Special Least Concern Birds

A small amount (2.6 ha) of regrowth watercourse vegetation potentially used by transient Oriental Cuckoos, Black-faced Monarchs and/or Satin Flycatchers is to be removed for the Vulcan Complex project. This habitat is highly unlikely to ever support 0.1% of the total population of any of these species, which would have qualified it as being of national significance for the relevant species. No potential aquatic habitat for Sharp-tailed Sandpipers, Glossy Ibis and/or Gull-billed Terns will be removed. Overall, no significant impacts to any migratory birds listed as Special Least Concern under the NC Act are predicted to arise through the Vulcan Complex project.

5.3.3.17 King Bluegrass

No habitat for King Bluegrass occurs in the vicinity of the Vulcan Complex Project footprint. No impacts to the species are anticipated.

5.3.3.18 Significant Residual Impacts

Significant residual impacts to matters of State environmental Significance may require offsetting under the *Environmental Offsets Act 2014.* In Queensland, the significance of residual impacts to prescribed matters is defined by the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (Department of Environment and Heritage Protection 2014), which is administered under the *Environmental Offsets Act 2014*.

As the criteria differ for threatened wildlife and special least concern wildlife, these are assessed separately in **Table 5-6** and **Table 5-7**, respectively. This assessment found that it is likely that the Project will have a significant residual impact on two matters of State environmental significance (Squatter Pigeons and Short-beaked Echidnas). One additional species (the Koala) could also experience residual impacts, but the small scale of this disturbance and the low quality of habitat being disturbed means that these impacts may not qualify as significant.

Table 5-6 Assessment of significance of impacts to threatened species of state significance

Threatened Species	Will there be a long-term decrease in the size of a local population?	Will the extent of occurrence of the species be reduced?	Will an existing population be fragmented?	Will it cause genetically distinct populations to form through isolation?	Will it result in harmful invasive species?	Will it introduce disease?	Will it interfere with the recovery of the species?	Will it cause disruption to ecologically significant locations?*
Koala	No	Minor	No	No	No	No	No	Minor
Greater Glider	No	No	No	No	No	No	No	No
Squatter Pigeon	No	Minor	No	No	No	No	No	Yes
Ornamental Snake	No	No	No	No	No	No	No	No
Australian Painted-snipe	No	No	No	No	No	No	No	No
Common Death Adder	No	No	No	No	No	No	No	No
Red Goshawk	No	No	No	No	No	No	No	No
Yakka Skink	No	No	No	No	No	No	No	No
Annual Wiregrass	No	No	No	No	No	No	No	No
Ghost Bat	No	No	No	No	No	No	No	No
Dunmall's Snake	No	No	No	No	No	No	No	No
Allan's Lerista	No	No	No	No	No	No	No	No
King Blue-grass	No	No	No	No	No	No	No	No

*Ecologically significant locations are defined as breeding, feeding, nesting, migration or resting sites.

Table 5-7 Assessment of significance of impacts to Special Least Concern species of state significance

Special Least Concern Species	Will there be a long-term decrease in the size of a local population?	Will the extent of occurrence of the species be reduced?	Will an existing population be fragmented?	Will gene flow among populations be reduced?	Will ecologically significant locations be disrupted?*
Short-beaked Echidna	No	No	No	No	Yes
Fork-tailed Swift	No	No	No	No	No
Latham's Snipe	No	No	No	No	No
Rufous Fantail	No	No	No	No	No
Sharp-tailed Sandpiper	No	No	No	No	No
Oriental Cuckoo	No	No	No	No	No
Gull-billed Tern	No	No	No	No	No
Black-faced Monarch	No	No	No	No	No
Satin Flycatcher	No	No	No	No	No
Glossy Ibis	No	No	No	No	No

*Ecologically significant locations are defined as breeding, feeding or nesting sites.

5.3.4 Matters of National Environmental Significance

Under the *Environment Protection and Biodiversity Conservation Act 1999*, an action will require approval from the Australian Government Environment Minister if the action has, will have, or is likely to have, a significant impact on a matter of national environmental significance. The significance of impacts to matters of national environmental significance is defined by the *Matters of National Environmental Significance Significant Impact Guidelines 1.1*. Each matter is assessed against these guidelines in the following subsections.

5.3.4.1 Threatened Ecological Communities

None of the threatened ecological community listed as "Brigalow (*Acacia harpophylla* dominant and co-dominant)" occurring within the survey area will be cleared or disturbed for the Project.

5.3.4.2 Endangered Species

The Australian Painted-snipe, Northern Quoll, Allan's Lerista and King Blue-grass are nationally endangered species for which possible habitat exists within the survey area. An action is likely to have a significant impact on an endangered species if there is a real chance or possibility that it will:

- lead to a long-term decrease in the size of a population;
- reduce the area of occupancy of the species;
- fragment an existing population into two or more populations;
- adversely affect habitat critical to the survival of a species;
- disrupt the breeding cycle of a population;
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;

- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat;
- introduce disease that may cause the species to decline; or
- interfere with the recovery of the species.

No important habitat for the Northern Quoll is contained within the disturbance footprint of the Vulcan Complex Project (see **Section 4.4.2.1**). Any disturbance is highly unlikely to reduce the size, spatial extent or connectedness of local populations (if present). It is also unlikely to lead to an increase in populations of Feral Cats or Cane Toads, invasive species that threaten Northern Quolls.

The project will not disturb any important habitat for the remaining three endangered species, or introduce invasive species or diseases that could affect these species. The Vulcan Complex Project is not expected to have a significant impact on any nationally endangered species.

5.3.4.3 Vulnerable Species

The Koala, Greater Glider, Squatter Pigeon, Ornamental Snake, Red Goshawk, Yakka Skink, Annual Wiregrass, Hairy Blue-grass, Ghost Bat and Dunmall's Snake are nationally vulnerable species with potential habitat in the survey area. An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

- Lead to a long-term decrease in the size of an important population of a species;
- reduce the area of occupancy of an important population;
- fragment an existing important population into two or more populations;
- adversely affect habitat critical to the survival of a species;
- disrupt the breeding cycle of an important population;
- modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline;
- result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;
- introduce disease that may cause the species to decline; or
- interfere substantially with the recovery of the species.

Of the ten nationally vulnerable species that may occur in the vicinity of the Project, only the Squatter Pigeon is likely to experience loss of primary habitat. The Koala will experience loss of secondary and marginal habitats, while the remaining seven species are unlikely to experience residual impacts as a result of the Vulcan Complex project.

Squatter Pigeon

As the Project lies north of the Carnarvon Ranges, the local population of Squatter Pigeons does not qualify as an "important population" according to the Department of Environment and Energy (2019b). The scale of habitat loss, relative to the large extent of habitat remaining in the local landscape, means that the Project is not likely to jeopardise the viability of local populations. Nevertheless, this local population is expected to decline by approximately 11 individuals (3% of the local population), which may trigger a significant impact under the sixth criterion listed above. The Project may also lead to localised increases in some weeds (see **Section 5.1.11**), which qualify as invasive species potentially threatening ground-feeding Squatter Pigeons. However, these impacts are not likely to extend far beyond the Project footprint. As this impact assessment assumes all habitat within this footprint is to be removed, no additional impacts of weeds are anticipated. Overall, the Project may have a significant residual impact on the Squatter Pigeon under the *Environment Protection and Biodiversity Conservation Act 1999* due to the expectation that it will remove habitat to the extent that the species is likely to decline. The project should be referred to the Department of the Environment and Energy for a formal assessment in order to decide on whether the anticipated impacts to the Squatter Pigeon qualify as significant.

Koala

The Department of Environment and Energy does not currently nominate "important populations" of the Koala in their Species Profile and Threats Database or within the *EPBC Act Referral Guidelines for the Vulnerable Koala*. Instead, the significance of impacts to Koalas is based on whether habitat critical to the survival or recovery of the Koala is affected. The *EPBC Act Referral Guidelines for the Vulnerable Koala* contains a "Koala habitat assessment tool" that assigns a score out of ten to each impact area, with scores of five or above constituting critical habitat. According to this tool, the footprint of the proposed action achieves a score of seven:

- +1 for Koalas known to be occurring within 2 km of the edge of the impact area;
- +2 for containing two or more species of known Koala food tree (*Eucalyptus crebra* and *Eucalyptus camaldulensis*), as well as having one food tree dominating the vegetation in some areas (*E. camaldulensis* in a narrow strip of regrowth RE 11.3.25);
- +2 for habitat connectivity;
- 0 for existing threats, due to the busy highway passing alongside the Project. Numerous fatalities occur along the Saraji Road annually; and
- +2 for recovery values as, while no habitat refuges within riparian habitats will be impacted, the extent of Koala habitat surrounding habitat refuges is being reduced.

Based on this score, impacts to the Koala are considered significant under the EPBC Act, and the project requires approval from the Australian Government Environment Minister due to its forecast impacts on the Koala.

5.3.4.4 Migratory Species

The Rufous Fantail is a migratory species that utilises habitats in the vicinity of the project. The Fork-tailed Swift, Latham's Snipe, Oriental Cuckoo, Black-faced Monarch, Satin Flycatcher, Sharp-tailed Sandpiper, Gull-billed Tern and Glossy Ibis are additional migratory species that possibly utilise habitats in the vicinity of the Project. An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

- Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species;
- result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or
- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

The definitions of "important habitat" for each of these species are defined by the *Referral Guideline for 14 birds Listed as Migratory* (Department of the Environment 2015), the *Industry Guidelines for Avoiding, Assessing and Mitigating Impacts on EPBC Act listed Migratory Shorebird Species* (Department of the Environment and Energy 2017) and the *Revision of the East Asian-Australasian Flyway Population Estimates for 37 Listed Migratory Shorebird Species* (Hansen *et al.* 2017). These are summarised in

Table 5-8 Definitions of "important habitat" and "ecologically significant proportion of the population" for migratory species potentially utilising the Vulcan Complex project area

Species	Important habitat	Invasive species that could be harmful	Ecologically significant proportion of the population	Area of important habitat likely to result in a significant impact if affected
Rufous Fantail	Moist, dense habitats, including mangroves, rainforest, riparian forests and thickets, and wet eucalypt forests with a dense understorey. When on passage a wider range of habitats are used including dry eucalypt forests and woodlands and Brigalow shrublands.	Black Rat *Rattus rattus*, invasive vines of riparian habitat (e.g. rubber vine *Cryptostegia grandiflora*).	1,100 individuals	260 ha
Fork-tailed Swift	Found across a range of habitats, from inland open plains to wooded areas, where it is exclusively aerial.	Unknown	100 individuals	Impacts only considered possible when wind turbines, tall buildings, airports, or other developments interrupt airspace.
Latham's Snipe	Areas that have previously been identified as internationally important for the species, or areas that support at least 18 individuals of the species.	Feral Cat, Red Fox	18 individuals	Not prescribed
Oriental Cuckoo	Monsoonal rainforest, vine thickets, wet sclerophyll forest or open *Casuarina*, *Acacia* or *Eucalyptus* woodlands. Frequently at edges or ecotones between habitat types. Riparian forest is favoured habitat in the Kimberley region.	Unknown	1,000 individuals	25,000 ha
Black-faced Monarch	Wet forest specialist, found mainly in rainforest and wet sclerophyll forest, especially in sheltered gullies and slopes with a dense understorey of ferns and/or shrubs.	Black Rat Rattus rattus, invasive vines of riparian habitat (e.g. rubber vine *Cryptostegia grandiflora*).	460 individuals	260 ha
Satin Flycatcher	Eucalypt forest and woodlands, at high elevations when breeding. They are particularly common in tall wet sclerophyll forest, often in gullies or along water courses. In woodlands they prefer open, grassy woodland types. During migration, habitat preferences expand, with the species recorded in most wooded habitats except rainforests. Wintering birds in northern Qld will use rainforest/gallery forests interfaces, and birds have been recorded wintering in mangroves and paperbark swamps.	Black Rat Rattus rattus, invasive vines of riparian habitat (e.g. rubber vine *Cryptostegia grandiflora*).	1,700 individuals	440 ha

Species	Important habitat	Invasive species that could be harmful	Ecologically significant proportion of the population	Area of important habitat likely to result in a significant impact if affected
Sharp-tailed Sandpiper	Nationally important habitat for migratory shorebirds is defined as supporting: • 0.1 per cent of the flyway population of a single species of migratory shorebird OR • 2000 migratory shorebirds OR • 15 migratory shorebird species.	Unknown	85 individuals	>0 ha
Gull-billed Tern	Not prescribed			
Glossy Ibis	Not prescribed			

The project will not disrupt an ecologically significant proportion of any migratory species population. The project is also not anticipated to cause the establishment of harmful invasive species. Within the disturbance footprint, important habitat (as defined by Department of the Environment 2015) exists for the Rufous Fantail, Oriental Cuckoo and Satin Flycatcher. However, the habitats present on site are marginal (more inland, drier and open than is generally preferred) for all three species. The most likely habitats to be used by the three species within the survey area (vine thickets and dense riparian forests) will not be disturbed by the project. It is highly unlikely that the marginal habitats to be disturbed are a limiting factor constraining the migration of any of the migratory bird species listed in

Table 5-8. For this reason, it is considered unlikely that the Vulcan Complex Project will result in a significant impact on any migratory species protected under the EPBC Act.

5.4 OFFSET REQUIREMENTS

Offsets are required if the residual impacts to prescribed matters, after avoidance and mitigation measures have been implemented, are considered significant in accordance with the relevant guidelines.

5.4.1 State

Based on the assessment contained in **Section 5.3** (especially **Section 5.3.3.18**), significant impacts to the vulnerable Squatter Pigeon (loss of 73.1 ha of primary habitat and 15.6 ha of secondary habitat) and special least concern Short-beaked Echidna (loss of 224.5 ha of habitat) are likely to occur as a result of the Project. Additional residual impacts to the vulnerable Koala (loss of 2.6 ha of secondary habitat and 66.3 ha of marginal habitat) may be significant.

The following regulated vegetation types also constitute matters of state significance that will be lost as a result of the project:

- 15.2 ha of category R vegetation; and
- 17.7 ha of category B, C or R areas on the regulated vegetation management map that are located within a specified distance from the defining banks of a relevant watercourse.

Nevertheless, not all significant impacts require offsets under the Queensland Environmental Offset Framework; according to the *Queensland Environmental Offsets Policy Significant Residual Impact Guideline* (Department of Environment and Heritage Protection 2014), if residual impacts are significant an offset *may* be required. In light of the small scale of the proposed impacts and the negligible effects the Project is likely to have on local populations of these three species, offsets may not be deemed necessary. This decision ultimately lies with the Department of Environment and Science, who will assess this via the Environmental Authority application process.

If environmental offsets are judged to be required, a Draft Offset Delivery Mechanism report is to be prepared by Vitrinite. Following confirmation of this approach via habitat quality assessments of the proposed offset area, an Offset Delivery Plan is then to be developed and submitted to the State Government for approval.

5.4.2 National

Based on the assessment contained in **Section 5.3.4**, the impacts of the project on the Koala are likely to qualify as significant residual impacts. It is therefore likely that offsets will be required under the *EPBC Act Environmental Offsets Policy 2012.* The impacts of the project on the Squatter Pigeon also possibly qualify as significant. This is to be decided by the Department of the Environment and Energy via a formal assessment of the information presented within this report. The project should be referred to the Department of the Environment and Energy under the EPBC Act, in order to assess the potential for significant impacts. The Minister will then decide whether the proposed actions will likely lead to a significant impact on matters of national environmental significance (defined as a controlled action). Controlled actions must be assessed and approved under the EPBC Act, and an offset proposal is one of many considerations that are weighed at the decision stage in determining the overall acceptability of the proposed action. An offset proposal should be developed for any matters likely to experience a significant residual impact.

As the matters of national environmental significance that are most likely to experience significant impacts are also matters of state environmental significance (requiring offsets under the *Environmental Offsets Act 2014*), duplicate offsets are not required. In accordance with the *Queensland Environmental Offsets Policy 2017*, the Queensland Government can only impose an offset condition in relation to a prescribed activity, if the same, or substantially the same, impact and the same, or substantially the same, matter has not been subject to assessment as a controlled action under the EPCB Act. However, an activity referred to the Commonwealth Government that receives a

'not a controlled action' or a 'not controlled action - particular manner' notice, could still be subject to an offset condition imposed by the Queensland Government. Consequently, in developing an Offset Delivery Plan, offsets for MNES must meet the requirements specified in the *EPBC Act Environmental Offsets Policy 2012*, while offsets for MSES that are not also MNES must meet requirements specified in the *Queensland Environmental Offsets Policy 2017.*

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APPENDIX A

FAUNA TRAP SITE DESCRIPTIONS

Appendix A Fauna trap site descriptions

Site Name: S1 **Description:** Remnant *Eucalyptus orgadophila* open woodland on clay derived from fine-grained sedimentary rock. **BVG:** 17b **Dates:** 24-28/10/2018 **Latitude, Longitude:** -22.3521, 148.2200	
Site Name: S2 **Description:** Remnant *Acacia harpophylla* open forest with emergent *Eucalyptus cambageana.* **BVG:** 25a **Dates:** 25-29/10/2018 **Latitude, Longitude:** -22.3515, 148.2272	
Site Name: S3 **Description:** Cleared pasture with *Carissa ovata* on clay soil **BVG:** n/a **Dates:** 25-29/10/2018 **Latitude, Longitude:** -22.3557, 148.2396	
Site Name: S4 **Description:** Edge of remnant riparian forest dominated by *Eucalyptus camaldulensis.* **BVG:** 16a/9e **Dates**: 25-29/10/2018 **Latitude, Longitude:** -22.3676, 148.2345	

Site Name: S5 **Description:** Ecotone between remnant *Corymbia tessellaris* forest on a sandy alluvial terrace and *Eucalyptus camaldulensis* and *Bauhinia hookeri* along the creek bank. **BVG:** 16a/9e **Dates:** 28/10-1/11/2018 **Latitude, Longitude:** -22.3749, 148.2401	
Site Name: S6 **Description:** Remnant open forest dominated by *Casuarina cristata* and *Acacia harpophylla* on clay soil. **BVG**: 25a **Dates**: 29/10-2/11/2018 **Latitude, Longitude:** -22.3834, 148.2431	
Site Name: S7 **Description:** Remnant *Eucalyptus populnea* open forest on a sand plain. **BVG:** 17a **Dates:** 29/10-2/11/2018 **Latitude, Longitude:** -22.3890, 148.2448	
Site Name: S8 **Description:** High-value regrowth of *Eucalyptus populnea* on a sand plain. **BVG:** 17a (regrowth) **Dates:** 29/10-2/11/2018 **Latitude, Longitude:** -22.3929, 148.2586	

Site Name: S9 **Description:** Heavily thinned *Eucalyptus crebra* and *Corymbia clarksoniana* woodland on a sand plain. **BVG:** 18b (regrowth) **Dates:** 25-28/3/2019 and 8-12/4/2019 **Latitude, Longitude:** -22.3900, 148.2267 Original trapping session was disrupted by heavy rain and had to be repeated at a later date.	
Site Name: S10 **Description:** Remnant *Eucalyptus populnea* open forest, with some *Eucalyptus melanophloia*, on a sandy alluvial terrace. **BVG:** 17a **Dates:** 26-28/3/2019 and 9-13/4/2019 **Latitude, Longitude**: -22.3757, 148.2155 Original trapping session was disrupted by heavy rain and had to be repeated at a later date.	
Site Name: S11 **Description:** Remnant *Corymbia clarksoniana* and *Eucalyptus crebra* open forest at the base of a rocky sandstone scree slope. **BVG:** 12a **Dates:** 26-28/3/2019 and 9-13/4/2019 **Latitude, Longitude:** -22.3773, 148.2017 Original trapping session was disrupted by heavy rain and had to be repeated at a later date.	
Site Name: S12 **Description:** Remnant *Acacia harpophylla* and *Eucalyptus cambageana* woodland on a clay plain. **BVG:** 25a **Dates:** 27-28/3/2019 and 8-12/4/2019 **Latitude, Longitude:** -22.3769, 148.2384 Original trapping session was disrupted by heavy rain and had to be repeated at a later date.	

Site Name: S13 **Description:** Cleared pasture with scattered *Eucalyptus populnea* on a sand plain. **BVG:** n/a **Dates:** 13-17/4/2019 **Latitude, Longitude:** -22.3761, 148.2588	
Site Name: S14 **Description:** Remnant *Eucalyptus populnea* woodland on a sand plain. **BVG:** 17a **Dates:** 9-13/4/2019 **Latitude, Longitude:** -22.3666, 148.2052	
Site Name: S15 **Description:** Partly thinned woodland dominated by *Eucalyptus crebra* on a low sandstone rise. **BVG:** 18b **Dates:** 12-16/4/2019 **Latitude, Longitude:** -22.3592, 148.1983	
Site Name: S16 **Description:** Remnant *Corymbia aureola* and *Eucalyptus melanophloia* open forest with a shrub layer dominated by *Acacia* spp. on sandstone. **BVG:** 12a **Dates:** 12-16/4/2019 **Latitude, Longitude**: -22.3567, 148.1928	

Site Name: S17 **Description:** Remnant *Eucalyptus orgadophila* open woodland on clay derived from fine-grained sedimentary rock. **BVG:** 17b **Dates:** 13-17/4/2019 **Latitude, Longitude:** -22.3537, 148.2339	
Site Name: S18 **Description:** Remnant open forest dominated by *Acacia rhodoxylon* and *Acacia shirleyi* on sandstone. **BVG:** 24a **Dates:** 1-5/5/2019 **Latitude, Longitude:** -22.3424, 148.2103	
Site Name: S19 **Description:** Remnant open forest dominated by *Acacia shirleyi* on sandstone. **BVG:** 24a **Dates:** 1-5/5/2019 **Latitude, Longitude:** -22.3497, 148.2013	
Site Name: S20 **Description:** Remnant woodland dominated by *Eucalyptus crebra* and *Corymbia clarksoniana*, with a shrub layer dominated by *Alphitonia excelsa, Petalostigma pubescens* and *Acacia burdekensis*, on a sand plain. **BVG:** 18b **Dates**: 1-5/5/2019 **Latitude, Longitude**: -22.3518, 148.2112	

Site Name: S21 **Description:** Remnant *Eucalyptus orgadophila* open woodland on heavy clay soil derived from fine-grained sedimentary rock. **BVG:** 17b **Dates:** 30/4-4/5/2019 **Latitude, Longitude:** -22.3593, 148.2296	
Site Name: S22 **Description:** Remnant open forest dominated by *Eucalyptus crebra, Corymbia clarksoniana* and *Eucalyptus melanophloia*, with a dense shrub layer containing *Alphitonia excelsa, Petalostigma pubescens* and *Acacia burdekensis.* **BVG:** 18b **Dates:** 4-8/5/2019 **Latitude, Longitude:** -22.3306, 148.2124	
Site Name: S23 **Description:** Remnant open forest dominated by *Corymbia tessellaris, Corymbia clarksoniana* and *Eucalyptus crebra* beside a creek lined with *Eucalyptus camaldulensis* and *Melaleuca* spp. **BVG:** 16a/9e **Dates:** 5-9/5/2019 **Latitude, Longitude:** -22.3062, 148.1943	
Site Name: S24 **Description:** Remnant open forest dominated by *Corymbia citriodora, Eucalyptus crebra* and *Corymbia trachyphloia,* with a shrub layer containing *Lysicarpus angustifolius* and *Acacia shirleyi.* **BVG:** 10a **Dates:** 5-9/5/2019 **Latitude, Longitude**: -22.2915, 148.1672	

Site Name: S25 **Description:** Remnant *Acacia shirleyi* open forest, but with many dead trees. **BVG:** 12a **Dates:** 5-9/5/2019 **Latitude, Longitude:** -22.2854, 148.1516	
Site Name: S26 **Description:** Non-remnant open woodland dominated by *E. melanophloia, C. clarksoniana* and *Melaleuca viridiflora* on sandy soil. One of the densest examples of non-remnant habitat. **BVG:** Cleared **Dates:** 23-27/09/2019 **Latitude, Longitude:** -22.2880, 148.1920.	
Site Name: S27 **Description:** Remnant open forest dominated by *C. citriodora* on coarse-grained sedimentary rocks. **BVG:** 10a **Dates:** 24-28/09/2019 **Latitude, Longitude:** -22.2860, 148.1471	
Site Name: S28 **Description:** Remnant woodlands dominated by *C. citriodora* on coarse-grained sedimentary rocks with dense *Acacia shirleyi* midstorey. **BVG:** 10a **Dates:** 24-28/09/2019 **Latitude, Longitude:** -22.2867, 148.1586	

Site Name: S29 **Description:** Remnant *A. shirleyi* open forest on coarse-grained sedimentary rocks. *C. aureola* also present with a sparse, grassy understorey. **BVG:** 24a **Dates:** 25-29/09/2019 **Latitude, Longitude:** -22.2905, 148.1746.	
Site Name: S30 **Description:** High-value regrowth with many dead trees and large amounts of fallen debris. Heavily grazed and very open. Canopy dominated by *C. clarksoniana* and *E. crebra.* **BVG:** 12a **Dates:** 27-1/10/2019 **Latitude, Longitude:** -22.2812, 148.1792.	
Site Name: S31 **Description:** High-value regrowth, dominated by *Eucalyptus crebra* with a dense midstorey of *A. burdekensis*, on coarse-grained sedimentary rocks. **BVG:** 12a (regrowth) **Dates:** 27-01/10/2019 **Latitude, Longitude:** -22.2797, 148.1767.	
Site Name: S32 **Description:** High-value regrowth *E. crebra* and *C. clarksoniana* woodland on coarse-grained sedimentary rocks. **BVG:** 12a (regrowth) **Dates:** 28-02/10/2019 **Latitude, Longitude:** -22.3098, 148.1940.	

Site Name: S33 **Description:** High-value regrowth *E. crebra* woodland with dense midstorey of *Acacia* spp. and *Melaleuca viridiflora*. **BVG:** 18b (regrowth) **Dates:** 28-02/10/2019 **Latitude, Longitude:** -22.3182, 148.1980.	
Site Name: S34 **Description:** High-value regrowth dominated by *A. rhodoxylon.* Contained large amounts of fallen debris. **BVG:** 24a (regrowth) **Dates:** 29-03/10/2019 **Latitude, Longitude:** -22.3990, 148.2654.	

APPENDIX B

VEGETATION DATA FROM SECONDARY SITES

SECONDARY SITE 1 **11.5.9**



Latitude, Longitude: -22.3307, 148.2130

Community description: Low open forest dominated by *Melaleuca nervosa,* with emergent *Alphitonia excelsa*, on a flat sandy plain. The species composition was similar to nearby RE 11.5.9, except for the absence of an upper stratum of *Eucalyptus crebra.* This was therefore considered to be a variation of 11.5.9.

Dominant species per stratum:

E: *Alphitonia excelsa, Melaleuca nervosa.*
T1: *Acacia burdekensis, Melaleuca nervosa.*
S1: *Acacia burdekensis, Melaleuca nervosa.*
S2: *Erythroxylum australe.*
G: *Perotis rara, Setaria surgens, Cheilanthes sieberi.*

Median (and range) canopy height per stratum: E = 9.2 m (9.0–12.4 m), T1 = 5.2 m (4.2–7.4 m), S1 = 2.25 m (2.0–3.0 m), S2 = 1 m (0.4–1.2 m).

% cover of each stratum (vertical projection along 100 m tape): E = 5.5%; T1 = 62.3%; S1 = 5.7%; S2 <0.1%; **total = 65.7%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

E: *Alphitonia excelsa* = 1 m^2/ha **(total = 1 m^2/ha).**
T1: *Melaleuca nervosa* = 4.17 m^2/ha; *Acacia burdekensis* = 0.67 m^2/ha; *Alphitonia excelsa* = 0.67 m^2/ha **(total = 5.51 m^2/ha).**
S1: *Melaleuca nervosa* = 0.5 m^2/ha; *Acacia burdekensis* = 0.17 m^2/ha **(total = 0.67 m^2/ha).**
S2: *Erythroxylum* < 0.15 m^2/ha **(total < 0.15 m^2/ha).**

Landform: Plain **Slope:** 1° E **Soil:** Brown sand

Disturbance: Nil

Ground cover: Rock = 0%, wood = 3%, bare = 30%, litter = 42%, vegetation = 25%.

Species (percent cover): *Acanthospermum hispidum** (0.1%), *Afrohybanthus stellarioides* (0.1%), *Alloteropsis cimicina* (0.4%), *Alphitonia excelsa* (0.2%), *Aristida holathera* (0.6%), *Bonamia media* (0.1%), *Cheilanthes sieberi* (7%), *Chrysocephalum apiculatum* (0.2%), *Crotalaria medicaginea* (0.1%), *Dactyloctenium radulans* (0.1%), *Desmodium varians* (0.3%), *Emilia sonchifolia** (0.1%), *Eragrostis sororia* (0.1%), *Erythroxylum australe* (0.1%), *Evolvulus alsinoides* (0.1%), *Fimbristylis dichotoma* (0.4%), *Heliotropium peninsulare* (0.1%), *Ipomoea polymorpha* (0.7%), *Melaleuca nervosa* (0.2%), *Murdannia graminea* (0.1%), *Perotis rara* (4%), *Phyllanthus* sp. (Myra Vale J.J.Bruhl+ 1810) (0.2%), *Portulaca filifolia* (0.1%), *Richardia brasiliensis** (0.1%), *Setaria surgens* (5%), *Sida cordifolia** (0.8%), *Spermacoce brachystema* (0.1%), *Stylosanthes hamata** (0.3%), *Stylosanthes scabra** (0.1%), *Tephrosia dietrichiae* (0.1%), *Tricoryne elatior* (0.1%), *Urochloa piligera* (3%), *Zornia muelleriana* subsp. *muelleriana* (0.1%).

SECONDARY SITE 2 **11.5.9**



Latitude, Longitude: -22.3337, 148.2100

Community description: Low woodland dominated by *Eucalyptus melanophloia* on a flat, sandy plain.

Dominant species per stratum:

T1: *Eucalyptus melanophloia.*
T2: *Acacia burdekensis, Eucalyptus melanophloia.*
S1: *Erythroxylum australe, Petalostigma pubescens.*
G: *Alloteropsis cimicina, Aristida calycina* var. *calycina, Eriachne obtusa, Evolvulus alsinoides*

Median (and range) canopy height per stratum: T1 = 6.8 m (5.2–11.4 m), T2 = 4 m (3.2–5 m), S1 = 1.5 m (0.8–2 m).

% cover of each stratum: T1 = 20.2%; T2 = 23.9%; S1 = 5%; **total = 44.6%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus melanophloia* = 4.83 m^2/ha; *Acacia burdekensis* = 0.17 m^2/ha **(total = 5 m^2/ha).**
T2: *Acacia burdekensis* = 1.5 m^2/ha; *Eucalyptus melanophloia* = 0.17 m^2/ha **(total = 1.67 m^2/ha).**
S1: total <0.17 m^2/ha.

Landform: Plain **Slope:** 1°NE **Soil:** Yellow-brown sand

Disturbance: Lightly grazed

Ground cover: Rock = 0%, wood = 1%, bare = 35%, litter = 40%, vegetation = 24%.

Species (percent cover): *Acacia burdekensis* (0.1%), *Afrohybanthus enneaspermus* (0.1%), *Afrohybanthus stellarioides* (0.1%), *Alloteropsis cimicina* (9%), *Alphitonia excelsa* (0.2%), *Alternanthera nana* (0.1%), *Aristida calycina* var. *calycina* (2%), *Chrysopogon fallax* (0.3%), *Digitaria divaricatissima* (0.1%), *Digitaria* sp. A (0.2%), *Eragrostis lacunaria* (0.2%), *Eragrostis sororia* (0.1%), *Eriachne obtusa* (8%), *Eucalyptus melanophloia* (0.1%), *Evolvulus alsinoides* (0.9%), *Fimbristylis dichotoma* (0.6%), *Ipomoea polymorpha* (0.1%), *Melaleuca nervosa* (0.1%), *Murdannia graminea* (0.1%), *Paspalidium rarum* (0.1%), *Petalostigma pubescens* (0.1%), *Phyllanthus carpentariae* (0.1%), *Phyllanthus collinus* (0.1%), *Phyllanthus* sp. (Myra Vale J.J.Bruhl+ 1810) (0.1%), *Portulaca pilosa** (0.1%), *Richardia brasiliensis** (0.1%), *Sida hackettiana* (0.1%), *Sida* sp. (Aramac E.J. Thompson+ JER192) (0.2%), *Stylosanthes scabra** (0.2%), *Tephrosia leptoclada* (0.1%), *Urochloa piligera* (0.1%), *Zornia muelleriana* subsp. *muelleriana* (0.1%).

SECONDARY SITE 3 **11.10.13**



Latitude, Longitude: -22.3370, 148.2069

Community description: Low open forest dominated by *Corymbia aureola, Eucalyptus melanophloia* and *Acacia shirleyi* on a low sandstone ridge.

Dominant species per stratum:

T1: *Acacia shirleyi, Corymbia aureola, Eucalyptus melanophloia.*
T2: *Acacia burdekensis.*
S1: *Erythroxylum australe.*
G: *Cleistochloa subjuncea*, *Digitaria diminuta.*

Median (and range) canopy height per stratum: T1 = 9.4 m (8.6–12.4 m), T2 = 5.2 m (3.4–6 m), S1 = 2.4 m (2–2.6 m), S2 = 1 m (0.5–1.5 m).

% cover of each stratum: T1 = 37.6%; T2 = 21.3%; S1 = 6.7%; t**otal = 56.6%**.

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Corymbia aureola* = 2.33 m^2/ha; *Acacia shirleyi* = 1.5 m^2/ha; *Eucalyptus melanophloia* = 1.17 m2/ha **(total = 5 m^2/ha).**
T2: *Acacia burdekensis* = 0.17 m^2/ha; *Acacia shirleyi* = 0.5 m^2/ha; *Alphitonia excelsa* = 0.17 m^2/ha; *Corymbia aureola* = 0.17 m^2/ha; *Eucalyptus melanophloia* = 0.17 m^2/ha **(total = 1.18 m^2/ha).**
S1: *Erythroxylum australe* = 0.33 m^2/ha **(total = 0.33 m^2/ha).**

Landform: Low rocky rise **Slope:** 3°NNE **Soil:** Grey sand

Disturbance: none

Ground cover: Rock = 45%, wood = 7%, bare = 10%, litter = 23%, vegetation = 15%.

Species (percent cover): *Acacia bancroftiorum* (0.1%), *Acacia shirleyi* (0.1%), *Achyranthes aspera* (0.1%), *Afrohybanthus stellarioides* (0.1%), *Alloteropsis imicina* (0.1%), *Alphitonia excelsa* (0.1%), *Aristida benthamii* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Cheilanthes sieberi* (0.1%), *Chrysopogon fallax* (0.1%), *Cleistochloa subjuncea* (7%), *Corymbia aureola* (0.1%), *Cyanthillium cinereum* (0.1%), *Desmodium macrocarpum* (0.1%), *Digitaria diminuta* (3.6%), *Eragrostis lacunaria* (0.1%), *Eragrostis sororia* (0.1%), *Eriochloa pseudoacrotricha* (0.1%), *Erythroxylum australe* (0.2%), *Eucalyptus melanophloia* (0.1%), *Euphorbia drummondii* (0.1%), *Evolvulus alsinoides* (0.1%), *Fimbristylis dichotoma* (0.1%), *Galactia tenuiflora* (0.1%), *Hibiscus meraukensis* (0.1%), *Ipomoea brownii* (0.2%), *Marsdenia microlepis* (0.1%), *Melinis repens* (0.1%), *Panicum effusum* (0.1%), *Paspalidium gracile* (0.1%), *Petalostigma pubescens* (0.1%), *Phyllanthus carpentariae* (0.1%), *Pseuderanthemum variabile* (0.1%), *Scleria brownii* (0.1%), *Sida* sp. (Musselbrook M.B.Thomas+ MRS437) (0.1%), *Spermacoce brachystema* (0.1%), *Stylosanthes scabra** (0.2%), *Tephrosia juncea* (0.1%), *Themeda triandra* (0.1%), *Ventilago viminalis* (0.1%), *Xenostegia tridentata* (0.1%).

SECONDARY SITE 4 **11.5.9**



Latitude, Longitude: -22.3403, 148.2247

Community description: Low woodland dominated by *Allocasuarina leuhmannii* on a sand plain. It is best considered a variant of 11.5.9 lacking a *Eucalyptus* upper stratum.

Dominant species per stratum:

T1: *Allocasuarina luehmannii.*
T2: *Acacia burdekensis, Allocasuarina luehmannii, Grevillea striata.*
S1: *Allocasuarina luehmannii.*
G: *Eragrostis sororia*, *Chrysopogon fallax*, *Eriachne obtusa*.

Median (and range) canopy height per stratum: T1 = 9.4 (8–11.6 m), T2 = 5 m (4.2–5.6 m), S1 = 2.8 m (1.6–3 m).

% cover of each stratum: T1 = 31.3%, T2 = 20.8%; S1 = 11%; **total = 55.2%**.

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Allocasuarina luehmannii* = 3.83 m^2/ha; *Eucalyptus melanophloia* = 0.17 m^2/ha **(total = 4 m^2/ha).**
T2: *Allocasuarina luehmannii* = 4.5 m^2/ha **(total = 4.5 m^2/ha).**
S1: < 0.17 m^2/ha.

Landform: Slight rise on a sandy plain **Slope:** 2°E **Soil:** Yellow-brown sand

Disturbance: Nil

Ground cover: Rock = 0%, wood = 2%, bare = 34%, litter = 45%, vegetation = 19%.

Species (percent cover): *Allocasuarina luehmannii* (0.4%), *Alternanthera nana* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Aristida holathera* (0.1%), *Brunoniella australis* (0.1%), *Carissa ovata* (0.1%), *Cheilanthes sieberi* (0.3%), *Chrysopogon fallax* (3.1%), *Commelina lanceolata* (0.1%), *Eragrostis lacunaria* (0.1%), *Eragrostis sororia* (5%), *Eremochloa bimaculata* (0.1%), *Eriachne obtusa* (7%), *Evolvulus alsinoides* (0.8%), *Fimbristylis dichotoma* (0.1%), *Grevillea striata* (0.1%), *Murdannia graminea* (0.4%), *Oldenlandia mitrasacmoides* subsp. *trachymenoides* (0.1%), *Panicum effusum* (0.1%), *Petalostigma pubescens* (0.1%), *Phyllanthus collinus* (0.1%), *Polycarpaea corymbosa* (0.1%), *Portulaca pilosa** (0.1%), *Sida hackettiana* (0.1%), *Sphaeromorphaea australis* (0.1%), *Stylosanthes scabra** (0.1%), *Tephrosia leptoclada* (0.1%).

SECONDARY SITE 5 **11.4.8**



Latitude, Longitude: -22.3424, 148.2219

Community description: Low open forest dominated by *Casuarina cristata* and *Acacia harpophylla* (subdominant), with emergent *Eucalyptus cambageana*, on clay plain.

Dominant species per stratum:

E: *Eucalyptus cambageana.*
T1: *Acacia harpophylla, Casuarina cristata.*
T2: *Acacia harpophylla, Terminalia oblongata.*
S1: *Carissa ovata*.
G: *Ancistrachne uncinata, Paspalidium constrictum*, *Chloris divaricata*, *Cyperus gracilis*.

Median (and range) canopy height per stratum: E = 16 (14.4–16.4 m) T1 = 9.2 m (7.2–11.6 m), T2 = 3.5 m (3.0–4.0 m), S1 = 2 m (1.0–2.5 m).

% cover of each stratum: E = 19%; T1 = 67.1%; T2 = 13.1%; S1 = 4.3%; **total = 78.8%**.

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

E: *Eucalyptus cambageana* = 2.17 **(total = 2.17 m^2/ha).**
T1: *Casuarina cristata* = 5.83 m^2/ha; *Acacia harpophylla* = 1.33 m^2/ha; *Eucalyptus cambageana* = 0.83 m^2/ha; *Terminalia oblongata* = 0.33 m^2/ha. **(total = 8.32 m^2/ha).**
T2: *Acacia harpophylla* =0.33 m^2/ha **(total = 0.33 m^2/ha).**
S1: <0.17 m^2/ha.

Landform: Slight rise on a plain **Slope:** 1°E **Soil:** Reddish-brown sand, but probably texture contrast, with a clay subsoil.

Disturbance: Nil

Ground cover: Rock = 0%, wood = 8%, bare = 4%, litter = 75%, vegetation = 13%.

Species (percent cover): *Abutilon oxycarpum* (0.1%), *Acacia harpophylla* (0.1%), *Alectryon diversifolius* (0.1%), *Ancistrachne uncinata* (1.2%), *Apowollastonia spilanthoides* (0.1%), *Boerhavia pubescens* (0.1%), *Bothriochloa pertusa** (0.1%), *Brunoniella australis* (0.1%), *Bursaria incana* (0.1%), *Capparis lasiantha* (0.1%), *Carissa ovata* (5.5%), *Casuarina cristata* (0.2%), *Cheilanthes sieberi* (0.1%), *Chloris divaricata* (0.9%), *Cymbidium canaliculatum* (0.1%), *Cymbopogon refractus* (0.1%), *Cynanchum viminale* (0.1%), *Cyperus gracilis* (0.7%), *Desmodium varians* (0.1%), *Einadia nutans* (0.1%), *Enchylaena tomentosa* var. *tomentosa* (0.1%), *Enneapogon lindleyanus* (0.1%), *Eremophila mitchellii* (0.1%), *Erythroxylum australe* (0.1%), *Evolvulus alsinoides* (0.1%), *Geijera parviflora* (0.1%), *Grewia retusifolia* (0.1%), *Hibiscus brachysiphonius* (0.1%), *Hibiscus sturtii* (0.1%), *Jasminum didymum* subsp. *lineare* (0.1%), *Nyssanthes erecta* (0.1%), *Parsonsia lanceolata* (0.1%), *Paspalidium constricutum* (0.9%), *Phyllanthus collinus* (0.1%), *Pseuderanthemum variabile* (0.1%), *Sida corrugata* (0.2%), *Solanum ellipticum* (0.1%), *Solanum parvifolium* (0.1%), *Sporobolus scabridus* (0.1%), *Themeda avenacea* (0.1%), *Vachellia bidwillii* (0.1%).

SECONDARY SITE 6 **11.9.2**



Latitude, Longitude: -22.3503, 148.2209

Community description: Woodland dominated by *Eucalyptus orgadophila* and *Corymbia erythrophloia* on clay soil derived from fine-grained sedimentary rock.

Dominant species per stratum:

T1: *Eucalyptus orgadophila.*
T2: *Corymbia erythrophloia*, *Eucalyptus orgadophila*.
S1: *Bursaria incana, Denhamia cunninghamii, Atalaya hemiglauca.*
S2: *Carissa ovata.*
U: *Bothriochloa pertusa*.*

Median (and range) canopy height per stratum: T1 = 12.8 m (10.4–17.6 m), T2 = 5.2 m (4.0–7.0 m), S1 = 1.7 m (1.5–2.1 m), S2 = 0.9 m (0.5–1.2 m).

% cover of each stratum: T1 = 15.6%; T2 = 11.2% S1 = 0.5%, S2 = 3%; **total = 26.9%**.

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Corymbia erythrophloia* = 1.33 m^2/ha; *Eucalyptus crebra* = 0.33 m^2/ha; *Eucalyptus orgadophila* = 0.5 m^2/ha **(total = 4.08 m^2/ha).**
T2: *Corymbia erythrophloia* = 1 m^2/ha **(total = 1 m^2/ha).**
S1: <0.17 m^2/ha).
S2: < 0.17 m^2/ha.

Landform: Low rise **Slope:** 1°N **Soil:** Dark-brown clay

Disturbance: Heavily grazed

Ground cover: Rock = 0%, wood = 0.5%, bare = 10%, litter = 4.2%, vegetation = 85.3%.

Species (percent cover): *Abildgaardia ovata* (0.1%), *Afrohybanthus enneaspermus* (0.1%), *Alloteropsis semialata* (0.1%), *Aristida gracilipes* (0.1%), *Atalaya hemiglauca* (0.1%), *Bothriochloa ewartiana* (0.2%), *Bothriochloa pertusa** (78.9%), *Brunoniella australis* (0.1%), *Carissa ovata* (3%), *Cenchrus ciliaris** (0.1%), *Chrysopogon fallax* (0.1%), *Corymbia erythrophloia* (0.1%), *Cyanthillium cinereum* (0.1%), *Denhamia cunninghamii* (0.1%), *Desmodium varians* (0.1%), *Enneapogon* sp. A (0.1%), *Evolvulus alsinoides* (0.1%), *Fimbristylis dichotoma* (0.1%), *Galactia tenuiflora* (0.1%), *Grewia latifolia* (0.1%), *Heliotropium peninsulare* (0.1%), *Indigofera linifolia* (0.1%), *Indigofera linnaei* (0.1%), *Melhania oblongifolia* (0.1%), *Neptunia gracilis* (0.1%), *Phyllanthus fuernrohrii* (0.1%), *Rhynchosia minima* (0.1%), *Rostellularia adscendens* (0.1%), *Scleria brownii* (0.1%), *Sida hackettiana* (0.1%), *Stylosanthes scabra** (0.3%), *Tephrosia filipes* subsp. *filipes* (0.1%), *Themeda triandra* (0.1%).

SECONDARY SITE 7 **11.10.7**



Latitude, Longitude: -22.3041, 148.1923

Community description: Low woodland dominated by *Corymbia clarksoniana* on a low sandstone rise. The community does not closely match any of the described regional ecosystems, but is closest to 11.10.1 and 11.10.7. Nearby areas of the ridge had *Eucalyptus crebra* and/or *Eucalyptus melanophloia* growing alongside *C. clarksoniana*, so 11.10.7 was considered the best fit for the community.

Dominant species per stratum:

T1: *Corymbia clarksoniana.*
T2: *Acacia flavescens, Acacia burdekensis, Alphitonia excelsa, Petalostigma pubescens.*
S1: *Erythroxylum australe, Leptospermum lamellatum, Petalostigma pubescens.*
G: *Melinis repens*, Digitaria eriantha*, Aristida calycina* var*. calycina.*

Median (and range) canopy height per stratum: T1 = 9.6 m (9.6–10.6 m), T2 = 6.4 m (4.6–6.8 m), S1 = 2.5 m (1–3 m)

% cover of each stratum: T1 = 22.1%; T2 = 13.6%; S1 = 6%; S2 = 11%; **total = 52.4%**.

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Corymbia clarksoniana* = 1.83 m^2/ha **(total = 1.83 m^2/ha).**
T2: *Petalostigma pubescens* = 0.33 m^2/ha; *Corymbia clarksoniana* = 0.33 m^2/ha; *Terminalia porphyrocarpa* = 0.33 m^2/ha; *Alphitonia excelsa* = 0.17 m^2/ha; *Acacia burdekensis* = 0.17 m^2/ha **(total = 1.33 m^2/ha).**
S1: *Erythoxylum australe* = 0.67 m^2/ha **(total = 0.67 m^2/ha).**

Landform: Crest of low sandstone rise **Slope:** 4°NE **Soil:** Light grey-pink sand

Disturbance: Heavily grazed

Ground cover: Rock = 59%, wood = 1%, bare = 12%, litter = 13%, vegetation = 15%.

Species (percent cover): *Acacia flavescens* (0.2%), *Achyranthes aspera* (0.1%), *Afrohybanthus enneaspermus* (0.1%), *Afrohybanthus stellarioides* (0.1%), *Alloteropsis cimicina* (0.5%), *Alphitonia excelsa* (0.1%), *Amaranthus interruptus* (0.1%), *Aristida benthamii* (0.1%), *Aristida calycina* var. *calycina* (1.7%), *Aristida holathera* (0.1%), *Bidens bipinnata** (0.1%), *Bidens pilosa** (0.1%), *Bonamia media* (0.1%), *Chamaecrista rotundifolia** (0.1%), *Cheilanthes sieberi* (0.1%), *Cleome viscosa* (0.1%), *Commelina lanceolata* (0.1%), *Cyperus betchei* (0.1%), *Digitaria eriantha** (3.7%), *Digitaria ramularis* (0.5%), *Dinebra decipiens* var. *decipiens* (0.1%), *Eragrostis spartinoides* (0.2%), *Eriachne mucronata* (0.5%), *Erythroxylum australe* (0.1%), *Euphorbia drummondii* (0.1%), *Evolvulus alsinoides* (0.1%), *Galactia tenuiflora* (0.1%), *Gomphrena celosioides** (0.1%), *Ipomoea brownii* (0.1%), *Larsenaikia ochreata* (0.1%), *Marsdenia microlepis* (0.1%), *Melinis repens** (2.7%), *Pandorea pandorana* (0.1%), *Paspalidium gracile* (0.1%), *Pavetta granitica* (0.3%), *Perotis rara* (0.1%), *Petalostigma pubescens* (0.1%), *Phyllanthus carpentariae* (0.1%), *Phyllanthus collinus* (0.1%), *Planchonella pohlmanniana* (0.1%), *Polycarpaea corymbosa* (0.1%), *Portulaca bicolor* (0.1%), *Portulaca oleracea** (0.1%), *Portulaca pilosa** (0.1%), *Pseuderanthemum variabile* (0.1%), *Setaria surgens* (0.1%), *Sida hackettiana* (0.3%), *Sida* sp. (Musselbrook M.B.Thomas+ MRS437) (0.1%), *Sida spinosa** (0.1%), *Stylosanthes scabra** (0.1%), *Tephrosia filipes* subsp. *filipes* (0.1%), *Urochloa mosambicensis** (0.1%), *Xenostegia tridentata* (0.1%), *Zornia* sp. (0.1%).

SECONDARY SITE 8 **11.10.3**



Latitude, Longitude: -22.3037, 148.1864

Community description: Woodland dominated by *Acacia shirleyi* on sandstone crest.

Dominant species per stratum:

T1: *Acacia shirleyi, Alphitonia excelsa* (subdominant) *Corymbia clarksoniana* (subdominant).
S1: *Erythroxylum australe.*
G: *Alloteropsis cimicina*, *Cleistochloa subjuncea, Urochloa piligera.*

Median (and range) canopy height per stratum: T1 = 11.4 m (9.2–11.4 m), S1 = 3.5 (3.0–4.0 m).

% cover of each stratum: T1 = 36%; S1 = 27%; **total = 60.6%**.

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Acacia shirleyi* = 8.67 m^2/ha; *Corymbia clarksoniana* = 0.83 m^2/ha; *Alphitonia excelsa* = 0.5 m^2/ha **(total = 10.25 m^2/ha).**
S1: *Erythroxylum australe* = 0.5 m^2/ha **(total = 0.33 m^2/ha).**

Landform: Crest of sandstone ridge **Slope:** 1°N **Soil:** Grey sand

Disturbance: Heavily grazed; burn marks indicate a relatively recent fire.

Ground cover: Rock = 38%, wood = 2%, bare = 14%, litter = 32%, vegetation = 14%.

Species (percent cover): *Achyranthes aspera* (0.1%), *Afrohybanthus stellarioides* (0.1%), *Alloteropsis cimicina* (6%), *Alphitonia excelsa* (0.1%), *Alternanthera nana* (0.1%), *Aristida enthamii* (0.5%), *Aristida calycina* var. *calycina* (0.1%), *Bidens bipinnata** (0.1%), *Chamaecrista absus* (0.1%), *Cheilanthes sieberi* (0.1%), *Cleistochloa subjuncea* (0.8%), *Cyanthillium cinereum* (0.1%), *Cyperus betchei* (0.1%), *Digitaria diminuta* (0.1%), *Eragrostis lacunaria* (0.1%), *Erythroxylum australe* (0.5%), *Euphorbia drummondii* (0.1%), *Evolvulus alsinoides* (0.1%), *Galactia tenuiflora* (0.1%), *Hibiscus meraukensis* (0.1%), *Ipomoea brownii* (0.1%), *Marsdenia microlepis* (0.1%), *Melinis repens** (0.2%), *Perotis rara* (0.1%), *Phyllanthus carpentariae* (0.1%), *Portulaca bicolor* (0.1%), *Portulaca pilosa** (0.1%), *Pseuderanthemum variabile* (0.1%), *Ptilotus polystachyus* (0.1%), *Scleria sphacelata* (0.1%), *Sida aprica* (0.1%), *Sida atherophora* (0.1%), *Sida cordifolia** (0.1%), *Sida hackettiana* (0.1%), *Sida spinosa** (0.1%), *Spermacoce brachystema* (0.1%), *Tinospora smilacina* (0.1%), *Urochloa piligera* (2.6%), *Wrightia saligna* (0.1%), *Xenostegia tridentata* (0.1%).

SECONDARY SITE 9 **11.10.3**



Latitude, Longitude: -22.3024, 148.1793

Community description: Low open forest dominated by *Acacia shirleyi*, with emergent *Corymbia citriodora*, on sandstone hillside.

Dominant species per stratum:

E: *Corymbia citriodora.*
T1: *Acacia shirleyi.*
S1: *Acacia shirleyi, Erythroxylum australe.*
G: *Cleistochloa subjuncea.*

Median (and range) canopy height per stratum: T1 = 9.8 m (7.6–9.8 m), S1 = (2.5–3.0 m).

% cover of each stratum: T1 = 52.7; S1 = 6.7; **total = 52.8%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

E: *Corymbia citriodora* = 0.17 m^2/ha **(total = 0.17 m^2/ha).**
T1: *Acacia shirleyi* = 7.5 m^2/ha; *Corymbia clarksoniana* = 0.17 m^2/ha **(total = 7.67 m^2/ha).**
S1: *Acacia shirleyi* <0.17 m^2/ha; *Erythroxylum australe* <0.17 m^2/ha **(total <0.17 m^2/ha).**

Landform: Rocky hillside **Slope:** 20°E **Soil:** Brown sandy-loam with sandstone boulders

Disturbance: Fire scars to 3 m high on tree trunks; lightly grazed.

Ground cover: Rock = 20%, wood = 4.5%, bare = 5%, litter = 10%, vegetation = 61.5%.

Species (percent cover): *Acacia shirleyi* (0.1%), *Alphitonia excelsa* (0.1%), *Aristida benthamii* (0.1%), *Cheilanthes sieberi* (0.1%), *Cleistochloa subjuncea* (60%), *Cyanthillium cinereum* (0.1%), *Digitaria diminuta* (0.1%), *Erythroxylum australe* (0.1%), *Goodenia* sp. (Mt Castletower M.D. Crisp 2753) (0.1%), *Marsdenia microlepis* (0.1%), *Paspalidium gracile* (0.1%), *Persoonia falcata* (0.1%), *Phyllanthus collinus* (0.1%), *Scleria sphacelata* (0.1%), *Sida* sp. (Musselbrook M.B.Thomas+ MRS437) (0.1%), *Solanum parvifolium* (0.1%).

SECONDARY SITE 10 **11.10.1**



Latitude, Longitude: -22.2971, 148.1753

Community description: Open forest dominated by *Corymbia citriodora* on sandstone.

Dominant species per stratum:

T1: *Corymbia citriodora, Corymbia trachyphloia.*
T2: *Acacia shirleyi, Lysicarpus angustifolius.*
S1: *Alphitonia excelsa, Dodonaea lanceolata.*
G: *Cleistochloa subjuncea, Melinis repens*, Scleria sphacelata.*

Median (and range) canopy height per stratum: T1 = 25.6 m (19–28.8 m), T2 = 10 m (9.2–11.8 m), S1 = 1.5 m (1.2–1.5 m).

% cover of each stratum: T1 = 51%; T2 = 45.6%; S1 = 3.6%; **total = 74.3%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Corymbia citriodora* = 2.83 m^2/ha **(total = 2.83 m^2/ha)**
T2: *Lysicarpus angustifolius* = 1.83 m^2/ha; *Acacia shirleyi* = 1 m^2/ha; *Eucalyptus crebra* = 1 m^2/ha; *Bursaria incana* = 0.33 m^2/ha; *Larsenaikia ochreata* = 0.17 m^2/ha; *Corymbia trachyphloia* = 0.17 m^2/ha **(total = 4.5 m^2/ha)**
S1: *Alphitonia excelsa* = 0.17 m^2/ha **(total = 0.17 m^2/ha)**

Landform: Steep foot slope of rocky hill **Slope:** 30°SE **Soil:** Sandy

Disturbance: Nil

Ground cover: Rock = 55%, wood = 1%, bare = 1%, litter = 25%, vegetation = 18%.

Species (percent cover): *Afrohybanthus stellarioides* (0.1%), *Alphitonia excelsa* (0.1%), *Aristida benthamii* (0.2%), *Aristida calycina var. calycina* (0.1%), *Breynia oblongifolia* (0.1%), *Bursaria incana* (0.1%), *Capparis canescens* (0.1%), *Cheilanthes sieberi* (0.1%), *Cleistochloa subjuncea* (9%), *Corymbia citriodora subsp. citriodora* (0.1%), *Corymbia trachyphloia* (0.1%), *Cyanthillium cinereum* (0.1%), *Cyclophyllum coprosmoides* (0.3%), *Cymbopogon obtectus* (0.1%), *Cymbopogon refractus* (0.2%), *Desmodium macrocarpum* (0.1%), *Dodonaea lanceolata* (0.1%), *Eragrostis spartinoides* (0.1%), *Erythroxylum australe* (0.1%), *Euphorbia drummondii* (0.1%), *Euphorbia tannensis* (0.1%), *Evolvulus alsinoides* (0.1%), *Gahnia aspera* (0.1%), *Galactia tenuiflora* (0.1%), *Goodenia* sp. (Mt Castletower M.D. Crisp 2753) (0.1%), *Hovea tholiformis* (0.1%), *Larsenaikia ochreata* (0.1%), *Leptospermum lamellatum* (0.1%), *Lomandra multiflora* (0.1%), *Marsdenia microlepis* (0.1%), *Melinis repens** (2%), *Murdannia graminea* (0.1%), *Oxalis corniculata* (0.1%), *Panicum effusum* (0.1%), *Persoonia amaliae* (0.1%), *Persoonia falcata* (0.1%), *Phyllanthus carpentariae* (0.1%), *Phyllanthus virgatus* (0.1%), *Pseuderanthemum variabile* (0.1%), *Rostellularia adscendens* (0.1%), *Scleria sphacelata* (2.2%), *Sida* sp. (0.1%), *Sida* sp. (Musselbrook M.B.Thomas+ MRS437) (0.1%), *Solanum ellipticum* (0.1%), *Themeda triandra* (0.2%).

SECONDARY SITE 11 **HVR 11.5.9**



Latitude, Longitude: -22.3198, 148.1956

Community description: Open forest dominated by *Eucalyptus crebra* on sand plain.

Dominant species per stratum:

T1: *Eucalyptus crebra, Eucalyptus melanophloia* (subdominant).
S1: *Erythroxylum australe, Petalostigma pubescens.*
G: *Chrysopogon fallax*, *Bothriochloa pertusa**.

Median (and range) canopy height per stratum: T1 =12 m (10–14 m), S1 = 3 m (0.5–3 m).

% cover of each stratum: T1 = 54.7%; **total = 54.7%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus crebra* = 8 m^2/ha; *Eucalyptus melanophloia* = 0.5 m^2/ha; *Corymbia dallachiana* = 0.17 m^2/ha; *Corymbia clarksoniana* = 0.17 m^2/ha **(total = 8.84 m^2/ha)**
S1: *Erythroxylum australe* <0.15 m^2/ha; *Petalostigma pubescens* <0.15 m^2/ha **(total <0.15 m^2/ha)**

Landform: Gently sloping plain **Slope:** 2°S **Soil:** Yellow-grey sand

Disturbance: Previously cleared; regular fire has maintained an open understorey.

Ground cover: Rock = 0%, wood = 1.5%, bare = 40%, litter = 35%, vegetation = 23.5%.

Species: *Afrohybanthus stellarioides* (0.1%), *Alphitonia excelsa* (0.1%), *Alternanthera nana* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Bothriochloa decipiens* var. *cloncurrensis* (0.3%), *Bothriochloa pertusa** (20%), *Brunoniella australis* (0.1%), *Cenchrus ciliaris** (0.1%), *Chamaecrista absus* (0.1%), *Chloris divaricata* (0.1%), *Chrysopogon fallax* (5%), *Cyanthillium cinereum* (0.1%), *Cyperus fulvus* (0.1%), *Digitaria divaricatissima* (0.1%), *Digitaria* sp. A (0.1%), *Eragrostis sororia* (0.1%), *Eulalia aurea* (0.1%), *Evolvulus alsinoides* (0.1%), *Fimbristylis dichotoma* (0.1%), *Galactia tenuiflora* (0.1%), *Glycine tomentella* (0.1%), *Gomphrena celosioides** (0.1%), *Grewia latifolia* (0.1%), *Ipomoea polymorpha* (0.1%), *Melaleuca nervosa* (0.1%), *Melhania oblongifolia* (0.1%), *Murdannia graminea* (0.1%), *Phyllanthus carpentariae* (0.8%), *Phyllanthus collinus* (0.1%), *Portulaca pilosa** (0.1%), *Rostellularia adscendens* (0.1%), *Scoparia dulcis** (0.1%), *Sida hackettiana* (0.1%), *Sida* sp. (Musselbrook M.B.Thomas+ MRS437) (0.1%), *Sida spinosa** (0.2%), *Stylosanthes scabra** (0.1%), *Urochloa piligera* (0.1%), *Zornia areolata* (0.1%), *Zornia muriculata* subsp. *angustata* (0.1%).

SECONDARY SITE 12 **HVR 11.10.3**



Latitude, longitude: -22.3166, 148.1914

Community description: Low open forest dominated by *Acacia shirleyi*, with emergent *Eucalyptus crebra* and *Eucalyptus exserta*, on a sandstone ridge.

Dominant species per stratum:

E: *Eucalyptus crebra, Eucalyptus exserta.*
T1: *Acacia shirleyi.*
S1: *Erythroxylum australe.*
G: *Cleistochloa subjuncea, Paspalidium caespitosum.*

Median (and range) canopy height per stratum: T1 = 8.2 m (7–9.8 m), S1 = (1.5–4 m).

% cover of each stratum: T1 = 66.8%; S1 = 10%; **total 73.3%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

E: <0.17 m^2/ha)
T1: *Acacia shirleyi* =5.83 m^2/ha; *Eucalyptus exserta* = 1.3 m^2/ha; *Eucalyptus crebra* = 0.67 m^2/ha **(total = 7.8 m^2/ha)**
S1: *Erythroxylum australe* = 0.5 m^2/ha **(total = 0.5 m^2/ha)**

Landform: Ridge top **Slope:** 3°E **Soil:** Grey-brown silty sand

Disturbance: Burnt and probably previously cleared. Mapped as non-remnant.

Ground cover: Rock = 1%, wood = 6%, bare = 31%, litter = 42%, vegetation = 20%.

Species (percent cover): *Acacia shirleyi* (0.1%), *Alloteropsis cimicina* (0.1%), *Alphitonia excelsa* (0.1%), *Alternanthera nana* (0.1%), *Aristida calycina* var. *calycina* (0.8%), *Calotis cuneifolia* (0.1%), *Cenchrus ciliaris** (0.1%), *Cheilanthes sieberi* (0.1%), *Chrysopogon fallax* (0.1%), *Cleistochloa subjuncea* (8%), *Dianella nervosa* (0.1%), *Digitaria diminuta* (0.1%), *Eragrostis lacunaria* (0.2%), *Eriachne obtusa* (0.1%), *Erythroxylum australe* (0.1%), *Eucalyptus crebra* (0.1%), *Evolvulus alsinoides* (0.1%), *Jasminum didymum* subsp. *lineare* (0.1%), *Larsenaikia ochreata* (0.1%), *Marsdenia microlepis* (0.1%), *Opuntia tomentosa** (0.1%), *Panicum effusum* (0.1%), *Paspalidium caespitosum* (5%), *Paspalidium gracile* (0.4%), *Pseuderanthemum variabile* (0.1%), *Sida* sp. (Musselbrook M.B.Thomas+ MRS437) (1%), *Stylosanthes scabra** (0.4%), *Thyridolepis xerophila* (0.1%), *Urochloa mosambicensis** (0.2%).

SECONDARY SITE 13 **11.3.25**



Latitude, Longitude: -22.3866, 148.2619

Community description: Closed forest dominated by *Eucalyptus camaldulensis* and *Melaleuca fluviatilis* along an ephemeral watercourse.

Dominant species per stratum:

T1: *Eucalyptus camaldulensis, Melaleuca fluviatilis.*
T2: *Bauhinia hookeri.*
G: *Megathyrsus maximus* var. *pubiglumis *, Sida rhombifolia*, Bothriochloa pertusa*, Acanthospermum hispidum*, Urochloa mosambicensis*.*

Median (and range) canopy height per stratum: T1 = 24.8 m (15.6–55.8 m), T2 = 5 m.

% cover of each stratum: T1 = 86.9%; T2 = 0.5%; **total = 86.9%**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus camaldulensis* = 5.67 m^2/ha; *Melaleuca fluviatilis* = 6 m^2/ha; *Corymbia tessellaris* = 0.3 m^2/ha **(total = 11.97 m^2/ha)**
T2: *Bauhinia hookeri* = 0.3 m^2/ha **(total = 0.3 m^2/ha)**

Landform: Creek bank **Slope:** 0° **Soil:** Brown clay

Disturbance: Grazed and with very high weed densities.

Ground cover: Rock = 0%, wood = 1%, bare = 5%, litter = 8%, vegetation = 86%.

Species (percent cover): *Acanthospermum hispidum** (8.3%), *Achyranthes aspera* (0.1%), *Afrohybanthus stellarioides* (0.1%), *Alloteropsis cimicina* (0.1%), *Bauhinia hookeri* (0.1%), *Bidens bipinnata** (0.1%), *Bothriochloa pertusa** (33%), *Calyptocarpus vialis** (0.1%), *Carissa ovata* (0.1%), *Cenchrus ciliaris** (0.1%), *Chloris virgata** (0.1%), *Commelina diffusa* (0.1%), *Crinum arenarium* (0.1%), *Cynodon dactylon** (3%), *Datura leichhardtii** (0.1%), *Digitaria eriantha** (2%), *Echinochloa colona** (1%), *Eragrostis elongata* (0.1%), *Eucalyptus camaldulensis* (0.1%), *Ficus opposita* (0.1%), *Gomphrena celosioides** (0.1%), *Ipomoea plebia* (0.1%), *Malvastrum coromandelianum** (0.1%), *Megathyrsus maximus* var. *pubiglumis** (4%), *Melinis repens** (0.1%), *Parthenium hysterophorus** (0.2%), *Perotis rara* (0.1%), *Phyllanthus virgatus* (0.1%), *Portulaca pilosa** (0.1%), *Scoparia dulcis** (0.1%), *Senna occidentalis** (0.1%), *Sida cordifolia** (0.3%), *Sida rhombifolia** (8%), *Sida spinosa** (0.1%), *Solanum ellipticum* (0.1%), *Stachytarpheta jamaicensis** (0.1%), *Stylosanthes hamata** (0.1%), *Urochloa mosambicensis** (23%), *Verbesina encelioides** (0.1%), *Xanthium occidentale** (0.2%), *Zornia muriculata* subsp. *angustata* (0.1%).

SECONDARY SITE 14 **Non-remnant**



Latitude, Longitude: -22.3909, 148.2546

Community description: Open pasture derived from cleared *Eucalyptus populnea* dominated woodland.

Dominant species per stratum:

T1: *Eucalyptus populnea.*
S1: *Atalaya hemiglauca, Carissa ovata, Eucalyptus populnea.*
G: *Cenchrus ciliaris, Bothriochloa pertusa, Urochloa mosambicensis*

Median (and range) canopy height per stratum: T1 = 10 m (8–15.2 m), S1 = 2.5 m (1.5–4 m).

% cover of each stratum: T1 < 0.1%; S1 = 1.9%; **total = 1.9%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Persoonia falcata* = 0.75 m^2/ha; *Eucalyptus populnea* = 0.5 m^2/ha **(total = 1.25 m^2/ha)**
S1: *Atalaya hemiglauca* <0.15 m^2/ha, *Carissa ovata* <0.15 m^2/ha, *Eucalyptus populnea* <0.15 m^2/ha **(total = <0.15 m^2/ha)**

Landform: Plain **Slope:** 0° **Soil:** Dark-brown silt

Disturbance: Cleared, weed-infested and heavily grazed.

Ground cover: Rock = 0%, wood = 0.2%, bare = 10%, litter = 1%, vegetation = 88.8%.

Species: *Alternanthera nana* (0.1%), *Apowollastonia spilanthoides* (0.1%), *Atalaya hemiglauca* (0.1%), *Boerhavia pubescens* (0.1%), *Bothriochloa ewartiana* (0.1%), *Bothriochloa pertusa** (0.1%), *Capparis lasiantha* (0.1%), *Carissa ovata* (0.2%), *Cenchrus ciliaris** (65%), *Chrysopogon fallax* (0.1%), *Crotalaria juncea** (0.1%), *Cyanthillium cinereum* (0.1%), *Digitaria eriantha** (0.1%), *Enteropogon ramosus* (0.1%), *Eucalyptus populnea* (0.1%), *Fimbristylis dichotoma* (0.1%), *Galactia tenuiflora* (0.1%), *Gomphrena celosioides** (0.1%), *Grewia retusifolia* (0.1%), *Indigofera colutea* (0.1%), *Indigofera linnaei* (0.1%), *Neptunia gracilis* (0.1%), *Panicum effusum* (0.1%), *Parsonsia lanceolata* (0.1%), *Phyllanthus virgatus* (0.1%), *Portulaca pilosa** (0.1%), *Rhynchosia minima* (0.1%), *Sida hackettiana* (0.1%), *Sida spinosa** (0.1%), *Sphaeromorphaea australis* (0.1%), *Sporobolus caroli* (0.1%), *Stylosanthes hamata** (0.1%), *Stylosanthes humilis** (0.1%), *Stylosanthes scabra** (0.1%), *Urochloa mosambicensis** (10%).

SECONDARY SITE 15 **Regrowth 11.5.3**



Latitude, Longitude: -22.3939, 148.25

Community description: Low open forest dominated by *Eucalyptus populnea* on a sand plain.

Dominant species per stratum:

T1: *Eucalyptus populnea*.
T2: *Eucalyptus populnea*.
S1: *Carissa ovata*.
G: *Bothriochloa pertusa*, Sida hackettiana*

Median (and range) canopy height per stratum: T1 = 9.8 m (9.6–12 m), S1 = 1.6 m (1.4–2.5 m).

% cover of each stratum: T1 = 62.9%; S1 = 7%; **total = 66.2%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus populnea* = 8.17 m^2/ha; *Corymbia clarksoniana* = 0.33 m^2/ha; *Persoonia falcata* = 0.16 m^2/ha **(total = 8.66 m^2/ha)**
T2: *Eucalyptus populnea* <0.17 m^2/ha **(total <0.17 m^2/ha)**
S1: *Carissa ovata* <0.17 m^2/ha **(total < 0.17 m^2/ha)**

Landform: Plain **Slope:** 1°SW **Soil:** Yellow-brown loam.

Disturbance: Previously cleared and not quite old enough to qualify as high-value regrowth?; heavily grazed.

Ground cover: Rock = 0%, wood = 1%, bare = 53%, litter = 32%, vegetation = 14%.

Species (percent cover): *Abutilon oxycarpum* (0.1%), *Alternanthera denticulata* (0.1%), *Alternanthera nana* (0.1%), *Apowollastonia spilanthoides* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Boerhavia pubescens* (0.1%), *Bothriochloa pertusa** (8.6%), *Brunoniella australis* (0.1%), *Carissa ovata* (0.1%), *Cenchrus ciliaris** (0.1%), *Chrysopogon fallax* (0.1%), *Cyperus gracilis* (0.1%), *Enteropogon ramosus* (0.1%), *Eremophila debilis* (0.1%), *Eucalyptus populnea* (0.1%), *Evolvulus alsinoides* (0.1%), *Glycine* sp. (Mackay S.B.Andrews+ 43) (0.1%), *Gomphrena celosioides** (0.1%), *Grewia latifolia* (0.1%), *Grewia retusifolia* (0.6%), *Owenia acidula* (0.1%), *Phyllanthus collinus* (0.1%), *Portulaca oleracea** (0.1%), *Rhynchosia minima* (0.1%), *Sida hackettiana* (1.4%), *Sida spinosa** (0.1%), *Solanum ellipticum* (0.1%), *Sporobolus caroli* (0.1%), *Stylosanthes scabra** (0.1%), *Urochloa mosambicensis** (0.8%).

SECONDARY SITE 16 **11.5.3**



Latitude, Longitude: -22.3920, 148.2295

Community description: Open forest dominated by *Eucalyptus populnea* on sandy soils.

Dominant species per stratum:

T1: *Eucalyptus populnea.*
T2: *Corymbia clarksoniana, Eucalyptus populnea.*
G: *Cenchrus ciliaris*.*

Median (and range) canopy height per stratum: T1 = 14.2 m (13.4–18 m), T2 = 7.2 m (0.4–7.2 m), S1 = 3 m (2.0–4.0 m).

% cover of each stratum: T1 = 52.2%; T2 = 45.6%; **total = 72%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus populnea* = 5.17 m^2/ha **(total = 5.17 m^2/ha)**
T2: *Eucalyptus populnea* = 4.25 m^2/ha; *Corymbia clarksoniana* = 0.5 m^2/ha **(total = 4.75 m^2/ha)**

Landform: Plain on low rise **Slope:** 2°S **Soil:** Yellow-brown sand

Disturbance: Grazed and dominated by weed understorey.

Ground cover: Rock = 0%, wood = 1.5%, bare = 20%, litter = 30%, vegetation = 48.5%.

Species (percent cover): *Acanthospermum hispidum** (0.1%), *Achyranthes aspera* (0.1%), *Afrohybanthus enneaspermus* (0.1%), *Alphitonia excelsa* (0.1%), *Alternanthera nana* (0.1%), *Archidendropsis basaltica* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Aristida holathera* (0.1%), *Aristolochia thozetii* (0.1%), *Boerhavia pubescens* (0.1%), *Bonamia media* (0.5%), *Bothriochloa pertusa** (0.5%), *Breynia oblongifolia* (0.1%), *Brunoniella australis* (0.1%), *Calotis cuneifolia* (0.1%), *Capparis canescens* (0.1%), *Capparis lasiantha* (0.1%), *Cenchrus ciliaris** (42%), *Chrysopogon fallax* (0.1%), *Clerodendrum tomentosum* (0.1%), *Cyanthillium cinereum* (0.1%), *Dactyloctenium radulans* (0.1%), *Dysphania melanocarpa* forma *melanocarpa* (0.1%), *Enneapogon lindleyanus* (0.1%), *Enteropogon ramosus* (0.1%), *Eragrostis lacunaria* (0.1%), *Eragrostis sororia* (0.1%), *Evolvulus alsinoides* (0.1%), *Fimbristylis dichotoma* (0.1%), *Galactia tenuiflora* (0.1%), *Glycine* sp. (Mackay S.B.Andrews+ 43) (0.1%), *Glycine tomentella* (0.1%), *Gomphrena celosioides** (0.1%), *Grewia retusifolia* (0.1%), *Ipomoea polymorpha* (0.1%), *Parsonsia lanceolata* (0.1%), *Phyllanthus collinus* (0.1%), *Portulaca filifolia* (0.1%), *Rostellularia adscendens* (0.1%), *Setaria surgens* (0.1%), *Sida cordifolia** (0.1%), *Sida hackettiana* (0.1%), *Sida spinosa** (0.1%), *Stylosanthes hamata** (0.1%), *Stylosanthes humilis** (0.1%), *Urochloa mosambicensis** (1%), *Ventilago viminalis* (0.1%), *Zornia areolata* (0.1%), *Zornia muelleriana* subsp. *muelleriana* (0.1%).

SECONDARY SITE 17 **11.5.9**



Latitude, Longitude: -22.3839, 148.2236

Community description: Low open woodland dominated by *Corymbia clarksoniana*. Despite the absence of *Eucalyptus crebra*, it otherwise resembles regional ecosystem 11.5.9 in structure and floristics of the lower strata. A small number of sandstone boulders suggests that it might be 11.10.7 instead of 11.5.2, but the land form was otherwise a sandy plain.

Dominant species per stratum:

T1: *Corymbia clarksoniana.*
T2: *Acacia burdekensis, Alphitonia excelsa.*
S1: *Melaleuca nervosa.*
G: *Melinis repens*, Perostis rara, Alloteropsis cimicina, Aristida calycina* var. *calycina.*

Median (and range) canopy height per stratum: T1 =9.6 m (8.6–12.2 m), T2 = 6.4 m (5.4–7 m), S1 = 3.0 m (2.0–4.0 m).

% cover of each stratum: T1 = 3.7%; T2 = 14.3%; S1 = 10.7%; t**otal = 26.6%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Corymbia clarksoniana* = 1.5 m^2/ha **(total = 1.5 m^2/ha)**
T2: *Acacia burdekensis* = 0.83 m^2/ha; *Alphitonia excelsa* = 0.33 m^2/ha; *Petalostigma pubescens* = 0.17 m^2/ha; *Bursaria incana* = 0.17 m^2/ha **(total = 1.5 m^2/ha)**
S1: *Melaleuca nervosa* = 1.5 m^2/ha **(total = 1.5 m^2/ha)**

Landform: Low sandy plateau **Slope:** 2°N **Soil:** Yellow-brown coarse sand with scattered sandstone boulders.

Disturbance: Lightly grazed.

Ground cover: Rock = 1%, wood = 2%, bare = 45%, litter = 22%, vegetation = 30%.

Species: *Acacia burdekensis* (0.1%), *Acanthospermum hispidum** (0.1%), *Afrohybanthus stellarioides* (0.1%), *Alloteropsis cimicina* (2%), *Alphitonia excelsa* (0.1%), *Aristida calycina* var. *calycina* (3%), *Bonamia media* (0.1%), *Chamaecrista absus* (0.1%), *Chrysopogon fallax* (0.1%), *Cleome tetrandra* var. *tetrandra* (0.1%), *Cyanthillium cinereum* (0.1%), *Dactyloctenium radulans* (0.9%), *Digitaria eriantha** (0.6%), *Dysphania melanocarpa* forma *melanocarpa* (0.1%), *Eragrostis lacunaria* (0.1%), *Eragrostis sororia* (0.1%), *Erythroxylum australe* (0.1%), *Fimbristylis dichotoma* (0.1%), *Glycine tomentella* (0.1%), *Goodenia glabra* (0.1%), *Heliotropium peninsulare* (0.1%), *Indigofera colutea* (0.1%), *Ipomoea polymorpha* (0.1%), *Melaleuca nervosa* (0.1%), *Melinis repens** (9%), *Paspalidium rarum* (0.1%), *Perotis rara* (3.7%), *Phyllanthus* sp. (Myra Vale J.J.Bruhl+ 1810) (0.1%), *Portulaca bicolor* (0.2%), *Psydrax oleifolia* (0.1%), *Setaria surgens* (0.1%), *Sida cordifolia** (0.1%), *Sida hackettiana* (1.3%), *Spermacoce brachystema* (0.1%), *Stylosanthes hamata** (0.1%), *Stylosanthes scabra** (0.4%), *Tribulopis angustifolia* (0.1%), *Urochloa mosambicensis** (1%), *Urochloa piligera* (5%), *Zornia* sp. (0.1%).

SECONDARY SITE 18 **11.5.3**



Latitude, Longitude: -22.3767, 148.2250

Community description: Woodland dominated by *Eucalyptus populnea* on a sand plain.

Dominant species per stratum:

T1: *Corymbia dallachiana.*
T2: *Alphitonia excelsa, Acacia burdekensis, Eucalyptus populnea, Melaleuca nervosa.*
S1: *Erythroxylum australe.*
G: *Alloteropsis cimicina, Chrysopogon fallax, Eragrostis speciosa*, *Perotis rara, Sida hackettiana, Urochloa piligera.*

Median (and range) canopy height per stratum: T1 = 16.6 m (12.8–17.2 m), T2 = 6.4 m (6.0–7.2 m), S1 = 1.8 m (1.0–2.0 m).

% cover of each stratum: T1 = 2%; T2 = 45.4%; S1 = 4.4%; **total = 51.4%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Acacia burdekensis* = 2.33 m^2/ha; *Eucalyptus populnea* = 1.67 m^2/ha; *Corymbia dallachiana* = 0.3 m^2/ha; *Corymbia clarksoniana* = 0.17 m^2/ha **(total = 4.47 m^2/ha)**
T2: *Melaleuca nervosa* = 4.83 m^2/ha; *Alphitonia excelsa* = 0.67 m^2/ha; **(total = 5.5 m^2/ha)**
S1: *Erythroxylum australe* <0.15 m^2/ha **(total <0.15 m^2/ha)**

Landform: Low sandy plateau. **Slope:** 2°N **Soil:** Yellow-brown sand with scattered boulders.

Disturbance: Light grazing.

Ground cover: Rock = 0.5%, wood = 2%, bare = 40%, litter = 23%, vegetation = 33.5%.

Species (percent cover): *Acanthospermum hispidum** (0.1%), *Afrohybanthus enneaspermus* (0.1%), *Afrohybanthus stellarioides* (0.1%), *Alloteropsis cimicina* (7.1%), *Alphitonia excelsa* (0.1%), *Alternanthera nana* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Cheilanthes sieberi* (0.1%), *Chrysopogon fallax* (8.1%), *Cyanthillium cinereum* (0.1%), *Desmodium filiforme* (0.1%), *Digitaria minima* (0.1%), *Eragrostis spartinoides* (0.1%), *Eragrostis speciosa* (2.1%), *Evolvulus alsinoides* (0.1%), *Fimbristylis dichotoma* (0.1%), *Ipomoea polymorpha* (0.1%), *Melaleuca nervosa* (0.1%), *Murdannia graminea* (0.1%), *Perotis rara* (8%), *Phyllanthus collinus* (0.1%), *Phyllanthus* sp. (Myra Vale J.J.Bruhl+ 1810) (0.1%), *Portulaca filifolia* (1.2%), *Portulaca pilosa** (0.1%), *Setaria surgens* (0.1%), *Sida cordifolia** (0.1%), *Sida hackettiana* (2.1%), *Sida spinosa** (0.1%), *Stylosanthes hamata** (0.1%), *Stylosanthes scabra** (0.1%), *Tephrosia leptoclada* (0.1%), *Tribulopis angustifolia,* (0.1%), *Urochloa piligera* (2.2%), *Zornia* sp. (0.1%).

SECONDARY SITE 19 **11.4.8**



Latitude, Longitude: -22.3772, 148.2379

Community description: Woodland dominated by *Acacia harpophylla* and *Eucalyptus cambageana* on a clay plain.

Dominant species per stratum:

T1: *Acacia harpophylla, Eucalyptus cambageana.*
S1: *Eremophila mitchellii, Ventilago viminalis.*
S2: *Carissa ovata.*
G: *Cenchrus ciliaris*, Chloris ventricosa, Urochloa mosambicensis*.*

Median (and range) canopy height per stratum: T1 = 11.6 m (10.6–14.6 m), S1 = 5.5 m (5.0–6.0 m), S2 = 1 m (0.5–1.6 m).

% cover of each stratum: T1 = 27.7%; S1 = 5.4%; S2 = 33.2%; **total = 53.8%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Acacia harpophylla* = 5.67 m^2/ha; *Eucalyptus cambageana* = 1.67 m^2/ha **(total = 7.34 m^2/ha)**
S1: *Eremophila mitchellii* = 0.3 m^2/ha; *Flindersia dissosperma* = 0.17 m^2/ha **(total = 0.47 m^2/ha)**
S2: *Carissa ovata* <0.15 m^2/ha **(total <0.15 m^2/ha)**

Landform: Plain **Slope:** 1°E **Soil:** Grey-brown sandy-clay, possibly heavier subsoil. No gilgais.

Disturbance: Grazed; numerous dead trees.

Ground cover: Rock = 0%, wood = 1%, bare = 20%, litter = 20%, vegetation = 59%.

Species (percent cover): *Abutilon oxycarpum* var. *incanum* (0.3%), *Acacia harpophylla* (0.6%), *Achyranthes aspera* (0.1%), *Alternanthera nana* (0.8%), *Ancistrachne uncinata* (0.1%), *Aristida gracilipes* (0.5%), *Atalaya hemiglauca* (0.1%), *Boerhavia pubescens* (0.1%), *Bothriochloa pertusa** (0.5%), *Brunoniella australis* (0.1%), *Capparis lasiantha* (0.1%), *Carissa ovata* (37%), *Cassia brewsteri* (0.1%), *Cenchrus ciliaris** (5%), *Cheilanthes sieberi* (0.1%), *Chloris divaricata* (6%), *Desmodium varians* (0.1%), *Ehretia membranifolia* (0.1%), *Einadia nutans* (0.1%), *Einadia nutans* subsp. *linifolia* (0.1%), *Eragrostis lacunaria* (1%), *Eremophila mitchellii* (0.1%), *Evolvulus alsinoides* (0.1%), *Grewia latifolia* (0.1%), *Harrisia martinii** (0.1%), *Jacquemontia paniculata* (0.1%), *Maireana microphylla* (0.1%), *Melhania oblongifolia* (0.1%), *Nyssanthes erecta* (0.1%), *Opuntia tomentosa** (0.1%), *Owenia acidula* (0.1%), *Parsonsia lanceolata* (0.1%), *Parthenium hysterophorus** (0.5%), *Paspalidium caespitosum* (0.1%), *Paspalidium distans* (0.1%), *Phyllanthus virgatus* (0.1%), *Portulaca oleracea** (0.1%), *Portulaca pilosa** (0.1%), *Pseuderanthemum variabile* (0.1%), *Salsola australis* (0.1%), *Sida hackettiana* (0.1%), *Sida rohlenae* (0.1%), *Sporobolus caroli* (0.4%), *Urochloa mosambicensis** (3%), *Urochloa piligera* (0.1%), *Ventilago viminalis* (0.1%).

SECONDARY SITE 20 **HVR 11.5.3**



Latitude, Longitude: -22.3787, 148.2139

Community description: Open forest dominated by *Eucalyptus populnea* on a sand plain.

Dominant species per stratum:

T1: *Eucalyptus populnea.*
T2: *Eucalyptus populnea.*
S1: *Eucalyptus populnea, Erythroxylum australe.*
G: *Bothriochloa pertusa*, Aristida calycina* var. *calycina, Fimbristylis dichotoma.*

Median (and range) canopy height per stratum: T1 = 14.8 m (10.0–15.6 m), T2 = 3.0 m (2.5–4.0 m), S1 = 1.0 m (0.5–1.5 m).

% cover of each stratum: T1 = 58.4%; T2 = 2.1%; S1 = 1.6%; **total = 60.5%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus populnea* = 12.17 m^2/ha **(total = 12.17 m^2/ha)**
T2: *Eucalyptus populnea* < 0.17 **(total < 0.17 m^2/ha)**
S1: *Erythroxylum australe* < 0.17 **(total < 0.17 m^2/ha)**

Landform: Plain **Slope:** 1°NE **Soil:** Yellow-brown sand

Disturbance: Previously cleared; heavily grazed.

Ground cover: Rock = 0%, wood = 2%, bare = 40%, litter = 20%, vegetation = 38%.

Species (percent cover): *Alloteropsis cimicina* (0.1%), *Alphitonia excelsa* (0.1%), *Alternanthera denticulata* (0.1%), *Alternanthera nana* (0.1%), *Apowollastonia spilanthoides* (0.1%), *Aristida calycina* var. *calycina* (1%), *Boerhavia pubescens* (0.1%), *Bothriochloa pertusa** (26.6%), *Carissa ovata* (0.1%), *Cenchrus ciliaris** (0.3%), *Cheilanthes sieberi* (0.1%), *Chloris divaricata* (3%), *Chloris virgata** (0.1%), *Chrysopogon fallax* (0.1%), *Cyanthillium cinereum* (0.1%), *Cyperus fulvus* (0.1%), *Digitaria longiflora* (0.1%), *Enneapogon lindleyanus* (0.1%), *Eragrostis lacunaria* (1%), *Eragrostis leptostachya* (0.1%), *Eragrostis sororia* (0.1%), *Eremophila debilis* (0.1%), *Erythroxylum australe* (0.1%), *Eucalyptus populnea* (0.1%), *Euphorbia drummondii* (0.1%), *Fimbristylis dichotoma* (2%), *Gomphrena celosioides** (0.1%), *Grewia latifolia* (0.1%), *Ipomoea polymorpha* (0.1%), *Melhania oblongifolia* (0.1%), *Murdannia graminea* (0.1%), *Opuntia tomentosa** (0.1%), *Panicum effusum* (0.1%), *Phyllanthus collinus* (0.1%), *Phyllanthus* sp. (Myra Vale J.J.Bruhl+ 1810) (0.1%), *Portulaca filifolia* (0.1%), *Portulaca pilosa** (0.1%), *Rhynchosia minima* (0.1%), *Rostellularia adscendens* (0.1%), *Sida hackettiana* (0.1%), *Sida spinosa** (0.1%), *Stylosanthes scabra** (0.1%), *Urochloa mosambicensis** (0.1%), *Vittadinia pustulata* (0.1%), *Zornia areolata* (0.1%).

SECONDARY SITE 21 **11.3.25**



Latitude, Longitude: -22.3736, 148.2149

Community description: Open forest dominated by *Corymbia tessellaris, Melaleuca fluviatilis, Eucalyptus camaldulensis* and *Casuarina cunninghamiana* on the banks of an ephemeral watercourse.

Dominant species per stratum:

T1: *Casuarina cunninghamiana, Corymbia tessellaris, Eucalyptus camaldulensis, Melaleuca fluviatilis.*
S1: *Bauhinia hookeri, Lophostemon grandiflorus.*
G: *Megathyrsus maximus* var. *pubiglumis*, Bothriochloa ewartiana.*

Median (and range) canopy height per stratum: T1 = 24.2 m (21.8–24.4 m), S1 = 5.0 m (3.0–9.6 m).

% cover of each stratum: T1 = 62.4%; S1 = 46.9%; **total = 95.5%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Corymbia tessellaris* = 4.33 m^2/ha; *Melaleuca fluviatilis* = 3.17 m^2/ha; *Casuarina cunninghamiana* = 1.17 m^2/ha; *Eucalyptus camaldulensis* = 1.17 m^2/ha; *Cassia brewsteri* = 0.17 m^2/ha **(total = 10.01 m^2/ha).**
S1: *Bauhinia hookeri* = 0.67 m^2/ha; *Casuarina cunninghamiana* = 0.17 m^2/ha; *Lophostemon grandiflorus* = 0.17 m^2/ha; *Melaleuca fluviatilis* = 0.17 m^2/ha **(total = 1.18 m^2/ha).**

Landform: Creek bank **Slope:** 40°N **Soil:** Yellow sand

Disturbance: High weed densities.

Ground cover: Rock = 0%, wood = 1%, bare = 3%, litter = 30%, vegetation = 66%.

Species (percent cover): *Abutilon guineense** (0.1%), *Acacia salicina* (0.1%), *Acanthospermum hispidum** (0.1%), *Achyranthes aspera* (0.1%), *Afrohybanthus enneaspermus* (0.1%), *Ageratum conyzoides** (0.1%), *Ajuga australis* (0.1%), *Alloteropsis cimicina* (0.1%), *Bauhinia hookeri* (0.1%), *Bidens pilosa** (0.1%), *Bothriochloa ewartiana* (7%), *Bothriochloa pertusa** (0.2%), *Calyptocarpus vialis** (0.1%), *Cenchrus ciliaris** (0.1%), *Chamaecrista absus* (0.1%), *Cheilanthes sieberi* (0.1%), *Chloris virgata** (0.1%), *Clematicissus opaca* (0.1%), *Clerodendrum floribundum* (0.1%), *Commelina diffusa* (0.7%), *Crotalaria mitchellii* (0.1%), *Cyanthillium cinereum* (0.2%), *Cynodon dactylon** (0.1%), *Cyperus gracilis* (0.1%), *Cyperus leiocaulon* (0.1%), *Digitaria ammophila* (0.1%), *Digitaria eriantha** (0.2%), *Dysphania melanocarpa* forma *melanocarpa* (0.1%), *Emilia sonchifolia** (0.1%), *Euphorbia hirta** (0.1%), *Ficus opposita* (0.1%), *Glycine tomentella* (0.7%), *Grewia retusifolia* (0.1%), *Heteropogon contortus* (0.1%), *Ipomoea plebia* (0.1%), *Lomandra longifolia* (0.1%), *Megathyrsus maximus* var. *pubiglumis** (52%), *Melaleuca fluviatilis* (0.1%), *Oxalis corniculata* (0.1%), *Parthenium hysterophorus** (0.1%), *Pimelea sericostachya* (0.3%), *Rostellularia adscendens* (0.1%), *Senna occidentalis** (0.1%), *Setaria surgens* (0.1%), *Sida cordifolia** (0.1%), *Sida rhombifolia** (0.1%), *Stephania japonica* (0.1%), *Stylosanthes hamata** (0.1%), *Stylosanthes humilis** (0.1%), *Tinospora smilacina* (0.1%), *Tridax procumbens** (0.1%), *Urochloa foliosa* (0.1%), *Urochloa mosambicensis** (0.1%), *Xanthium occidentale** (0.1%).

SECONDARY SITE 22 **HVR 11.5.9**



Latitude, Longitude: -22.3761, 148.2097

Community description: Woodland dominated by *Eucalyptus melanophloia* on a sand plain.

Dominant species per stratum:

T1: *Eucalyptus melanophloia.*
T2: *Melaleuca nervosa.*
S1: *Melaleuca nervosa.*
G: *Chrysopogon fallax, Bothriochloa pertusa*, Perotis rara, Alloteropsis cimicina.*

Median (and range) canopy height per stratum: T1 = 10.2 m (8.0–11.8 m), T2 = 5.2 m (4.6–5.6 m), S1 = 1.6 m (1.0–2.4 m).

% cover of each stratum: T1 = 37%; T2 < 0.1%; S1 < 0.1%; **total = 37%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus melanophloia* = 9.83 m^2/ha **(total = 9.83 m^2/ha)**
T2: *Melaleuca nervosa* = 0.83 m^2/ha **(total = 0.83 m^2/ha)**
S1: total < 0.17 m^2/ha

Landform: Slight rise. **Slope:** 3°N **Soil:** Yellow sand.

Disturbance: Previously cleared but probably very old regrowth; heavily grazed.

Ground cover: Rock = 0%, wood = 1%, bare = 30%, litter = 18%, vegetation = 51%.

Species (percent cover): *Acanthospermum hispidum** (0.1%), *Alloteropsis cimicina* (8%), *Aristida inaequiglumis* (0.1%), *Bonamia media* (0.1%), *Bothriochloa pertusa** (28%), *Chrysopogon fallax* (8%), *Dactyloctenium radulans* (0.1%), *Digitaria longiflora* (0.1%), *Eragrostis sororia* (0.1%), *Eragrostis speciosa* (0.1%), *Eucalyptus melanophloia* (0.1%), *Fimbristylis dichotoma* (0.1%), *Galactia tenuiflora* (0.1%), *Heliotropium peninsulare* (0.1%), *Ipomoea polymorpha* (0.1%), *Melaleuca nervosa* (0.1%), *Paspalidium rarum* (0.1%), *Perotis rara* (1%), *Phyllanthus* sp. (Myra Vale J.J.Bruhl+ 1810) (0.1%), *Phyllanthus virgatus* (0.1%), *Portulaca pilosa** (0.1%), *Setaria surgens* (0.2%), *Sida hackettiana* (0.2%), *Stylosanthes hamata** (3.5%), *Stylosanthes scabra** (0.1%), *Tribulopis angustifolia* (0.1%), *Urochloa piligera* (0.1%), *Zornia muelleriana* subsp. *muelleriana* (0.1%).

SECONDARY SITE 23 **11.9.2**



Latitude, Longitude: -22.3641, 148.2071

Community description: Open forest dominated by *Eucalyptus orgadophila* on clay soil derived from fine-grained sedimentary rock.

Dominant species per stratum:

T1: *Eucalyptus orgadophila.*
T2: *Acacia excelsa, Corymbia erythrophloia.*
S1: *Erythroxylum australe, Ventilago viminalis.*
G: *Bothriochloa pertusa*, Enneapogon* sp., *Jaquemontia paniculata*, *Melhania oblongifolia*

Median (and range) canopy height per stratum: T1 = 17.6 m (12.4–18.2 m), T2 = 7.6 m (6.8–8.6 m), S1 = 2.3 m (2.0–3.0 m).

% cover of each stratum: T1 = 69.6%; T2 = 5%; S1 = 4.9%; **total = 75.1%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus orgadophila* = 6.5 m^2/ha; *Acacia excelsa* = 2.5 m^2/ha **(total = 9 m^2/ha)**
T2: *Bursaria incana* = 0.17 m^2/ha; *Corymbia erythrophloia* = 0.33 m^2/ha **(total = 0.5 m^2/ha)**
S1: total < 0.17 m^2/ha

Landform: Low rise. **Slope:** 12°S **Soil:** Dark-brown clay-loam imbedded sandstone.

Disturbance: Lightly grazed

Ground cover: Rock = 0.1%, wood = 0.7%, bare = 25%, litter = 55%, vegetation = 19.2%.

Species (percent cover): *Acacia excelsa* (0.1%), *Afrohybanthus enneaspermus* (0.1%), *Aristida gracilipes* (0.5%), *Aristida holathera* (0.1%), *Atalaya hemiglauca* (0.1%), *Bothriochloa ewartiana* (0.4%), *Bothriochloa pertusa** (9%), *Brunoniella australis* (0.1%), *Bursaria incana* (0.1%), *Carissa ovata* (0.4%), *Cassytha filiformis* (0.4%), *Cenchrus ciliaris** (0.3%), *Enneapogon* sp. A (2%), *Eucalyptus orgadophila* (0.1%), *Euphorbia drummondii* (0.1%), *Eustrephus latifolius* (0.1%), *Glycine tomentella* (0.1%), *Heteropogon contortus* (0.1%), *Indigofera linifolia* (0.1%), *Indigofera linnaei* (0.1%), *Jacquemontia paniculata* (1%), *Lomandra multiflora* (0.1%), *Melhania oblongifolia* (1.6%), *Melinis repens* (0.1%), *Ocimum caryophyllinum* (0.6%), *Peripleura hispidula* var. *setosa* (0.1%), *Phyllanthus maderaspatensis* (0.1%), *Psydrax oleifolia* (0.1%), *Rostellularia adscendens* (0.4%), *Scleria brownii* (0.1%), *Sida hackettiana* (0.1%), *Stylosanthes hamata** (0.1%), *Stylosanthes scabra** (0.1%), *Themeda triandra* (0.1%), *Urochloa foliosa* (0.1%), *Vachellia bidwillii* (0.1%), *Ventilago viminalis* (0.1%).

SECONDARY SITE 24 **11.10.13**



Latitude, Longitude: -22.3566, 148.1916

Community description: Woodland dominated by *Corymbia aureola* on a low sandstone rise.

Dominant species per stratum:

T1: *Corymbia aureola, Eucalyptus crebra, Eucalyptus melanophloia.*
T2: *Acacia curvinervia, Acacia burdekensis.*
S1: *Erythroxylum australe.*
G: *Alloteropsis cimicina, Melinis repens*.*

Median (and range) canopy height per stratum: T1 = 13.8 m (10.8–15.2 m), T2 = 5.6 m (4.0–6.0 m), S1 = 2.5 m (1.0–3.0 m).

% cover of each stratum: T1 = 33.6%; T2 = 62%; S1 = 15.1%; **total = 84.9%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Corymbia aureola* = 2.83 m^2/ha; *Alphitonia excelsa* = 1 m^2/ha; *Acacia burdekensis* = 0.5 m^2/ha; *Eucalyptus crebra* = 0.33 m^2/ha; *Eucalyptus melanophloia* = 0.17 m^2/ha; *Petalostigma pubescens* = 0.17 m^2/ha; **(total = 5 m^2/ha)**
T2: *Acacia curvinervia* = 3 m^2/ha; *Corymbia aureola* = 1 m^2/ha; *Eucalyptus melanophloia* = 0.17 m^2/ha; **(total = 4.17 m^2/ha)**
S1: *Erythroxylum australe* = 1 m^2/ha **(total = 1 m^2/ha)**

Landform: Rocky hillside. **Slope:** 9°NE **Soil:** Yellow-grey sand

Disturbance: Grazed

Ground cover: Rock = 28%, wood = 1.5%, bare = 33%, litter = 20%, vegetation = 17.5%.

Species (percent cover): *Acacia bancroftiorum* (0.1%), *Acacia curvinervia* (0.1%), *Acacia dietrichiana* (0.1%), *Alloteropsis cimicina* (8%), *Alphitonia excelsa* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Bonamia media* (0.1%), *Chamaecrista absus* (0.1%), *Cheilanthes sieberi* (0.1%), *Cleistochloa subjuncea* (0.1%), *Corymbia aureola* (0.1%), *Eragrostis lacunaria* (0.1%), *Erythroxylum australe* (0.1%), *Euphorbia bifida* (0.1%), *Euphorbia drummondii* (0.1%), *Evolvulus alsinoides* (0.1%), *Galactia tenuiflora* (0.1%), *Heliotropium peninsulare* (0.1%), *Hibiscus meraukensis* (0.1%), *Ipomoea brownii* (0.1%), *Ipomoea plebia* (0.1%), *Larsenaikia ochreata* (0.1%), *Melinis repens** (1.5%), *Phyllanthus carpentariae* (0.1%), *Sida hackettiana* (0.1%), *Sida spinosa** (0.1%), *Spermacoce brachystema* (0.1%), *Stylosanthes scabra** (0.1%), *Tephrosia filipes* subsp. *filipes* (0.1%), *Tinospora smilacina* (0.1%), *Urochloa piligera* (5.1%), *Xenostegia tridentata* (0.1%).

SECONDARY SITE 25 **Non-remnant**



Latitude, Longitude: -22.3597, 148.1994

Community description: Pasture with scattered *Eucalyptus crebra* on sand plain. Area was likely to formerly have been regional ecosystem 11.5.9.

Dominant species per stratum:

T1: *Eucalyptus crebra, Grevillea striata.*
S1: *Archidendropsis basaltica, Atalaya hemiglauca.*
G: *Urochloa mosambicensis*, Chloris barbata*.*

Median (and range) canopy height per stratum: T1 = 14.8 m (12.4–19 m), S1 = 2.0 m (0.5–4.0 m).

% cover of each stratum: T1 < 0.1%, S1 = 3.4; **total = 3.4%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus crebra* = 3 m^2/ha **(total = 3 m^2/ha).**
S2: *Archidendropsis basaltica* = 0.17 m^2/ha; *Atalaya hemiglauca* = 0.17 m^2/ha **(total = 0.34 m^2/ha).**

Landform: Low rise on sand plain **Slope:** 2°SSE **Soil:** Yellow-sand

Disturbance: Previously cleared, and probably thinned since; heavily grazed.

Ground cover: Rock = 0%, wood = 0.2%, bare = 49.8%, litter = 18%, vegetation = 32%.

Species (percent cover): *Acanthospermum hispidum** (0.1%), *Alloteropsis cimicina* (0.1%), *Alphitonia excelsa* (0.1%), *Alternanthera nana* (0.1%), *Archidendropsis basaltica* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Bothriochloa pertusa** (0.9%), *Brunoniella australis* (0.1%), *Cenchrus ciliaris** (0.4%), *Chamaecrista absus* (0.1%), *Cheilanthes sieberi* (0.1%), *Chloris barbata** (6.1%), *Chrysopogon fallax* (0.1%), *Cyanthillium cinereum* (0.1%), *Dactyloctenium radulans* (0.1%), *Digitaria ciliaris* (0.1%), *Dysphania melanocarpa* forma *melanocarpa* (0.1%), *Einadia nutans* (0.1%), *Enteropogon ramosus* (0.1%), *Eragrostis lacunaria* (0.1%), *Evolvulus alsinoides* (0.1%), *Fimbristylis dichotoma* (0.8%), *Gomphrena celosioides** (0.1%), *Indigofera colutea* (0.1%), *Ipomoea polymorpha* (0.1%), *Murdannia graminea* (0.1%), *Perotis rara* (0.1%), *Petalostigma pubescens* (0.1%), *Phyllanthus* sp. (Myra Vale J.J.Bruhl+ 1810) (0.1%), *Portulaca pilosa** (0.1%), *Sida cordifolia** (0.1%), *Sida spinosa** (0.1%), *Stylosanthes scabra** (1%), *Urochloa mosambicensis** (20%).

SECONDARY SITE 26 **11.5.3**



Latitude, Longitude: -22.3707, 148.2025

Community description: Open forest dominated by *Eucalyptus populnea* on a sand plain.

Dominant species per stratum:

T1: *Eucalyptus populnea.*
T2: *Acacia excelsa, Eremophila mitchellii, Ventilago viminalis.*
S1: *Carissa ovata, Erythroxylum australe.*
G: *Bothriochloa pertusa*, Aristida gracilipes*, *Cyperus gracilis.*

Median (and range) canopy height per stratum: T1 = 15.6 m (11–16.6 m), T2 = 7.2 m (5.2–9.0 m), S1 = 1.8 m (1.4–2.5 m).

% cover of each stratum: T1 = 53.3%; T2 = 17%; S1 = 49.5%; **total = 88.4%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus populnea* = 8.67 m^2/ha; *Acacia excelsa* = 0.33 m^2/ha **(total = 9 m^2/ha)**
T2: *Eremophila mitchellii* = 3.33 m^2/ha; *Ventilago viminalis* = 2.33 m^2/ha; *Alphitonia excelsa* = 0.17 m^2/ha **(total = 5.83 m^2/ha)**
S1: *Erythroxylum australe* = 0.17 m^2/ha **(total = 0.17 m^2/ha)**

Landform: Plain. Supposed to be land zone 3, but there was no noticeable terrace. It was a high bank from the creek up to the plain.

Slope: 0° **Soil:** Fine yellow-grey sand

Disturbance: Grazed

Ground cover: Rock = 0%, wood = 2%, bare = 31%, litter = 52%, vegetation = 15%.

Species (percent cover): *Abutilon oxycarpum* (0.1%), *Abutilon oxycarpum* var. *incanum* (0.1%), *Acacia excelsa* (0.1%), *Achyranthes aspera* (0.1%), *Alternanthera denticulata* (0.1%), *Alternanthera nana* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Aristida gracilipes* (4%), *Atalaya hemiglauca* (0.1%), *Boerhavia pubescens* (0.2%), *Bonamia media* (0.1%), *Bothriochloa pertusa** (3.7%), *Breynia oblongifolia* (0.1%), *Capparis lasiantha* (0.1%), *Carissa ovata* (1%), *Cassia brewsteri* (0.1%), *Cenchrus ciliaris** (0.2%), *Chloris divaricata* (0.1%), *Cyanthillium cinereum* (0.1%), *Cyperus gracilis* (1.7%), *Einadia nutans* (0.2%), *Enneapogon lindleyanus* (0.1%), *Eragrostis lacunaria* (0.2%), *Eremophila mitchellii* (0.1%), *Erythroxylum australe* (0.1%), *Eucalyptus populnea* (0.1%), *Evolvulus alsinoides* (0.1%), *Galactia tenuiflora* (0.1%), *Gomphrena celosioides** (0.1%), *Grewia retusifolia* (0.1%), *Malvastrum americanum** (0.1%), *Melhania oblongifolia* (0.2%), *Nyssanthes erecta* (0.1%), *Parsonsia lanceolata* (0.3%), *Phyllanthus collinus* (0.1%), *Portulaca oleracea** (0.1%), *Salsola australis* (0.1%), *Sida hackettiana* (0.1%), *Sida spinosa** (0.2%), *Sporobolus caroli* (0.1%), *Tribulus terrestris** (0.1%), *Ventilago viminalis* (0.1%).

SECONDARY SITE 27 **Non-remnant**



Latitude, Longitude: -22.3803, 148.2550

Community description: Open pasture with scattered *Eucalyptus populnea*

Dominant species per stratum:

T1: *Eucalyptus populnea.*
S1: *Cassia brewsteri.*
G: *Bothriochloa pertusa*, Urochloa mosambicensis*, Fimbristylis dichotoma.*

Median (and range) canopy height per stratum: T1 = 9.1 m (7.2–24.6 m), S1 = 1.5 m (1.0–4.0 m).

% cover of each stratum: T1 = 8.2%; S1 = 2.1%; **total = 10.3%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus populnea* =1.17 m^2/ha **(total = 1.17 m^2/ha)**.
S1: *Corymbia tessellaris* = 0.17 m^2/ha **(total = 0.17 m^2/ha)**.

Landform: Plain **Slope:** 1°S **Soil:** Dark-brown clay with sand

Disturbance: Cleared and heavily grazed; high weed density.

Ground cover: Rock = 0%, wood = 0.5%, bare = 10%, litter = 5%, vegetation = 84.5%.

Species (percent cover): *Aristida calycina* var. *calycina* (0.1%), *Bothriochloa pertusa** (76%), *Cassia brewsteri* (0.1%), *Cenchrus ciliaris** (1.1%), *Chrysopogon fallax* (0.1%), *Crinum arenarium* (0.1%), *Dactyloctenium radulans* (0.1%), *Digitaria diminuta* (0.1%), *Eragrostis sororia* (0.1%), *Fimbristylis dichotoma* (2%), *Gomphrena celosioides** (0.1%), *Grewia retusifolia* (0.1%), *Heteropogon contortus* (0.5%), *Indigofera colutea* (0.1%), *Ipomoea polymorpha* (0.1%), *Murdannia graminea* (0.1%), *Neptunia gracilis* (0.1%), *Owenia acidula* (0.1%), *Oxalis corniculata* (0.1%), *Phyllanthus virgatus* (0.1%), *Portulaca pilosa** (0.1%), *Salsola australis* (0.1%), *Sida hackettiana* (0.1%), *Sida spinosa** (0.1%), *Sphaeromorphaea australis* (0.1%), *Stylosanthes hamata** (0.1%), *Stylosanthes scabra** (0.5%), *Urochloa mosambicensis** (2%), *Zornia muriculata* subsp. *angustata* (0.1%), *Zornia* sp. (0.1%).

SECONDARY SITE 28 **11.3.2**



Latitude, Longitude: -22.3819, 148.2465

Community description: Woodland dominated by *Eucalyptus populnea* on alluvial flats beside a watercourse.

Dominant species per stratum:

T1: *Eucalyptus populnea, Eucalyptus melanophloia* (subdominant).
T2: *Cassia brewsteri.*
S1: *Carissa ovata.*
G: *Cenchrus ciliaris*, Bothriochloa pertusa*.*

Median (and range) canopy height per stratum: T1 =22 m (15–24 m), T2 = 7.0 m (6.4–9.0 m), S1 = 1.5 m (0.5–2.5 m).

% cover of each stratum: T1 = 30.2%; T2 = 6.4%; S1 = 8.8%; **total = 38.4%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus populnea* = 3.83 m^2/ha; *Eucalyptus camaldulensis* = 0.33 m^2/ha; *Acacia excelsa* = 0.67 m^2/ha; *Eucalyptus melanophloia* = 0.83 **(total = 5.66 m^2/ha).**
T2: *Eucalyptus populnea* = 0.5 m^2/ha; *Cassia brewsteri* = 1 m^2/ha; *Ventilago viminalis* = 0.5 m^2/ha; *Corymbia erythrophloia* = 0.17 m^2/ha; *Bauhinia hookeri* = 0.33 m^2/ha; *Eucalyptus melanophloia* = 0.5 m^2/ha **(total = 3 m^2/ha)**.
S1 < 0.17 m^2/ha

Landform: Plain **Slope:** 1°SW **Soil:** Brown sand.

Disturbance: Grazed; very high weed cover.

Ground cover: Rock = 0%, wood = 1%, bare = 20%, litter = 8%, vegetation = 71%.

Species (percent cover): *Afrohybanthus enneaspermus* (0.1%), *Alternanthera nana* (0.1%), *Aristida calycina var. calycina* (0.1%), *Aristida gracilipes* (0.1%), *Atalaya hemiglauca* (0.1%), *Bothriochloa ewartiana* (0.1%), *Bothriochloa pertusa** (9%), *Capparis lasiantha* (0.1%), *Carissa ovata* (0.5%), *Cenchrus ciliaris** (55%), *Cheilanthes sieberi* (0.1%), *Chrysopogon fallax* (0.5%), *Cymbidium canaliculatum* (0.1%), *Cyperus fulvus* (0.1%), *Cyperus gracilis* (0.1%), *Desmodium macrocarpum* (0.1%), *Eragrostis sororia* (0.1%), *Eucalyptus melanophloia* (0.1%), *Eucalyptus populnea* (0.1%), *Evolvulus alsinoides* (0.1%), *Fimbristylis dichotoma* (2%), *Grewia retusifolia* (0.1%), *Harrisia martinii** (0.1%), *Heteropogon contortus* (0.1%), *Jacquemontia paniculata* (0.1%), *Melhania oblongifolia* (0.1%), *Opuntia tomentosa** (0.1%), *Oxalis corniculata* (0.1%), *Panicum effusum* (0.1%), *Phyllanthus virgatus* (0.1%), *Portulaca pilosa** (0.1%), *Sida cordifolia** (0.1%), *Sida hackettiana* (0.1%), *Sida spinosa** (0.1%), *Stylosanthes scabra** (0.6%), *Urochloa mosambicensis** (0.1%), *Zornia muriculata* subsp. *angustata* (0.4%).

SECONDARY SITE 29 **11.4.9**



Latitude, Longitude: -22.3827, 148.2447

Community description: Woodland dominated by *Acacia harpophylla* and *Casuarina cristata* on a clay plain.

Dominant species per stratum:

T1: *Acacia harpophylla, Casuarina cristata.*
T2: *Bauhinia hookeri, Eremophila mitchellii, Terminalia oblongata.*
S1: *Acacia harpophylla, Bauhinia hookeri, Carissa ovata.*
G: *Cenchrus ciliaris*.*

Median (and range) canopy height per stratum: T1 =16.4 m (15.2–16.8 m), T2 = 6.2 m (5.0–10.6 m), S1 = 1.0 m (0.5–2.0 m).

% cover of each stratum: T1 = 40.6%; T2 = 26.2%; S1 = 58.8%; **total = 72.8%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Acacia harpophylla* = 2.83 m^2/ha; *Bauhinia carroniii* = 0.33 m^2/ha **(total = 3.16 m^2/ha)**.
T2: *Eremophila mitchellii* = 1.33 m^2/ha; *Bauhinia carronii* = 0.83 m^2/ha; *Casuarina cristata* = 0.5 m^2/ha; *Ventilago viminalis* = 0.83 m^2/ha **(total = 3.49 m^2/ha)**.
S1: *Bauhinia carronii* = 1 m^2/ha; *Casuarina cristata* = 0.5 m^2/ha **(total = 1.5 m^2/ha)**.

Landform: Plain **Slope:** 1°S **Soil:** Dark-brown clay with thin surface covering of sand; shallow gilgais.

Disturbance: Minimal.

Ground cover: Rock = 0%, wood = 7%, bare = 12%, litter = 50%, vegetation = 31%.

Species (percent cover): *Abutilon oxycarpum* var. *incanum* (0.2%), *Alectryon diversifolius* (0.1%), *Alternanthera denticulata* (0.1%), *Amaranthus interruptus* (0.1%), *Amaranthus viridis** (0.1%), *Apophyllum anomalum* (0.1%), *Bauhinia hookeri* (0.1%), *Boerhavia pubescens* (0.1%), *Brunoniella australis* (0.1%), *Carissa ovata* (19.5%), *Cenchrus ciliaris** (8%), *Cheilanthes sieberi* (0.1%), *Cyperus concinnus* (0.1%), *Cyperus gracilis* (0.1%), *Cyperus perangustus* (0.1%), *Dactyloctenium radulans* (0.1%), *Echinochloa colona** (0.1%), *Ehretia membranifolia* (0.1%), *Eragrostis pilosa** (0.1%), *Eriochloa crebra* (0.1%), *Geijera parviflora* (0.1%), *Ipomoea plebia* (0.1%), *Malvastrum americanum** (0.1%), *Marsdenia viridiflora* subsp. *viridiflora* (0.1%), *Owenia acidula* (0.1%), *Parsonsia lanceolata* (0.1%), *Parthenium hysterophorus** (0.1%), *Plumbago zeylanica* (0.1%), *Portulaca oleracea** (0.1%), *Salsola australis* (0.1%), *Senna coronilloides* (0.1%), *Sporobolus caroli* (0.1%), *Sporobolus scabridus* (0.1%), *Tribulus terrestris** (0.1%), *Urochloa foliosa* (0.1%), *Ventilago viminalis* (0.1%).

SECONDARY SITE 30 **11.3.2**



Latitude, Longitude: -22.3672, 148.2353

Community description: Open woodland dominated by *Eucalyptus populnea* on sandy alluvial flat.

Dominant species per stratum:

T1: *Corymbia tessellaris, Eucalyptus populnea.*
T2: *Acacia salicina, Cassia brewsteri.*
S1: *Capparis canescens, Eucalyptus populnea.*
G: *Cenchrus ciliaris*.*

Median (and range) canopy height per stratum: T1 =11.6 m (11.0–19.2 m), T2 = 7.4 m (6.4–8.4 m), S1 = 1.5 m (1.0–3.0 m).

% cover of each stratum: T1 = 15%; T2 = 20.1%; S1 = 2.9%; **total = 32.9%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus populnea* = 6.33 m^2/ha; *Corymbia dallachiana* = 0.33 m^2/ha **(total = 6.66 m^2/ha)**.
T2: *Eucalyptus populnea* = 1.33 m^2/ha; *Corymbia dallachiana* = 0.17 m^2/ha; *Corymbia tessellaris* = 0.5 m^2/ha; *Acacia salicina* = 0.33 m^2/ha; *Cassia brewsteri* = 0.5 m^2/ha **(total = 2.83 m^2/ha).**

Landform: Plain **Slope:** 0° **Soil:** Yellow-brown sand.

Disturbance: Grazed; high weed densities.

Ground cover: Rock = 0%, wood = 1%, bare = 30%, litter = 25%, vegetation = 44%.

Species (percent cover): *Acacia salicina* (0.1%), *Afrohybanthus enneaspermus* (0.1%), *Alphitonia excelsa* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Aristida gracilipes* (0.1%), *Boerhavia pubescens* (0.1%), *Bonamia media* (0.1%), *Bothriochloa ewartiana* (0.1%), *Bothriochloa pertusa** (0.1%), *Capparis canescens* (0.1%), *Capparis lasiantha* (0.1%), *Carissa ovata* (0.1%), *Cassia brewsteri* (0.1%), *Cenchrus ciliaris** (40.3%), *Chrysopogon fallax* (0.1%), *Crinum arenarium* (0.1%), *Cyanthillium cinereum* (0.1%), *Eremophila mitchellii* (0.1%), *Eucalyptus populnea* (0.1%), *Evolvulus alsinoides* (0.1%), *Fimbristylis dichotoma* (0.1%), *Glycine tomentella* (0.1%), *Gomphrena celosioides** (0.1%), *Grewia retusifolia* (0.1%), *Harrisia martinii** (0.1%), *Hibiscus sturtii* (0.1%), *Indigofera colutea* (0.1%), *Indigofera linnaei* (0.1%), *Melhania oblongifolia* (0.1%), *Oxalis corniculata* (0.1%), *Parsonsia lanceolata* (0.1%), *Phyllanthus virgatus* (0.1%), *Portulaca filifolia* (0.1%), *Rostellularia adscendens* (0.1%), *Sida hackettiana* (0.1%), *Sida spinosa** (0.1%), *Stylosanthes humilis** (0.1%), *Stylosanthes scabra** (0.1%).

SECONDARY SITE 31 **11.9.2**



Latitude, Longitude: -22.3656, 148.2267

Community description: Open woodland dominated by *Eucalyptus orgadophila* on a clay plain derived from fine-grained sedimentary rock.

Dominant species per stratum:

T1: *Eucalyptus orgadophila.*
T2: *Cassia brewsteri, Vachellia bidwillii, Ventilago viminalis.*
S1: *Carissa ovata.*
G: *Cenchrus ciliaris*, Bothriochloa pertusa*.*

Median (and range) canopy height per stratum: T1 =13.4 m (9.4–15 m), T2 = 6.2 m (5.2–6.6 m), S1 = 1.5 m (0.5–2.5 m).

% cover of each stratum: T1 = 6%; T2 < 0.1%, S1 < 0.1%; **total = 6%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus orgadophila* = 2 m^2/ha **(total = 2 m^2/ha)**.
T2: *Vachellia bidwillii* = 0.33 m^2/ha; *Atalaya hemiglauca* = 0.17 m^2/ha; *Acacia salicina* = 0.17 m^2/ha **(total = 0.67 m^2/ha)**.
S1: < 0.17 m^2/ha

Landform: Plain **Slope:** 2°S **Soil:** Spongy, dark-brown clay-loam.

Disturbance: Many dead trees; heavily grazed; high weed densities.

Ground cover: Rock = 0%, wood = 0%, bare = 10%, litter = 7%, vegetation = 83%.

Species (percent cover): *Acacia salicina* (0.1%), *Atalaya hemiglauca* (0.1%), *Boerhavia pubescens* (0.1%), *Bothriochloa ewartiana* (0.1%), *Bothriochloa pertusa** (76.8%), *Camptacra barbata* (0.3%), *Cenchrus ciliaris** (2%), *Cleome viscosa* (0.1%), *Cyperus rotundus** (0.1%), *Datura leichhardtii** (0.1%), *Digitaria eriantha** (0.1%), *Euphorbia bifida* (0.1%), *Glycine* sp. (Mackay S.B.Andrews+ 43) (0.1%), *Indigofera linifolia* (0.1%), *Lomandra multiflora* (0.1%), *Malvastrum americanum** (0.1%), *Neptunia gracilis* (0.4%), *Parthenium hysterophorus** (0.1%), *Phyllanthus maderaspatensis* (0.1%), *Polymeria pusilla* (0.1%), *Portulaca oleracea** (0.1%), *Rhynchosia minima* (0.1%), *Sida pleiantha* (0.1%), *Sida spinosa** (0.3%), *Stylosanthes scabra** (0.1%), *Tephrosia* sp. B (0.1%), *Tribulus terrestris** (0.1%), *Urochloa mosambicensis** (1%).

SECONDARY SITE 32 **11.5.9**



Latitude, Longitude: -22.3618, 148.217

Community description: Open woodland dominated by *Eucalyptus crebra* and *Corymbia dallachiana* (subdominant) on a sand plain. A small number of sandstone rocks were present, but otherwise the landform was a sand plain.

Dominant species per stratum:

T1: *Corymbia dallachiana, Eucalyptus crebra.*
S1: *Melaleuca nervosa.*
G: *Chrysopogon fallax, Bothriochloa pertusa, Bothriochloa bladhii*

Median (and range) canopy height per stratum: T1 = 13.8 m (12.0–14.4 m), S1 = 0.6 m (0.5–2.5 m).

% cover of each stratum: T1 = 7.8%; S1 = 6.7%; **total = 14.5%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus crebra* = 3 m^2/ha; *Corymbia dallachiana* = 1.67 m^2/ha; *Grevillea striata* = 0.17 m^2/ha **(total = 4.84 m^2/ha)**
S1: <0.17 m^2/ha)

Landform: Low rise on plain. **Slope:** 3°W **Soil:** Dark, yellow-brown sand.

Disturbance: Minimal.

Ground cover: Rock = 0.2%, wood = 0%, bare = 40%, litter = 18%, vegetation = 41.8%.

Species: *Alloteropsis cimicina* (0.4%), *Apowollastonia spilanthoides* (0.1%), *Aristida benthamii* (0.1%), *Aristida calycina* var. *calycina* (0.4%), *Aristida holathera* (0.1%), *Bonamia media* (0.1%), *Bothriochloa pertusa** (30%), *Brunoniella australis* (0.1%), *Cenchrus ciliaris** (0.1%), *Chamaecrista absus* (0.1%), *Chrysopogon fallax* (5%), *Corymbia dallachiana* (0.1%), *Dactyloctenium radulans* (0.1%), *Digitaria divaricatissima* (0.1%), *Eragrostis sororia* (0.1%), *Eriachne mucronata* (0.1%), *Evolvulus alsinoides* (0.1%), *Fimbristylis dichotoma* (0.1%), *Glycine tomentella* (0.1%), *Grewia retusifolia* (0.1%), *Heteropogon contortus* (2%), *Indigofera linnaei* (0.1%), *Ipomoea polymorpha* (0.1%), *Melaleuca nervosa* (0.1%), *Melhania oblongifolia* (0.1%), *Murdannia graminea* (0.3%), *Parthenium hysterophorus** (0.1%), *Perotis rara* (0.1%), *Petalostigma pubescens* (0.1%), *Phyllanthus collinus* (0.1%), *Portulaca pilosa** (0.1%), *Sida hackettiana* (0.1%), *Spermacoce brachystema* (0.1%), *Stylosanthes scabra** (0.7%), *Tephrosia leptoclada* (0.1%), *Urochloa mosambicensis** (0.1%), *Urochloa piligera* (0.1%).

SECONDARY SITE 33 **Non-remnant**



Latitude, Longitude: -22.3607, 148.2331

Community description: Open cleared pasture in what was formerly open *Eucalyptus orgadophila* woodland (regional ecosystem 11.9.2).

Dominant species per stratum:

T1: *Corymbia erythrophloia, Eucalyptus orgadophila.*
S1: *Cassia brewsteri.*
G: *Bothriochloa pertusa*.*

Median (and range) canopy height per stratum: E = 6.8 m (6.8 – 7.8 m), T1 = 1.5 m (0.5 – 2.5 m).

% cover of each stratum: T1 = 1%; S1 = 11.9%; **total = 12.9%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Corymbia erythrophloia* = 0.33 m^2/ha; *Eucalyptus orgadophila* = 0.17 m^2/ha **(total = 0.5 m^2/ha)**
S1: <0.15 m^2/ha

Landform: Low rise. **Slope:** 3°SE **Soil:** Dark brown clay-loam.

Disturbance: Cleared and heavily grazed.

Ground cover: Rock = 0%, wood = 0.1%, bare = 10%, litter = 5%, vegetation = 84.9%.

Species (percent cover): *Abutilon guineense** (0.1%), *Acacia salicina* (0.1%), *Archidendropsis basaltica* (0.2%), *Bothriochloa pertusa** (82%), *Brunoniella australis* (0.1%), *Capparis lasiantha* (0.1%), *Carissa ovata* (0.6%), *Cassia brewsteri* (0.1%), *Cenchrus ciliaris** (0.1%), *Clerodendrum floribundum* (0.1%), *Dactyloctenium radulans* (0.1%), *Digitaria eriantha** (0.1%), *Eulalia aurea* (0.1%), *Euphorbia bifida* (0.1%), *Eustrephus latifolius* (0.1%), *Galactia tenuiflora* (0.1%), *Glycine tomentella* (0.1%), *Heliotropium cunninghamii* (0.1%), *Indigofera linifolia* (0.2%), *Indigofera linnaei* (0.1%), *Ipomoea plebia* (0.1%), *Macroptilium atropurpureum** (0.1%), *Neptunia gracilis* (0.1%), *Parthenium hysterophorus** (0.1%), *Phyllanthus maderaspatensis* (0.1%), *Polymeria pusilla* (0.1%), *Portulaca filifolia* (0.1%), *Psydrax oleifolia* (0.1%), *Rhynchosia minima* (0.1%), *Sida hackettiana* (0.1%), *Sida pleiantha* (0.1%), *Sida spinosa** (0.1%), *Stylosanthes scabra** (0.1%), *Tragus australianus* (0.1%), *Urochloa mosambicensis** (0.1%), *Urochloa piligera* (0.1%).

SECONDARY SITE 34 **11.4.8**



Latitude, Longitude: -22.3446, 148.2355

Community description: Tall shrubland dominated by *Acacia harpophylla*, with scattered emergent *Acacia harpophylla* and *Eucalyptus cambageana*.

Dominant species per stratum:

E: *Acacia harpophylla, Eucalyptus cambageana.*
T1: *Acacia harpophylla.*
S1: *Acacia harpophylla, Carissa ovata.*
G: *Cenchrus ciliaris*.*

Median (and range) canopy height per stratum: E = 12 m (11.2–13.2 m), T1 = 4.0 m (3.0–5.4 m), S1 = 1.0 m (0.5–1.5 m).

% cover of each stratum: E = 4%; T1 = 41.1%; S1 = 26.5%; **total = 53.5%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

E: *Acacia harpophylla* = 0.3 m^2/ha; *Eucalyptus cambageana* = 0.3 m^2/ha; *Bauhinia carronii* = 0.3 m^2/ha **(total = 1 m^2/ha)**.
T1: *Acacia harpophylla* = 5.33 m^2/ha **(total = 5.33 m^2/ha)**.
S1: <0.17 m^2/ha.

Landform: Plain **Slope:** 0° **Soil:** Dark brown clay-loam; no gilgais; some surface pebbles.

Disturbance: Very few large trees and these were mostly dead. Most of the living vegetation was relatively young regrowth (DBH < 5 cm).

Ground cover: Rock = 0.1%, wood = 1%, bare = 30%, litter = 48.9%, vegetation = 20%.

Species (percent cover): *Abutilon oxycarpum* (0.1%), *Abutilon oxycarpum* var. *incanum* (0.1%), *Acacia harpophylla* (2%), *Apophyllum anomalum* (0.1%), *Boerhavia pubescens* (0.1%), *Brunoniella australis* (0.1%), *Capparis lasiantha* (0.1%), *Carissa ovata* (8%), *Cenchrus ciliaris** (8%), *Cheilanthes sieberi* (0.1%), *Chloris divaricata* (0.1%), *Cyanthillium cinereum* (0.1%), *Cyperus gracilis* (0.1%), *Enchylaena tomentosa* var. *tomentosa* (0.1%), *Eragrostis lacunaria* (0.1%), *Evolvulus alsinoides* (0.1%), *Harrisia martinii** (0.1%), *Paspalidium distans* (0.1%), *Phyllanthus virgatus* (0.1%), *Portulaca filifolia* (0.1%), *Portulaca oleracea** (0.1%), *Solanum esuriale* (0.1%), *Terminalia oblongata* (0.1%).

SECONDARY SITE 35 **11.5.9**



Latitude, Longitude: -22.3336, 148.2134

Community description: Closed scrub dominated by *Melaleuca nervosa* and *Acacia burdekensis,* with emergent *Corymbia clarksoniana*, on a sand plain. Resembles regional ecosystem 11.5.9 but with a very dense mid-storey. Presumably drainage is impeded by texture contrast soil or shallow bedrock.

Dominant species per stratum:

E: *Corymbia clarksoniana.*
T1: *Acacia burdekensis, Melaleuca nervosa.*
S1: *Alphitonia excelsa, Melaleuca nervosa.*
G: *Eriochloa crebra, Perotis rara, Sida hackettiana, Setaria surgens, Alloteropsis cimicina.*

Median (and range) canopy height per stratum: E = 15.2 m (13.8–16.8 m), T1 = 4.0 m (3.5–4.8 m), S1 = 2.0 m (1.0–2.5 m).

% cover of each stratum: E < 0.1%; T1 = 84.3%; S1 = 16.6%; **total = 90.6%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

E: *Corymbia clarksoniana* = 0.17 m^2/ha **(total = 0.17 m^2/ha)**.
T1: *Melaleuca nervosa* = 6.67 m^2/ha; *Acacia burdekensis* = 6.3 m^2/ha; *Alphitonia excelsa* = 0.67 m^2/ha **(total = 13.64 m^2/ha)**.
S1: *Acacia burdekensis* = 0.33 m^2/ha; *Melaleuca nervosa* =0.33 m^2/ha **(total = 0.66 m^2/ha)**.

Landform: Plain. **Slope:** 1°N **Soil:** Grey sand.

Disturbance: Nil.

Ground cover: Rock = 0%, wood = 2%, bare = 10%, litter = 50%, vegetation = 38%.

Species (percent cover): *Acacia burdekensis* (0.1%), *Afrohybanthus stellarioides* (0.1%), *Alloteropsis cimicina* (4%), *Alphitonia excelsa* (0.3%), *Bidens pilosa** (0.1%), *Bonamia media* (0.1%), *Cassytha filiformis* (0.1%), *Cheilanthes sieberi* (0.1%), *Chrysocephalum apiculatum* (0.1%), *Cleome tetrandra* var. *tetrandra* (0.1%), *Crotalaria medicaginea* (0.1%), *Dactyloctenium radulans* (0.1%), *Desmodium filiforme* (0.1%), *Dysphania melanocarpa* forma *melanocarpa* (0.1%), *Emilia sonchifolia** (0.1%), *Eriochloa crebra* (9%), *Fimbristylis dichotoma* (0.1%), *Galactia tenuiflora* (0.1%), *Glycine tomentella* (0.1%), *Indigofera colutea* (0.1%), *Ipomoea polymorpha* (0.4%), *Melaleuca nervosa* (0.1%), *Perotis rara* (3%), *Petalostigma pubescens* (0.1%), *Portulaca pilosa** (0.1%), *Richardia brasiliensis** (0.1%), *Setaria surgens* (9%), *Sida cordifolia** (0.3%), *Sida hackettiana* (1.6%), *Spermacoce brachystema* (0.1%), *Tribulopis angustifolia* (0.1%), *Urochloa piligera* (8%), *Zornia muelleriana* subsp. *muelleriana* (0.1%).

SECONDARY SITE 36 **11.10.3**



Latitude, Longitude: -22.3434, 148.2104

Community description: Low open forest dominated by *Acacia shirleyi* and *Acacia rhodoxylon*, with emergent *Corymbia clarksoniana*, on the crest of a sandstone rise.

Dominant species per stratum:

E: *Corymbia clarksoniana.*
T1: *Acacia rhodoxylon, Acacia shirleyi.*
S1: *Erythroxylum australe.*
G: *Cleistochloa subjuncea, Alloteropsis cimicina, Thyridolepis xerophila.*

Median (and range) canopy height per stratum: E = 15.2 m (12.2–15.6 m), T1= 5.6 m (5.2–5.6 m), S1 = 2.0 m (1.5–3.5 m).

% cover of each stratum: E = 21.1%; T1 = 58.6%; S1 = 4.3%; **total = 68.5%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

E: *Corymbia clarksoniana* = 1.33 m^2/ha **(total = 1.33 m^2/ha)**.
T1: *Acacia shirleyi* = 6 m^2/ha; *Acacia rhodoxylon* = 2.5 m^2/ha; *Lysicarpus angustifolius* = 0.17 m^2/ha; *Corymbia clarksoniana* = 0.17 m^2/ha; *Alphitonia excelsa* = 0.17 m^2/ha **(total = 9.0 m^2/ha)**.
S1: <0.17 m^2/ha.

Landform: Crest **Slope:** 2°NE **Soil:** Yellow-grey sand.

Disturbance: Nil.

Ground cover: Rock = 0%, wood = 4%, bare = 20%, litter = 65%, vegetation = 11%.

Species (percent cover): *Acacia rhodoxylon* (0.1%), *Acacia shirleyi* (0.2%), *Afrohybanthus stellarioides* (0.1%), *Alloteropsis cimicina* (1.5%), *Alphitonia excelsa* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Cheilanthes sieberi* (0.6%), *Cleistochloa subjuncea* (2%), *Digitaria diminuta* (0.1%), *Eragrostis lacunaria* (0.1%), *Eragrostis sororia* (0.1%), *Larsenaikia ochreata* (0.1%), *Lysicarpus angustifolius* (0.1%), *Murdannia graminea* (0.1%), *Sida hackettiana* (0.1%), Sida sp. (Musselbrook M.B.Thomas+ MRS437) (0.1%), *Stylosanthes scabra** (0.1%), *Thyridolepis xerophila* (5.3%), *Zornia muelleriana* subsp. *muelleriana* (0.1%).

SECONDARY SITE 37 **11.10.13**



Latitude, Longitude: -22.3471, 148.1894

Community description: Woodland dominated by *Corymbia aureola* on a low sandstone rise.

Dominant species per stratum:

T1: *Corymbia aureola*
T2: *Alphitonia excelsa, Acacia flavescens.*
S1: *Erythroxylum australe.*
G: *Melinis repens, Alloteropsis cimicina.*

Median (and range) canopy height per stratum: T1 = 13 m (10.2–14.8 m), T2 = 3.8 m (3.4–5 m), S1 = 1.5 m (0.5–2.5 m).

% cover of each stratum: T1 = 32.8%; T2 = 19.5%; S1 = 3.6%; **total = 45.3%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Corymbia aureola* = 4.33 m^2/ha; *Eucalyptus melanophloia* = 0.33 m^2/ha; *Corymbia clarksoniana* = 0.17 m^2/ha; *Larsenaikia ochreata* = 0.17 m^2/ha **(total = 5 m^2/ha)**
T2: *Alphitonia excelsa* = 1.33 m^2/ha; *Acacia flavescens* = 1.33 m^2/ha; *Acacia burdekensis* = 0.33 m^2/ha; **(total = 2.99 m^2/ha)**
S1: <0.15 m^2/ha

Landform: Low rise **Slope:** 3°S **Soil:** Yellow-grey sand with large sandstone boulders.

Disturbance: Grazed.

Ground cover: Rock = 9%, wood = 4%, bare = 33%, litter = 19%, vegetation = 35%.

Species (percent cover): *Acacia burdekensis* (0.1%), *Afrohybanthus stellarioides* (0.1%), *Alloteropsis cimicina* (2%), *Alphitonia excelsa* (0.4%), *Aristida calycina* var. *calycina* (0.1%), *Aristida holathera* (0.1%), *Bidens bipinnata** (0.1%), *Bonamia media* (0.1%), *Breynia oblongifolia* (0.1%), *Chamaecrista absus* (0.6%), *Commelina lanceolata* (0.1%), *Corymbia aureola* (0.1%), *Cyperus betchei* (0.1%), *Digitaria longiflora* (0.1%), *Eragrostis sororia* (0.1%), *Eriochloa crebra* (2%), *Erythroxylum australe* (0.1%), *Evolvulus alsinoides* (0.1%), *Glycine tomentella* (0.1%), *Hibiscus meraukensis* (0.1%), *Ipomoea brownii* (0.1%), *Ipomoea plebia* (0.1%), *Ipomoea polymorpha* (0.1%), *Larsenaikia ochreata* (0.1%), *Lomandra longifolia* (1%), *Melinis repens* (20%), *Oxalis corniculata* (0.1%), *Phyllanthus virgatus* (0.1%), *Portulaca filifolia* (0.1%), *Setaria surgens* (0.1%), *Sida hackettiana* (0.8%), *Sida spinosa** (0.1%), *Stylosanthes scabra** (0.1%), *Tephrosia filipes* subsp. *filipes* (0.1%), *Tinospora smilacina* (0.1%), *Trema tomentosa* (0.5%), *Tribulopis angustifolia* (0.1%), *Urochloa piligera* (4%), *Xanthorrhoea johnsonii* (0.7%), *Xenostegia tridentata* (0.1%).

SECONDARY SITE 38 **11.10.7**



Latitude, Longitude: -22.3411, 148.1925

Community description: Open forest dominated by *Eucalyptus crebra* on a flat terrace of a sandstone slope.

Dominant species per stratum:

T1: *Eucalyptus crebra, Corymbia clarksoniana* (subdominant), *Corymbia dallachiana* (subdominant).
T2: *Acacia burdekensis, Alphitonia excelsa, Petalostigma pubescens.*
S1: *Petalostigma pubescens.*
G: *Chrysopogon fallax, Aristida calycina* var. *calycina, Bothriochloa pertusa*.*

Median (and range) canopy height per stratum: T1 = 15 m (13.6–22 m), T2 = 8.0 m (3.6–9.2 m), S1 = 1.5 m (0.5–1.5 m).

% cover of each stratum: T1 = 75.2%; T2 = 11.5%; S1 = 7.7%; **total = 77.7%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus crebra* = 5.5 m^2/ha; *Corymbia clarksoniana* = 0.33 m^2/ha; *Corymbia dallachiana* = 0.33 m^2/ha; *Acacia burdekensis* = 0.17 m^2/ha. **(total = 6.33 m^2/ha)**
T2: *Petalostigma pubescens* = 0.33 m^2/ha; *Eucalyptus crebra* = 0.17 m^2/ha; *Corymbia dallachiana* = 0.17 m^2/ha; *Alphitonia excelsa* = 0.17 m^2/ha; **(total =0.84 m^2/ha)**
S1: <0.15 m^2/ha

Landform: Terrace of sandstone slope. **Slope:** 3°E **Soil:** Yellow-grey sand with no rocks.

Disturbance: Numerous dead trees.

Ground cover: Rock = 0%, wood = 0.5%, bare = 35%, litter = 30%, vegetation = 34.5%.

Species (percent cover): *Afrohybanthus stellarioides* (0.1%), *Alphitonia excelsa* (0.1%), *Aristida calycina* var. *calycina* (4%), *Bothriochloa pertusa** (19%), *Breynia oblongifolia* (0.1%), *Cenchrus ciliaris** (0.4%), *Chamaecrista absus* (0.1%), *Chrysopogon fallax* (8%), *Cyperus fulvus* (0.1%), *Digitaria divaricatissima* (0.1%), *Eragrostis sororia* (0.1%), *Eriochloa crebra* (0.1%), *Eucalyptus crebra* (0.1%), *Evolvulus alsinoides* (0.1%), *Fimbristylis dichotoma* (0.1%), *Glycine sp.* (Mackay S.B.Andrews+ 43) (0.1%), *Grewia retusifolia* (0.3%), *Heliotropium peninsulare* (0.1%), *Marsdenia microlepis* (0.1%), *Panicum effusum* (0.4%), *Petalostigma pubescens* (0.1%), *Phyllanthus carpentariae* (0.1%), *Phyllanthus collinus* (0.1%), *Pseuderanthemum variabile* (0.1%), *Scoparia dulcis** (0.1%), *Sida hackettiana* (0.3%), *Sida spinosa** (0.1%), *Stylosanthes scabra** (0.1%).

SECONDARY SITE 39 **11.10.1**



Latitude, Longitude: -22.2909, 148.1633

Community description: Open forest dominated by *Corymbia citriodora, Corymbia trachyphloia* and *Lysicarpus angustifolius* on a steep, sandstone hillside.

Dominant species per stratum:

T1: *Corymbia citriodora, Corymbia trachyphloia, Lysicarpus angustifolius.*
T2: *Lysicarpus angustifolius, Corymbia trachyphloia*
S1: *Acacia dietrichiana, Lysicarpus angustifolius.*
G: *Cleistochloa subjuncea, Scleria sphacelata, Digitaria diminuta, Goodenia* sp. (Mt Castletower M.D. Crisp 2753).

Median (and range) canopy height per stratum: T1 =11.8 m (10.4–18.2 m), T2 = 4.0 m (3.0–5.2 m), S1 = 1.5 m (0.5 – 2.0 m).

% cover of each stratum: T1 = 49.8%; T2 = 8.8%; S1 = 5.2%; **total = 56.6%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Lysicarpus angustifolius* = 4.67 m^2/ha; *Corymbia trachyphloia* = 1.67 m^2/ha; *Acacia shirleyi* = 1.5 m^2/ha; *Corymbia citriodora* = 0.83 m^2/ha; *Eucalyptus crebra* = 0.33 m^2/ha **(total = 9 m^2/ha)**.
T2: *Corymbia trachyphloia* = 0.33 m^2/ha; *Lysicarpus angustifolius* = 0.17 m^2/ha; *Larsenaikia ochreata* = 0.17 m^2/ha **(total = 0.67 m^2/ha)**.
S1: <0.15 m^2/ha.

Landform: Steep rocky slope. **Slope:** 38°S **Soil:** Grey sand with abundant sandstone.

Disturbance: Regular but not recent fire.

Ground cover: Rock = 30%, wood = 0.5%, bare = 1%, litter = 40%, vegetation = 28.5%.

Species (percent cover): *Acacia dietrichiana* (0.1%), *Acacia flavescens* (0.1%), *Afrohybanthus stellarioides* (0.1%), *Alternanthera nana* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Aristida gracilipes* (0.1%), *Calotis cuneifolia* (0.1%), *Cheilanthes sieberi* (0.1%), *Cleistochloa subjuncea* (13.5%), *Coelospermum reticulatum* (0.1%), *Commelina lanceolata* (0.1%), *Coronidium oxylepis* (0.1%), *Corymbia trachyphloia* (0.4%), *Cyanthillium cinereum* (0.1%), *Cymbopogon obtectus* (0.5%), *Cyperus betchei* (0.1%), *Daviesia filipes* (0.1%), *Desmodium rhytidophyllum* (0.1%), *Digitaria diminuta* (3%), *Eragrostis spartinoides* (0.1%), *Eriachne obtusa* (0.1%), *Evolvulus alsinoides* (0.1%), *Fimbristylis dichotoma* (0.1%), *Goodenia* sp. (Mt Castletower M.D. Crisp 2753) (4%), *Hovea tholiformis* (0.1%), *Larsenaikia ochreata* (0.1%), *Lysicarpus angustifolius* (0.9%), *Oxalis corniculata* (0.1%), *Panicum effusum* (0.3%), *Persoonia falcata* (0.1%), *Phyllanthus collinus* (0.1%), *Pomax umbellata* (0.1%), *Scleria sphacelata* (2%), *Setaria surgens* (0.1%), *Sorghum leiocladum* (0.1%), *Tephrosia* sp. A (0.1%), *Xanthorrhoea johnsonii* (1%), *Zornia* sp. (0.1%).

SECONDARY SITE 40 **11.10.7**



Latitude, Longitude: -22.2930, 148.1505

Community description: Woodland dominated by *Eucalyptus crebra* and *Eucalyptus melanophloia* growing on a low terrace on a sandstone slope.

Dominant species per stratum:

T1: *Eucalyptus crebra, Eucalyptus melanophloia, Acacia shirleyi.*
T2: *Petalostigma pubescens, Acacia burdekensis.*
S1: *Eucalyptus crebra*
G: *Aristida calycina* var. *calycina, Chrysopogon fallax, Eriochloa crebra.*

Median (and range) canopy height per stratum: T1 = 12.8 m (9.2–14.6 m), T2 = 5.6 m (4.0–7.0 m), S1 = 2 m (0.5–3.0 m).

% cover of each stratum: T1 = 23%; T2 = 8.7%; S1 = 5.1%; **total = 33.7%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus crebra* = 2.67 m^2/ha; *Eucalyptus melanophloia* = 1.83 m^2/ha; *Acacia shirleyi* = 0.5 m^2/ha; *Corymbia dallachiana* = 0.17 m^2/ha **(total = 5.17 m^2/ha)**
T2: *Petalostigma pubescens* = 1 m^2/ha; *Acacia burdekensis* = 0.5 m^2/ha **(total = 1.5 m^2/ha)**
S1: < 0.17 m^2/ha

Landform: Ledge on foot slope of sandstone ridge. **Slope:** 6°ESE **Soil:** Grey-brown sand with no outcropping rock.

Disturbance: Lightly grazed.

Ground cover: Rock = 0%, wood = 1%, bare = 59%, litter = 20%, vegetation = 20%.

Species (percent cover): *Acacia burdekensis* (0.1%), *Afrohybanthus stellarioides* (0.1%), *Alphitonia excelsa* (0.1%), *Aristida calycina* var. *calycina* (4%), *Cenchrus ciliaris** (0.1%), *Chamaecrista absus* (0.1%), *Cheilanthes sieberi* (0.1%), *Chrysopogon fallax* (6.6%), *Corymbia dallachiana* (0.1%), *Cyanthillium cinereum* (0.1%), *Digitaria brownii* (0.1%), *Digitaria diminuta* (0.1%), *Digitaria* sp. A (0.4%), *Eragrostis leptostachya* (0.1%), *Eragrostis sororia* (0.5%), *Eriochloa crebra* (5%), *Erythroxylum australe* (0.1%), *Eucalyptus crebra* (0.1%), *Eucalyptus melanophloia* (0.1%), *Evolvulus alsinoides* (0.1%), *Fimbristylis dichotoma* (0.1%), *Lobelia purpurascens* (0.1%), *Melinis repens** (0.1%), *Murdannia graminea* (0.1%), *Panicum effusum* (0.1%), *Petalostigma pubescens* (0.1%), *Phyllanthus collinus* (0.1%), *Phyllanthus* sp. (Myra Vale J.J.Bruhl+ 1810) (0.1%), *Rostellularia adscendens* (0.1%), *Sida cordifolia** (0.1%), *Sida hackettiana* (0.2%), *Sida spinosa** (0.3%), *Stylosanthes scabra** (0.2%), *Themeda triandra* (0.1%), *Urochloa mosambicensis** (0.1%), *Zornia muelleriana* subsp. *muelleriana* (0.1%).

SECONDARY SITE 41 **11.10.1**



Latitude, Longitude: -22.2933, 148.1519

Community description: Open forest dominated by *Corymbia citriodora* on a rocky sandstone foot slope.

Dominant species per stratum:

T1: *Corymbia citriodora, Eucalyptus crebra* (subdominant).
T2: *Corymbia citriodora, Corymbia trachyphloia, Eucalyptus crebra.*
S1: *Acacia flavescens, Acacia burdekensis.*
G: *Cymbopogon refractus, Themeda triandra, Melinis repens*.*

Median (and range) canopy height per stratum: T1 = 24.4 m (23–25.8 m), T2 = 11 m (8.4–13 m), S1 = 2.5 m (0.6–4 m).

% cover of each stratum: T1 = 46.2%; T2 = 30.2%; S1 = 14.1%; **total = 69.6%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Corymbia citriodora* = 3.17 m^2/ha; *Eucalyptus crebra* = 0.67 m^2/ha **(total = 3.84 m^2/ha)**.
T2: *Eucalyptus crebra* = 4.67 m^2/ha; *Corymbia trachyphloia* = 0.33 m^2/ha **(total = 5 m^2/ha)**.
S1: < 0.17 m^2/ha

Landform: Rocky foot slope next to gully **Slope:** 18°E **Soil:** Grey-brown sand with sandstone boulders

Disturbance: Few weeds and light grazing.

Ground cover: Rock = 35%, wood = 0.5%, bare = 10%, litter = 31.5%, vegetation = 23%.

Species (percent cover): *Acacia burdekensis* (0.1%), *Acacia macradenia* (0.2%), *Afrohybanthus stellarioides* (0.1%), *Alphitonia excelsa* (0.3%), *Aristida benthamii* (0.1%), *Aristida spuria* (0.1%), *Breynia oblongifolia* (0.1%), *Brunoniella australis* (0.1%), *Capparis canescens* (0.1%), *Cenchrus ciliaris** (0.2%), *Cheilanthes sieberi* (0.1%), *Chrysopogon fallax* (0.1%), *Coelospermum reticulatum* (0.1%), *Corymbia citriodora* subsp. *citriodora* (0.1%), *Crotalaria montana* (0.1%), *Cyanthillium cinereum* (0.1%), *Cymbopogon refractus* (8.4%), *Dichanthium sericeum* (0.1%), *Enneapogon lindleyanus* (0.1%), *Eriochloa pseudoacrotricha* (0.1%), *Erythroxylum australe* (0.1%), *Eucalyptus crebra* (0.1%), *Eucalyptus melanophloia* (0.1%), *Eustrephus latifolius* (0.1%), *Glycine tomentella* (0.1%), *Grewia latifolia* (0.1%), *Hakea lorea* (0.1%), *Indigofera australis* (0.1%), *Larsenaikia ochreata* (0.1%), *Marsdenia microlepis* (0.1%), *Melhania oblongifolia* (0.1%), *Melinis repens** (2%), *Panicum effusum* (0.1%), *Persoonia falcata* (0.1%), *Petalostigma pubescens* (0.1%), *Phyllanthus virgatus* (0.1%), *Pterocaulon ciliosum* (0.1%), *Pycnospora lutescens* (0.1%), *Rostellularia adscendens* (0.1%), *Scleria sphacelata* (0.1%), *Sida spinosa** (0.1%), *Solanum ellipticum* (0.1%), *Stylosanthes scabra** (0.1%), *Tephrosia juncea* (0.1%), *Themeda triandra* (8%).

SECONDARY SITE 42 **11.10.3**



Latitude, Longitude: -22.2988, 148.1585

Community description: Low open forest dominated by *Acacia shirleyi*, with emergent *Corymbia aureola*, on a terrace of a sandstone ridge.

Dominant species per stratum:

E: *Corymbia aureola.*
T1: *Acacia shirleyi.*
S1: *Alphitonia excelsa, Erythroxylum australe.*
G: *Cleistochloa subjuncea, Eriachne obtusa, Thyridolepis xerophila*

Median (and range) canopy height per stratum: E = 13.2 m (11.8–13.6 m), T1 = 9.8 m (5.6–10.4 m), S1 = 1.5 m (1.0–1.5 m).

% cover of each stratum: E = 21.5%; T1 = 58.2%; S1 = 1.4%; t**otal = 70.7%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

E: *Acacia shirleyi* = 0.5 m^2/ha; *Corymbia aureola* = 0.83 m^2/ha **(total = 1.33 m^2/ha)**.
T1: *Acacia shirleyi* = 5.83 m^2/ha **(total = 5.83 m^2/ha)**.
S1: <0.15 m^2/ha.

Landform: Ledge of sandstone ridge. **Slope:** 8°N **Soil:** Pink-grey sand with many small rocks.

Disturbance: Recent fire seems to have resulted in many large dead *A. shirleyi*.

Ground cover: Rock = 5%, wood = 8%, bare = 28%, litter = 35%, vegetation = 24%.

Species (percent cover): *Acacia shirleyi* (0.1%), *Afrohybanthus stellarioides* (0.1%), *Alphitonia excelsa* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Aristida gracilipes* (0.1%), *Cheilanthes sieberi* (0.1%), *Cleistochloa subjuncea* (17.7%), *Digitaria diminuta* (0.1%), *Eragrostis sororia* (0.1%), *Eriachne obtusa* (4%), *Marsdenia microlepis* (0.1%), *Pseuderanthemum variabile* (0.1%), *Scleria sphacelata* (0.1%), *Solanum parvifolium* (0.1%), *Thyridolepis xerophila* (1%), *Wrightia saligna* (0.1%).

SECONDARY SITE 43 **HVR 11.5.9**



Latitude, Longitude: -22.2852, 148.1759

Community description: Woodland dominated by *Eucalyptus crebra* on a sand plain.

Dominant species per stratum:

T1: *Eucalyptus crebra.*
T2: *Ventilago viminalis, Grevillea parallela, Acacia excelsa.*
S1: *Erythroxylum australe.*
G: *Cenchrus ciliaris*, Bothriochloa pertusa*.*

Median (and range) canopy height per stratum: T1 = 14.8 m (11.2–17.4 m), T2 = 7.8 m (7.4–9.2 m), S1 = 2.0 m (1.0–3.0 m).

% cover of each stratum: T1 = 22.5%; T2 = 16.9%; S1 = 16%; **total = 43.9%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus crebra* = 3.33 m^2/ha; *Grevillea striata* = 0.17 m^2/ha; *Acacia excelsa* = 0.17 m^2/ha **(total = 3.67 m^2/ha)**.
T2: *Ventilago viminalis* = 1.67 m^2/ha *Corymbia dallachiana* = 1.33 m^2/ha; *Corymbia clarksoniana* = 1.17 m^2/ha; **(total = 4.17 m^2/ha)**.
S1: <0.15 m^2/ha.

Landform: Sandy foot slope **Slope:** 2°N **Soil:** Yellow sand

Disturbance: Heavily grazed; evidence of heavy thinning of vegetation; probably previously cleared.

Ground cover: Rock = 0%, wood = 0.5%, bare = 45%, litter = 30%, vegetation = 24.5%.

Species (percent cover): *Acacia excelsa* (0.1%), *Alphitonia excelsa* (0.1%), *Alternanthera nana* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Boerhavia pubescens* (0.1%), *Bothriochloa pertusa** (2%), *Capparis canescens* (0.1%), *Cenchrus ciliaris** (18.5%), *Chamaecrista absus* (0.1%), *Chrysopogon fallax* (0.1%), *Clerodendrum floribundum* (0.1%), *Commelina lanceolata* (0.1%), *Dianella nervosa* (0.1%), *Digitaria longiflora* (0.1%), *Eragrostis lacunaria* (0.1%), *Eragrostis spartinoides* (0.1%), *Erythroxylum australe* (0.3%), *Eucalyptus crebra* (0.1%), *Evolvulus alsinoides* (0.1%), *Fimbristylis dichotoma* (0.1%), *Flindersia dissosperma* (0.1%), *Galactia tenuiflora* (0.1%), *Harrisia martinii** (0.1%), *Jacquemontia paniculata* (0.1%), *Melhania oblongifolia* (0.1%), *Murdannia graminea* (0.1%), *Parsonsia lanceolata* (0.4%), *Phyllanthus collinus* (0.1%), *Portulaca oleracea** (0.1%), *Portulaca pilosa** (0.1%), *Pseuderanthemum variabile* (0.1%), *Rostellularia adscendens* (0.1%), *Sida spinosa** (0.1%), *Stylosanthes scabra** (0.1%), *Urochloa mosambicensis** (0.1%), *Ventilago viminalis* (0.1%), *Vittadinia pustulata* (0.1%).

SECONDARY SITE 44 **11.10.13**



Latitude, Longitude: -22.2774, 148.1604

Community description: Low woodland dominated by *Corymbia aureola* on a sandstone plateau. Mapped as high-value regrowth, but it is probably remnant and naturally stunted by the lack of topsoil. It is improbable that it would have been cleared considering the difficult terrain.

Dominant species per stratum:

T1: *Corymbia aureola.*
S1: *Acacia bancroftiorum, Acacia flavescens, Acacia burdekensis.*
G: *Cleistochloa subjuncea, Melinis repens*

Median (and range) canopy height per stratum: T1 = 9.6 m (6.4–10.4 m), S1 = 2.5 m (0.5–3.5 m).

% cover of each stratum: T1 = 26.2%; S1 = 40.7%; **total = 62.1%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Corymbia aureola* = 5 m^2/ha; *Terminalia porphyrocarpa* = 0.17 m^2/ha **(total = 5.17 m^2/ha)**.
S1: *Acacia shirleyi* = 0.17 m^2/ha; *Acacia flavescens* = 0.17 m^2/ha **(total = 0.34 m^2/ha)**.

Landform: Rocky plateau. **Slope:** 12°W **Soil:** Quartz/white sand.

Disturbance: Lightly grazed; many large dead trees appear to have been killed by a severe historical fire. This may be why the site appeared to be non-remnant from aerial imagery.

Ground cover: Rock = 35%, wood = 0.5%, bare = 5%, litter = 43%, vegetation = 17%.

Species (percent cover): *Acacia bancroftiorum* (0.1%), *Acacia burdekensis* (0.2%), *Acacia dietrichiana* (0.1%), *Acacia flavescens* (0.3%), *Acacia shirleyi* (0.2%), *Afrohybanthus stellarioides* (0.1%), *Alphitonia excelsa* (0.1%), *Aristida benthamii* (0.8%), *Cheilanthes sieberi* (0.1%), *Cleistochloa subjuncea* (12%), *Corymbia aureola* (0.1%), *Digitaria diminuta* (0.2%), *Eragrostis spartinoides* (0.1%), *Eriachne obtusa* (0.1%), *Erythroxylum australe* (0.4%), *Euphorbia drummondii* (0.1%), *Evolvulus alsinoides* (0.1%), *Galactia tenuiflora* (0.1%), *Hovea tholiformis* (0.3%), *Larsenaikia ochreata* (0.1%), *Lomandra longifolia* (0.1%), *Melinis repens* (1%), *Panicum effusum* (0.1%), *Solanum ellipticum* (0.1%), *Urochloa piligera* (0.1%).

SECONDARY SITE 45 **HVR 11.10.3**



Latitude, Longitude: -22.2905, 148.1883

Community description: Open forest dominated by *Acacia shirleyi*, with emergent *Eucalyptus crebra* and *Corymbia clarksoniana*, on a low sandstone ridge.

Dominant species per stratum:

E: *Eucalyptus crebra, Corymbia clarksoniana.*
T1: *Acacia shirleyi.*
S1: *Erythroxylum australe***.**
G: *Alloteropsis cimicina, Melinis repens*.*

Median (and range) canopy height per stratum: E = 12.8 m; T1 = 10.6 m (7.4–11.6 m), S1 = 3.0 m (1.0–4.0 m).

% cover of each stratum: E < 0.1%; T1 = 74.2%; S1 = 12%; **total = 76.7%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

E: *Corymbia clarksoniana* = 0.17 m^2/ha **(total = 0.17 m^2/ha)**.
T1: *Acacia shirleyi* = 14.67 m^2/ha **(total = 14.67 m^2/ha)**.
S1: <0.15 m^2/ha.

Landform: Low ridge. **Slope:** 15°S **Soil:** Pink-grey sand with lots of gravel.

Disturbance: Previously cleared; much dumped rubbish.

Ground cover: Rock = 5%, wood = 1%, bare = 20%, litter = 67%, vegetation = 7%.

Species (percent cover): *Acacia shirleyi* (0.1%), *Alloteropsis cimicina* (3.9%), *Alphitonia excelsa* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Calotis cuneifolia* (0.1%), *Capparis canescens* (0.1%), *Cheilanthes sieberi* (0.1%), *Cyanthillium cinereum* (0.1%), *Digitaria diminuta* (0.1%), *Eragrostis lacunaria* (0.1%), *Erythroxylum australe* (0.1%), *Harrisia martinii** (0.1%), *Melinis repens* (1%), *Paspalidium gracile* (0.1%), *Portulaca filifolia* (0.1%), *Portulaca oleracea** (0.1%), *Pseuderanthemum variabile* (0.1%), *Ptilotus polystachyus* (0.1%), *Sida* sp. (Musselbrook M.B.Thomas+ MRS437) (0.4%), *Urochloa mosambicensis** (0.1%).

SECONDARY SITE 46 **11.3.25**



Latitude, Longitude: -22.3061, 148.1946

Community description: Closed forest dominated by *Eucalyptus camaldulensis* and *Melaleuca leucadendra* on the bank of an ephemeral watercourse.

Dominant species per stratum:

T1: *Eucalyptus camaldulensis, Melaleuca leucadendra.*
T2: *Alphitonia excelsa.*
S1: *Ficus opposita.*
G: *Bidens pilosa*, Megathyrsus maximus* var. *pubiglumis*, Acanthospermum hispidum*, Richardia brasiliensis*.*

Median (and range) canopy height per stratum: T1 = 21 m (18.4–21.2 m), T2 = 10.8 m (9.2–11 m), S1 = 2.5 m (1.0–4.0 m).

% cover of each stratum: T1 = 87.3%; T2 = 18.8%; S1 = 30.7%; **total = 87.7%**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Melaleuca leucadendra* = 9.83 m^2/ha; *Eucalyptus camaldulensis* = 8 m^2/ha; *Corymbia clarksoniana* = 0.5 m^2/ha **(total = 18.5 m^2/ha)**.
T2: *Alphitonia excelsa* = 0.33 m^2/ha; *Flindersia australis* =0.17 m^2/ha **(total = 0.5 m^2/ha)**.
S1: *Acacia macradenia* = 0.17 m^2/ha; *Ficus opposita* = 0.17 m^2/ha **(total = 0.33 m^2/ha)**.

Landform: Creek bank. **Slope:** 0° **Soil:** Sand.

Disturbance: Very high weed densities.

Ground cover: Rock = 0%, wood = 1%, bare = 15%, litter = 60%, vegetation = 24%.

Species (percent cover): *Acacia macradenia* (0.1%), *Acanthospermum hispidum** (3%), *Ageratum conyzoides** (0.4%), *Albizia canescens* (0.1%), *Alternanthera nana* (0.1%), *Aristolochia thozetii* (0.1%), *Bidens pilosa** (7%), *Bothriochloa pertusa** (0.6%), *Cenchrus ciliaris** (0.1%), *Clerodendrum floribundum* (0.1%), *Commelina diffusa* (0.1%), *Crinum arenarium* (0.1%), *Crotalaria mitchellii* (0.1%), *Crotalaria pallida** (0.1%), *Cryptostegia grandiflora** (0.1%), *Cyanthillium cinereum* (0.1%), *Cyperus gracilis* (0.1%), *Dactyloctenium radulans* (0.1%), *Desmodium filiforme* (0.1%), *Digitaria brownii* (0.1%), *Digitaria eriantha** (0.2%), *Echinochloa colona** (0.1%), *Emilia sonchifolia** (0.2%), *Erythrina vespertilio* (0.1%), *Eucalyptus camaldulensis* (0.1%), *Ficus opposita* (3%), *Ipomoea plebia* (0.1%), *Juncus usitatus* (0.1%), *Lomandra longifolia* (0.1%), *Macroptilium atropurpureum** (0.1%), *Megathyrsus maximus* var. *pubiglumis** (1.4%), *Parthenium hysterophorus** (0.1%), *Passiflora foetida** (0.7%), *Richardia brasiliensis** (3%), *Scoparia dulcis** (0.1%), *Senna occidentalis** (0.1%), *Sida cordifolia** (1%), *Sida hackettiana* (0.1%), *Sida rhombifolia** (0.2%), *Urochloa mosambicensis** (0.5%), *Xanthium occidentale** (0.1%).

SECONDARY SITE 47 **HVR 11.5.3**



Latitude, Longitude: -22.3940, 148.2580

Community description: Woodland dominated by *Eucalyptus populnea* on sand plain. A very small amount of sandstone present at the surface, but otherwise is land zone 5.

Dominant species per stratum:

T1: *Eucalyptus populnea.*
T2: *Alphitonia excelsa, Cassia brewsteri, Melaleuca nervosa.*
S1: *Erythroxylum australe.*
G: *Alloteropsis cimicina, Eriochloa crebra, Sida hackettiana, Stylosanthes scabra*.*

Median (and range) canopy height per stratum: T1 = 15.2 m (11.6–16 m), T2 = 6.6 m (6.2–8.6 m), S1 = 2.5 m (1.0–4.2 m).

% cover of each stratum: T1 = 31.1%; T2 = 16.4%; S1 = 0.6; **total = 44.9%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus populnea* = 6.83 m^2/ha **(total = 6.83 m^2/ha)**.
T2: *Cassia brewsteri* = 0.5 m^2/ha; *Alphitonia excelsa* = 1.67 m^2/ha **(total = 2.17 m^2/ha)**.
S1: <0.15 m^2/ha.

Landform: Plain **Slope:** 1°N **Soil:** Yellow-grey sand.

Disturbance: Previously cleared; grazed.

Ground cover: Rock = 0.1%, wood =0.5%, bare = 45%, litter = 25%, vegetation = 29.4%.

Species (percent cover): *Acacia burdekensis* (0.1%), *Acacia salicina* (0.1%), *Afrohybanthus enneaspermus* (0.1%), *Alloteropsis cimicina* (13%), *Alphitonia excelsa* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Aristida holathera* (0.9%), *Bonamia media* (0.1%), *Carissa ovata* (0.1%), *Cenchrus ciliaris** (0.4%), *Cheilanthes sieberi* (0.1%), *Chrysopogon fallax* (0.3%), *Desmodium filiforme* (0.1%), *Digitaria divaricatissima* (0.2%), *Digitaria eriantha** (0.1%), *Diospyros humilis* (0.1%), *Eragrostis lacunaria* (0.1%), *Eragrostis sororia* (0.2%), *Eragrostis speciosa* (0.1%), *Eriachne mucronata* (0.1%), *Eriochloa crebra* (6%), *Erythroxylum australe* (0.3%), *Eucalyptus populnea* (0.1%), *Euphorbia bifida* (0.1%), *Evolvulus alsinoides* (0.1%), *Fimbristylis dichotoma* (0.1%), *Ipomoea polymorpha* (0.1%), *Melinis repens* (0.1%), *Perotis rara* (0.2%), *Phyllanthus collinus* (0.2%), *Phyllanthus* sp. (Myra Vale J.J.Bruhl+ 1810) (0.2%), *Phyllanthus virgatus* (0.1%), *Portulaca filifolia* (0.1%), *Portulaca oleracea** (0.1%), *Sida hackettiana* (2%), *Sida spinosa** (0.1%), *Stylosanthes hamata** (0.1%), *Stylosanthes scabra** (2%), *Tephrosia leptoclada* (0.2%), *Urochloa mosambicensis** (0.1%), *Zornia* sp. (0.7%)**.**

SECONDARY SITE 48 **11.5.3**



Latitude, Longitude: -22.3895, 148.2367

Community description: Woodland dominated by *Eucalyptus populnea* on a sand plain.

Dominant species per stratum:

T1: *Eucalyptus populnea.*
T2: *Vachellia bidwillii, Eucalyptus populnea.*
S1: *Carissa ovata.*
G: *Scoparia dulcis*, Heteropogon contortus, Fimbristylis dichotoma, Bothriochloa pertusa*, Cenchrus ciliaris*, Urochloa mosambicensis*.*

Median (and range) canopy height per stratum: T1 = 16.8 m (11.6–19.8 m), T2 = 4.2 m (2.8–6.8 m), S1 = 1.0 m (0.5–1.5 m).

% cover of each stratum: T1 = 44.2%; T2 = 3%; S1 = 12.7%; **total = 45.3%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

T1: *Eucalyptus populnea* = 14.67 m^2/ha; *Corymbia clarksoniana* = 0.33 m^2/ha; *Eucalyptus crebra* = 0.17 m^2/ha; *Eucalyptus melanophloia* = 0.17 m^2/ha **(total = 15.34 m^2/ha)**
T2: *Corymbia dallachiana* = 0.17 m^2/ha; *Cassia brewsteri* = 0.17 m^2/ha; *Vachellia bidwillii* = 0.17 m^2/ha **(total = 0.51 m^2/ha)**
S1: < 0.15 m^2/ha

Landform: Plain. **Slope:** 0° **Soil:** Fine grey-brown sand.

Disturbance: Grazed.

Ground cover: Rock = 0%, wood =0.8%, bare = 25%, litter = 35%, vegetation = 39.2%.

Species (percent cover): *Achyranthes aspera* (0.1%), *Afrohybanthus enneaspermus* (0.1%), *Afrohybanthus stellarioides* (0.1%), *Alphitonia excelsa* (0.1%), *Alternanthera nana* (0.1%), *Aristida calycina* var. *calycina* (0.4%), *Boerhavia pubescens* (0.1%), *Bothriochloa ewartiana* (0.2%), *Bothriochloa pertusa** (4%), *Carissa ovata* (2%), *Cenchrus ciliaris** (5%), *Chamaecrista absus* (0.1%), *Chrysopogon fallax* (0.8%), *Crotalaria juncea** (0.1%), *Cyanthillium cinereum* (0.1%), *Cynodon dactylon** (0.1%), *Cyperus fulvus* (0.1%), *Cyperus gracilis* (0.1%), *Desmodium filiforme* (0.1%), *Enteropogon ramosus* (0.2%), *Eragrostis sororia* (0.1%), *Eriochloa crebra* (0.3%), *Eucalyptus populnea* (0.1%), *Euphorbia drummondii* (0.1%), *Evolvulus alsinoides* (0.1%), *Fimbristylis dichotoma* (3%), *Glycine tomentella* (0.1%), *Grewia retusifolia* (0.2%), *Heteropogon contortus* (3%), *Indigofera colutea* (0.1%), *Ipomoea plebia* (0.1%), *Malvastrum americanum** (0.1%), *Melinis repens* (0.5%), *Phyllanthus collinus* (0.1%), *Polygala triflora* (0.1%), *Scoparia dulcis** (5%), *Sida hackettiana* (0.2%), *Sida spinosa** (0.8%), *Spermacoce brachystema* (0.1%), *Stylosanthes scabra** (2%), *Urochloa mosambicensis** (9%), *Vachellia bidwillii* (0.1%), *Zornia areolata* (0.1%).

SECONDARY SITE 49 **11.4.8**



Latitude, Longitude: -22.3526, 148.2236

Community description: Open forest dominated by *Acacia harpophylla* and *Casuarina cristata*, with emergent *Eucalyptus cambageana*, on a clay plain.

Dominant species per stratum:

E: *Eucalyptus cambageana*.
T1: *Acacia harpophylla*, *Casuarina cristata*, *Terminalia oblongata.*
T2: *Acacia harpophylla*, *Terminalia oblongata.*
S1: *Carissa ovata, Terminalia oblongata.*
G: *Paspalidium caespitosum*, *Eragrostis lacunaria*.

Median (and range) canopy height per stratum: E = 20.4 m (18.4–24.6 m); T1 = 12.8 m (12.2–16.6 m), T2 = 5.0 m (4.8–5.8 m), S1 = 1.5 m (0.5–3.0 m).

% cover of each stratum: E = 10.6%; T1 = 56.5%; T2 = 12%; S1 = 43.1%; **total = 83.4%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

E: *Eucalyptus cambageana* = 0.5 m^2/ha **(total = 0.5 m^2/ha)**.
T1: *Casuarina cristata* = 4.67 m^2/ha; *Acacia harpophylla* = 4.5 m^2/ha; *Terminalia oblongata* = 3 m^2/ha; *Eucalyptus cambageana* = 0.67 m^2/ha; *Ventilago viminalis* = 0.17 m^2/ha **(total = 13.01 m^2/ha)**.
T2: <0.17 m^2/ha.
S1: <0.17 m^2/ha.

Landform: Plain. **Slope:** 2°NE **Soil:** Brown clay loam with some surface pebbles. No obvious gilgais.

Disturbance: Grazed.

Ground cover: Rock = 0.1%, wood = 1%, bare = 24%, litter = 38%, vegetation = 36.9%.

Species (percent cover): *Abutilon oxycarpum* (0.1%), *Aristida calycina* var. *calycina* (0.1%), *Bothriochloa pertusa** (0.1%), *Brunoniella australis* (0.1%), *Carissa ovata* (0.1%), *Casuarina cristata* (31.4%), *Cenchrus ciliaris** (0.1%), *Chloris divaricata* (0.1%), *Chrysopogon fallax* (0.1%), *Cymbopogon refractus* (0.1%), *Cynanchum viminale* (0.1%), *Desmodium varians* (0.1%), *Enneapogon* sp. A (0.1%), *Eragrostis lacunaria* (0.4%), *Eremophila mitchellii, Erythroxylum australe, Evolvulus alsinoides, Flindersia dissosperma, Glycine* sp. (Mackay S.B.Andrews+ 43), *Grewia latifolia* (0.1%), *Hibiscus sturtii* (0.1%), *Jacquemontia paniculata* (0.1%), *Jasminum didymum* subsp. *lineare* (0.1%), *Melhania oblongifolia* (0.1%), *Ocimum caryophyllinum* (0.1%), *Paspalidium caespitosum* (0.1%), *Phyllanthus virgatus* (0.1%), *Rhynchosia minima* (0.1%), *Scleria brownii* (0.2%), *Terminalia oblongata* (2%).

SECONDARY SITE 50 **11.10.8**



Latitude, Longitude: -22.2892, 148.1563.
Community description: Low closed forest (semi-evergreen microphyll vine-thicket) dominated by *Planchonella pubescens*, *Geijera salicifolia*, *Gossia bidwillii* and *Hovea longipes* in a sheltered sandstone gorge.

Dominant species per stratum:

E: *Acacia shirleyi, Lophostemon suaveolens, Euroschinus falcatus.*
T1: *Planchonella pubescens, Geijera salicifolia, Drypetes deplanchei, Acronychia laevis, Psydrax odorata.*
S1: *Hovea longipes, Alyxia ruscifolia, Gossia bidwillii.*
G: *Ancistrachne uncinata.*

Median (and range) canopy height per stratum: E =11 m (10–13 m); T1 = 5 m (4–6 m); S1 = 1.5 m (1–2 m).

% cover of each stratum: E = 46.8%; T1 =64.7%; S1 = 30.4%; **total = 92.4%.**

Basal area (using a Bitterlich gauge, measured at three points along the transect)**:**

E: *Acacia shirleyi* = 0.83 m^2/ha; *Alectryon connatus* = 0.17 m^2/ha; *Bursaria incana* = 0.33 m^2/ha; *Euroschinus falcata* = 0.5 m^2/ha; *Ficus rubiginosa* = 0.17 m^2/ha; *Pleiogynium timoriense* **=** 0.33 m^2/ha; (**total = 2.33 m^2/ha)**.
T1: *Planchonella pubescens* = 3.17 m^2/ha; *Geijera salicifolia* = 2.67 m^2/ha; *Gossia bidwillii* = 1.5 m^2/ha; *Ehretia membranifolia* = 0.5 m^2/ha; *Exocarpos latifolius* = 0.67 m^2/ha; *Drypetes deplanchei* = 0.17 m^2/ha; *Psydrax odorata* subsp. *buxifolia* = 0.17 m^2/ha; **(total = 8.85 m^2/ha)**.
S1: *Hovea longipes* = 1.33 m^2/ha; *Psydrax odorata* subsp. *buxifolia* = 0.67 m^2/ha **(total = 2 m^2/ha)**.

Landform: Rocky gorge. **Slope:** 45°ESE **Soil:** Abundant sandstone boulders.

Disturbance: nil.

Ground cover: Rock = 70%, bare = 2%, litter = 20%, vegetation = 8%.

Species (percent cover): *Abutilon oxycarpum* (0.1%), *Acacia burdekensis* (0.1%), *Acacia shirleyi* (0.1%), *Acronychia laevis* (0.1%), *Alectryon connatus* (0.1%), *Alphitonia excelsa* (0.1%), *Alyxia ruscifolia* (0.7%), *Amyema conspicua* (0.1%), *Ancistrachne uncinata* (0.5%), *Bidens bipinnata** (0.1%), *Bursaria incana* (0.1%), *Capparis lasiantha* (0.1%), *Cassytha filiformis* (0.1%), *Cheilanthes nudiuscula* (0.2%), *Cissus oblonga* (0.1%), *Cleistochloa subjuncea* (0.7%), *Commelina diffusa* (0.2%), *Cyanthillium cinereum* (0.2%), *Deeringia amaranthoides* (0.1%), *Dinebra decipiens* var. *decipiens* (0.1%), *Diospyros humilis* (0.1%), *Drypetes deplanchei* (0.3%), *Ehretia membranifolia* (0.1%), *Exocarpos latifolius* (0.3%), *Ficus rubiginosa* (0.1%), *Gahnia aspera* (0.1%), *Geijera salicifolia* (0.1%), *Gossia bidwillii* (0.2%), *Harrisia martinii** (0.1%), *Hovea longipes* (0.3%), *Jasminum didymum* subsp. *racemosum* (0.1%), *Jasminum simplicifolium* subsp. *australiense* (0.1%), *Larsenaikia ochreata* (0.2%), *Lophostemon suaveolens* (0.1%), *Myrsine variabilis* (0.1%), *Parsonsia lanceolata* (0.1%), *Pavetta granitica* (0.1%), *Planchonella pubescens* (0.1%), *Plectranthus parviflorus* (0.2%), *Pleiogynium timoriense* (0.1%), *Psydrax odorata* subsp. *buxifolia* (0.1%), *Richardia brasiliensis** (0.1%), *Scleria brownii* (0.1%), *Scleria sphacelata* (0.1%), *Scoparia dulcis** (0.1%), *Secamone elliptica* (0.1%), *Setaria surgens* (0.1%), *Sida hackettiana* (0.1%), *Solanum ellipticum* (0.1%), *Tetrastigma nitens* (0.1%), *Trema tomentosa* (0.1%), *Trophis scandens* (0.1%).

APPENDIX C

FLORA AND FAUNA RECORDED DURING SURVEYS

Appendix D1 Flora recorded during field surveys

Family	Scientific Name	Common Name	Percentage of secondary sites in each regional ecosystem containing the species												
			11.3.2	11.3.25	11.4.8	11.4.9	11.5.3	11.5.9	11.9.2	11.10.1	11.10.3	11.10.7	11.10.8	11.10.13	Non-remnant
Acanthaceae	*Brunoniella australis*	Blue Trumpet	0	0	100	100	29	33	67	33	0	0	0	0	50
Acanthaceae	*Pseuderanthemum variabile*	Pastel Flower; Love Flower	0	0	50	0	0	11	0	33	80	67	0	20	0
Acanthaceae	*Rostellularia adscendens*	Pink Tongues	50	33	0	0	29	22	67	67	0	33	0	0	0
Aizoaceae	*Portulaca bicolor*		0	0	0	0	0	11	0	0	20	33	0	0	0
Aizoaceae	*Portulaca filifolia*		50	0	25	0	57	11	0	0	20	0	0	20	25
Aizoaceae	*Portulaca oleracea**	Common Purslane	0	0	50	100	43	11	33	0	20	33	0	0	0
Aizoaceae	*Portulaca pilosa**	Pink Purslane	50	33	25	0	29	78	0	0	20	33	0	0	75
Aizoaceae	*Trianthema portulacastrum**	Black Pigweed	0	0	0	0	0	0	0	0	0	0	0	0	0
Amaranthaceae	*Achyranthes aspera*	Devil's Horsewhip; Chaff Flower	0	67	25	0	43	0	0	0	20	33	0	20	0
Amaranthaceae	*Alternanthera denticulata*	Lesser Joyweed	0	0	0	100	43	0	0	0	0	0	0	0	0
Amaranthaceae	*Alternanthera nana*	Hairy Joyweed	50	33	25	0	86	44	0	33	40	0	0	0	50
Amaranthaceae	*Alternanthera pungens**	Khaki Weed	0	0	0	0	0	0	0	0	0	0	0	0	0
Amaranthaceae	*Amaranthus interruptus*		0	0	0	100	0	0	0	0	0	33	0	0	0
Amaranthaceae	*Amaranthus viridis**	Green Amaranth	0	0	0	100	0	0	0	0	0	0	0	0	0
Amaranthaceae	*Deeringia amaranthoides*	Redberry; Shrubby Deeringia	0	0	0	0	0	0	0	0	0	0	100	0	0
Amaranthaceae	*Gomphrena celosioides**	Gomphrena Weed	50	33	0	0	57	11	0	0	0	33	0	0	75
Amaranthaceae	*Nyssanthes erecta*		0	0	50	0	14	0	0	0	0	0	0	0	0
Amaranthaceae	*Ptilotus polystachyus*		0	0	0	0	0	0	0	0	40	0	0	0	0
Amaryllidaceae	*Crinum arenarium*	Field Lily	50	67	0	0	0	0	0	0	0	0	0	0	25
Anacardiaceae	*Euroschinus falcata*	Ribbonwood	0	0	0	0	0	0	0	0	0	0	0	0	0
Anacardiaceae	*Pleiogynium timoriense*	Burdekin Plum	0	0	0	0	0	0	0	0	0	0	100	0	0

Family	Scientific Name	Common Name	Percentage of secondary sites in each regional ecosystem containing the species												
			11.3.2	11.3.25	11.4.8	11.4.9	11.5.3	11.5.9	11.9.2	11.10.1	11.10.3	11.10.7	11.10.8	11.10.13	Non-remnant
Apiaceae	*Platysace valida*		0	0	0	0	0	0	0	0	0	0	0	0	0
Apocynaceae	*Alstonia constricta*	Bitter Bark; Quinine Bush	0	0	0	0	0	0	0	0	0	0	0	0	0
Apocynaceae	*Alyxia ruscifolia*	Chain Fruit	0	0	0	0	0	0	0	0	0	0	100	0	0
Apocynaceae	*Carissa ovata*	Conkerberry; Currant Bush	100	33	100	100	71	11	67	0	0	0	0	0	50
Apocynaceae	*Cryptostegia grandiflora**	Rubber Vine	0	33	0	0	0	0	0	0	0	0	0	0	0
Apocynaceae	*Cynanchum viminale*	Caustic Vine	0	0	50	0	0	0	0	0	0	0	0	0	0
Apocynaceae	*Marsdenia microlepis*		0	0	0	0	0	0	0	67	80	67	0	20	0
Apocynaceae	*Marsdenia viridiflora* subsp. *viridiflora*	Native Pear	0	0	0	100	0	0	0	0	0	0	0	0	0
Apocynaceae	*Parsonsia lanceolata*	Rough Silkpod	50	0	50	100	29	11	0	0	0	0	100	0	25
Apocynaceae	*Secamone elliptica*	Corky Milk Vine	0	0	0	0	0	0	0	0	0	0	100	0	0
Apocynaceae	*Wrightia saligna*	Milk Wood	0	0	0	0	0	0	0	0	40	0	0	0	0
Aristolochiaceae	*Aristolochia thozetii*	Australian Native Dutchman's Pipe	0	33	0	0	14	0	0	0	0	0	0	0	0
Asteraceae	*Acanthospermum hispidum**	Bristly Star Bur; Goat's Head	0	100	0	0	29	33	0	0	0	0	0	0	25
Asteraceae	*Ageratum conyzoides**	Billygoat Weed	0	67	0	0	0	0	0	0	0	0	0	0	0
Asteraceae	*Apowollastonia spilanthoides*		0	0	25	0	29	11	0	0	0	0	0	0	25
Asteraceae	*Bidens bipinnata**	Bipinnate Cobbler's Pegs	0	33	0	0	0	0	0	0	20	33	100	20	0
Asteraceae	*Bidens pilosa**	Cobbler's Pegs	0	67	0	0	0	11	0	0	0	33	0	0	0
Asteraceae	*Calotis cuneifolia*	Purple Burr-daisy	0	0	0	0	14	0	0	33	40	0	0	0	0
Asteraceae	*Calyptocarpus vialis*	Creeping Cinderella Weed	0	67	0	0	0	0	0	0	0	0	0	0	0
Asteraceae	*Camptacra barbata*		0	0	0	0	0	0	33	0	0	0	0	0	0
Asteraceae	*Centipeda minima*	Spreading Sneezeweed	0	0	0	0	0	0	0	0	0	0	0	0	0
Asteraceae	*Chrysocephalum apiculatum*	Billy Buttons	0	0	0	0	0	22	0	0	0	0	0	0	0

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			11.3.2	11.3.25	11.4.8	11.4.9	11.5.3	11.5.9	11.9.2	11.10.1	11.10.3	11.10.7	11.10.8	11.10.13	Non-remnant
Asteraceae	*Coronidium oxylepis*	Pointed Everlasting Daisy	0	0	0	0	0	0	0	33	0	0	0	0	0
Asteraceae	*Cyanthillium cinereum*	Vernonia	50	67	25	0	71	22	33	100	60	33	100	20	50
Asteraceae	*Eclipta prostrata**	False Daisy; Eclipta	0	0	0	0	0	0	0	0	0	0	0	0	0
Asteraceae	*Emilia sonchifolia**	Tassel Flower; Emilia	0	67	0	0	0	22	0	0	0	0	0	0	0
Asteraceae	*Parthenium hysterophorus**	Parthenium Weed	0	100	25	100	0	11	33	0	0	0	0	0	25
Asteraceae	*Peripleura hispidula* var. *setosa*		0	0	0	0	0	0	33	0	0	0	0	0	0
Asteraceae	*Pterocaulon ciliosum*		0	0	0	0	0	0	0	33	0	0	0	0	0
Asteraceae	*Sonchus oleraceus**	Common Sowthistle	0	0	0	0	0	0	0	0	0	0	0	0	0
Asteraceae	*Sphaeromorphaea australis*	Spreading Nut-heads	0	0	0	0	0	11	0	0	0	0	0	0	50
Asteraceae	*Tridax procumbens**	Tridax Daisy	0	33	0	0	0	0	0	0	0	0	0	0	0
Asteraceae	*Verbesina encelioides**	Golden Crownbeard; Butter Daisy	0	33	0	0	0	0	0	0	0	0	0	0	0
Asteraceae	*Vittadinia pustulata*		0	0	0	0	14	11	0	0	0	0	0	0	0
Asteraceae	*Xanthium occidentale**	Noogoora Burr	0	100	0	0	0	0	0	0	0	0	0	0	0
Bignoniaceae	*Pandorea pandorana*	Wonga Vine	0	0	0	0	0	0	0	0	0	33	0	0	0
Boraginaceae	*Ehretia membranifolia*	Peach Bush; Weeping Koda	0	0	25	100	0	0	0	0	0	0	100	0	0
Boraginaceae	*Heliotropium cunninghamii*		0	0	0	0	0	0	0	0	0	0	0	0	25
Boraginaceae	*Heliotropium peninsulare*		0	0	0	0	0	33	33	0	0	33	0	20	0
Brassicaceae	*Cardamine hirsuta**	Hairy Bittercress	0	0	0	0	0	0	0	0	0	0	0	0	0
Byttneriaceae	*Hannafordia shanesii*		0	0	0	0	0	0	0	0	0	0	0	0	0
Cactaceae	*Harrisia martinii**	Harrisia Cactus	100	0	50	0	0	11	0	0	20	0	100	0	0
Cactaceae	*Opuntia stricta**	Prickly Pear	0	0	0	0	0	0	0	0	0	0	0	0	0
Cactaceae	*Opuntia tomentosa **	Velvet Pear; Wooly Pear	50	0	25	0	14	0	0	0	20	0	0	0	0

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			11.3.2	11.3.25	11.4.8	11.4.9	11.5.3	11.5.9	11.9.2	11.10.1	11.10.3	11.10.7	11.10.8	11.10.13	Non-remnant
Caesalpiniaceae	*Bauhinia hookeri*	White Bauhinia	0	67	0	100	0	0	0	0	0	0	0	0	0
Caesalpiniaceae	*Cassia brewsteri*	Brewster's Cassia	50	0	25	0	14	0	0	0	0	0	0	0	50
Caesalpiniaceae	*Chamaecrista absus*	Pig's ear; Sensitive Pea	0	33	0	0	14	44	0	0	20	67	0	40	25
Caesalpiniaceae	*Chamaecrista nomame*		0	0	0	0	0	0	0	0	0	0	0	0	0
Caesalpiniaceae	*Chamaecrista rotundifolia**	Round-leaf Senstive Pea	0	0	0	0	0	0	0	0	0	33	0	0	0
Caesalpiniaceae	*Petalostylis labicheoides*	Butterfly Bush	0	0	0	0	0	0	0	0	0	0	0	0	0
Caesalpiniaceae	*Senna coronilloides*	Brigalow Senna	0	0	0	100	0	0	0	0	0	0	0	0	0
Caesalpiniaceae	*Senna occidentalis**	Coffee Senna	0	100	0	0	0	0	0	0	0	0	0	0	0
Campanulaceae	*Lobelia purpurascens*	White Root	0	0	0	0	0	0	0	0	0	33	0	0	0
Campanulaceae	*Wahlenbergia gracilis*	Blue Bell	0	0	0	0	0	0	0	0	0	0	0	0	0
Capparaceae	*Apophyllum anomalum*	Warrior Bush; Broom Bush	0	0	25	100	0	0	0	0	0	0	0	0	0
Capparaceae	*Capparis canescens*	Bumble Bush; Wild Orange	50	0	0	0	14	11	0	67	20	0	0	0	0
Capparaceae	*Capparis lasiantha*	Wyjeelah; Nepine	100	0	75	0	29	0	0	0	0	0	100	0	50
Caryophyllaceae	*Polycarpaea corymbosa*		0	0	0	0	0	11	0	0	0	33	0	0	0
Casuarinaceae	*Allocasuarina luehmannii*	Bull Oak	0	0	0	0	0	11	0	0	0	0	0	0	0
Casuarinaceae	*Casuarina cristata*	Belah	0	0	50	0	0	0	0	0	0	0	0	0	0
Celastraceae	*Denhamia cunninghamii*	Yellow-berry Bush	0	0	0	0	0	0	33	0	0	0	0	0	0
Celastraceae	*Denhamia oleaster*		0	0	0	0	0	0	0	0	0	0	0	0	0
Chenopodiaceae	*Dysphania melanocarpa* forma *melanocarpa*	Black Crumbweed	0	33	0	0	14	22	0	0	0	0	0	0	25
Chenopodiaceae	*Einadia nutans* subsp. *nutans*	Climbing Saltbush	0	0	50	0	14	0	0	0	0	0	0	0	25
Chenopodiaceae	*Einadia nutans* subsp. *linifolia*	Narrow Climbing Saltbush	0	0	25	0	0	0	0	0	0	0	0	0	0
Chenopodiaceae	*Enchylaena tomentosa* var.	Ruby Saltbush	0	0	50	0	0	0	0	0	0	0	0	0	0

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	tomentosa														
Chenopodiaceae	*Maireana microphylla*	Small-leaf Bluebush	0	0	25	0	0	0	0	0	0	0	0	0	0
Chenopodiaceae	*Salsola australis*	Roly-Poly	0	0	25	100	14	0	0	0	0	0	0	0	25
Chenopodiaceae	*Sclerolaena birchii*	Galvanised Burr	0	0	0	0	0	0	0	0	0	0	0	0	0
Cleomaceae	*Cleome tetrandra* var. *tetrandra*		0	0	0	0	0	22	0	0	0	0	0	0	0
Cleomaceae	*Cleome viscosa*	Tick Weed	0	0	0	0	0	0	33	0	0	33	0	0	0
Combretaceae	*Terminalia oblongata*	Yellow-wood	0	0	50	0	0	0	0	0	0	0	0	0	0
Commelinaceae	*Commelina diffusa*	Climbing Dayflower	0	100	0	0	0	0	0	0	0	0	100	0	0
Commelinaceae	*Commelina lanceolata*		0	0	0	0	0	22	0	33	0	33	0	20	0
Commelinaceae	*Murdannia graminea*	Grass Lily	0	0	0	0	29	67	0	33	0	33	0	20	50
Convolvulaceae	*Bonamia media*		50	0	0	0	43	56	0	0	0	33	0	40	0
Convolvulaceae	*Evolvulus alsinoides*	Dwarf Morning Glory	100	0	100	0	86	67	33	67	40	100	0	80	25
Convolvulaceae	*Ipomoea brownii*		0	0	0	0	0	0	0	0	20	33	0	60	0
Convolvulaceae	*Ipomoea plebia*	Bell Vine	0	100	0	100	14	0	0	0	0	0	0	40	25
Convolvulaceae	*Ipomoea polymorpha*		0	0	0	0	57	78	0	0	0	0	0	20	50
Convolvulaceae	*Jacquemontia paniculata*		50	0	50	0	0	11	33	0	0	0	0	0	0
Convolvulaceae	*Polymeria pusilla*		0	0	0	0	0	0	33	0	0	0	0	0	25
Convolvulaceae	*Xenostegia tridentata*		0	0	0	0	0	0	0	0	20	33	0	60	0
Cyperaceae	*Abildgaardia ovata*		0	0	0	0	0	0	33	0	0	0	0	0	0
Cyperaceae	*Bulbostylis barbata*		0	0	0	0	0	0	0	0	0	0	0	0	0
Cyperaceae	*Cyperus betchei*		0	0	0	0	0	0	0	33	20	33	0	20	0
Cyperaceae	*Cyperus concinnus*		0	0	0	100	0	0	0	0	0	0	0	0	0

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Cyperaceae	*Cyperus conicus* var. *conicus*		0	0	0	0	0	0	0	0	0	0	0	0	0
Cyperaceae	*Cyperus difformis*	Variable Flatsedge	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyperaceae	*Cyperus fulvus*	Sticky Sedge	50	0	0	0	29	11	0	0	0	33	0	0	0
Cyperaceae	*Cyperus gracilis*	Slender Flat-sedge	50	67	50	100	43	0	0	0	0	0	0	0	0
Cyperaceae	*Cyperus leiocaulon*		0	33	0	0	0	0	0	0	0	0	0	0	0
Cyperaceae	*Cyperus perangustus*		0	0	0	100	0	0	0	0	0	0	0	0	0
Cyperaceae	*Cyperus rotundus**	Purple Nutsedge	0	0	0	0	0	0	33	0	0	0	0	0	0
Cyperaceae	*Eleocharis acuta*	Common Spikerush	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyperaceae	*Fimbristylis dichotoma*	Common Fringe-sedge	100	0	0	0	71	100	33	33	0	67	0	20	75
Cyperaceae	*Gahnia aspera*	Rough Saw-sedge	0	0	0	0	0	0	0	33	0	0	100	0	0
Cyperaceae	*Scleria brownii*		0	0	25	0	0	0	67	0	0	0	100	20	0
Cyperaceae	*Scleria sphacelata*		0	0	0	0	0	0	0	100	60	0	100	0	0
Ebenaceae	*Diospyros humilis*	Small-leaved Ebony	0	0	0	0	14	0	0	0	0	0	100	0	0
Erythroxylaceae	*Erythroxylum australe*	Australian Coccaine Bush; Dogwood	0	0	50	0	43	33	0	67	80	67	0	80	0
Euphorbiaceae	*Acalypha eremorum*	Soft Acalypha	0	0	0	0	0	0	0	0	0	0	0	0	0
Euphorbiaceae	*Euphorbia bifida*		0	0	0	0	14	0	33	0	0	0	0	20	25
Euphorbiaceae	*Euphorbia drummondii*	Caustic Weed	0	0	0	0	29	0	33	33	20	33	0	60	0
Euphorbiaceae	*Euphorbia hirta**	Asthma Weed	0	33	0	0	0	0	0	0	0	0	0	0	0
Euphorbiaceae	*Euphorbia tannensis*	Desert Spurge	0	0	0	0	0	0	0	33	0	0	0	0	0
Euphorbiaceae	*Jatropha gossypiifolia**	Bellyache Bush	0	0	0	0	0	0	0	0	0	0	0	0	0
Fabaceae	*Aeschynomene brevifolia*		0	0	0	0	0	0	0	0	0	0	0	0	0
Fabaceae	*Aeschynomene indica*	Indian Jointvetch	0	0	0	0	0	0	0	0	0	0	0	0	0

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Fabaceae	*Bossiaea carinalis*		0	0	0	0	0	0	0	0	0	0	0	0	0
Fabaceae	*Crotalaria juncea**	Brown Hemp	0	0	0	0	14	0	0	0	0	0	0	0	25
Fabaceae	*Crotalaria medicaginea*	Trefoil Rattlepod	0	0	0	0	0	22	0	0	0	0	0	0	0
Fabaceae	*Crotalaria mitchellii*	Yellow Rattlepod	0	67	0	0	0	0	0	0	0	0	0	0	0
Fabaceae	*Crotalaria montana*		0	0	0	0	0	0	0	33	0	0	0	0	0
Fabaceae	*Crotalaria pallida**	Smooth Rattlepod	0	33	0	0	0	0	0	0	0	0	0	0	0
Fabaceae	*Daviesia filipes*		0	0	0	0	0	0	0	33	0	0	0	0	0
Fabaceae	*Desmodium filiforme*		0	33	0	0	43	11	0	0	0	0	0	0	0
Fabaceae	*Desmodium macrocarpum*	Large-podded Trefoil	50	0	0	0	0	0	0	33	0	0	0	20	0
Fabaceae	*Desmodium rhytidophyllum*	Hairy Trefoil	0	0	0	0	0	0	0	33	0	0	0	0	0
Fabaceae	*Desmodium varians*	Slender Tick-trefoil	0	0	75	0	0	11	33	0	0	0	0	0	0
Fabaceae	*Erythrina vespertilio*	Bat's Wing Coral Tree	0	33	0	0	0	0	0	0	0	0	0	0	0
Fabaceae	*Galactia tenuiflora*		0	0	0	0	29	44	33	33	20	33	0	60	50
Fabaceae	*Glycine* sp. (Mackay S.B.Andrews+ 43)		0	0	25	0	29	0	33	0	0	33	0	0	0
Fabaceae	*Glycine tomentella*	Woolly Glycine	50	33	0	0	29	44	33	33	0	0	0	20	25
Fabaceae	*Hovea longipes*	Brush Hovea	0	0	0	0	0	0	0	0	0	0	100	0	0
Fabaceae	*Hovea tholiformis*		0	0	0	0	0	0	0	67	0	0	0	20	0
Fabaceae	*Indigofera australis*	Australian Indigo	0	0	0	0	0	0	0	33	0	0	0	0	0
Fabaceae	*Indigofera colutea*	Sticky Indigo	50	0	0	0	14	22	0	0	0	0	0	0	75
Fabaceae	*Indigofera hirsuta*	Hairy Indigo	0	0	0	0	0	0	0	0	0	0	0	0	0
Fabaceae	*Indigofera linifolia*	Narrow-leafed Indigo	0	0	0	0	0	0	100	0	0	0	0	0	25
Fabaceae	*Indigofera linnaei*	Birdsville indigo	50	0	0	0	0	11	67	0	0	0	0	0	50

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Fabaceae	*Indigofera* sp. A		0	0	0	0	0	0	0	0	0	0	0	0	0
Fabaceae	*Macroptilium atropurpureum**	Siratro	0	33	0	0	0	0	0	0	0	0	0	0	25
Fabaceae	*Pycnospora lutescens*	Pycnospora	0	0	0	0	0	0	0	33	0	0	0	0	0
Fabaceae	*Rhynchosia minima*	Least Snout-bean	0	0	25	0	29	0	67	0	0	0	0	0	50
Fabaceae	*Sesbania cannabina*	Sesbania Pea	0	0	0	0	0	0	0	0	0	0	0	0	0
Fabaceae	*Stylosanthes hamata**	Caribbean Stylo	0	67	0	0	43	33	33	0	0	0	0	0	50
Fabaceae	*Stylosanthes humilis**	Townsville Stylo	50	33	0	0	14	0	0	0	0	0	0	0	25
Fabaceae	*Stylosanthes scabra**	Shrubby Stylo	100	0	0	0	71	89	100	33	20	100	0	80	100
Fabaceae	*Tephrosia dietrichiae*		0	0	0	0	0	11	0	0	0	0	0	0	0
Fabaceae	*Tephrosia filipes* subsp. *filipes*		0	0	0	0	0	0	33	0	0	33	0	40	0
Fabaceae	*Tephrosia juncea*		0	0	0	0	0	0	0	33	0	0	0	20	0
Fabaceae	*Tephrosia leptoclada*		0	0	0	0	29	33	0	0	0	0	0	0	0
Fabaceae	*Tephrosia* sp. A		0	0	0	0	0	0	0	33	0	0	0	0	0
Fabaceae	*Tephrosia* sp. B		0	0	0	0	0	0	33	0	0	0	0	0	0
Fabaceae	*Zornia areolata*		0	0	0	0	43	11	0	0	0	0	0	0	0
Fabaceae	*Zornia muelleriana subsp. muelleriana*		0	0	0	0	14	44	0	0	0	33	0	20	0
Fabaceae	*Zornia muriculata subsp. angustata*		50	33	0	0	0	11	0	0	0	0	0	0	25
Fabaceae	*Zornia* sp.		0	0	0	0	29	11	0	33	0	33	0	0	25
Goodeniaceae	*Goodenia glabra*	Smooth Goodenia	0	0	0	0	0	11	0	0	0	0	0	0	0
Goodeniaceae	*Goodenia grandiflora*	Large-flowered Goodenia	0	0	0	0	0	0	0	0	0	0	0	0	0
Goodeniaceae	*Goodenia* sp. (Mt Castletower M.D. Crisp 2753)		0	0	0	0	0	0	0	67	20	0	0	0	0

Family	Scientific Name	Common Name	Percentage of secondary sites in each regional ecosystem containing the species												
			11.3.2	11.3.25	11.4.8	11.4.9	11.5.3	11.5.9	11.9.2	11.10.1	11.10.3	11.10.7	11.10.8	11.10.13	Non-remnant
Hemerocallidaceae	*Dianella nervosa*	Flax Lily	0	0	0	0	0	11	0	0	20	0	0	0	0
Johnsoniaceae	*Tricoryne elatior*	Yellow Autumn-lily	0	0	0	0	0	11	0	0	0	0	0	0	0
Juncaceae	*Juncus polyanthemus*	Australian Grey Rush	0	0	0	0	0	0	0	0	0	0	0	0	0
Juncaceae	*Juncus usitatus*	Common Rush	0	33	0	0	0	0	0	0	0	0	0	0	0
Lamiaceae	*Ajuga australis*	Australian Bugle	0	33	0	0	0	0	0	0	0	0	0	0	0
Lamiaceae	*Anisomeles malabarica*	Catmint	0	0	0	0	0	0	0	0	0	0	0	0	0
Lamiaceae	*Clerodendrum floribundum*	Lolly Bush	0	67	0	0	0	11	0	0	0	0	0	0	25
Lamiaceae	*Clerodendrum tomentosum*	Hairy Lolly Bush	0	0	0	0	14	0	0	0	0	0	0	0	0
Lamiaceae	*Ocimum caryophyllinum*	Holy Basil	0	0	25	0	0	0	33	0	0	0	0	0	0
Lamiaceae	*Plectranthus parviflorus*	Little Spurflower	0	0	0	0	0	0	0	0	0	0	100	0	0
Lauraceae	*Cassytha filiformis*	Love Vine; Dodder Laurel	0	0	0	0	0	11	33	0	0	0	100	0	0
Laxmanniaceae	*Eustrephus latifolius*	Wombat Berry	0	0	0	0	0	0	33	33	0	0	0	0	25
Laxmanniaceae	*Lomandra longifolia*	Spiny-head Mat-rush	0	67	0	0	0	0	0	0	0	0	0	40	0
Laxmanniaceae	*Lomandra multiflora*	Many-flowered Mat-rush	0	0	0	0	0	0	67	33	0	0	0	0	0
Loranthaceae	*Amyema congener*	Variable Mistletoe	0	0	0	0	0	0	0	0	0	0	0	0	0
Loranthaceae	*Amyema conspicua*	Alphitonia Mistletoe	0	0	0	0	0	0	0	0	0	0	100	0	0
Malvaceae	*Abutilon guineense**	Chinese Lantern	0	33	0	0	0	0	0	0	0	0	0	0	25
Malvaceae	*Abutilon oxycarpum*	Lantern Bush	0	0	75	0	29	0	0	0	0	0	100	0	0
Malvaceae	*Abutilon oxycarpum* var. *incanum*	Lantern Bush	0	0	50	100	14	0	0	0	0	0	0	0	0
Malvaceae	*Gossypium australe*	Australian Cotton	0	0	0	0	0	0	0	0	0	0	0	0	0
Malvaceae	*Hibiscus brachysiphonius*	Low Hibiscus	0	0	25	0	0	0	0	0	0	0	0	0	0
Malvaceae	*Hibiscus meraukensis*	Merauke Hibiscus	0	0	0	0	0	11	0	0	20	0	0	60	0

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			11.3.2	11.3.25	11.4.8	11.4.9	11.5.3	11.5.9	11.9.2	11.10.1	11.10.3	11.10.7	11.10.8	11.10.13	Non-remnant
Malvaceae	*Hibiscus sturtii*	Hill Hibiscus	50	0	50	0	0	0	0	0	0	0	0	0	0
Malvaceae	*Malvastrum americanum**	Spiked Malvastrum	0	0	0	100	29	0	33	0	0	0	0	0	0
Malvaceae	*Malvastrum coromandelianum**	Prickly Malvastrum	0	33	0	0	0	0	0	0	0	0	0	0	0
Malvaceae	*Sida aprica*		0	0	0	0	0	0	0	0	20	0	0	0	0
Malvaceae	*Sida atherophora*		0	0	0	0	0	0	0	0	20	0	0	0	0
Malvaceae	*Sida cordifolia**	Flannel Weed	50	100	0	0	29	33	0	0	20	33	0	0	25
Malvaceae	*Sida corrugata*	Variable Sida	0	0	25	0	0	0	0	0	0	0	0	0	0
Malvaceae	*Sida hackettiana*	Golden Rod; Spiked Sida	100	33	25	0	100	78	67	0	20	100	100	60	75
Malvaceae	*Sida pleiantha*		0	0	0	0	0	0	33	0	0	0	0	0	25
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	0	100	0	0	0	0	0	0	0	0	0	0	0
Malvaceae	*Sida rohlenae*	Shrub Sida	0	0	25	0	0	0	0	0	0	0	0	0	0
Malvaceae	*Sida* sp.		0	0	0	0	0	0	0	33	0	0	0	0	0
Malvaceae	*Sida* sp. (Aramac E.J. Thompson+ JER192)		0	0	0	0	0	11	0	0	0	0	0	0	0
Malvaceae	*Sida* sp. (Musselbrook M.B.Thomas+ MRS437)		0	0	0	0	0	11	0	33	60	33	0	40	0
Malvaceae	*Sida spinosa**	Spiny Sida	100	33	0	0	100	22	33	33	20	100	0	40	100
Marsileaceae	*Marsilea sp.*	Nardoo	0	0	0	0	0	0	0	0	0	0	0	0	0
Meliaceae	*Owenia acidula*	Emu Apple	0	0	25	100	14	0	0	0	0	0	0	0	25
Menispermaceae	*Stephania japonica*	Snake Vine	0	33	0	0	0	0	0	0	0	0	0	0	0
Menispermaceae	*Tinospora smilacina*	Heart Vine	0	33	0	0	0	0	0	0	20	0	0	40	0
Menyanthaceae	*Nymphoides* sp.	Water Snowflake	0	0	0	0	0	0	0	0	0	0	0	0	0
Mimosaceae	*Vachellia bidwillii*	Corkwood Wattle	0	0	25	0	14	0	33	0	0	0	0	0	0

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			11.3.2	11.3.25	11.4.8	11.4.9	11.5.3	11.5.9	11.9.2	11.10.1	11.10.3	11.10.7	11.10.8	11.10.13	Non-remnant
Mimosaceae	*Acacia bancroftiorum*	Bancroft Wattle	0	0	0	0	0	0	0	0	0	0	0	60	0
Mimosaceae	*Acacia burdekensis*	Burdekin Wattle	0	0	0	0	14	33	0	33	0	33	100	40	0
Mimosaceae	*Acacia curvinervia*		0	0	0	0	0	0	0	0	0	0	0	20	0
Mimosaceae	*Acacia dietrichiana*	Dietrich Wattle	0	0	0	0	0	0	0	33	0	0	0	40	0
Mimosaceae	*Acacia excelsa*	Ironwood Wattle	0	0	0	0	14	11	33	0	0	0	0	0	0
Mimosaceae	*Acacia flavescens*	Red Wattle	0	0	0	0	0	0	0	33	0	33	0	20	0
Mimosaceae	*Acacia harpophylla*	Brigalow	0	0	75	0	0	0	0	0	0	0	0	0	0
Mimosaceae	*Acacia julifera* subsp. *julifera*		0	0	0	0	0	0	0	0	0	0	0	0	0
Mimosaceae	*Acacia macradenia*	Zig-Zag Wattle	0	33	0	0	0	0	0	33	0	0	0	0	0
Mimosaceae	*Acacia rhodoxylon*	Ringy Rosewood	0	0	0	0	0	0	0	0	0	0	0	20	0
Mimosaceae	*Acacia salicina*	Sally Wattle; Willow Wattle	50	33	0	0	14	0	33	0	0	0	0	0	25
Mimosaceae	*Acacia shirleyi*	Lancewood	0	0	0	0	0	0	0	0	80	0	100	60	0
Mimosaceae	*Albizia canescens*	Belmont Siris	0	33	0	0	0	0	0	0	0	0	0	0	0
Mimosaceae	*Archidendropsis basaltica*	Dead Finish	0	0	0	0	14	0	0	0	0	0	0	0	50
Mimosaceae	*Leucaena leucocephala**	Leucaena	0	0	0	0	0	0	0	0	0	0	0	0	0
Mimosaceae	*Neptunia gracilis*	Native Sensitive Plant	0	0	0	0	0	0	67	0	0	0	0	0	75
Molluginaceae	*Glinus lotoides*	Hairy Carpet-weed	0	0	0	0	0	0	0	0	0	0	0	0	0
Moraceae	*Ficus opposita*	Sandpaper Fig	0	100	0	0	0	0	0	0	0	0	0	0	0
Moraceae	*Ficus rubiginosa*	Rock Fig	0	0	0	0	0	0	0	0	0	0	100	0	0
Moraceae	*Trophis scandens*	Burny Vine	0	0	0	0	0	0	0	0	0	0	100	0	0
Myrsinaceae	*Myrsine variabilis*	Muttonwood	0	0	0	0	0	0	0	0	0	0	100	0	0
Myrtaceae	*Corymbia aureola*	Yellowjacket	0	0	0	0	0	0	0	0	0	0	0	80	0

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			11.3.2	11.3.25	11.4.8	11.4.9	11.5.3	11.5.9	11.9.2	11.10.1	11.10.3	11.10.7	11.10.8	11.10.13	Non-remnant
Myrtaceae	*Corymbia citriodora* subsp. *citriodora*	Lemon-scented Gum	0	0	0	0	0	0	0	67	0	0	0	0	0
Myrtaceae	*Corymbia clarksoniana*	Clarkson's Bloodwood	0	0	0	0	0	0	0	0	0	0	0	0	0
Myrtaceae	*Corymbia dallachiana*	Ghost Gum	0	0	0	0	0	11	0	0	0	33	0	0	0
Myrtaceae	*Corymbia erythrophloia*	Variable-barked Bloodwood	0	0	0	0	0	0	33	0	0	0	0	0	0
Myrtaceae	*Corymbia tessellaris*	Carbeen; Blackbutt	0	0	0	0	0	0	0	0	0	0	0	0	0
Myrtaceae	*Corymbia trachyphloia*	Brown Bloodwood	0	0	0	0	0	0	0	67	0	0	0	0	0
Myrtaceae	*Eucalyptus camaldulensis*	River Red Gum	0	67	0	0	0	0	0	0	0	0	0	0	0
Myrtaceae	*Eucalyptus crebra*	Narrow-Leaved Ironbark	0	0	0	0	0	11	0	33	20	67	0	0	0
Myrtaceae	*Eucalyptus melanophloia*	Silver-leaved Ironbark	50	0	0	0	0	22	0	33	0	33	0	20	0
Myrtaceae	*Eucalyptus orgadophila*	Mountain Coolibah	0	0	0	0	0	0	33	0	0	0	0	0	0
Myrtaceae	*Eucalyptus populnea*	Poplar Box	100	0	0	0	71	0	0	0	0	0	0	0	25
Myrtaceae	*Gossia bidwillii*	Python Tree	0	0	0	0	0	0	0	0	0	0	100	0	0
Myrtaceae	*Leptospermum lamellatum*	Weeping Tea-tree	0	0	0	0	0	0	0	33	0	0	0	0	0
Myrtaceae	*Lophostemon grandiflorus*	Northern Swamp Mahogany	0	33	0	0	0	0	0	0	0	0	0	0	0
Myrtaceae	*Lophostemon suaveolens*	Swamp Mahogany	0	0	0	0	0	0	0	0	0	0	100	0	0
Myrtaceae	*Lysicarpus angustifolius*	Budgeroo	0	0	0	0	0	0	0	33	0	0	0	20	0
Myrtaceae	*Melaleuca fluviatilis*	Weeping Paperbark	0	33	0	0	0	0	0	0	0	0	0	0	0
Myrtaceae	*Melaleuca leucadendra*	Paperbark	0	0	0	0	0	0	0	0	0	0	0	0	0
Myrtaceae	*Melaleuca nervosa*	Broad-leaved Paperbark	0	0	0	0	14	78	0	0	0	0	0	0	0
Nyctaginaceae	*Boerhavia pubescens*		50	0	75	100	71	11	33	0	0	0	0	0	25
Olacaceae	*Ximenia americana**	Tallow Wood; Yellow Plum	0	0	0	0	0	0	0	0	0	0	0	0	0
Oleaceae	*Jasminum didymum* subsp. *lineare*	Desert Jasmine	0	0	50	0	0	0	0	0	20	0	0	0	0

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			11.3.2	11.3.25	11.4.8	11.4.9	11.5.3	11.5.9	11.9.2	11.10.1	11.10.3	11.10.7	11.10.8	11.10.13	Non-remnant
Oleaceae	*Jasminum didymum* subsp. *racemosum*	Native Jasmine	0	0	0	0	0	0	0	0	0	0	100	0	0
Oleaceae	*Jasminum simplicifolium* subsp. *australiense*	Stiff Jasmine	0	0	0	0	0	0	0	0	0	0	100	0	0
Orchidaceae	*Cymbidium canaliculatum*	Black Orchid	50	0	25	0	0	0	0	0	0	0	0	0	0
Oxalidaceae	*Oxalis corniculata*	Creeping Woodsorrel	100	33	0	0	0	0	0	67	0	0	0	20	25
Passifloraceae	*Passiflora foetida**	Stinking Passionflower	0	33	0	0	0	0	0	0	0	0	0	0	0
Pentapetaceae	*Melhania oblongifolia*		100	0	50	0	29	33	67	33	0	0	0	0	0
Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush	0	0	0	0	29	0	0	67	0	33	0	20	0
Phyllanthaceae	*Phyllanthus carpentariae*		0	0	0	0	0	22	0	33	20	67	0	40	0
Phyllanthaceae	*Phyllanthus collinus*		0	0	25	0	100	56	0	33	20	100	0	0	0
Phyllanthaceae	*Phyllanthus fuernrohrii*	Sand Spurge	0	0	0	0	0	0	33	0	0	0	0	0	0
Phyllanthaceae	*Phyllanthus maderaspatensis*		0	0	0	0	0	0	67	0	0	0	0	0	25
Phyllanthaceae	*Phyllanthus* sp. (Myra Vale J.J.Bruhl+ 181)		0	0	0	0	43	44	0	0	0	33	0	0	25
Phyllanthaceae	*Phyllanthus virgatus*	Creeping Phyllanthus	100	33	75	0	14	11	0	67	0	0	0	20	50
Picrodendraceae	*Petalostigma pubescens*	Quinine Tree	0	0	0	0	0	44	0	33	0	100	0	20	25
Pittosporaceae	*Bursaria incana*	Prickly Pine	0	0	25	0	0	0	33	33	0	0	100	0	0
Plantaginaceae	*Scoparia dulcis**	Licorice Weed	0	67	0	0	14	11	0	0	0	33	100	0	0
Plumbaginaceae	*Plumbago zeylanica*	Wild Plumbago	0	0	0	100	0	0	0	0	0	0	0	0	0
Poaceae	*Alloteropsis cimicina*	Summer Grass	0	67	0	0	43	67	0	0	60	33	0	80	25
Poaceae	*Alloteropsis semialata*	Cockatoo Grass	0	0	0	0	0	0	33	0	0	0	0	0	0
Poaceae	*Ancistrachne uncinata*	Hooky Grass	0	0	50	0	0	0	0	0	0	0	100	0	0
Poaceae	*Aristida benthamii*	Bentham's Wiregrass	0	0	0	0	0	11	0	67	40	33	0	40	0

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			11.3.2	11.3.25	11.4.8	11.4.9	11.5.3	11.5.9	11.9.2	11.10.1	11.10.3	11.10.7	11.10.8	11.10.13	Non-remnant
Poaceae	*Aristida calycina var. calycina*	Dark Wiregrass	100	0	25	0	100	67	0	67	80	100	0	80	50
Poaceae	*Aristida gracilipes*		100	0	50	0	14	0	67	33	20	0	0	0	0
Poaceae	*Aristida holathera*	Tall Kerosene Grass	0	0	0	0	29	44	33	0	0	33	0	20	0
Poaceae	*Aristida inaequiglumis*	Unequal Wiregrass	0	0	0	0	0	11	0	0	0	0	0	0	0
Poaceae	*Aristida spuria*		0	0	0	0	0	0	0	33	0	0	0	0	0
Poaceae	*Arundinella nepalensis*	Reedgrass	0	0	0	0	0	0	0	0	0	0	0	0	0
Poaceae	*Bothriochloa decipiens var. cloncurrensis*	Pitted Bluegrass	0	0	0	0	0	11	0	0	0	0	0	0	0
Poaceae	*Bothriochloa ewartiana*	Desert Bluegrass	100	33	0	0	14	0	100	0	0	0	0	0	25
Poaceae	*Bothriochloa pertusa**	Indian Couch	100	100	75	0	71	44	100	0	0	33	0	0	100
Poaceae	*Capillipedium parviflorum*	Scented-top Grass	0	0	0	0	0	0	0	0	0	0	0	0	0
Poaceae	*Cenchrus ciliaris**	Buffel Grass	100	100	75	100	86	33	100	33	20	67	0	0	100
Poaceae	*Chloris barbata**	Purpletop Chloris	0	0	0	0	0	0	0	0	0	0	0	0	25
Poaceae	*Chloris divaricata*	Slender Chloris	0	0	100	0	29	11	0	0	0	0	0	0	0
Poaceae	*Chloris virgata**	Feathertop Rhodes Grass	0	67	0	0	14	0	0	0	0	0	0	0	0
Poaceae	*Chrysopogon fallax*	Golden Beard Grass	100	0	25	0	86	78	33	33	20	67	0	20	75
Poaceae	*Cleistochloa subjuncea*		0	0	0	0	0	0	0	67	80	0	100	80	0
Poaceae	*Cymbopogon obtectus*	Silkyheads	0	0	0	0	0	0	0	67	0	0	0	0	0
Poaceae	*Cymbopogon refractus*	Barbed Wire Grass	0	0	50	0	0	0	0	67	0	0	0	0	0
Poaceae	*Cynodon dactylon**	Bermuda Grass; Green Couch	0	67	0	0	14	0	0	0	0	0	0	0	0
Poaceae	*Dactyloctenium radulans*	Button Grass	0	33	0	100	14	56	0	0	0	0	0	0	75
Poaceae	*Dichanthium sericeum*	Queensland Bluegrass	0	0	0	0	0	0	0	33	0	0	0	0	0
Poaceae	*Digitaria ammophila*	Silky Umbrella Grass	0	33	0	0	0	0	0	0	0	0	0	0	0

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			11.3.2	11.3.25	11.4.8	11.4.9	11.5.3	11.5.9	11.9.2	11.10.1	11.10.3	11.10.7	11.10.8	11.10.13	Non-remnant
Poaceae	*Digitaria brownii*	Cotton Panic Grass	0	33	0	0	0	0	0	0	0	33	0	0	0
Poaceae	*Digitaria ciliaris*	Summer Grass	0	0	0	0	0	0	0	0	0	0	0	0	25
Poaceae	*Digitaria diminuta*		0	0	0	0	0	0	0	33	100	33	0	60	25
Poaceae	*Digitaria divaricatissima*	Umbrella Grass	0	0	0	0	14	33	0	0	0	33	0	0	0
Poaceae	*Digitaria eriantha**		0	100	0	0	14	11	33	0	0	33	0	0	50
Poaceae	*Digitaria longiflora*		0	0	0	0	14	22	0	0	0	0	0	20	0
Poaceae	*Digitaria minima*		0	0	0	0	14	0	0	0	0	0	0	0	0
Poaceae	*Digitaria ramularis*		0	0	0	0	0	0	0	0	0	33	0	0	0
Poaceae	*Digitaria* sp. A		0	0	0	0	0	22	0	0	0	33	0	0	0
Poaceae	*Dinebra decipiens* var. *decipiens*	Slender Cane Grass	0	0	0	0	0	0	0	0	0	33	100	0	0
Poaceae	*Dinebra ligulata*		0	0	0	0	0	0	0	0	0	0	0	0	0
Poaceae	*Echinochloa colona**	Awnless Barnyard Grass	0	67	0	100	0	0	0	0	0	0	0	0	0
Poaceae	*Eleusine indica**	Indian Crowfoot Grass	0	0	0	0	0	0	0	0	0	0	0	0	0
Poaceae	*Enneapogon lindleyanus*	Conetop Nineawn	0	0	25	0	43	0	0	33	0	0	0	0	0
Poaceae	*Enneapogon* sp. A		0	0	25	0	0	0	67	0	0	0	0	0	0
Poaceae	*Enteropogon ramosus*	Curly Windmill Grass	0	0	0	0	43	0	0	0	0	0	0	0	50
Poaceae	*Eragrostis elongata*	Clustered Lovegrass	0	33	0	0	0	0	0	0	0	0	0	0	0
Poaceae	*Eragrostis lacunaria*	Purple Lovegrass	0	0	75	0	57	44	0	0	60	0	0	60	25
Poaceae	*Eragrostis leptostachya*	Paddock Lovegrass	0	0	0	0	14	0	0	0	0	33	0	0	0
Poaceae	*Eragrostis parviflora*	Weeping Lovegrass	0	0	0	0	0	0	0	0	0	0	0	0	0
Poaceae	*Eragrostis pilosa**	Soft Lovegrass	0	0	0	100	0	0	0	0	0	0	0	0	0
Poaceae	*Eragrostis sororia*		50	0	0	0	57	78	0	0	20	67	0	60	25

Family	Scientific Name	Common Name	Percentage of secondary sites in each regional ecosystem containing the species												
			11.3.2	11.3.25	11.4.8	11.4.9	11.5.3	11.5.9	11.9.2	11.10.1	11.10.3	11.10.7	11.10.8	11.10.13	Non-remnant
Poaceae	*Eragrostis spartinoides*		0	0	0	0	14	11	0	67	0	33	0	20	0
Poaceae	*Eragrostis speciosa*	Hansome Lovegrass	0	0	0	0	29	11	0	0	0	0	0	0	0
Poaceae	*Eremochloa bimaculata*	Poverty Grass	0	0	0	0	0	11	0	0	0	0	0	0	0
Poaceae	*Eriachne mucronata*	Mountain Wanderrie Grass	0	0	0	0	14	11	0	0	0	33	0	0	0
Poaceae	*Eriachne obtusa*	Northern Wanderrie Grass	0	0	0	0	0	22	0	33	40	0	0	20	0
Poaceae	*Eriochloa crebra*	Cup Grass	0	0	0	100	29	11	0	0	0	67	0	20	0
Poaceae	*Eriochloa pseudoacrotricha*	Early Spring Grass	0	0	0	0	0	0	0	33	0	0	0	20	0
Poaceae	*Eulalia aurea*	Silky Browntop	0	0	0	0	0	11	0	0	0	0	0	0	25
Poaceae	*Heteropogon contortus*	Black Speargrass	50	33	0	0	14	11	33	0	0	0	0	0	25
Poaceae	*Hymenachne amplexicaulis*	Olive Hymenachne	0	0	0	0	0	0	0	0	0	0	0	0	0
Poaceae	*Hyparrhenia rufa*	Thatch Grass	0	0	0	0	0	0	0	0	0	0	0	0	0
Poaceae	*Megathyrsus maximus* var. *maximus*	Guinea Grass	0	0	0	0	0	0	0	0	0	0	0	0	0
Poaceae	*Megathyrsus maximus* var. *pubiglumis*	Green Panic	0	100	0	0	0	0	0	0	0	0	0	0	0
Poaceae	*Melinis repens*	Red Natal Grass	0	33	0	0	29	11	33	67	40	67	0	80	0
Poaceae	*Panicum effusum*	Hairy Panic	50	0	0	0	14	11	0	100	20	67	0	40	25
Poaceae	*Paspalidium caespitosum*	Brigalow Grass	0	0	50	0	0	0	0	0	20	0	0	0	0
Poaceae	*Paspalidium constricutum*	Knottybutt Grass	0	0	25	0	0	0	0	0	0	0	0	0	0
Poaceae	*Paspalidium distans*		0	0	50	0	0	0	0	0	0	0	0	0	0
Poaceae	*Paspalidium gracile*	Slender Panic	0	0	0	0	0	0	0	0	60	33	0	20	0
Poaceae	*Paspalidium rarum*	Rare Paspalidium	0	0	0	0	0	33	0	0	0	0	0	0	0
Poaceae	*Perotis rara*	Comet Grass	0	33	0	0	29	56	0	0	20	33	0	0	25

Family	Scientific Name	Common Name	Percentage of secondary sites in each regional ecosystem containing the species												
			11.3.2	11.3.25	11.4.8	11.4.9	11.5.3	11.5.9	11.9.2	11.10.1	11.10.3	11.10.7	11.10.8	11.10.13	Non-remnant
Poaceae	*Schizachyrium fragile*	Firegrass	0	0	0	0	0	0	0	0	0	0	0	0	0
Poaceae	*Setaria surgens*		0	33	0	0	29	44	0	33	0	33	100	20	0
Poaceae	*Sorghum leiocladum*	Wild Sorghum	0	0	0	0	0	0	0	33	0	0	0	0	0
Poaceae	*Sporobolus caroli*	Fairy Grass	0	0	25	100	29	0	0	0	0	0	0	0	25
Poaceae	*Sporobolus scabridus*		0	0	25	100	0	0	0	0	0	0	0	0	0
Poaceae	*Thellungia advena*	Coolibah Grass	0	0	0	0	0	0	33	0	0	0	0	0	0
Poaceae	*Themeda avenacea*	Native Oatgrass	0	0	25	0	0	0	0	0	0	0	0	0	0
Poaceae	*Themeda triandra*	Kangaroo Grass	0	0	0	0	0	0	67	67	0	33	0	20	0
Poaceae	*Thyridolepis xerophila*		0	0	0	0	0	0	0	0	40	0	0	20	0
Poaceae	*Tragus australianus*	Small Burrgrass	0	0	0	0	0	0	0	0	0	0	0	0	25
Poaceae	*Tripogon loliiformis*	Five-minute Grass	0	0	0	0	0	0	0	0	0	0	0	0	0
Poaceae	*Urochloa foliosa*	Leafy Panic	0	33	0	100	0	0	33	0	0	0	0	0	0
Poaceae	*Urochloa mosambicensis**	Sabi Grass	50	100	25	0	71	33	33	0	40	67	0	0	100
Poaceae	*Urochloa piligera*	Hairy Armgrass	0	0	25	0	14	78	0	0	20	0	0	60	25
Polygalaceae	*Polygala triflora*		0	0	0	0	14	0	0	0	0	0	0	0	0
Polygonaceae	*Persicaria attenuata*	White Smartweed	0	0	0	0	0	0	0	0	0	0	0	0	0
Pontederiaceae	*Monochoria cyanea*	Native Water Hyacinth	0	0	0	0	0	0	0	0	0	0	0	0	0
Proteaceae	*Grevillea decora*		0	0	0	0	0	0	0	0	0	0	0	0	0
Proteaceae	*Grevillea parallela*	Silver Oak; Beefwood	0	0	0	0	0	0	0	0	0	0	0	0	0
Proteaceae	*Grevillea pteridifolia*	Golden Parrot Tree; Fern-leaved Grevillea	0	0	0	0	0	0	0	0	0	0	0	0	0
Proteaceae	*Grevillea sessilis*		0	0	0	0	0	0	0	0	0	0	0	0	0
Proteaceae	*Grevillea striata*	Beefwood	0	0	0	0	0	11	0	0	0	0	0	0	0

Family	Scientific Name	Common Name	Percentage of secondary sites in each regional ecosystem containing the species												
			11.3.2	11.3.25	11.4.8	11.4.9	11.5.3	11.5.9	11.9.2	11.10.1	11.10.3	11.10.7	11.10.8	11.10.13	Non-remnant
Proteaceae	*Hakea lorea*	Corkwood; Bootlace Oak	0	0	0	0	0	0	0	33	0	0	0	0	0
Proteaceae	*Persoonia amaliae*		0	0	0	0	0	0	0	33	0	0	0	0	0
Proteaceae	*Persoonia falcata*	Wild Pear; Geebung	0	0	0	0	0	0	0	100	20	0	0	0	0
Pteridaceae	*Cheilanthes sieberi*	Poison Rock Fern	50	33	75	100	43	33	0	100	100	67	0	80	25
Pteridaceae	*Cheilanthes nudiuscula*		0	0	0	0	0	0	0	0	0	0	100	0	0
Putranjivaceae	*Drypetes deplanchei*	Yellow Tulip; Grey Boxwood	0	0	0	0	0	0	0	0	0	0	100	0	0
Rhamnaceae	*Alphitonia excelsa*	Red Ash; Soap Tree	50	0	0	0	71	67	0	67	100	100	100	100	25
Rhamnaceae	*Ventilago viminalis*	Vine Tree	0	0	25	100	29	11	33	0	0	0	0	20	0
Rubiaceae	*Coelospermum reticulatum*	Medicine Bush	0	0	0	0	0	0	0	67	0	0	0	0	0
Rubiaceae	*Cyclophyllum coprosmoides*	Coast Canthium; Sweet Susie	0	0	0	0	0	0	0	33	0	0	0	0	0
Rubiaceae	*Larsenaikia ochreata*	Native Gardenia	0	0	0	0	0	0	0	100	20	33	100	80	0
Rubiaceae	*Oldenlandia mitrasacmoides* subsp. *trachymenoides*		0	0	0	0	0	11	0	0	0	0	0	0	0
Rubiaceae	*Pavetta granitica*		0	0	0	0	0	0	0	0	0	33	100	0	0
Rubiaceae	*Pomax umbellata*	Pomax	0	0	0	0	0	0	0	33	0	0	0	0	0
Rubiaceae	*Psydrax odorata* subsp. *buxifolia*	Shiny-leaved Canthium	0	0	0	0	0	0	0	0	0	0	100	0	0
Rubiaceae	*Psydrax oleifolia*	Wild Lemon; Myrtle	0	0	0	0	0	11	33	0	0	0	0	0	25
Rubiaceae	*Richardia brasiliensis**	White Eye; Mexican Clover	0	33	0	0	0	33	0	0	0	0	100	0	0
Rubiaceae	*Spermacoce brachystema*	Stiff-leafed Spermacoce	0	0	0	0	14	44	0	0	20	0	0	40	0
Rutaceae	*Acronychia laevis*	Hard Aspen	0	0	0	0	0	0	0	0	0	0	100	0	0
Rutaceae	*Flindersia australis*	Crow's Ash	0	0	0	0	0	0	0	0	0	0	0	0	0
Rutaceae	*Flindersia dissosperma*	Scrub Leopardwood	0	0	25	0	0	11	0	0	0	0	0	0	0
Rutaceae	*Geijera parviflora*	Wilga	0	0	25	100	0	0	0	0	0	0	0	0	0

Family	Scientific Name	Common Name	Percentage of secondary sites in each regional ecosystem containing the species												
			11.3.2	11.3.25	11.4.8	11.4.9	11.5.3	11.5.9	11.9.2	11.10.1	11.10.3	11.10.7	11.10.8	11.10.13	Non-remnant
Rutaceae	*Geijera salicifolia*	Scrub Wilga; Green Satinheart	0	0	0	0	0	0	0	0	0	0	100	0	0
Santalaceae	*Exocarpos latifolius*	Broad-leaved Ballart; Scrub Cherry	0	0	0	0	0	0	0	0	0	0	100	0	0
Santalaceae	*Santalum lanceolatum*	Northern Sandalwood	0	0	0	0	0	0	0	0	0	0	0	0	0
Sapindaceae	*Alectryon connatus*	Grey Bird's-eye	0	0	0	0	0	0	0	0	0	0	100	0	0
Sapindaceae	*Alectryon diversifolius*	Scrub Boonaree	0	0	25	100	0	0	0	0	0	0	0	0	0
Sapindaceae	*Atalaya hemiglauca*	Whitewood	50	0	25	0	14	0	100	0	0	0	0	0	25
Sapindaceae	*Dodonaea lanceolata*	Hop Bush	0	0	0	0	0	0	0	33	0	0	0	0	0
Sapindaceae	*Dodonaea stenophylla*		0	0	0	0	0	0	0	0	0	0	0	0	0
Sapotaceae	*Planchonella pohlmanniana*	Yellow Boxwood	0	0	0	0	0	0	0	0	0	33	0	0	0
Sapotaceae	*Planchonella pubescens*		0	0	0	0	0	0	0	0	0	0	100	0	0
Scrophulariaceae	*Eremophila debilis*	Winter Apple	0	0	0	0	29	0	0	0	0	0	0	0	0
Scrophulariaceae	*Eremophila mitchellii*	False Sandalwood	50	0	75	0	14	0	0	0	0	0	0	0	0
Scrophulariaceae	*Myoporum montanum*	Western Boobialla	0	0	0	0	0	0	0	0	0	0	0	0	0
Solanaceae	*Datura leichhardtii**	Thornapple	0	33	0	0	0	0	33	0	0	0	0	0	0
Solanaceae	*Pimelea sericostachya*		0	33	0	0	0	0	0	0	0	0	0	0	0
Solanaceae	*Solanum ellipticum*	Potato Bush	0	33	25	0	14	0	0	67	0	0	100	20	0
Solanaceae	*Solanum esuriale*	Quena	0	0	25	0	0	0	0	0	0	0	0	0	0
Solanaceae	*Solanum parvifolium*		0	0	25	0	0	0	0	0	40	0	0	0	0
Sparrmanniaceae	*Corchorus trilocularis*	Wild Jute	0	0	0	0	0	0	0	0	0	0	0	0	0
Sparrmanniaceae	*Grewia latifolia*	Dysentery Plant; Dog's Balls	0	0	50	0	29	11	33	33	0	0	0	0	0
Sparrmanniaceae	*Grewia retusifolia*	Dysentery Bush; Emu Berry	100	33	25	0	57	11	0	0	0	33	0	0	50
Stylidiaceae	*Stylidium eglandulosum*	Woolly-stemmed Triggerplant	0	0	0	0	0	0	0	0	0	0	0	0	0

Family	Scientific Name	Common Name	Percentage of secondary sites in each regional ecosystem containing the species												
			11.3.2	11.3.25	11.4.8	11.4.9	11.5.3	11.5.9	11.9.2	11.10.1	11.10.3	11.10.7	11.10.8	11.10.13	Non-remnant
Typhaceae	*Typha* sp.	Bulrush	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulmaceae	*Trema tomentosa*	Poison Peach	0	0	0	0	0	0	0	0	0	0	100	20	0
Verbenaceae	*Stachytarpheta jamaicensis**	Snake weed	0	33	0	0	0	0	0	0	0	0	0	0	0
Violaceae	*Afrohybanthus enneaspermus*	Purple Spade Flower	100	33	0	0	57	11	67	0	0	33	0	0	0
Violaceae	*Afrohybanthus stellarioides*	Orange Spade Flower	0	33	0	0	29	56	0	100	40	100	0	80	0
Vitaceae	*Cissus oblonga*	Smooth Water Vine	0	0	0	0	0	0	0	0	0	0	100	0	0
Vitaceae	*Clematicissus opaca*	Pepper Vine	0	33	0	0	0	0	0	0	0	0	0	0	0
Vitaceae	*Tetrastigma nitens*	Native Grape; Three-leaf Water Vine	0	0	0	0	0	0	0	0	0	0	100	0	0
Xanthorrhoeaceae	*Xanthorrhoea johnsonii*	Johnson's Grass Tree	0	0	0	0	0	0	0	33	0	0	0	20	0
Zygophyllaceae	*Tribulopis angustifolia*		0	0	0	0	14	33	0	0	0	0	0	20	0
Zygophyllaceae	*Tribulus terrestris**	Goat's Head; Bullhead; Small Caltrop	0	0	0	100	14	0	33	0	0	0	0	0	0

Appendix D2 Fauna recorded during field surveys

Common Name	Scientific Name	Abundance per Broad Vegetation Group*										
		7a	10a	12a	16a/9e	17a	17b	18b	24a	25a	34d	NR†
MAMMALS												
Short-beaked Echidna	*Tachyglossus aculeatus*	++		+	+				++	+		+
Eastern Grey Kangaroo	*Macropus giganteus*				++		+	++	+		+	++
Common Wallaroo	*Macropus robustus*		++	++					+++			
Unadorned/Herbert's Rock-wallaby	*Petrogale inornata/herberti*	+++										

Common Name	Scientific Name	Abundance per Broad Vegetation Group*										
		7a	10a	12a	16a/9e	17a	17b	18b	24a	25a	34d	NR†
Swamp Wallaby	*Wallabia bicolor*		++	+	+				+++	+		
Rufous Bettong	*Aepyprymnus rufescens*			+		+		++				++
Narrow-nosed Planigale	*Planigale tenuirostris*						+			++		+
Common Planigale	*Planigale maculata*							+				+
Koala	*Phascolarctos cinereus*		+	+	+++	+			+			
Common Brush-tailed Possum	*Trichosurus vulpecula*	+		++	+++	+++	+	++				
Sugar Glider	*Petaurus breviceps*						+			+		
Squirrel Glider	*Petaurus norfolcensis*				++			+				
Greater Glider	*Petauroides volans*	+	++		+++	++					++	
House Mouse	*Mus musculus*		+	+				+	++			
Delicate Mouse	*Pseudomys delicatulus*		+					++				+
Eastern Pebble Mouse	*Pseudomys patrius*			++				++				
Lakeland Downs Mouse	*Leggadina lakedownensis*		++	++				+				
Water Rat	*Hydromys chrysogaster*											+
European Rabbit	*Oryctolagus cuniculus*		+		++	++	+++	+	+	++		+
Little Red Flying-fox	*Pteropus scapulatus*				++							++
Feral Pig	*Sus scrofa*				+							+
Feral Cat	*Felis catus*			+	+		+	+	+	+		++
Dingo	*Canis lupus dingo*			++	++			++				
Red Fox	*Vulpes vulpes*							+				
Bats												
Gould's Wattle Bat	*Chalinolobus gouldii*		+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Chocolate Wattle Bat	*Chalinolobus morio*		++	++		+	+	++	+++			+++

Common Name	Scientific Name	Abundance per Broad Vegetation Group*									
		7a	10a	12a	16a/9e	17a	17b	18b	24a	25a	34d	NR†
Hoary Wattle Bat	*Chalinolobus nigrogriseus*				++	+				+		
Little Pied Bat	*Chalinolobus picatus*		+++	++	+	-	+	+++	+++	-	+++	+++
Long-eared Bat	*Nyctophilus* sp.			+++	+	++	+	+	+	++		+
Western Broad-nosed Bat	*Scotorepens balstoni*		-	+	++	+++	-	+++	+++	+++	-	+++
Little Broad-nosed bat	*Scotorepens greyii*		+++	+++	+++	+++	+	+++	+++	+++	+++	+++
Inland Forest Bat	*Vespadelus baverstocki*		+	+++	-	-	-	+	++	-		+++
Eastern Cave Bat	*Vespadelus troughtoni*		+	+++		+++	+	+++	+++			+
Eastern Bentwing Bat	*Miniopterus orianae oceanensis*		+++	++	++	+	+	+++	+++		-	
White-striped Freetail-bat	*Austronomus australis*			+								
Greater Northern Freetail-bat	*Chaerephon jobensis*		+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Northern Freetail Bat	*Ozimops lumsdenae*		+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Eastern Freetail Bat	*Ozimops ridei*		++	+++	+++	+++	+++	+++	+++	+++	-	+++
Bristle-faced Freetail Bat	*Setriostris eleryi*		-	-					-			++
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*		-	+++	+++	+++	+	+++	+++	+++	+++	+++
Troughton's Sheathtail-bat	*Taphozous troughtoni*		-	-	-		-	-	-	-		-
BIRDS												
Emu	*Dromaius novaehollandiae*			+					+		+	
Magpie Goose	*Anseranas semipalmata*											++
Plumed Whistling-duck	*Dendrocygna eytoni*				+							++
Australian Wood Duck	*Chenonetta jubata*											++
Pacific Black Duck	*Anas superciliosa*										++	++
Grey Teal	*Anas gracilis*										++	

Common Name	Scientific Name	Abundance per Broad Vegetation Group*										
		7a	10a	12a	16a/9e	17a	17b	18b	24a	25a	34d	NR†
Hardhead	*Aythya australis*											+
Brown Quail	*Synoicus ypsilophorus*			++							+	++
Stubble Quail	*Coturnix pectoralis*											+
Australasian Grebe	*Tachybaptus novaehollandiae*											+
Common Bronzewing	*Phaps chalcoptera*					++			+			
Crested Pigeon	*Ocyphaps lophotes*			+		++	+++	++				++
Squatter Pigeon	*Geophaps scripta*			++		++		+				++
Bar-shouldered Dove	*Geopelia humeralis*				+			++	+			
Diamond Dove	*Geopelia cuneata*			+				+				
Peaceful Dove	*Geopelia placida*			+++	+++	++		+++	+++	++		+++
Australian Bustard	*Ardeotis australis*							++				+
Pheasant Coucal	*Centropus phasianinus*		+	++	++	++	+	++		++		
Channel-billed Cuckoo	*Scythrops novaehollandiae*			+	++		++	++	+	+		+
Horsfield's Bronze-cuckoo	*Chrysococcyx basalis*					+						
Shining Bronze-cuckoo	*Chrysococcyx lucidus*		++						++			
Little Bronze-cuckoo	*Chrysococcyx minutillus*				+							+
Pallid Cuckoo	*Cacomantis pallidus*					+			+			++
Fan-tailed Cuckoo	*Cacomantis flabelliformis*								+			
Pacific Koel	*Eudynamys orientalis*				++	++	+					
Tawny Frogmouth	*Podargus strigoides*	+		+	++			++	+			
Australian Owlet-nightjar	*Aegotheles cristatus*		++	+				+				
White-throated Nightjar	*Eurostopodus mystacalis*	+		+						++		+
Eurasian coot	*Fulica atra*											+

Common Name	Scientific Name	Abundance per Broad Vegetation Group*										
		7a	10a	12a	16a/9e	17a	17b	18b	24a	25a	34d	NR†
Brolga	*Antigone rubicunda*											++
Bush Stone-curlew	*Burhinus grallarius*				+				+			
Pied Stilt	*Himantopus himantopus*									+		+
Masked Lapwing	*Vanellus miles*					++						++
Black-fronted Dotterel	*Elseyornis melanops*											++
Painted Buttonquail	*Turnix varius*		++	++				++				++
Little Black Cormorant	*Phalacrocorax sulcirostris*											++
Australasian Darter	*Anhinga novaehollandiae*											+
Australian Pelican	*Pelecanus conspicillatus*											+
Eastern Great Egret	*Ardea alba modesta*				+							+
Intermediate Egret	*Ardea intermedia*											+
White-necked Heron	*Ardea pacifica*											+
Cattle Egret	*Bubulcus ibis*											+
White-faced heron	*Egretta novaehollandiae*											++
Nankeen Night-heron	*Nycticorax caledonicus*											++
Straw-necked Ibis	*Threskiornis spinicollis*											++
Royal Spoonbill	*Platalea regia*											+
Black-shouldered Kite	*Elanus axillaris*									+		
Wedge-tailed Eagle	*Aquila audax*		++	++	+							++
Pacific Baza	*Aviceda subcristata*		+							+		
Brown Goshawk	*Accipiter fasciatus*			+				+				
Black Kite	*Milvus migrans*							++		+		++
Whistling Kite	*Haliastur sphenurus*			+++	+++	+++	+	+++	++	++	+	+++

Common Name	Scientific Name	Abundance per Broad Vegetation Group*										
		7a	10a	12a	16a/9e	17a	17b	18b	24a	25a	34d	NR†
Southern Boobook	*Ninox novaeseelandiae*	+	+	++	++	+++	+	++	+	++		++
Laughing Kookaburra	*Dacelo novaeguineae*		++	+++	+++	+++	+++	+++	+++	+++		+++
Blue-winged Kookaburra	*Dacelo leachii*				++	+	+	++		+++		
Red-backed Kingfisher	*Todiramphus pryrrhopygius*											+
Forest Kingfisher	*Todiramphus macleayii*				+	++			+	+++		
Sacred Kingfisher	*Todiramphus sanctus*		+							+++		
Rainbow Bee-eater	*Merops ornatus*		+	+++	++	++		++	+++	++		++
Dollarbird	*Eurystomus orientalis*				+++	+++				+++		
Nankeen Kestrel	*Falco cenchroides*				+	++						++
Peregrine Falcon	*Falco peregrinus*			+			+					
Brown Falcon	*Falco berigora*		+									
Sulphur-crested Cockatoo	*Cacatua galerita*	+++	+++	+++	+++	+++	++	+++	+++	+++	++	++
Galah	*Eolophus roseicapilla*			++	++	++	+	++				++
Cockatiel	*Nymphicus hollandicus*						++					+
Red-winged Parrot	*Aprosmictus erythropterus*		++	+++	+++	+++	+++	+++	++	+++		+++
Pale-headed Rosella	*Platycercus adscitus*		++	+++	+++	+++	+++	+++	+++	++	++	++
Budgerigar	*Melopsittacus undulatus*		++	++				+				++
Little Lorikeet	*Glossopsitta pusilla*					+						
Rainbow Lorikeet	*Trichoglossus haematodus*	++	+++	+++	+++	+++	++	+++	+++	+++		++
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*			++								
Spotted Bowerbird	*Chlamydera maculata*			+	++	+++	++	+	+			
Red-backed Fairywren	*Malurus melanocephalus*		++	++	++	+++	+++	++	++	+++	+	+++
Purple-backed Fairywren	*Malurus assimilis*				+			++		++		

Common Name	Scientific Name	Abundance per Broad Vegetation Group*										
		7a	10a	12a	16a/9e	17a	17b	18b	24a	25a	34d	NR†
Noisy Miner	*Manorina melanocephala*		+++	++	+++	+++	++	++	++	+++	++	++
Yellow-throated Miner	*Manorina flavigula*			++		++	+++	++	++			++
Singing Honeyeater	*Gavicalis virescens*			+			+			+		
Scarlet Honeyeater	*Myzomela sanguinolenta*									+		
Brown Honeyeater	*Lichmera indistincta*	+		++	++			+++	+			++
Blue-faced Honeyeater	*Entomyzon cyanotis*		++	+++	+++	+++		+++	++		++	++
White-throated Honeyeater	*Melithreptus albogularis*	+	+++	+++	+++	++	+	+++	++	+	+	
Striped Honeyeater	*Plectorhyncha lanceolata*			++	+			++	+++			
Little Friarbird	*Philemon citreogularis*		+++	+++	+++	++	+++	++	+++	+++	+	++
Noisy Friarbird	*Philemon corniculatus*		+++	+++	+++	+++	++	+++	+++	+++	+	+++
Striated Pardalote	*Pardalotus striatus*		+++	+++	+++	+++	+++	+++	+++	+++	++	+++
Yellow Thornbill	*Acanthiza nana*		++						+++			
Buff-rumped Thornbill	*Acanthiza reguloides*		+++					++	+++	++		
Speckled Warbler	*Pyrrholaemus sagittatus*			+				+				
Weebill	*Smicrornis brevirostris*		+++	+++	+++	+++	+	+++	+++	+++	++	++
White-throated Gerygone	*Gerygone olivacea*	+		+++	++	++		+++	+++	+++		+
Grey-crowned Babbler	*Pomatostomus temporalis*		+++	+++	++	++		+++	+++	+++		
Golden-headed Cisticola	*Cisticola exilis*											+
Silvereye	*Zosterops lateralis*	++								++		
Masked Woodswallow	*Artamus personatus*											++
White-browed Woodswallow	*Artamus superciliosus*				++				++			++
Black-faced Woodswallow	*Artamus cinereus*							+				
White-breasted Woodswallow	*Artamus leucorynchus*				++							

Common Name	Scientific Name	Abundance per Broad Vegetation Group*									
		7a	10a	12a	16a/9e	17a	17b	18b	24a	25a	34d	NR†
Grey Butcherbird	*Cracticus torquatus*		+++	++	+++	++		++	+++	+	+	
Pied Butcherbird	*Cracticus nigrogularis*		++	+++	+++	+++	+++	+++	+++	+++	+	+++
Australian Magpie	*Gymnorhina tibicen*		+++	+++	+++	+++	+++	+++	+++	+++		+++
Pied Currawong	*Strepera graculina*	+++	+++	+++	++	++		+++	+++	+		+
Black-faced Cuckooshrike	*Coracina novaehollandiae*		+++	+++	++	++	+++	+++	+++	+++		+++
White-bellied Cuckooshrike	*Coracina papuensis*			++	+	+	++					
White-winged Triller	*Lalage tricolor*					+		++				
Common Cicadabird	*Edolisoma tenuirostre*								+			
Varied Sitella	*Daphoenositta chrysoptera*		+++		++				++			
Grey Shrikethrush	*Colluricincla harmonica*		+++		++			++	+++			+
Golden Whistler	*Pachycephala pectoralis*	+										
Rufous Whistler	*Pachycephala rufiventris*		++	+++	++	+++	+	+++	+++	+++	+	++
Olive-backed Oriole	*Oriolus sagittatus*		+++	++	++	+	+	+++	++			
Australasian Figbird	*Sphecotheres vieilloti*			++	++	++						
Spangled Drongo	*Dicrurus bracteatus*				+					++		
Grey Fantail	*Rhipidura albiscapa*	+	++	++	++			+++	+++			++
Rufous Fantail	*Rhipidura rufifrons*	+						+				
Willie Wagtail	*Rhipidura leucophrys*		+	+	++	+	+	++	+	++	+	++
Magpie-lark	*Grallina cyanoleuca*			+		+++		++				+++
Leaden Flycatcher	*Myiagra rubecula*	+	+++	+	++		++	++	++	++		
Australian Raven	*Corvus coronoides*			++	+	+						
Torresian Crow	*Corvus orru*		+++	+++	+++	+++	+++	+++	+++	+++		+++
White-winged Chough	*Corcorax melanorhamphos*			++	++	+			+			

Common Name	Scientific Name	Abundance per Broad Vegetation Group*										
		7a	10a	12a	16a/9e	17a	17b	18b	24a	25a	34d	NR†
Apostlebird	*Struthidea cinerea*	+	++	+++	++	+++		++	++		++	++
Jacky Winter	*Microeca fascinans*			+								
Eastern Yellow Robin	*Eopsaltria australis*								+			
Australasian Reed Warbler	*Acrocephalus australis*											+
Brown Songlark	*Megalurus cruralis*											+
Rufous Songlark	*Megalurus mathewsi*						+++		+	+		++
Common Myna	*Acridotheres tristis*											++
Mistletoebird	*Dicaeum hirundinaceum*	+	+	+	+			+	+++		+	
Australasian Pipit	*Anthus novaeseelandiae*											++
Chestnut-breasted Mannikin	*Lonchura castaneothorax*			++								++
Plum-headed Finch	*Neochmia modesta*			++								
Double-barred Finch	*Taeniopygia bichenovii*	+	++	+++	+			+++	++		+	
REPTILES												
Robust Blind Snake	*Anilios ligatus*				+							
Small-headed Blind Snake	*Anilios affinis*					+		+	+			
Spotted Python	*Antaresia maculosa*			+								
Black-headed Python	*Aspidites melanocephalus*									+		
Brown Tree Snake	*Boiga irregularis*				+							
Green Tree Snake	*Dendrelaphis punctulatus*											+
Eastern Brown Snake	*Pseudonaja textilis*											+
Coral Snake	*Brachyurophis australis*			+								
Yellow-faced Whipsnake	*Demansia psammophis*						+			+		
Curl Snake	*Suta suta*			+								

Common Name	Scientific Name	Abundance per Broad Vegetation Group*									
		7a	10a	12a	16a/9e	17a	17b	18b	24a	25a	34d	NR†
Burton's Legless Lizard	*Lialis burtonis*		+		+				+			
Eastern Striped Skink	*Ctenotus robustus*		+++	++		+	+	+	++			++
Eastern Barred Wedgesnout Ctenotus	*Ctenotus strauchii*							++		++		
Eastern mulch-Slider	*Lerista fragilis*		+++	++		+		+	+++	+		+
Common Dwarf Skink	*Menetia greyii*			++								
Dwarf Litter-Skink	*Pygmaeascincus timlowi*			+	++	++						++
Iridescent Litter-Skink	*Lygisaurus foliorum*		+++		++				+++			
Shaded-litter Rainbow-Skink	*Carlia munda*			++	++	++		++		+		++
Open-litter Rainbow-Skink	*Carlia pectoralis*	+++		++	+++	+++		++	+++			
Robust Rainbow-Skink	*Carlia schmeltzii*			+	+		+		+			
Tussock Rainbow-Skink	*Carlia vivax*				++					++		
Elegant Snake-eyed Skink	*Cryptoblepharus pulcher*		++	++	++	+	+	++				
Fire-tailed Skink	*Morethia taeniopleura*		+++	+++	++	++	+	+	+++			+
Bearded Dragon	*Pogona barbata*			+				+				
Tommy Roundhead	*Diporiphora australis*		++	+++				++	++			
Black-headed Monitor	*Varanus tristis*					+		++				+
Dubious Dtella	*Gehyra dubia*	+		+++	++		+++	++	+++	++		+
Chain-backed Dtella	*Gehyra catenata*				++		+		++	+++		
Bynoe's Gecko	*Heteronotia binoei*	+++	+++	+++	+++	+++	++	+++	+++	+++		+++
Spiny Knob-tail Gecko	*Nephrurus asper*								+			
Box-patterned Gecko	*Lucasium steindachneri*		++	+++		++	++	+++		++		
Variable fat-tailed Gecko	*Diplodactylus conspicillatus*			++		+++			+			
Wood Gecko	*Diplodactylus vittatus*		+						+++			

Common Name	Scientific Name	Abundance per Broad Vegetation Group*										
		7a	10a	12a	16a/9e	17a	17b	18b	24a	25a	34d	NR†
Ocellated Velvet Gecko	*Oedura monilis*			++				+	+	+++		
Eastern Spiny-tailed Gecko	*Strophurus williamsi*			++			+			+		+
AMPHIBIANS												
Cane Toad	*Rhinella marina*	+		+++	+++	+++	++	+++	+++	++	+++	+++
Spotted Grass Frog	*Limnodynastes tasmaniensis*			+		++	++	+		+		++
Scarlet sided Pobblebonk	*Limnodynastes terraereginae*				++	++					++	
Green Tree-Frog	*Litoria caerulea*			+					++	+	++	
Desert Tree-Frog	*Litoria rubella*							+		++	+++	++
Roth's Tree Frog	*Litoria rothii*										++	
Bumpy Rocket Frog	*Litoria inerma*					++					++	+++
Broad-palmed Frog	*Litoria latopalmata*											+
Ornate Burrowing Frog	*Platyplectrum ornatum*		+	++	+++	+++	++	+++	++	+++	+++	+++
Short-footed Frog	*Cyclorana brevipes*					++	+	++	+	+		
New Holland Frog	*Cyclorana novaehollandiae*					++					+++	++
Green-stripe Frog	*Cyclorana albogutata*										+	++
Wrinkled Toadlet	*Uperoleia rugosa*							+				+
Major Toadlet	*Pseudophryne major*										++	

*Abundance: + = only one individual recorded; ++ = more than one individual but present in fewer than half the sites surveyed; +++ = present in the majority of sites surveyed.
†NR = non-remnant pasture.

APPENDIX D

ANABAT RESULTS

Microbat Call Interpretation Report

Prepared for ("Client"):	METSERVE
Survey location/project name:	Saraji West
Survey dates:	25 October – 3 November 2018
Client project reference:	
Job no.:	MET-1802
Report date:	14 December 2018

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Methods

Data received & post-processing

Balance! Environmental received 14 ZCA data files and associated log files, recorded using two Anabat Express detectors (Titley Scientific, Brisbane) over seven consecutive nights (25th October – 2nd November 2018).

The ZCA files were processed with *AnalookW* (Corben 2018) to extract individual Anabat ZC call-sequence files for analysis. This process yielded some 33,000 ZC files; however, when a generic noise filter was applied in *AnalookW*, fewer than 3000 ZC files were found to contain identifiable bat-calls. Most of the noise files were generated from Anabat B (Meserve).

Call analysis and identification

All ZC files that passed the noise filter were analysed in *AnalookW*, with species identification achieved manually by comparing call spectrograms and derived metrics with those of reference calls from central and northern Queensland and/or with published call descriptions (e.g. Reinhold et al. 2001). Consideration was also given to the probability of species' occurrence based on published distribution information (e.g. Churchill 2008; van Dyck *et al.* 2013) and on-line database records (e.g. http://www.ala.org.au).

Reporting standard

The format and content of this report follows Australasian Bat Society standards for the interpretation and reporting of bat call data (Reardon 2003), available on-line at http://www.ausbats.org.au/.

Species nomenclature follows Jackson & Groves (2015), which elevates the sub-genus names proposed by Reardon *et al.* (2014) for the *Mormopterus* free-tailed bats to genus level; hence *Ozimops lumsdenae* (syn. *M.* beccarii) and *O. ridei* (syn. *M. ridei* and *M.* 'species 2') are used herein.

Results & Discussion

A total of 2469 individual bat calls were identified in this data set, with 82% (2031) of those recorded by Anabat B (Metserve) and the remainder (438 calls) recorded by Anabat ECO1019.

Reliable identification was achieved on 2191 calls (89% of total), which were attributed to seven unique species and two species pairs, the members of which cannot be differentiated based on call characteristics. The positively-identified species included the following:

- *Chalinolobus gouldii;*
- *Nyctophilus geoffroyi / N. gouldi;*
- *Scotorepens balstoni;*
- *Scotorepens greyii / S. sanborni;*
- *Vespadelus troughtoni;*
- *Chaerephon jobensis;*
- *Ozimops lumsdenae;*
- *Ozimops ridei;* and
- *Saccolaimus flaviventris.*

Eighteen percent (278) of the calls could not be reliably identified due to similarities in call characteristics shared by several species that are likely to occur in the study area. These unresolved calls were allocated to one of the following species groups:

- *Chalinolobus gouldii / Ozimops ridei;*
- *C. gouldii / Scotorepens balstoni;*
- *Scotorepens greyii / Chalinolobus nigrogriseus;*
- *Saccolaimus flaviventris / Chaerephon jobensis;* and
- *S. flaviventris / Ozimops lumsdenae.*

Of these unresolved groups, only one potentially represents an additional species (*i.e. Chalinolobus nigrogriseus*), with the others all containing species that were otherwise positively identified form more typical calls.

Table 1 provides a summary of species' presence on each detector-night throughout the survey. Where unresolved calls were identified, all members of the relevant group are listed as "possible" unless positive identification was achieved on other calls.

Sample spectrograms of each recorded call type are shown at Appendix 1.

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Churchill, S. (2008). *Australian Bats*. Jacana Books, Allen & Unwin; Sydney.

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Jackson, S. and Groves, C. (2015). *Taxonomy of Australian Mammals*. CSIRO Publishing, Melbourne.

Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**, 41-43.

Reardon, T. B., McKenzie, N. L., Cooper, S. J. B., Appleton, B., Carthew, S. and Adams, M. (2014). A molecular and morphological investigation of species boundaries and phylogenetic relationships in Australian free-tailed bats *Mormopterus* (Chiroptera : Molossidae). *Australian Journal of Zoology* **62**, 109–136.

Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales*. Department of Natural Resources and Mines, Brisbane.

van Dyck, S., Gynther, I. and Baker, A. (ed.) (2013). *Field Companion to the Mammals of Australia*. New Holland; Sydney.

Table 1. Microbat species recorded during the Saraji West survey, 25 October – 2 November 2018.

♦ = 'definite' - at least one call was attributed unequivocally to the species

□ = 'possible' - calls similar to those of the species were recorded, but were not reliably identified

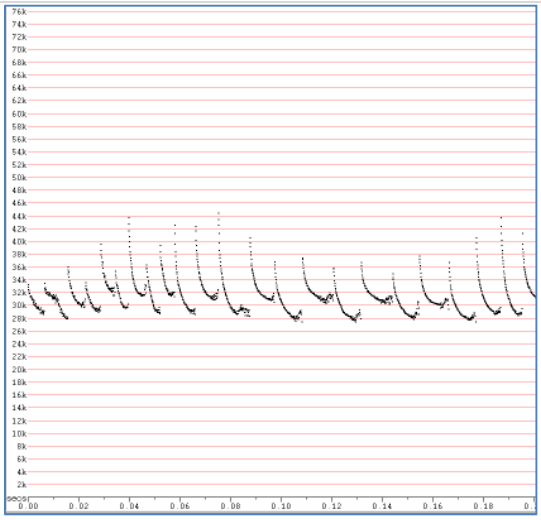
Detector:	Anabat B Metserve							Anabat ECO1019				
Date:	25-Oct	26-Oct	27-Oct	28-Oct	29-Oct	30-Oct	1-Nov	26-Oct	27-Oct	28-Oct	29-Oct	30-Oct
Chalinolobus gouldii	♦	♦	♦	♦	♦	♦	♦	♦		♦	♦	♦
Chalinolobus nigrogriseus	□	□	□			□	□			□		
Nyctophilus species						♦						
Scotorepens balstoni	♦	♦	♦	□	□	♦	♦					♦
Scotorepens greyii / S. sanborni		♦	♦	♦	♦	♦	♦				♦	♦
Vespadelus troughtoni							♦					♦
Chaerephon jobensis	□	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	
Ozimops lumsdenae		♦	♦	♦	♦	♦	♦	♦		♦	♦	♦
Ozimops ridei	□	♦	♦	□	□	♦	♦	♦		♦	□	□
Saccolaimus flaviventris	♦	♦	♦		♦	♦	♦		♦	♦	♦	♦

Glossary

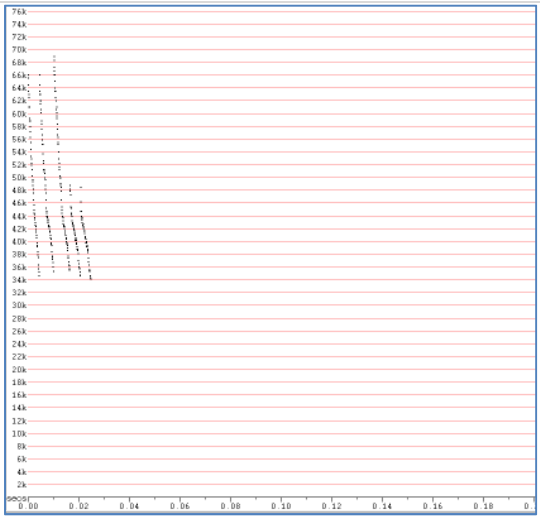
Technical terms used in this report are described in the following table.

Approach phase	The part of a bat *call* emitted as the bat starts to home in on a detected prey item; a transitional series of *pulses* between the *search phase* and *feeding buzz*, that become progressively steeper and shorter in duration.
Call	Refers to a single bat call, made up of a series of individual sound *pulses* in one or more *phases* (*search, approach, feeding buzz*).
CF (=Constant Frequency)	A type of *pulse* in which the dominant component consists of a more-or-less 'pure tone' of sound at a Constant Frequency; with *shape* appearing flat on the sonogram. Often also contains a brief *FM* component at the beginning and/or end of the CF component (*viz.* FM-CF-FM).
Characteristic frequency (Fc)	The frequency of the flattest part of a *pulse*; usually the lowest frequency reached in the *qCF* component of a pulse. This is often the primary diagnostic feature for species identification.
Duration	The time period from the beginning of a *pulse* to the end of the pulse.
Feeding buzz	The terminal part of a *call*, following the *approach phase*, emitted as the bat catches a prey item; a distinctive, rapid series of very steep, very short-duration pulses.
FM (=Frequency Modulated)	A type of *pulse* in which there is substantial change in frequency from beginning to end; *shape* ranges from almost vertical and linear through varying degrees of curvature.
FC range	Refers to the range of frequencies occupied by the *characteristic frequency* section of *pulses* within a call or set of calls.
Frequency sweep or "band-width"	The range of frequencies through which a *pulse* sweeps from beginning to end; Maximum frequency (Fmax) – minimum frequency (Fmin).
Knee	The transitional part of a *pulse* between the initial (usually steeper) frequency sweep and the *characteristic frequency* section (usually flatter); time to knee (Tk) and frequency of knee (Fk) can be diagnostic for some species.
Pulse	An individual pulse of sound within a bat *call*; the *shape*, *duration* and *characteristic frequency* of a pulse are the key diagnostic features used to differentiate species.
Pulse body	The part of the *pulse* between the *knee* and *tail* and containing the *characteristic frequency* section.
Pulse shape	The general appearance of a *pulse* on the sonogram, described using relative terms related to features such as slope and degree of curvature. See also *CF, qCF* and *FM*.
qCF (=quasi Constant Frequency)	A type of *pulse* in which there is very little change in frequency from beginning to end; *shape* appears to be almost flat. Some pulses also contain an *FM* component at the beginning and/or end of the qCF component (*viz.* FM-qCF).
Search phase	The part of a bat *call* generally required for reliable species diagnosis. A consistent series of *pulses* emitted by a bat that is searching for prey or and/or navigating through its habitat. Search phase pulses generally have longer duration, flatter slope and more consistent shape than *approach phase* and *feeding buzz* pulses.
Sequence	Literally, a sequence of *pulses* that may be from one or more bats; but generally refers to a *call* or part (e.g. *phase*) of a call.
Tail	The final component of a *pulse*, following the *characteristic frequency* section; may consist of a short or long sweep of frequencies either upward or downward from the Fc; or may be absent.

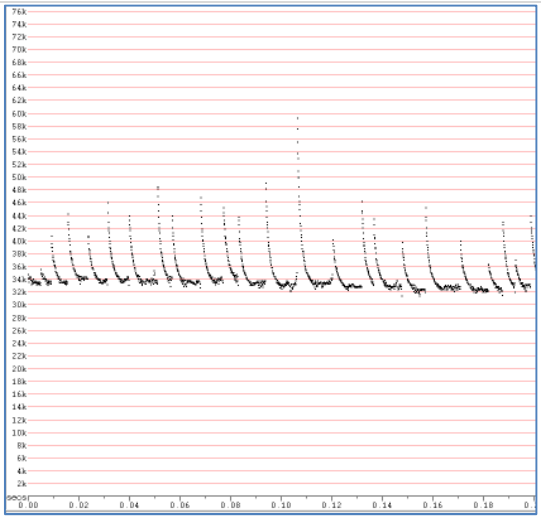
Appendix 1 Representative call sequences from the Saraji West survey, October 2018.
AnalookW spectrograms with time between pulses removed pulses



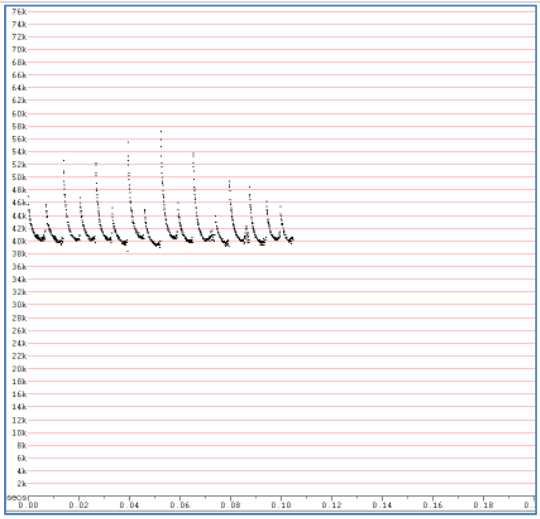
Chalinolobus gouldii



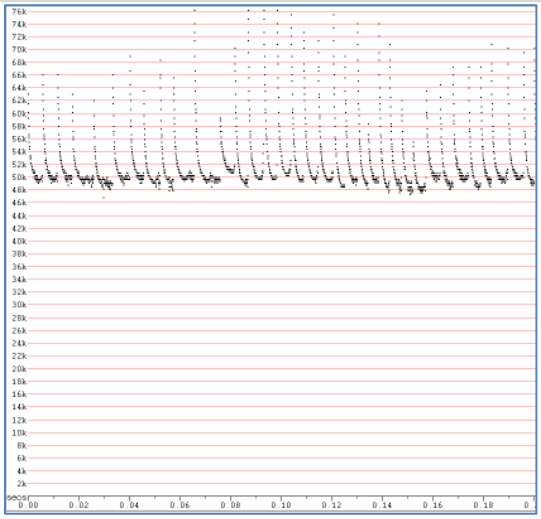
Nyctophilus species



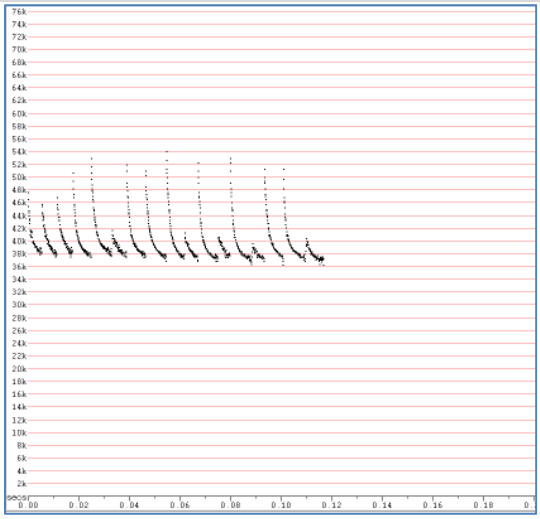
Scotorepens balstoni



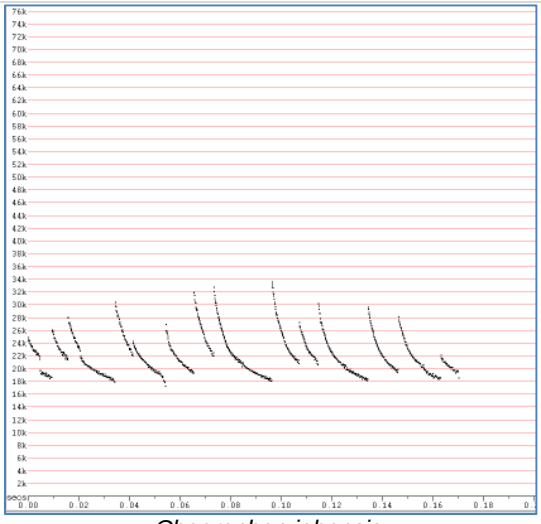
Scotorepens greyii / S. sanborni



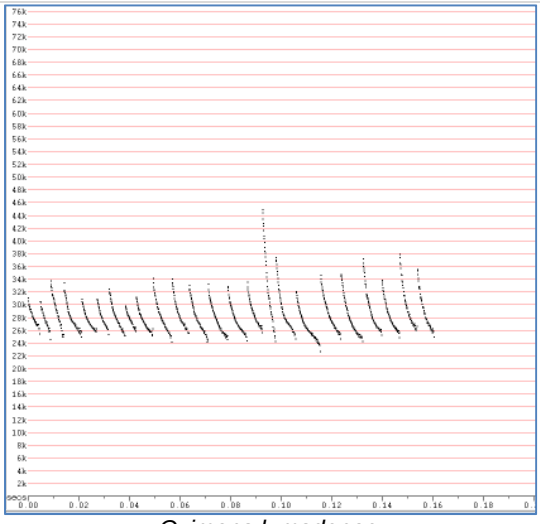
Vespadelus troughtoni



Scotorepens spp. or *Chalinolobus nigrogriseus*



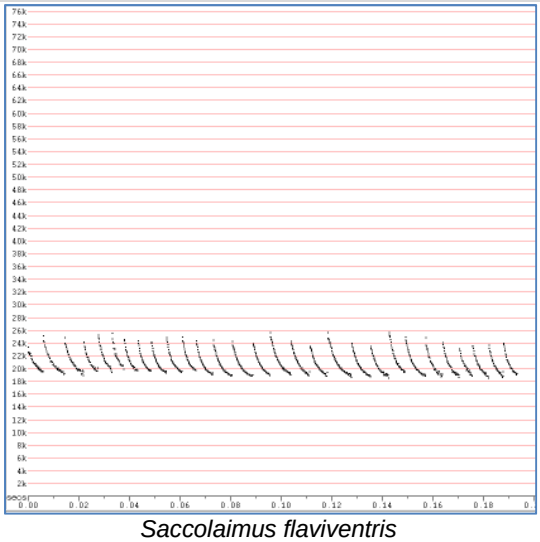
Chaerephon jobensis



Ozimops lumsdenae



Ozimops ridei



Saccolaimus flaviventris

Microbat Call Interpretation Report

Prepared for ("Client"):	METSERVE
Survey location/project name:	Saraji West
Survey dates:	26 March – 7 May 2019
Client project reference:	
Job no.:	MET-1901
Report date:	19 August 2019

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Methods

Data received & post-processing

Balance! Environmental received 30 ZCA data files and associated log files, recorded using two Anabat Express detectors (Titley Scientific, Brisbane) over three survey periods: 26-28 March; 8-15 April; and 30 April – 7 May 2019.

Deployment locations for the two detectors were extracted from the included LOG files. These are plotted on the map at **Figure 1**, with the GPS data extract for each detector listed in **Appendix 1**.

The ZCA files were processed with *Anabat Insight* (version 1.8.9; Titley Scientific) to extract individual Anabat ZC call-sequence files for analysis. This process yielded 37,660 ZC files; however, 33,931 of those files were discarded by the application of a noise filter to remove those files containing only non-bat sounds (e.g. from insects, wind, etc.).

Call analysis and identification

All ZC files that passed the noise filter were analysed in *Anabat Insight*. First-pass call identification was achieved using a Decision Tree analysis to group and label similar calls based primarily on frequency characteristics. Species identities within each group were then verified and/or altered manually by reviewing call spectrograms and derived metrics and comparing them with those of reference calls from central and northern Queensland and/or with published call descriptions (e.g. Reinhold et al. 2001). Consideration was also given to the probability of species' occurrence based on published distribution information (e.g. Churchill 2008; van Dyck *et al.* 2013) and on-line database records (e.g. http://www.ala.org.au).

Reporting standard

The format and content of this report follows Australasian Bat Society standards for the interpretation and reporting of bat call data (Reardon 2003), available on-line at http://www.ausbats.org.au/.

Species nomenclature follows Jackson & Groves (2015).



Figure 1 Bat detector deployment locations – Saraji West surveys, March, April and May 2019.

Results & Discussion

Detector A recorded no bat-call data on the nights of 28th March and 10th April; and Detector B failed to record any bat calls on the nights of 27th March and 10th April. A total of 3737 individual bat calls were identified across the remaining detector-nights.

Reliable identification was achieved on 1636 calls (44% of total detected calls), which were attributed to the following 11 unique species and two indistinguishable species pairs:

- *Chalinolobus gouldii;*
- *Chalinolobus morio;*
- *Chalinolobus picatus;*
- *Nyctophilus geoffroyi / N. gouldi;*
- *Scotorepens balstoni;*
- *Scotorepens greyii / S. sanborni;*
- *Vespadelus troughtoni;*
- *Miniopterus orianae oceanensis;*
- *Austronomus australis;*
- *Chaerephon jobensis;*
- *Ozimops lumsdenae;*
- *Ozimops ridei;* and
- *Saccolaimus flaviventris.*

Fifty-six percent (2101) of the calls could not be reliably identified due to similarities in call characteristics shared by several species that are likely to occur in the study area. These unresolved calls were allocated to one of several multi-species groups, including:

- *C. gouldii / O. ridei;*
- *C. gouldii / S. balstoni;*
- *C. morio / V. troughtoni;*
- *C. picatus / M. o. oceanensis;*
- *C. picatus / S. greyii / S. sanborni;*
- *C. picatus / Vespadelus baverstocki;*
- *S. flaviventris / C. jobensis;*
- *S. flaviventris / O. lumsdenae;* and
- *O. lumsdenae / Taphozous troughtoni.*

Two of these unresolved groups represent potential additional species (*i.e. C. picatus* / ***V. baverstocki*** and *O. lumsdenae* / ***T. troughtoni***); however, it is considered unlikely that *V. baverstocki* would occur in the study area. The latter species, *T. troughtoni*, may be present if suitable subterranean roost sites exist in the broader study area.

Table 1 provides a summary of species' presence on each detector-night throughout the survey. Where unresolved calls were identified, all members of the relevant group are listed as "possible" unless positive identification was achieved on other calls.

Sample spectrograms of each recorded call type are shown at **Appendix 2**.

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Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales*. Department of Natural Resources and Mines, Brisbane.

van Dyck, S., Gynther, I. and Baker, A. (ed.) (2013). *Field Companion to the Mammals of Australia*. New Holland; Sydney.

Table 1-A. Microbat species recorded during the Saraji West survey, March-May 2019 – **Detector A**.

♦ = 'definite' - at least one call was attributed unequivocally to the species

□ = 'possible' - calls similar to those of the species were recorded, but were not reliably identified

Detector - serial number:	**A - SN318011**														
Detector-night:	26/3	27/3	28/3	08/4	09/4	10/4	11/4	12/4	13/4	15/4	30/4	01/5	03/5	06/5	07/5
Chalinolobus gouldii	♦	♦		♦	♦		♦		♦	♦	♦	♦	□	♦	□
Chalinolobus morio	♦				□					□	□	♦			
Chalinolobus picatus	□				□		♦		□	□	♦	♦	♦		♦
Nyctophilus sp.	♦				♦				♦				♦		
Scotorepens balstoni	♦			♦	□		□				□	♦			♦
Scotorepens greyii	♦				♦		♦		♦	♦	□	♦	♦		□
Vespadelus baverstocki	□				□				□	□	□		□		
Vespadelus troughtoni	♦				♦				♦	□	□	♦		♦	♦
Miniopterus orianae oceanensis	♦						□			♦		♦	♦		♦
Austronomus australis								♦							
Chaerephon jobensis	♦	♦		♦	♦		♦	♦	♦	♦	♦	♦	♦	♦	♦
Ozimops lumsdenae	♦	□		♦	♦		♦	♦	♦	♦	♦	♦		♦	
Ozimops ridei	♦	□		□	□		□		□	♦	♦	□	□	♦	□
Saccolaimus flaviventris	♦	□		♦	♦		♦	□	□		□	□	□	♦	
Taphozous troughtoni												□	□		

Table 1-B. Microbat species recorded during the Saraji West survey, March-May 2019 – **Detector B**.

♦ = 'definite' - at least one call was attributed unequivocally to the species

□ = 'possible' - calls similar to those of the species were recorded, but were not reliably identified

Detector - serial number:	**B - SN324680**														
Detector-night:	26/3	27/3	28/3	08/4	09/4	10/4	11/4	12/4	13/4	15/4	30/4	01/5	03/5	06/5	07/5
Chalinolobus gouldii	♦		♦	♦	♦		♦	♦	♦	♦	□	♦	♦	♦	♦
Chalinolobus morio								□	□	♦	□	♦	♦	□	
Chalinolobus picatus	□			□			□	□	□	□	□	♦	♦	♦	□
Nyctophilus sp.			♦	♦					♦			♦		♦	
Scotorepens balstoni	□		□	□	□							♦	□		
Scotorepens greyii	□			♦			□	♦	♦	♦	□	♦	♦	♦	□
Vespadelus baverstocki				□				□	□			□	□		
Vespadelus troughtoni								♦	♦	♦	□		♦	♦	
Miniopterus orianae oceanensis			♦					♦	♦	♦	♦	♦	♦	♦	♦
Austronomus australis															
Chaerephon jobensis	♦		♦	♦	♦		♦	♦	♦	♦	♦	♦	♦	♦	♦
Ozimops lumsdenae	♦		♦	♦	♦		♦		♦	♦	♦	♦	♦		♦
Ozimops ridei	♦		♦	♦	♦		♦	♦	♦	♦	♦	♦	♦	□	□
Saccolaimus flaviventris			♦	♦			♦	♦	♦	♦	□	♦	♦	□	□
Taphozous troughtoni				□						□			□		□

Glossary

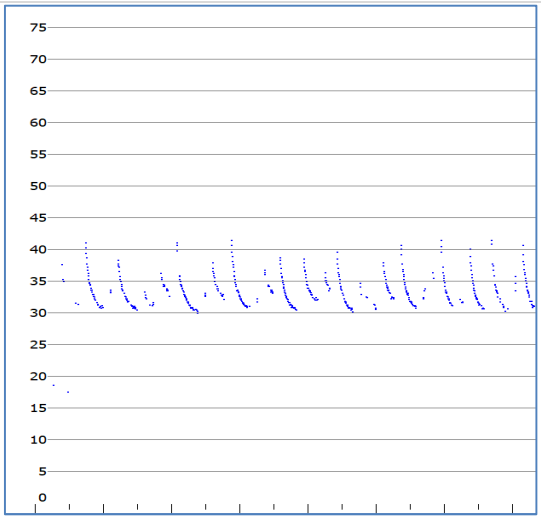
Technical terms used in this report are described in the following table.

Approach phase	The part of a bat *call* emitted as the bat starts to home in on a detected prey item; a transitional series of *pulses* between the *search phase* and *feeding buzz*, that become progressively steeper and shorter in duration.
Call	Refers to a single bat call, made up of a series of individual sound *pulses* in one or more *phases* (*search, approach, feeding buzz*).
CF (=Constant Frequency)	A type of *pulse* in which the dominant component consists of a more-or-less 'pure tone' of sound at a Constant Frequency; with *shape* appearing flat on the sonogram. Often also contains a brief *FM* component at the beginning and/or end of the CF component (*viz.* FM-CF-FM).
Characteristic frequency (Fc)	The frequency of the flattest part of a *pulse*; usually the lowest frequency reached in the *qCF* component of a pulse. This is often the primary diagnostic feature for species identification.
Duration	The time period from the beginning of a *pulse* to the end of the pulse.
Feeding buzz	The terminal part of a *call*, following the *approach phase*, emitted as the bat catches a prey item; a distinctive, rapid series of very steep, very short-duration pulses.
FM (=Frequency Modulated)	A type of *pulse* in which there is substantial change in frequency from beginning to end; *shape* ranges from almost vertical and linear through varying degrees of curvature.
FC range	Refers to the range of frequencies occupied by the *characteristic frequency* section of *pulses* within a call or set of calls.
Frequency sweep or "band-width"	The range of frequencies through which a *pulse* sweeps from beginning to end; Maximum frequency (Fmax) – minimum frequency (Fmin).
Knee	The transitional part of a *pulse* between the initial (usually steeper) frequency sweep and the *characteristic frequency* section (usually flatter); time to knee (Tk) and frequency of knee (Fk) can be diagnostic for some species.
Pulse	An individual pulse of sound within a bat *call*; the *shape*, *duration* and *characteristic frequency* of a pulse are the key diagnostic features used to differentiate species.
Pulse body	The part of the *pulse* between the *knee* and *tail* and containing the *characteristic frequency* section.
Pulse shape	The general appearance of a *pulse* on the sonogram, described using relative terms related to features such as slope and degree of curvature. See also *CF, qCF* and *FM*.
qCF (=quasi Constant Frequency)	A type of *pulse* in which there is very little change in frequency from beginning to end; *shape* appears to be almost flat. Some pulses also contain an *FM* component at the beginning and/or end of the qCF component (*viz.* FM-qCF).
Search phase	The part of a bat *call* generally required for reliable species diagnosis. A consistent series of *pulses* emitted by a bat that is searching for prey or and/or navigating through its habitat. Search phase pulses generally have longer duration, flatter slope and more consistent shape than *approach phase* and *feeding buzz* pulses.
Sequence	Literally, a sequence of *pulses* that may be from one or more bats; but generally refers to a *call* or part (e.g. *phase*) of a call.
Tail	The final component of a *pulse*, following the *characteristic frequency* section; may consist of a short or long sweep of frequencies either upward or downward from the Fc; or may be absent.

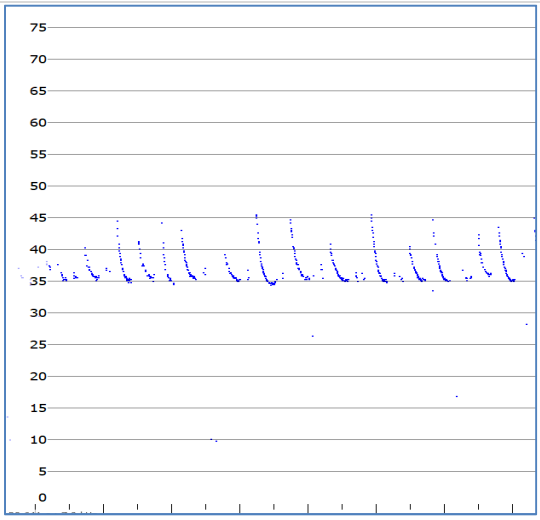
Appendix 1 GPS coordinates derived from detector LOG files.

Detector name	Serial Number	Date	Latitude	Longitude
A	SN318011	26/03/2019	-22.37716	148.21459
		27/03/2019	-22.37623	148.23676
		28/03/2019	-22.37618	148.23673
		8/04/2019	-22.39008	148.22679
		9/04/2019	-22.3665	148.20516
		10/04/2019	-22.39518	148.23804
		11/04/2019	-22.37769	148.22077
		12/04/2019	-22.35665	148.19285
		13/04/2019	-22.37584	148.25864
		15/04/2019	-22.35043	148.19961
		30/04/2019	-22.35911	148.2297
		1/05/2019	-22.34987	148.20114
		3/05/2019	-22.35026	148.19531
		6/05/2019	-22.28541	148.15191
		7/05/2019	-22.30574	148.19387
B	SN324680	26/03/2019	-22.3904	148.22627
		27/03/2019	-22.37693	148.20079
		28/03/2019	-22.37695	148.20086
		8/04/2019	-22.37699	148.20077
		9/04/2019	-22.37691	148.20069
		10/04/2019	-22.37602	148.2143
		11/04/2019	-22.37597	148.21452
		12/04/2019	-22.35903	148.1982
		13/04/2019	-22.35358	148.23393
		15/04/2019	-22.3537	148.23395
		30/04/2019	-22.35166	148.21131
		1/05/2019	-22.34241	148.21047
		3/05/2019	-22.34033	148.21277
		6/05/2019	-22.29084	148.16613
		7/05/2019	-22.33003	148.21279

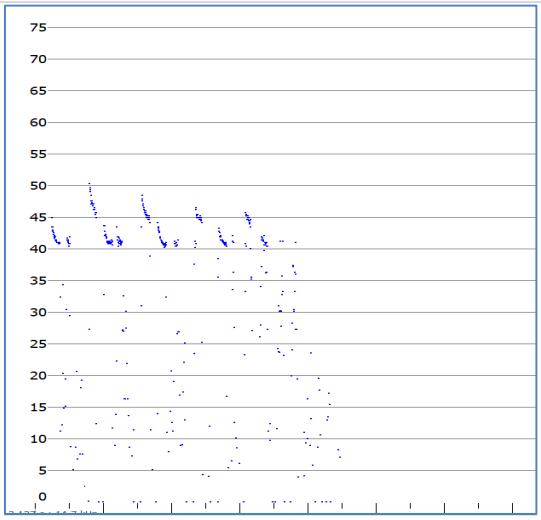
Appendix 2 Representative call sequences from the Saraji West surveys, March-May 2019.
AnalookW spectrograms with time between pulses removed pulses



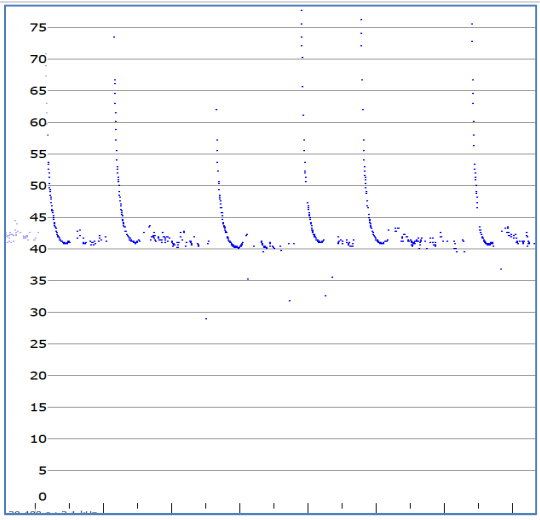
Chalinolobus gouldii



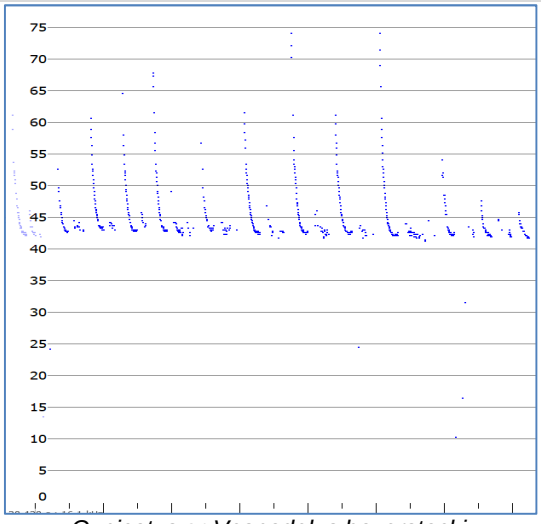
Scotorepens balstoni



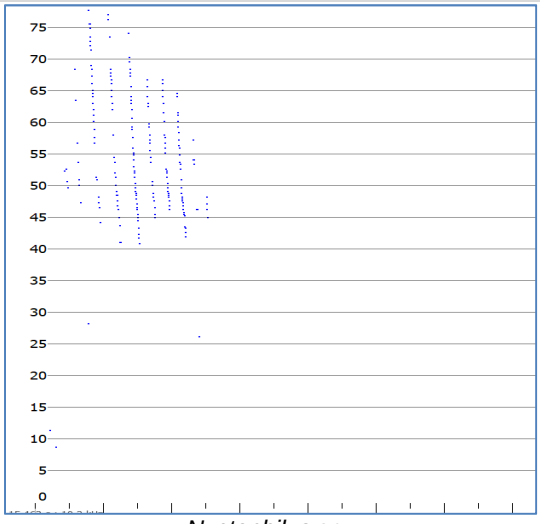
Chalinolobus picatus



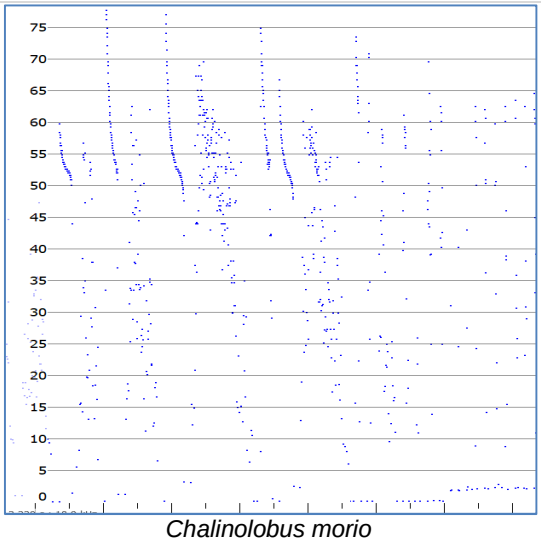
Scotorepens greyii / S. sanborni



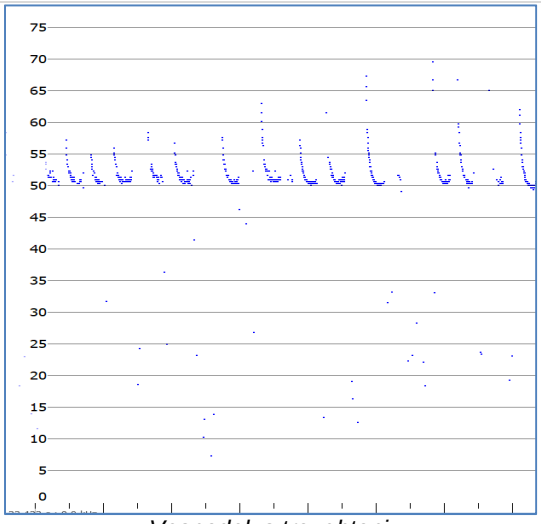
C. picatus or *Vespadelus baverstocki*



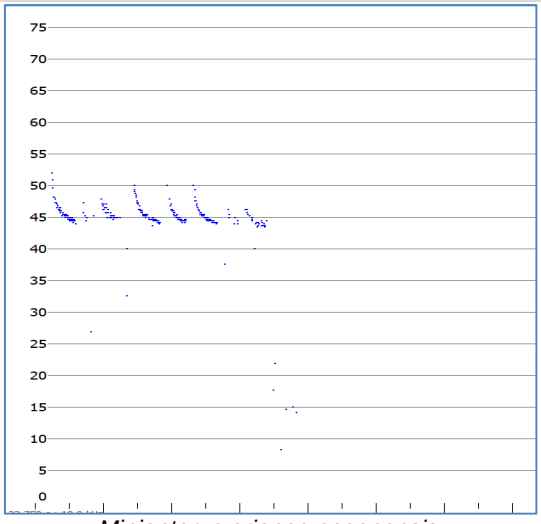
Nyctophilus sp.



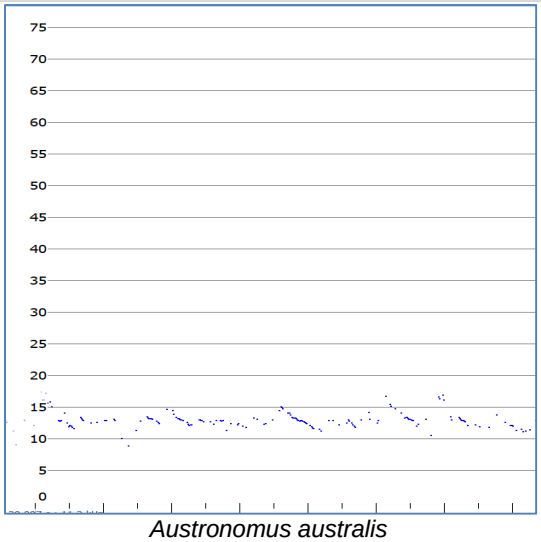
Chalinolobus morio



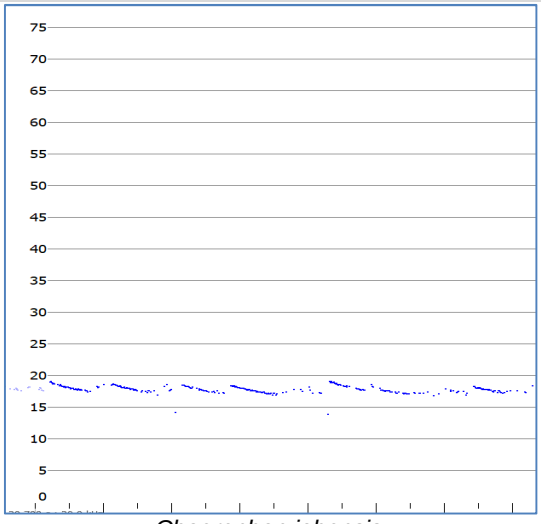
Vespadelus troughtoni



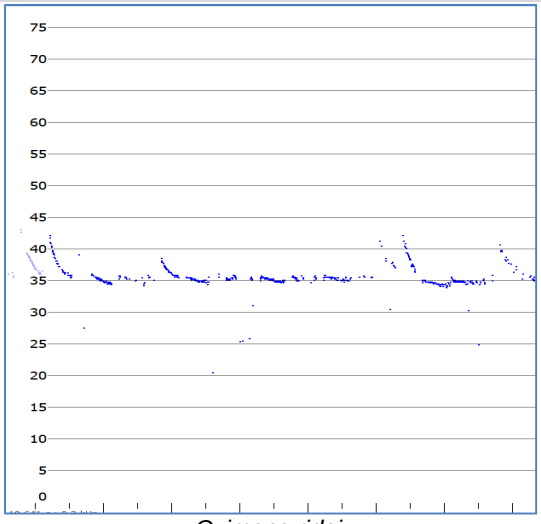
Miniopterus orianae oceanensis



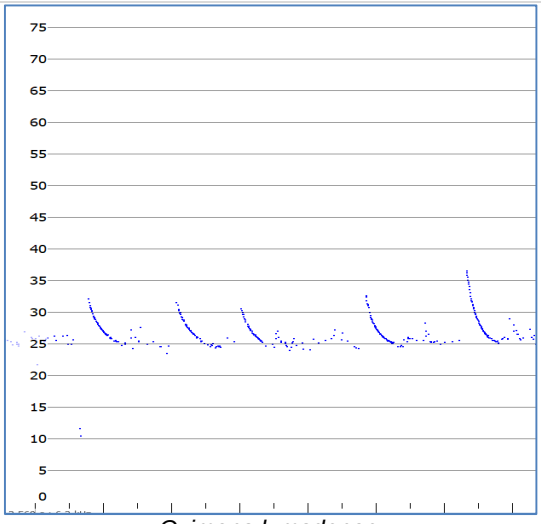
Austronomus australis



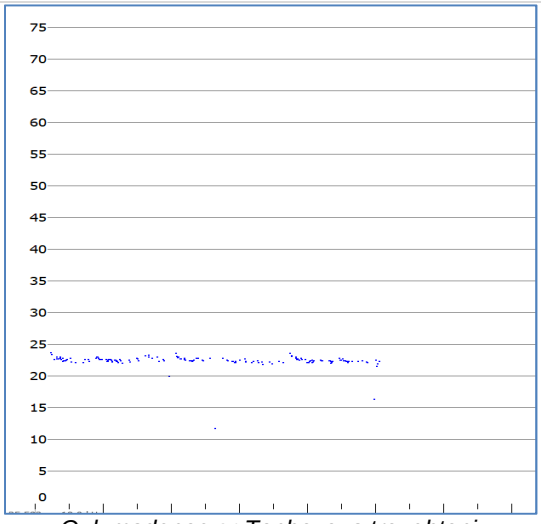
Chaerephon jobensis



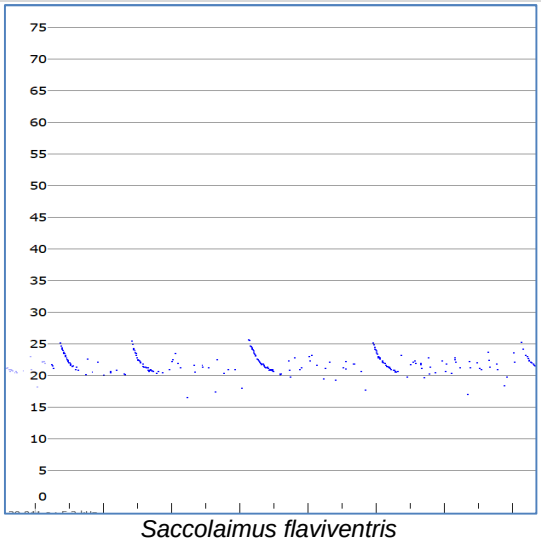
Ozimops ridei



Ozimops lumsdenae



O. lumsdenae or *Taphozous troughtoni*



Saccolaimus flaviventris

Microbat Call Interpretation Report

Prepared for ("Client"):	METSERVE
Survey location/project name:	Dysart area
Survey dates:	23-30 September 2019
Client project reference:	
Job no.:	MET-1902
Report date:	4 December 2019

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Methods

Data received & post-processing

Balance! Environmental received 13 ZCA data files and associated log files, recorded using two Anabat Express detectors (Titley Scientific, Brisbane) deployed over eight consecutive nights (23-30 September 2019). The raw data files were named according to the site numbers at which each detector was deployed. These deployment details are summarised in **Table 1**.

The ZCA files were processed with *Anabat Insight* (version 1.9.1; Titley Scientific) to extract individual Anabat ZC call-sequence files for analysis. This process yielded 23,231 ZC files; however, 19,620 of those files were discarded by the application of a noise filter to remove files containing only non-bat sounds (e.g. from insects, wind, etc.).

Call analysis and identification

All ZC files that passed the noise filter were analysed in *Anabat Insight*. First-pass call identification was achieved using a Decision Tree analysis to group and label similar calls based primarily on frequency characteristics. Species identities within each group were then verified and/or altered manually by reviewing call spectrograms and derived metrics and comparing them with those of reference calls from central and northern Queensland and/or with published call descriptions (e.g. Reinhold et al. 2001). Consideration was also given to the probability of species' occurrence based on published distribution information (e.g. Churchill 2008; van Dyck *et al.* 2013) and on-line database records (e.g. http://www.ala.org.au).

Reporting standard

The format and content of this report follows Australasian Bat Society standards for the interpretation and reporting of bat call data (Reardon 2003), available on-line at http://www.ausbats.org.au/.

Species nomenclature follows Jackson & Groves (2015).

Table 1 Bat detector deployment details extracted from the data files.

Detector:	Anabat A - SN318011						Anabat B - SN324680						
Date:	24/9	25/9	26/9	27/9	28/9	29/9	23/9	24/9	25/9	27/9	28/9	29/9	30/9
Site:	S27	A7	A8	A9	S32	S34	S26	S28	S29	S31	S30	S33	A10

Results & Discussion

Of the 3,611 ZC files passed the noise filter, 913 were found to contain only brief and/or weak and/or highly-fragmented bat calls that were of no use for species identification. From the 2,698 files that remained a total of 2881 bat calls were identified.

Reliable identification was achieved on 2184 calls (76% of total), which were attributed to 12 unique species and two indistinguishable species pairs. These positively identified species included:

- *Chalinolobus gouldii;*
- *Chalinolobus morio;*
- *Chalinolobus picatus;*
- *Nyctophilus geoffroyi / N. gouldi;*
- *Scotorepens balstoni;*
- *Scotorepens greyii / S. sanborni;*
- *Vespadelus baverstocki;*
- *Vespadelus troughtoni;*
- *Miniopterus orianae oceanensis;*
- *Chaerephon jobensis;*
- *Ozimops lumsdenae;*
- *Ozimops ridei;*
- *Setirostris eleryi;* and
- *Saccolaimus flaviventris*.

The other 697 calls could not be reliably identified due to similarities in call characteristics shared by several species. These unresolved calls were allocated to one of the following multi-species groups:

- *C. gouldii / O. ridei / S. balstoni;*
- *C. morio / V. troughtoni;*
- *C. picatus / S. greyii / S. sanborni;*
- *S. greyii / S. eleryi;*
- *S. flaviventris / C. jobensis;*
- *S. flaviventris / O. lumsdenae;* and
- *O. lumsdenae / Taphozous troughtoni.*

The above groups mostly represent species that were also identified positively from more typical calls. The last group potentially represents an additional species for this survey. *Taphozous troughtoni* is likely present in the study area, but it's calls can be difficult to distinguish from those of *O. lumsdenae*. Calls allocated to the group had shorter duration, more uniform pulses than those allocated positively to *O. lumsdenae*, but it was still not possible to reliably attribute them to *T. troughtoni*.

Table 2 provides a summary of species' presence per site. Where unresolved calls were identified, all members of the relevant group are listed as "possible" unless positive identification was achieved on other calls. Sample spectrograms of each recorded call type are shown at **Appendix 1**.

References

Churchill, S. (2008). *Australian Bats*. Jacana Books, Allen & Unwin; Sydney.

Jackson, S. and Groves, C. (2015). *Taxonomy of Australian Mammals*. CSIRO Publishing, Melbourne.

Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**, 41-43.

van Dyck, S., Gynther, I. and Baker, A. (ed.) (2013). *Field Companion to the Mammals of Australia*. New Holland; Sydney.

Table 2. Microbat species recorded during the Dysart surveys, 23-30 September 2019.

♦ = 'definite' - at least one call was attributed unequivocally to the species

□ = 'possible' - calls similar to those of the species were recorded, but were not reliably identified

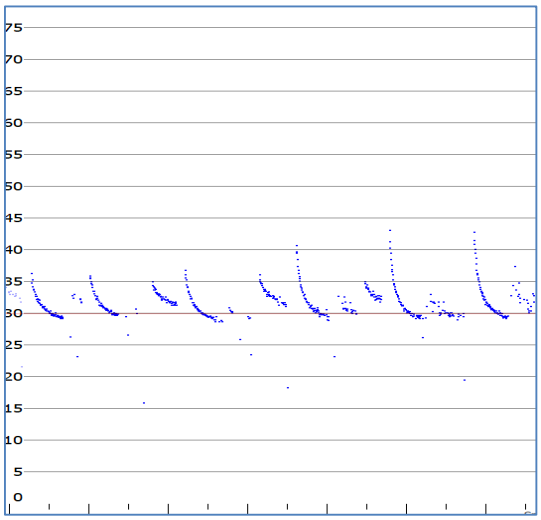
Site:	A7	A8	A9	A10	S26	S27	S28	S29	S30	S31	S32	S33	S34
Chalinolobus gouldii	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	□
Chalinolobus morio		♦	♦	♦	♦	□	♦		□	♦	♦	♦	□
Chalinolobus picatus	♦	♦	♦	♦	□	□	□	□	♦	♦	□	♦	□
Nyctophilus sp.			♦			♦				♦	♦	♦	
Scotorepens balstoni	□	♦	♦	♦		□	□	♦			♦	♦	♦
Scotorepens greyii	♦	♦	♦	♦	□	♦	♦	♦	♦	♦	♦	♦	♦
Vespadelus baverstocki		♦		♦	♦	♦		♦	♦	♦	♦	♦	
Vespadelus troughtoni			♦	□		□			□	♦	♦	♦	♦
Miniopterus orianae oceanensis	♦								♦	□			□
Chaerephon jobensis	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Ozimops lumsdenae	♦		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Ozimops ridei	□	♦	♦	♦	♦	□	♦	♦	♦	□	□	♦	♦
Setirostris eleryi		□	♦	□	□	□		□	□	□	□		□
Saccolaimus flaviventris		♦	♦	♦	♦	□		♦	♦	♦	♦	♦	♦
Taphozous troughtoni	□		□			□	□		□	□	□	□	□

Glossary

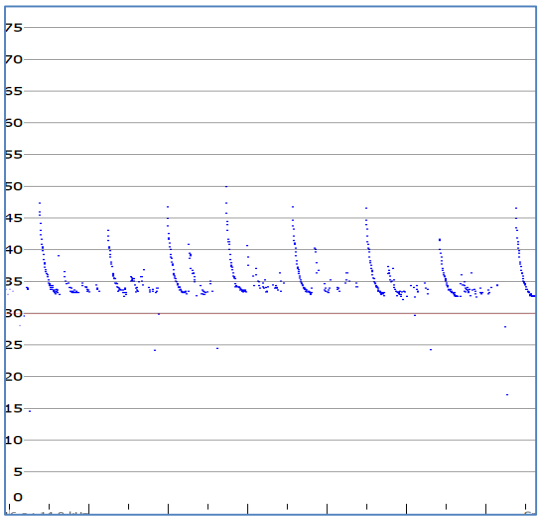
Technical terms used in this report are described in the following table.

Approach phase	The part of a bat *call* emitted as the bat starts to home in on a detected prey item; a transitional series of *pulses* between the *search phase* and *feeding buzz*, that become progressively steeper and shorter in duration.
Call	Refers to a single bat call, made up of a series of individual sound *pulses* in one or more *phases* (*search, approach, feeding buzz*).
CF (=Constant Frequency)	A type of *pulse* in which the dominant component consists of a more-or-less 'pure tone' of sound at a Constant Frequency; with *shape* appearing flat on the sonogram. Often also contains a brief *FM* component at the beginning and/or end of the CF component (*viz.* FM-CF-FM).
Characteristic frequency (Fc)	The frequency of the flattest part of a *pulse*; usually the lowest frequency reached in the *qCF* component of a pulse. This is often the primary diagnostic feature for species identification.
Duration	The time period from the beginning of a *pulse* to the end of the pulse.
Feeding buzz	The terminal part of a *call*, following the *approach phase*, emitted as the bat catches a prey item; a distinctive, rapid series of very steep, very short-duration pulses.
FM (=Frequency Modulated)	A type of *pulse* in which there is substantial change in frequency from beginning to end; *shape* ranges from almost vertical and linear through varying degrees of curvature.
FC range	Refers to the range of frequencies occupied by the *characteristic frequency* section of *pulses* within a call or set of calls.
Frequency sweep or "band-width"	The range of frequencies through which a *pulse* sweeps from beginning to end; Maximum frequency (Fmax) – minimum frequency (Fmin).
Knee	The transitional part of a *pulse* between the initial (usually steeper) frequency sweep and the *characteristic frequency* section (usually flatter); time to knee (Tk) and frequency of knee (Fk) can be diagnostic for some species.
Pulse	An individual pulse of sound within a bat *call*; the *shape*, *duration* and *characteristic frequency* of a pulse are the key diagnostic features used to differentiate species.
Pulse body	The part of the *pulse* between the *knee* and *tail* and containing the *characteristic frequency* section.
Pulse shape	The general appearance of a *pulse* on the sonogram, described using relative terms related to features such as slope and degree of curvature. See also *CF, qCF* and *FM*.
qCF (=quasi Constant Frequency)	A type of *pulse* in which there is very little change in frequency from beginning to end; *shape* appears to be almost flat. Some pulses also contain an *FM* component at the beginning and/or end of the qCF component (*viz.* FM-qCF).
Search phase	The part of a bat *call* generally required for reliable species diagnosis. A consistent series of *pulses* emitted by a bat that is searching for prey or and/or navigating through its habitat. Search phase pulses generally have longer duration, flatter slope and more consistent shape than *approach phase* and *feeding buzz* pulses.
Sequence	Literally, a sequence of *pulses* that may be from one or more bats; but generally refers to a *call* or part (e.g. *phase*) of a call.
Tail	The final component of a *pulse*, following the *characteristic frequency* section; may consist of a short or long sweep of frequencies either upward or downward from the Fc; or may be absent.

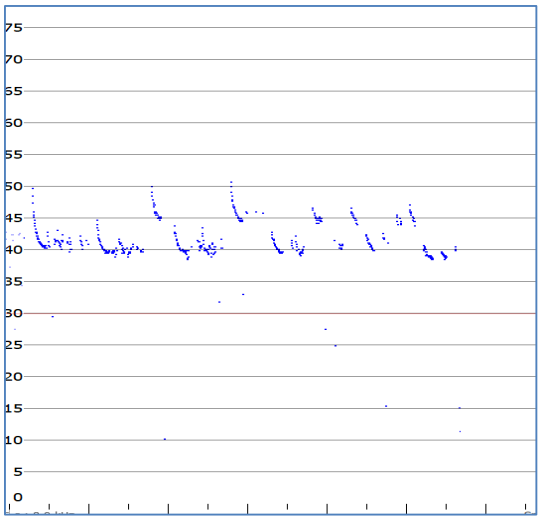
Appendix 1 Representative call sequences from the Dysart survey, 23-30 September 2019.
Time scale (*x*-axis) = 10ms per tick; time between pulses removed



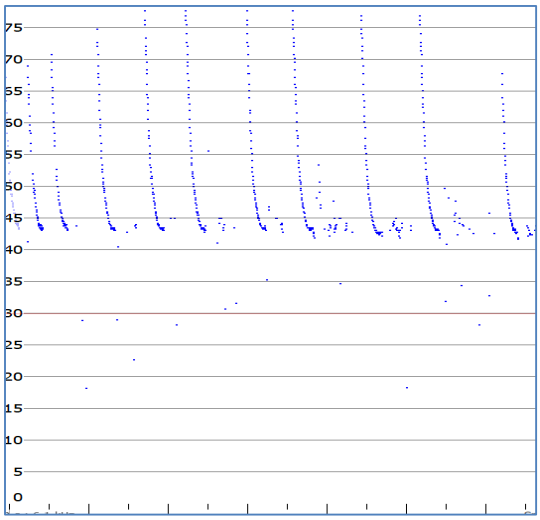
Chalinolobus gouldii



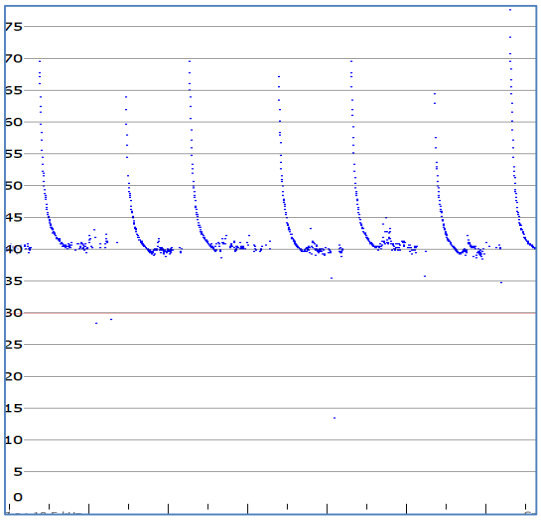
Scotorepens balstoni



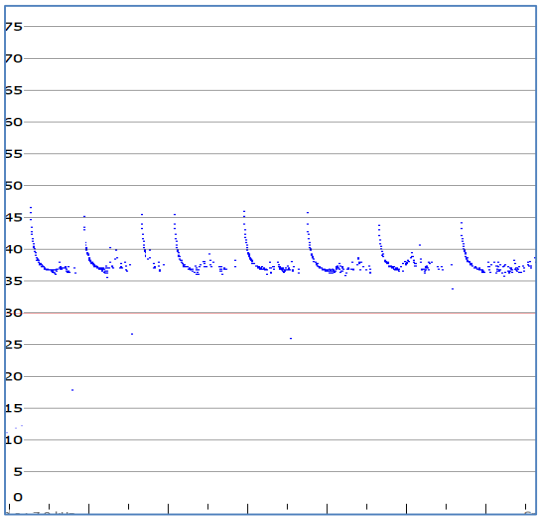
Chalinolobus picatus



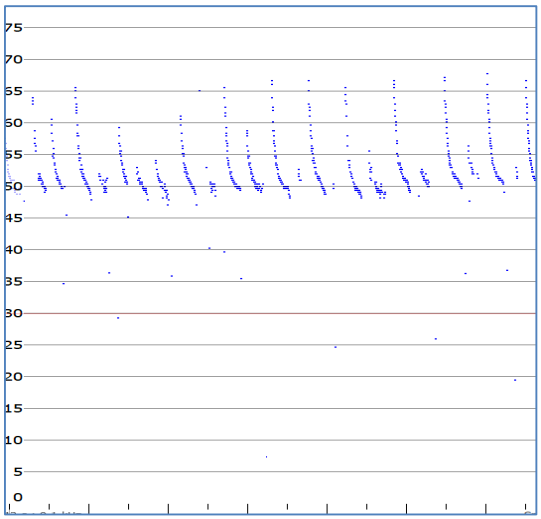
Vespadelus baverstocki



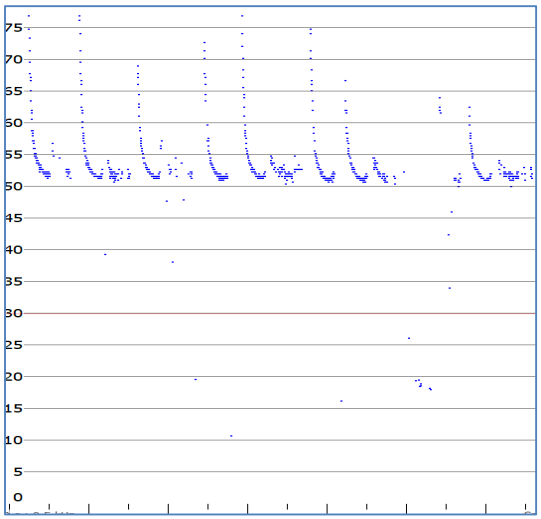
Scotorepens greyii / S. sanborni



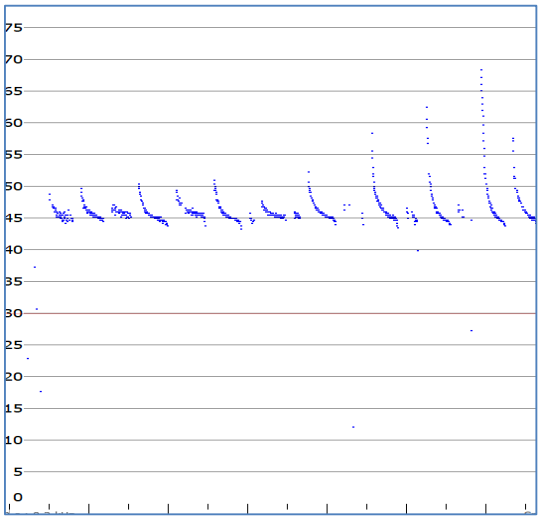
Setirostris eleryi



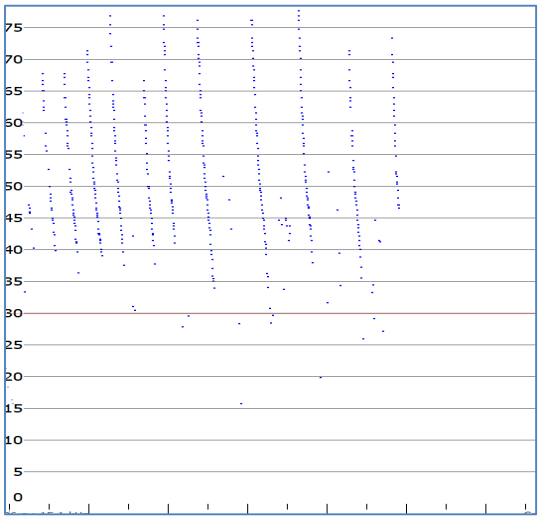
Chalinolobus morio



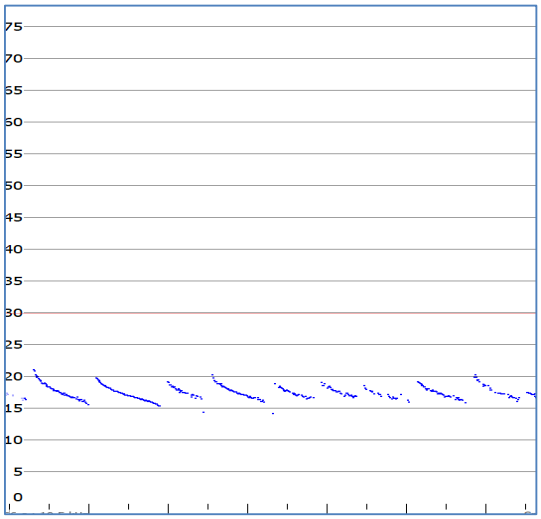
Vespadelus troughtoni



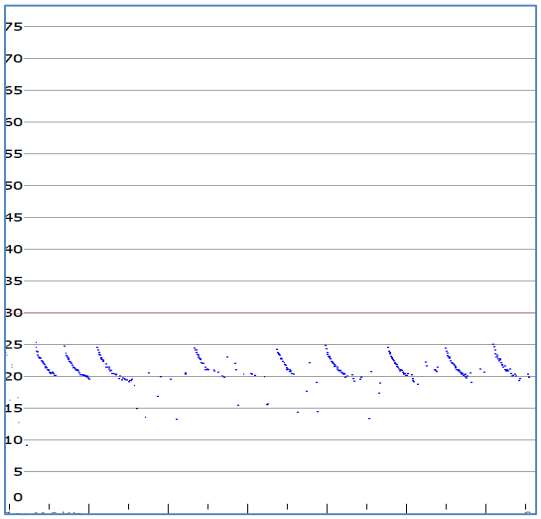
Miniopterus orianae oceanensis



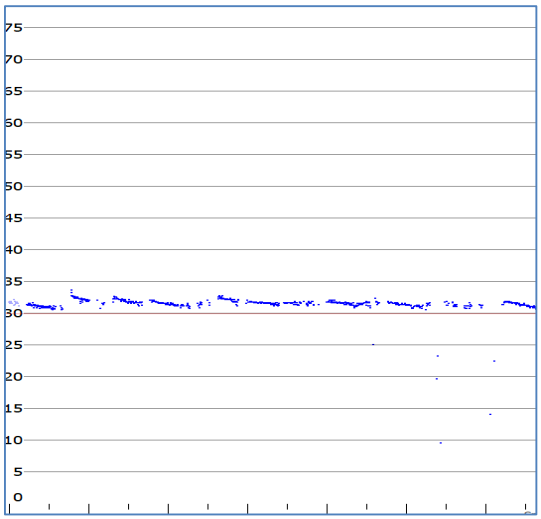
Nyctophilus sp.



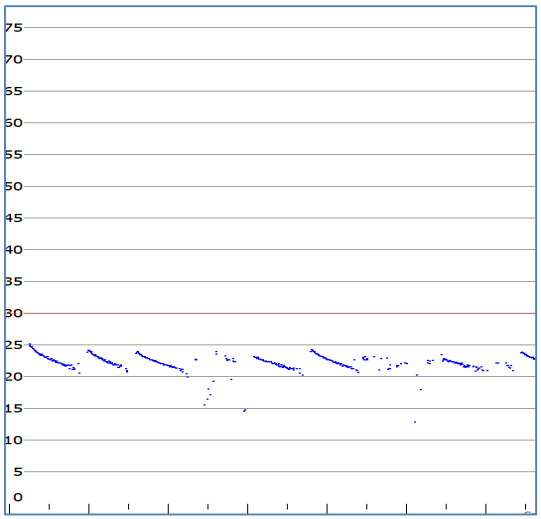
Chaerephon jobensis



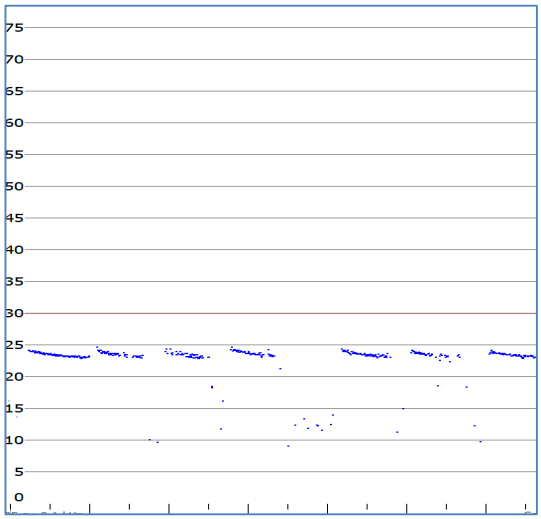
Saccolaimus flaviventris



Ozimops ridei



Ozimops lumsdenae



O. lumsdenae / Taphozous troughtoni

APPENDIX E

TERRESTRIAL ECOLOGY RISK ASSESSMENT

Inclusions and exclusions

This risk assessment considers the construction and operational phases of the project; an in-depth risk assessment of the decommissioning and rehabilitation phases of the project is provided in the PRC Plan. Matters of State or National Environmental Significance (MSES or MNES) that have been confirmed in or near the project area and those that are considered likely to occur within the project area are assessed.

Table 1 outlines the definitions for likelihood and consequence used to assess ecological risk, while **Table 2** itemises each of the risks posed by the project.

Table 1 Risk Criteria Matrix (Source: *Vulcan Mine - Safety and Health Management System*)

	CONSEQUENCES				
	Level 1 **Insignificant**	**Level 2** **Minor**	**Level 3** **Moderate**	**Level 4** **Major**	**Level 5** **Catastrophic**
Environmental Impact (E)	No environmental harm or remedial action.	Environmental nuisance event (as per EP Act 1994). No regulatory action likely. Remedial action required.	Environmental Harm Event (as per EP Act 1994) – localised to site. Environmental infringement notice possible. Remedial action required.	Environmental Harm Event – extending off-site OR Material Environmental Harm Event (as per EP Act 1994). Environmental prosecution possible Remedial action required.	Material Environmental Harm Event – extending off-site. Possible suspension of licence to operate. Remedial action required.
LIKELIHOOD OF IMPACT	**RISK RATING**				
A – Extremely Likely: Almost certain to happen. Would be expected daily or more frequently.	**M (11)**	**H (16)**	**E (20)**	**E (23)**	**E (25)**
B – Very Likely: Could happen anytime. Could occur as often as weekly.	**M (7)**	**M (12)**	**H (17)**	**E (21)**	**E (24)**
C –Likely: Could happen sometime. Could occur as often as monthly.	**L (4)**	**M (8)**	**H (13)**	**E (18)**	**E (22)**
D – Unlikely: Could happen. Could occur once a year or less.	**L (2)**	**L (5)**	**M (9)**	**H (14)**	**E (19)**
E – Rarely: Could happen but probably never will. Would require exceptional circumstances. Occurs less than every 10 years.	**L (1)**	**L (3)**	**M (6)**	**M (10)**	**H (15)**

Table 2 Vulcan Bulk Sample Terrestrial Ecology Risk Assessment

CONSTRUCITON PHASE							
MSES/MNES	**Activity**	**Hazard**	**Impact Description**	**Proposed Controls**	**Consequence**	**Likelihood**	**Risk Rating**
Biodiversity	Vegetation Clearing	Decline in local biodiversity from reduced habitat extent or connectivity.	No locally unique ecological values will be disturbed by the proposed clearing of (mostly) regrowth and already-cleared pastures. All vegetation to be disturbed is represented by extensive areas of remnant vegetation within the broader region. The rehabilitated landscape post-mining is expected to have slightly reduced floral diversity, as is typical of mined landscapes. However, most other pre-mining habitat values are expected to be restored in the rehabilitated landscape.	1) The footprint of the Project has been positioned to largely avoid key ecological values, including remnant vegetation, watercourses and habitat for flora and fauna. 2) The Project is to be of a small scale and short duration. 3) The total footprint of the Project has been minimised by returning overburden to the mined pits, using off-site accommodation in nearby towns, and utilising existing infrastructure at nearby mines for all processing. 4) The edges of the project footprint are to be marked out, to prevent unnecessary accidental clearing of neighbouring habitats. 5) Topsoil removed in preparation for mining is to be stored and managed in accordance with a Progressive Rehabilitation and Closure Plan, to protect a favourable growing medium for vegetation post-mining. 6) Post-mine rehabilitation should aim for a post-mine land use with similar environmental values to those being lost (see the Progressive Rehabilitation and Closure Plan).	1	C	L (4)
Koala	Vegetation clearing	Habitat loss	No primary habitat is to be removed. A total of 2.6 ha of secondary habitat (regrowth containing primary food tree species) and 66.3 ha of marginal foraging habitat (regrowth containing secondary food tree species) for Koalas will be removed. This impact will last until mature food trees have been re-established in rehabilitated areas post-mining (approximately 15 years post-planting). Viability of local Koala populations is not threatened by the proposed habitat loss.	1) Large tracts of connected, high-quality habitat are to be retained in the surrounding area, throughout construction and operations (100% of primary habitat and 99.9% of secondary habitat is retained in the broader landscape), providing a source of recruitment to rehabilitated areas in the future. 2) The project has been located adjacent to existent mining operations and at the edge of potential Koala habitat, so that no new barriers to Koala movement will be created by habitat loss. 3) Vitrinite employees and contractors are to be made aware of environmental obligations and compliance requirements through a site induction program. 4) The edges of the project footprint are to be marked out, to prevent unnecessary accidental clearing of neighbouring habitats. 5) Overburden is mostly to be returned to the mined pits, to limit the total disturbance footprint of the project. 6) Topsoil removed from each site in preparation for mining is to be stored and managed in accordance with a Progressive Rehabilitation and Closure Plan, to protect a favourable growing medium for vegetation post-mining. 7) Restoration of Koala habitat in the rehabilitated landscape has been incorporated into progressive rehabilitation and closure criteria (see the Progressive Rehabilitation and Closure Plan).	2	A	H (16)
		Direct Mortality	Koala mortality during vegetation clearance.	1) The clearing footprint was located primarily in Koala habitat of the lowest quality (marginal), which rarely supports Koalas (none were recorded in this habitat type during surveys). 2) Clearing should occur in stages, to allow fauna the opportunity to exit the area. 3) Injured fauna is to be taken to the nearest wildlife carer or veterinarian. 4) Any injury and/or mortality is to be communicated to the Department of Environment and Science within 24 hours. 5) Vitrinite employees and contractors will be made aware of environmental obligations and compliance requirements through the site induction program.	2	D	L (5)
Greater Glider	Vegetation clearing	Clearing outside approved areas.	No habitat for Greater Gliders is contained within the proposed clearing footprint of the Project. Loss of habitat may only occur through unauthorised clearing outside the Project's defined boundaries.	1) Vitrinite employees and contractors are to be made aware of environmental obligations and compliance requirements through a site induction program. 2) The edges of the project footprint are to be marked out, to prevent unnecessary accidental clearing of neighbouring habitats.	2	E	L (3)
Squatter Pigeon	Vegetation clearing	Habitat loss	No water sources for the Squatter Pigeon will be disturbed by the Project. The clearing of 73.1 ha of primary habitat and 15.6 ha of secondary habitat is the principal anticipated impact of the Project on the Squatter Pigeon (3% of the total habitat contained within the survey area). This constitutes a loss of approximately 11 territories. The impacts of habitat clearance will persist at least for the short- to medium-term, until vegetation is re-established on mined land. Viability of local Squatter Pigeon populations is not threatened by the proposed habitat loss.	1) Where practicable, infrastructure has been positioned away from Squatter Pigeon habitat. 2) Overburden is mostly to be returned to the mined pits, to limit the total disturbance footprint of the project. 3) Topsoil removed from each site in preparation for mining is to be stored and managed in accordance with a Progressive Rehabilitation and Closure Plan, to protect a favourable growing medium for vegetation post-mining. 4) Habitat for Squatter Pigeons has been incorporated into progressive rehabilitation and closure criteria. 5) Large, connected tracts of Squatter Pigeon habitat are to be retained in the local landscape, protecting approximately 176 pairs of Squatter Pigeons, and providing a source of recruitment to rehabilitated areas in the future. 6) Vitrinite employees and contractors are to be made aware of environmental obligations and compliance requirements through a site induction program. 7) The edges of the project footprint are to be marked out, to prevent unnecessary accidental clearing of neighbouring habitats.	3	A	E (20)

CONSTRUCITON PHASE							
MSES/MNES	**Activity**	**Hazard**	**Impact Description**	**Proposed Controls**	**Consequence**	**Likelihood**	**Risk Rating**
		Direct Mortality	Adult Squatter Pigeons are highly mobile and not susceptible to injury or mortality during vegetation clearing. However, nestlings may experience mortality during clearing. The narrow window of vulnerability (chicks remain in the nest for only 2-3 weeks) and the small number of breeding pairs potentially in the disturbance footprint (approximately 11) means that the risk of direct mortality is relatively low.	1) Clearing should occur in stages, to allow fauna the opportunity to exit the area. The disturbance associated with nearby clearing also dissuades fauna from nesting in or using areas soon to be cleared. 2) Injured fauna is to be taken to the nearest wildlife carer or veterinarian. 3) Any injury and/or mortality is to be communicated to the Department of Environment and Science within 24 hours. 4) Vitrinite employees and contractors will be made aware of environmental obligations and compliance requirements through the site induction program.	2	D	L (5)
Short-beaked Echidna	Vegetation clearing	Habitat loss	Short-beaked Echidnas potentially occupy all habitats on site, including the 224.5 ha to be cleared. This constitutes a potential loss of 2-5 territories. There are no habitat features of the Project footprint that make it locally significant, and extensive tracts of habitat will be retained to the west. Viability of the local echidna population is not threatened by the proposed habitat loss.	1) The disturbance footprint has been designed to largely avoid remnant vegetation, which is of higher quality for echidnas than the regrowth to be removed, because it contains an abundance of fallen timber, important for denning and providing termites. Undisturbed sandstone areas to the west also contain an abundance of boulders, which provide den sites. 2) Vitrinite employees and contractors are to be made aware of environmental obligations and compliance requirements through a site induction program. 3) The edges of the project footprint are to be marked out, to prevent unnecessary accidental clearing of neighbouring habitats. 4) The total footprint of the Project has been minimised by returning overburden to the mined pits. 5) Topsoil removed from each site in preparation for mining is to be stored and managed in accordance with a Progressive Rehabilitation and Closure Plan, to protect a favourable growing medium for vegetation post-mining. 6) Post-mining rehabilitation will aim to restore habitat values for the Short-beaked Echidna.	2	A	H (16)
		Direct Mortality	Short-beaked Echidna mortality during vegetation clearing. The small number of echidnas potentially within the disturbance footprint (2-5 individuals) means there is a relatively low risk of direct mortality.	1) Clearing should occur in stages, to allow fauna the opportunity to exit the area. The disturbance associated with nearby clearing also dissuades fauna from using areas soon to be cleared. 2) Injured fauna is to be taken to the nearest wildlife carer or veterinarian. 3) Any injury and/or mortality is to be communicated to the Department of Environment and Science within 24 hours. 4) Vitrinite employees and contractors will be made aware of environmental obligations and compliance requirements through the site induction program.	3	D	L (5)
Rufous Fantail	Vegetation clearing	Habitat loss	A total of 9.2 ha of potential habitat for transient Rufous Fantails will be removed to accommodate the Vulcan Complex project. Habitat for this species is highly unlikely to be limiting within the local landscape. The habitat loss will not disturb a nationally significant proportion of the population of the species.	1) The edges of the project footprint are to be marked out, to prevent unnecessary accidental clearing of neighbouring habitats. 2) The total footprint of the Project has been minimised by returning overburden to the mined pits.	1	A	M (11)
		Direct Mortality	Adult Rufous Fantails are highly mobile and not susceptible to impact with machinery. No breeding occurs on site.	1) Clearing should occur in stages, to allow fauna the opportunity to exit the area. 2) Injured fauna is to be taken to the nearest wildlife carer or veterinarian. 3) Any injury and/or mortality is to be communicated to the Department of Environment and Science within 24 hours. 4) Vitrinite employees and contractors will be made aware of environmental obligations and compliance requirements through the site induction program.	1	E	L (1)
Fork-tailed Swift	Vegetation clearing	Habitat loss for prey species	Given the scale of the project, the availability of insect habitat that will remain both within and adjacent to the project, and the limited and transient use of the area by Fork-tailed Swifts, there are not likely to be declines in insect populations within and surrounding the project area that could affect Fork-tailed Swifts.	N/A	1	E	L (1)
Latham's Snipe	Vegetation clearing	Clearing outside designated areas, habitat loss.	A small dam comprising potential habitat for Latham's Snipe is located less than 100 m from the proposed clearing footprint. Loss of habitat may only occur through unauthorised clearing outside the Project's defined boundaries.	1) The footprint of the Vulcan Complex project has been designed to avoid all dams and natural wetlands. 2) Vitrinite employees and contractors are to be made aware of environmental obligations and compliance requirements through a site induction program. 3) The edges of the project footprint are to be marked out, to prevent unnecessary accidental clearing of neighbouring habitats.	3	E	M (6)
Common Death Adder	Vegetation clearing	Habitat loss	75.5 ha of marginal habitat (lowland areas with an abundance of Cane Toads and few rocks) will be removed for the proposed mine and associated infrastructure. Few or no Common Death Adders are expected to be present within this footprint. None were detected during extensive surveys of the broader region.	1) Core habitat for the species (rugged sandstone areas to the west) is avoided by the Project. 2) Vitrinite employees and contractors are to be made aware of environmental obligations and compliance requirements through a site induction program. 3) The edges of the project footprint are to be marked out, to prevent unnecessary accidental clearing of neighbouring habitats. 4) The total footprint of the Project has been minimised by returning overburden to the mined pits.	2	E	L (3)

CONSTRUCITON PHASE							
MSES/MNES	**Activity**	**Hazard**	**Impact Description**	**Proposed Controls**	**Consequence**	**Likelihood**	**Risk Rating**
		Direct mortality	Common Death Adders may experience mortality during vegetation clearing, as they are slow-moving and mostly nocturnal. The probable absence of the species within the disturbance footprint means that the risk of direct mortality during clearing is low. In the unlikely event that any mortality occurs, very few individuals would be affected.	1) Clearing should occur in stages, to allow fauna the opportunity to exit the area. 2) Injured fauna is to be taken to the nearest wildlife carer or veterinarian. 3) Any injury and/or mortality is to be communicated to the Department of Environment and Science within 24 hours. 4) Vitrinite employees and contractors will be made aware of environmental obligations and compliance requirements through the site induction program.	2	E	L (3)
	Damming of water	Proliferation of Cane Toads as a result of increased water storage on-site.	Common Death Adders eat cane toads, but this usually results in mortality. Proliferation of cane toads reduces habitat quality for Common Death Adders. High densities of Cane Toads already occur in the vicinity of the Project, due to pre-existing dams. This existing surface water, in conjunction with the short duration of the Project, means that the Project will have a negligible impact on local toad populations.	N/A	1	D	L (2)
Threatened Ecological Communities (TECs)	Vegetation clearing	Clearing outside approved areas	The nearest TEC (Brigalow *Acacia harpophylla* dominant and co-dominant) occurs 5 km away and is of negligible risk of accidental disturbance as a result of unauthorised clearing.	1) Vitrinite employees and contractors are to be made aware of environmental obligations and compliance requirements through a site induction program. 2) The edges of the project footprint are to be marked out, to prevent unnecessary accidental clearing of neighbouring habitats.	3	E	M (6)
"Endangered" or "of concern" Category B Vegetation	Vegetation clearing	Clearing outside approved areas leading to reduced extent of regulated vegetation.	There is no "endangered" or "of concern" Category B regulated vegetation cleared within areas designated for clearing. None occurs within 500 m of the Project, and there is therefore negligible risk that unauthorised clearing could occur inadvertently.	1) The Project has been designed to minimise disturbance to category B vegetation and avoid disturbance to any vegetation listed as "endangered" or "of concern". 2) Vitrinite employees and contractors are to be made aware of environmental obligations and compliance requirements through a site induction program. 3) The edges of the project footprint are to be marked out, to prevent unnecessary accidental clearing of neighbouring habitats.	3	E	M (6)
"Endangered" or "of concern" Category C Vegetation	Vegetation clearing	Clearing outside approved areas leading to reduced extent of regulated vegetation.	There is no "endangered" or "of concern" Category C regulated vegetation cleared within areas designated for clearing. None occurs within 500 m of the Project, and there is therefore negligible risk that unauthorised clearing could occur inadvertently.	1) The Project has been designed to avoid disturbance to category C vegetation listed as "endangered" or "of concern". 2) Vitrinite employees and contractors are to be made aware of environmental obligations and compliance requirements through a site induction program. 3) The edges of the project footprint are to be marked out, to prevent unnecessary accidental clearing of neighbouring habitats.	3	E	M (6)
Category R Vegetation	Vegetation clearing	Reduced extent of regulated vegetation.	17.9 ha of Category R vegetation, as mapped on the regulated vegetation map, is to be cleared to accommodate the Project. Field-verified RE mapping indicates that the true extent of Category R vegetation to be removed is 15.2 ha. Vegetation removal will be short-term, as post-mining rehabilitation will return vegetation to all watercourses once the Project is complete.	1) The Project was designed to avoid disturbance to watercourses to the maximum extent practicable. 2) The total footprint of the Project has been minimised by returning overburden to the mined pits. 3) The edges of the project footprint are to be marked out, to prevent unnecessary accidental clearing of neighbouring habitats. 4) Topsoil removed from each site in preparation for mining is to be stored and managed in accordance with a Progressive Rehabilitation and Closure Plan, to protect a favourable growing medium for vegetation post-mining. 5) Post-mine rehabilitation aims for a post-mine land use with similar environmental values to those being lost (see the Progressive Rehabilitation and Closure Plan).	3	A	E (20)
Vegetation within a defined distance from the defining bank of a watercourse.	Vegetation clearing	Reduced extent of vegetation along creek banks.	Field-verified RE mapping indicates that 17.7 ha of watercourse vegetation will be removed for the Project. This comprises 11.4 ha of non-remnant Category R vegetation (see above) and 6.3 ha of "least concern" regrowth Category C vegetation. Vegetation removal will be short-term, as post-mining rehabilitation will return vegetation to all watercourses once the Project is complete.	1) The Project was designed to avoid disturbance to watercourses to the maximum extent practicable. 2) The total footprint of the Project has been minimised by returning overburden to the mined pits. 3) The edges of the project footprint are to be marked out, to prevent unnecessary accidental clearing of neighbouring habitats. 4) Topsoil removed from each site in preparation for mining is to be stored and managed in accordance with a Progressive Rehabilitation and Closure Plan, to protect a favourable growing medium for vegetation post-mining. 5) Post-mine rehabilitation aims for a post-mine land use with similar environmental values to those being lost (see the Progressive Rehabilitation and Closure Plan).	3	A	E (20)

OPERATIONAL PHASE							
MSES/MNES	**Activity**	**Hazard**	**Impact Description**	**Proposed Controls**	**Consequence**	**Likelihood**	**Risk Rating**
Biodiversity	Excavation Blasting Machinery operation Transport	Dust	Any effects of dust on local biodiversity are expected to be highly localised (within 100 m of operational areas) and short-lasting. After the project ceases in four years, no lasting effects of dust on local biodiversity are anticipated.	1) Haulage between the mine and coal-processing facilities is along a sealed road. 2) Dust covers will cover coal in haulage trucks. 3) Topsoil will not be stripped on extremely windy days. 4) Topsoil stockpiles will be vegetated. 5) Water carts will be used to supress dust on haul roads. 6) Land disturbance will be restricted to that necessary for the works. 7) Progressive rehabilitation of disturbed areas will occur to reduce the potential for dust generation.	1	C	L (4)
		Light pollution	Any effects of artificial lighting on local biodiversity are expected to be highly localised (within 500 m of operational areas) and short-lasting. After the project ceases in four years, no lasting effects of lighting on local biodiversity are anticipated.	1) The following lighting designs should be used, where appropriate, in operational areas within 500 m of remnant vegetation: i. Artificial lighting used in operational areas is to be angled away from habitats supporting sensitive species (e.g., riparian areas supporting Koalas and Greater Gliders). ii. Floodlights with "low glare" louvres/attachments are recommended to limit lateral transmission of light. Note that newer LED-type flood lights may have glare-reduction technology built-in. iii. Any street lights used are recommended to be of the "aeroscreen" type (flat glass lenses), to reduce sideways glare. iv. Light fittings should be positioned as close to horizontally as possible.	1	C	L (4)
		Noise and vibration	Any effects of noise and vibration on local biodiversity are expected to be localised (within 500 m of operational areas) and short-lasting. After the project ceases in four years, no lasting effects of noise on local biodiversity are anticipated.	1) The Project has been located beside a busy road and adjacent to large-scale mining operations, such that any increase in noise resulting from the Project is expected to be negligible relative to existing background noise. 2) All coal-screening and processing is to take place at existing facilities at nearby mines, rather than on site.	1	C	L (4)
		Vehicle impact	Due to the design of internal roads away from habitat, fauna mortality due to vehicle strikes within the MLA area is expected to be negligible. Haulage will increase traffic rates on existing roads by up to 4.8% over current levels. The daily commute of workers to/from accommodation in Moranbah and/or Dysart will increase traffic on existing roads by up to 3.4%. This relatively minor increase in traffic could result in slightly increased fauna mortality along public roads. Impacts of increased traffic will be largely limited to the extraction phase of the mine (years 2-4), and will largely cease after four years, when the project is completed.	1) Haulage of coal to processing areas is on existing sealed roads. 2) Buses will transport ~80% of workers daily from accommodation to site, to reduce the total number of vehicles using the roads. Transportation of workers is on existing sealed roads. 3) Deposition of overburden within mined pits means that most on-site transportation occurs within the pit (away from habitat). 4) All infrastructure, mining areas, offices and soil stockpiles adjoin one another, so that there is to be minimal transport through fauna habitat to access various parts of the operations. The only exception is the explosives magazine, which must be located away from operations for safety reasons. While the track to the magazine passes through fauna habitat, this will experience very little traffic.	2	C	M (8)
		Weeds	Weeds, if introduced to the site via soil, machinery or footwear, could establish in or around the edges of the Project's disturbance footprint. With appropriate controls in place, this risk is considered to be low. Neighbouring vegetation grows on nutrient-deficient soils unfavourable for the establishment of most weeds, such that any weeds that establish as a result of the Project are unlikely to spread far beyond the disturbance footprint. An exception is riparian areas, which are prone to weed invasion due to elevated soil moisture and nutrients. Such areas already have very high pre-project weed densities (non-native plants comprise 80-90% of the groundcover in landzone 3) and, with measures in place, there is relatively little risk that the project will worsen this weed cover.	1) All vehicles that will enter undisturbed parts of the site are to be washed and certified prior to arrival at the Project site, to restrict the introduction of new weeds. Weed management activities will control weeds in high-traffic areas. 2) Light vehicles used for commuting between the project area and nearby towns (where they may be exposed to weeds) are to be parked in the visitor carpark. 3) Operational areas and the visitor carpark are to be inspected regularly (at least biannually) to identify new infestations of restricted weeds. These should be treated soon after detection, with follow-up treatment required until populations are eradicated. 4) Any weeds germinating on topsoil stockpiles should be treated and eradicated to maintain a source of weed-free growing medium for use post-mining. 5) Access to riparian areas is to be restricted, with signage installed to notify staff and contractors.	2	C	M (8)
Koala	Excavation Blasting Machinery operation Transport	Noise and vibration	A small amount (0.9 ha) of primary habitat is located within 200 m of the main operational areas (mine pit, waste rock dumps and offices) and may experience minor disturbance from noise. Any disturbance will be of a short duration given the short life (up to four years) of the Project.	1) The Project has been located beside a busy road and adjacent to large-scale mining operations, such that any increase in noise resulting from the Project is expected to be negligible relative to existing background noise. 2) All coal-screening and processing is to take place at existing facilities at nearby mines, rather than on site.	1	C	L (4)
		Dust	Reduced photosynthetic activity in plants from dust deposition could result in lower food production for Koalas in trees close to operational areas. No primary habitat is located within 100 m of the project, and therefore will not be affected by dust. Some secondary and marginal habitat adjacent to operations may experience dust deposition, but the effects are expected to be short-lasting, given the short life (up to four years) of the Project.	1) Haulage between the mine and coal-processing facilities is along a sealed road. 2) Dust covers will cover coal in haulage trucks. 3) Topsoil will not be stripped on extremely windy days. 4) Topsoil stockpiles will be vegetated. 5) Water carts will be used to supress dust on haul roads. 6) Land disturbance will be restricted to that necessary for the works. 7) Progressive rehabilitation of disturbed areas will occur to reduce the potential for dust generation.	1	C	L (4)

OPERATIONAL PHASE							
MSES/MNES	**Activity**	**Hazard**	**Impact Description**	**Proposed Controls**	**Consequence**	**Likelihood**	**Risk Rating**
Greater Glider		Vehicle impact	Mortality or injury can arise through vehicle strikes. Haulage will increase traffic rates on existing roads by up to 4.8% over current levels. The daily commute of workers to/from accommodation in Moranbah and/or Dysart will increase traffic on existing roads by up to 3.4%. Impacts of increased traffic will be largely limited to the extraction phase of the mine (years 2-4).	1) Buses will transport ~80% of workers daily from accommodation to site, to reduce the total number of vehicles using the roads. 2) Road trucks used to transport coal are to be of the largest size safely driven on the relevant roads, to reduce the total number of trips required. 3) Commuters and haul trucks will utilise existing road infrastructure, to avoid introducing the threat of vehicles to new areas. 4) Injured fauna is to be taken to the nearest wildlife carer or veterinarian. 5) Any injury and/or mortality is to be communicated to the Department of Environment and Science within 24 hours. 6) Vitrinite employees and contractors will be made aware of environmental obligations and compliance requirements through the site induction program.	3	D	M (9)
	Artificial Lighting	Light pollution	Artificial lighting could disrupt sleep cycles or increase Koala's vulnerability to predators such as dingoes. A small amount (0.9 ha) of primary habitat is located within 200 m of the main operational areas (mine pit, waste rock dumps and offices), but further than 100 m, and may experience minor disturbance from lighting. Any impacts of lighting are short-term given the short life (up to four years) of the Project.	1) The following lighting designs should be used, where appropriate, in operational areas within 500 m of remnant vegetation: i. Artificial lighting used in operational areas is to be angled away from habitats supporting sensitive species (e.g., riparian areas supporting Koalas and Greater Gliders). ii. Floodlights with "low glare" louvres/attachments are recommended to limit lateral transmission of light. Note that newer LED-type flood lights may have glare-reduction technology built-in. iii. Any street lights used are recommended to be of the "aeroscreen" type (flat glass lenses), to reduce sideways glare. iv. Light fittings should be positioned as close to horizontally as possible.	1	C	L (4)
	Excavation Blasting Machinery operation Transport	Noise and vibration	A small amount (0.9 ha) of primary habitat is located within 200 m of the main operational areas (mine pit, waste rock dumps and offices) and may experience minor disturbance from noise. Any disturbance will be of a short duration given the short life (up to four years) of the Project.	1) The Project has been located beside a busy road and adjacent to large-scale mining operations, such that any increase in noise resulting from the Project is expected to be negligible relative to existing background noise. 2) All coal-screening and processing is to take place at existing facilities at nearby mines, rather than on site.	1	C	L (4)
		Vehicle impact	Greater Gliders have a relatively low risk of injury or mortality from vehicle strikes due to the fact they do not disperse across the ground, but rather glide between trees. While this risk may be negligible it is not zero, as low-flying gliders may be struck by vehicles. Haulage will increase traffic rates on existing roads by up to 4.8% over current levels. The daily commute of workers to/from accommodation in Moranbah and/or Dysart will increase traffic on existing roads by up to 3.4%. Impacts of increased traffic will be largely limited to the extraction phase of the mine (years 2-4).	1) Buses will transport ~80% of workers daily from accommodation to site, to reduce the total number of vehicles using the roads. 2) Road trucks used to transport coal are to be of the largest size safely driven on the relevant roads, to reduce the total number of trips required. 3) Commuters and haul trucks will utilise existing road infrastructure, to avoid introducing the threat of vehicles to new areas. 4) Injured fauna is to be taken to the nearest wildlife carer or veterinarian. 5) Any injury and/or mortality is to be communicated to the Department of Environment and Science within 24 hours. 6) Vitrinite employees and contractors will be made aware of environmental obligations and compliance requirements through the site induction program.	2	E	L (3)
		Dust	Reduced photosynthetic activity in plants from dust deposition could result in lower food production for Koalas in trees close to operational areas. No primary habitat is located within 100 m of the project, and therefore will not be affected by dust. Some secondary and marginal habitat adjacent to operations may experience dust deposition, but the effects are expected to be short-lasting, given the short life (up to four years) of the Project.	1) Haulage between the mine and coal-processing facilities is along a sealed road. 2) Dust covers will cover coal in haulage trucks. 3) Topsoil will not be stripped on extremely windy days. 4) Topsoil stockpiles will be vegetated. 5) Water carts will be used to supress dust on haul roads. 6) Land disturbance will be restricted to that necessary for the works. 7) Progressive rehabilitation of disturbed areas will occur to reduce the potential for dust generation.	1	C	L (4)
	Artificial Lighting	Light pollution	Artificial lighting could disrupt sleep cycles or increase Greater Gliders' vulnerability to predators such as owls. A small amount (0.9 ha) of habitat is located within 200 m of the main operational areas (mine pit, waste rock dumps and offices), but further than 100 m, and may experience minor disturbance from lighting. Any impacts of lighting are short-term given the short life (up to four years) of the Project.	1) The following lighting designs should be used, where appropriate, in operational areas within 500 m of remnant vegetation: i. Artificial lighting used in operational areas is to be angled away from habitats supporting sensitive species (e.g., riparian areas supporting Koalas and Greater Gliders). ii. Floodlights with "low glare" louvres/attachments are recommended to limit lateral transmission of light. Note that newer LED-type flood lights may have glare-reduction technology built-in. iii. Any street lights used are recommended to be of the "aeroscreen" type (flat glass lenses), to reduce sideways glare. iv. Light fittings should be positioned as close to horizontally as possible.	1	C	L (4)

OPERATIONAL PHASE							
MSES/MNES	**Activity**	**Hazard**	**Impact Description**	**Proposed Controls**	**Consequence**	**Likelihood**	**Risk Rating**
Squatter Pigeon	Excavation Blasting Machinery operation Transport	Noise and vibration	Squatter Pigeons are relatively tolerant of noise disturbance, based on regular sightings near high-traffic areas. Nevertheless, given that habitat for the species is located adjacent to operational areas, some disturbance is likely. Any disturbance will be of a short duration given the short life (up to four years) of the Project.	1) The Project has been located beside a busy road and adjacent to large-scale mining operations, such that any increase in noise resulting from the Project is expected to be negligible relative to existing background noise. 2) All coal-screening and processing is to take place at existing facilities at nearby mines, rather than on site.	1	B	M (7)
		Vehicle impact	Squatter Pigeons often forage on or beside dirt tracks, where they are vulnerable to vehicle impact. However, they rarely forage on sealed roads and increased road traffic as a result of the Project will have a negligible impact on the species.	1) Haulage of coal to processing areas is on existing sealed roads. 2) Buses will transport ~80% of workers daily from accommodation to site, to reduce the total number of vehicles using the roads. Transportation of workers is on existing sealed roads. 3) Deposition of overburden within mined pits means that most on-site transportation occurs within the pit (away from potential Squatter Pigeon habitat). 4) All infrastructure, mining areas, offices and soil stockpiles adjoin one another, so that there is to be minimal transport through potential Squatter Pigeon habitat to access various parts of the operations. The only exception is the explosives magazine, which must be located away from operations for safety reasons. While the track to the magazine passes through Squatter Pigeon habitat, this will experience very little traffic.	2	D	L (5)
		Dust	Reduced photosynthetic activity in plants from dust deposition could result in lower food production for Squatter Pigeons close to operational areas. As most food plants (primarily grasses) have a short growing and seeding season coinciding with periods of heavy rainfall (when the effects of dust are limited), their productivity is unlikely to be significantly affected by dust-generation at the project. Furthermore, any effects are expected to be short-lasting, given the short life (up to four years) of the Project.	1) Haulage between the mine and coal-processing facilities is along a sealed road. 2) Dust covers will cover coal in haulage trucks. 3) Topsoil will not be stripped on extremely windy days. 4) Topsoil stockpiles will be vegetated. 5) Water carts will be used to supress dust on haul roads. 6) Land disturbance will be restricted to that necessary for the works. 7) Progressive rehabilitation of disturbed areas will occur to reduce the potential for dust generation.	1	B	M (7)
		Weeds	Weeds, if introduced to the site via soil, machinery or footwear, could establish in or around the edges of the Project's disturbance footprint. Certain species (especially tall-growing exotic grasses, which can smother bare ground used by Squatter Pigeons for foraging) may reduce habitat suitability for the species. With appropriate controls in place, this risk is considered to be low. Neighbouring vegetation grows on nutrient-deficient soils unfavourable for the establishment of most weeds, such that any weeds that establish as a result of the Project are unlikely to spread far beyond the disturbance footprint.	1) All vehicles that will enter undisturbed parts of the site are to be washed and certified prior to arrival at the Project site, to restrict the introduction of new weeds. Weed management activities will control weeds in high-traffic areas. 2) Light vehicles used for commuting between the project area and nearby towns (where they may be exposed to weeds) are to be parked in the visitor carpark. 3) Operational areas and the visitor carpark are to be inspected regularly (at least biannually) to identify new infestations of restricted weeds. These should be treated soon after detection, with follow-up treatment required until populations are eradicated. 4) Any weeds germinating on topsoil stockpiles should be treated and eradicated to maintain a source of weed-free growing medium for use post-mining.	2	C	M (8)
	Artificial Lighting	Light pollution	Artificial lighting could disrupt sleep cycles or increase Squatter Pigeons' vulnerability to nocturnal predators such as cats and dingos where habitat occurs within 100 m of operational areas. Any impacts of lighting are short-term given the short life (up to four years) of the Project.	1) The following lighting designs should be used, where appropriate, in operational areas within 500 m of remnant vegetation: i. Artificial lighting used in operational areas is to be angled away from habitats supporting sensitive species (e.g., remnant forest). ii. Floodlights with "low glare" louvres/attachments are recommended to limit lateral transmission of light. Note that newer LED-type flood lights may have glare-reduction technology built-in. iii. Any street lights used are recommended to be of the "aeroscreen" type (flat glass lenses), to reduce sideways glare. iv. Light fittings should be positioned as close to horizontally as possible.	1	B	M (7)
Short-beaked Echidna	Excavation Blasting Machinery operation Transport	Noise and vibration	Noise emanating from operations constitutes a potential disturbance to Short-beaked Echidnas in close proximity. The minor disturbance to habitat as a result of noise is of short duration, and will cease once extraction is complete (within four years).	1) The Project has been located beside a busy road and adjacent to large-scale mining operations, such that any increase in noise resulting from the Project is expected to be negligible relative to existing background noise. 2) All coal-screening and processing is to take place at existing facilities at nearby mines, rather than on site.	1	B	M (7)

OPERATIONAL PHASE							
MSES/MNES	**Activity**	**Hazard**	**Impact Description**	**Proposed Controls**	**Consequence**	**Likelihood**	**Risk Rating**
		Vehicle impact	Being ground-dwelling and slow-moving, Short-beaked Echidnas are vulnerable to vehicle strikes. Haulage will increase traffic rates on existing roads by up to 4.8% over current levels. The daily commute of workers to/from accommodation in Moranbah and/or Dysart will increase traffic on existing roads by up to 3.4%. It is anticipated that this increase in traffic due to the Project could result in approximately one echidna death per year. Impacts of increased traffic will be largely limited to the extraction phase of the mine (years 2-4).	1) Buses will transport ~80% of workers daily from accommodation to site, to reduce the total number of vehicles using the roads. 2) Road trucks used to transport coal are to be of the largest size safely driven on the relevant roads, to reduce the total number of trips required. 3) Commuters and haul trucks will utilise existing road infrastructure, to avoid introducing the threat of vehicles to new areas. 4) Deposition of overburden within mined pits means that most on-site transportation occurs within the pit (away from potential echidna habitat). 5) All infrastructure, mining areas, offices and soil stockpiles adjoin one another, so that there is to be minimal transport through potential echidna habitat to access various parts of the operations. The only exception is the explosives magazine, which must be located away from operations for safety reasons. While the track to the magazine passes through echidna habitat, this will experience very little traffic. 6) Injured fauna is to be taken to the nearest wildlife carer or veterinarian. 7) Any injury and/or mortality is to be communicated to the Department of Environment and Science within 24 hours. 8) Vitrinite employees and contractors will be made aware of environmental obligations and compliance requirements through the site induction program.	3	D	M (9)
	Artificial Lighting	Light pollution	Artificial lighting could disrupt sleep cycles in echidnas living in close proximity to operations. Given the large home rages of echidnas and the relatively little time each individual is expected to spend in proximity to artificial lighting, this effect is negligible.	1) The following lighting designs should be used, where appropriate, in operational areas within 500 m of remnant vegetation: i. Artificial lighting used in operational areas is to be angled away from habitats supporting sensitive species (e.g., remnant forest). ii. Floodlights with "low glare" louvres/attachments are recommended to limit lateral transmission of light. Note that newer LED-type flood lights may have glare-reduction technology built-in. iii. Any street lights used are recommended to be of the "aeroscreen" type (flat glass lenses), to reduce sideways glare. iv. Light fittings should be positioned as close to horizontally as possible.	1	E	L (1)
Rufous Fantail	Excavation Blasting Machinery operation Transport	Noise and vibration	Given the relatively small amount of potential habitat adjoining operational areas, the brief period of time transient individuals are expected to be present, and the relative insensitivity of the species to noise during migration (occurring in highly disturbed urban bushland or near busy roads), noise is considered a relatively minor impact of the Project on the Rufous Fantail.	1) The Project has been located beside a busy road and adjacent to large-scale mining operations, such that any increase in noise resulting from the Project is expected to be negligible relative to existing background noise. 2) All coal-screening and processing is to take place at existing facilities at nearby mines, rather than on site.	1	D	L (2)
		Vehicle impact	Rufous Fantails are highly mobile and occur in very low densities and for a brief window of time each year within the dry woodlands that comprise the project area. Consequently, they are at very low risk of vehicle strike resulting from increasing traffic due to the project.	1) Buses will transport ~80% of workers daily from accommodation to site, to reduce the total number of vehicles using the roads. 2) Road trucks used to transport coal are to be of the largest size safely driven on the relevant roads, to reduce the total number of trips required. 3) Commuters and haul trucks will utilise existing road infrastructure, to avoid introducing the threat of vehicles to new areas. 4) Deposition of overburden within mined pits means that most on-site transportation occurs within the pit (away from potential Rufous Fantail habitat). 5) All infrastructure, mining areas, offices and soil stockpiles adjoin one another, so that there is to be minimal transport through potential Rufous Fantail habitat to access various parts of the operations. 6) Injured fauna is to be taken to the nearest wildlife carer or veterinarian. 7) Any injury and/or mortality is to be communicated to the Department of Environment and Science within 24 hours. 8) Vitrinite employees and contractors will be made aware of environmental obligations and compliance requirements through the site induction program.	1	E	L (1)
	Artificial Lighting	Light pollution	Artificial lighting could disrupt sleep cycles in Rufous Fantails living in close proximity to operations. Given the limited extent of nearby habitat and the highly transient nature of local populations of Rufous Fantails (individuals are unlikely to remain in this habitat for long), the effects of light pollution arising from the project are expected to be negligible.	1) The following lighting designs should be used, where appropriate, in operational areas within 500 m of remnant vegetation: i. Artificial lighting used in operational areas is to be angled away from habitats supporting sensitive species (e.g., remnant forest and riparian areas). ii. Floodlights with "low glare" louvres/attachments are recommended to limit lateral transmission of light. Note that newer LED-type flood lights may have glare-reduction technology built-in. iii. Any street lights used are recommended to be of the "aeroscreen" type (flat glass lenses), to reduce sideways glare. iv. Light fittings should be positioned as close to horizontally as possible.	1	E	L (1)

OPERATIONAL PHASE							
MSES/MNES	**Activity**	**Hazard**	**Impact Description**	**Proposed Controls**	**Consequence**	**Likelihood**	**Risk Rating**
Fork-tailed Swift	Excavation Blasting Machinery operation Transport	Noise and vibration	Fork-tailed Swifts are only expected to utilise airspace above the project transiently and briefly (for a matter of minutes per year), and are therefore of very little risk of being impacted by noise. Any minor disturbance to habitat as a result of the Vulcan Complex Project is of short duration, and will cease once extraction is complete (within four years).	N/A	1	E	L (1)
		Vehicle impact	Fork-tailed Swifts are fast-flying and usually high above the ground. They are very rarely hit by vehicles.	N/A	1	E	L (1)
	Artificial Lighting	Light pollution	Fork-tailed Swifts are diurnal and do not roost near the project. Light pollution can lead to long-term declines in insect populations (Conrad et al. 2006), the main food of swifts. However, the short life and scale of the project, relatively to existing sources of light in the local landscape, suggest that any effects of the project on Fork-tailed Swifts are negligible.	N/A	1	E	L (1)
Latham's Snipe	Excavation Blasting Machinery operation	Noise and vibration	Sudden, loud noises emanating from close to the existing dam could cause any visiting Latham's Snipe to startle and leave. The main activity occurring adjacent to this dam is the out-of-pit waste rock dump, which will only be active for the first 1-2 years of the project. Thereafter, there will be negligible impacts on Latham's Snipe due to noise disturbance.	1) The Project has been located beside a busy road and adjacent to large-scale mining operations, such that any increase in noise resulting from the Project is expected to be negligible relative to existing background noise. 2) All coal-screening and processing is to take place at existing facilities at nearby mines, rather than on site. 3) The pre-existing flood levee wall is positioned between the dam and the main mining areas, and acts to dampen noise emanating from operational areas.	2	D	L (5)
		Clearing outside designated areas, habitat loss.	Unauthorised, inadvertent damage to the existing dam could reduce the extent of habitat for Latham's Snipe. This is considered unlikely with appropriate controls in place.	1) Vitrinite employees and contractors are to be made aware of environmental obligations and compliance requirements through a site induction program. 2) The edges of the project footprint are to be marked out, to prevent unnecessary accidental clearing of neighbouring habitats.	3	E	M (6)
		Mine-affected water	Based on the geochemistry of waste rock, there is minimal risk of acid and/or metalliferous drainage from waste rock into the existing dam (potential habitat for Latham's Snipe). Furthermore, the catchment of the dam is entirely upstream from operational areas. There is therefore negligible risk that the project will compromise water quality within the dam.	1) Water management infrastructure includes surface water drains around the base of the out-of-pit waste rock dump, which direct mine-affected water away from the dam and into sediment ponds.	3	E	M (6)
	Artificial Lighting	Light pollution	Light emanating from out-of-pit and in-pit waste rock dumps has the potential to disperse to the dam. These low levels of light may elevate the predation risk for Latham's Snipe, making them potentially more visible to cats and owls. Given the brief periods of time the species is expected to utilise the dam, and the short life of the project, these impacts are expected to be minor.	1) The following lighting designs should be used, where appropriate, in operational areas within 500 m of remnant vegetation: i. Artificial lighting used in operational areas is to be angled away from habitats supporting sensitive species (e.g., the dam). ii. Floodlights with "low glare" louvres/attachments are recommended to limit lateral transmission of light. Note that newer LED-type flood lights may have glare-reduction technology built-in. iii. Any street lights used are recommended to be of the "aeroscreen" type (flat glass lenses), to reduce sideways glare. iv. Light fittings should be positioned as close to horizontally as possible.	2	B	M (12)
Common Death Adder	Machinery operation Transport	Vehicle impact	Common Death Adders may experience mortality due to impacts with machinery and light vehicles. The probable absence of the species within the disturbance footprint means that the risk of direct mortality is low. Furthermore, with the exception of the infrequently used track to the explosives magazine, all internal roads will not pass through potential habitat for the Common Death Adder. There is a slight risk that elevated traffic on the public roads as a result of the project could result in up to one death per year.	1) Buses will transport ~80% of workers daily from accommodation to site, to reduce the total number of vehicles using the roads. 2) Road trucks used to transport coal are to be of the largest size safely driven on the relevant roads, to reduce the total number of trips required.	2	D	L (5)

OPERATIONAL PHASE							
MSES/MNES	**Activity**	**Hazard**	**Impact Description**	**Proposed Controls**	**Consequence**	**Likelihood**	**Risk Rating**
Threatened Ecological Communities (TECs)	Excavation Blasting Machinery operation Transport	Dust	The nearest TEC (Brigalow *Acacia harpophylla* dominant and co-dominant) occurs 5 km away and is of negligible risk of impacts through dust and weeds during the project's operations.	N/A	1	E	L (1)
		Weeds		N/A	1	E	L (1)
"Endangered" or "of concern" Category B Vegetation	Excavation Blasting Machinery operation Transport	Dust	The nearest "endangered" or "of concern" category B vegetation is over 2 km from operational areas, and therefore has a negligible risk of impact from dust deposition or weeds.	N/A	1	E	L (1)
		Weeds		N/A	1	E	L (1)
Endangered" or "of concern" Category C Vegetation	Excavation Blasting Machinery operation Transport	Dust	The nearest "endangered" or "of concern" category C vegetation is over 2 km from operational areas, and therefore has a negligible risk of impact from dust deposition or weeds.	N/A	1	E	L (1)
		Weeds		N/A	1	E	L (1)
Category R Vegetation	Excavation Blasting Machinery operation Transport	Dust	19.4 ha of Category R vegetation occurs within the MLA area outside the proposed clearing footprint. There is the potential that dust arising from the project may settle on some of this vegetation (particularly that within 100 m of operational areas) and impair photosynthesis. Given the short life of the project (dust levels will return to baseline after four years), there will be no long-term impacts of dust on Category R vegetation.	1) Haulage between the mine and coal-processing facilities is along a sealed road. 2) Dust covers will cover coal in haulage trucks. 3) Topsoil will not be stripped on extremely windy days. 4) Topsoil stockpiles will be vegetated. 5) Water carts will be used to supress dust on haul roads. 6) Land disturbance will be restricted to that necessary for the works. 7) Progressive rehabilitation of disturbed areas will occur to reduce the potential for dust generation.	1	B	M (7)
		Weeds	Weeds, if introduced to the site via soil, machinery or footwear, could establish in or around the edges of the Project's disturbance footprint and be carried downstream. With appropriate controls in place, this risk is considered to be low. Neighbouring Category R vegetation grows on nutrient-deficient soils unfavourable for the establishment of most weeds, such that any weeds that establish as a result of the project are unlikely to spread far beyond the disturbance footprint. Most local Category R vegetation is located upstream of the project. Downstream areas are already highly modified by neighbouring large-scale mining projects.	1) All vehicles that will enter undisturbed parts of the site are to be washed and certified prior to arrival at the Project site, to restrict the introduction of new weeds. Weed management activities will control weeds in high-traffic areas. 2) Light vehicles used for commuting between the project area and nearby towns (where they may be exposed to weeds) are to be parked in the visitor carpark. 3) Operational areas and the visitor carpark are to be inspected regularly (at least biannually) to identify new infestations of restricted weeds. These should be treated soon after detection, with follow-up treatment required until populations are eradicated. 4) Any weeds germinating on topsoil stockpiles should be treated and eradicated to maintain a source of weed-free growing medium for use post-mining.	2	C	M (8)
Vegetation within a defined distance from the defining bank of a watercourse.	Excavation Blasting Machinery operation Transport	Dust	There is the potential that dust arising from the project may settle on some vegetation along watercourses (particularly that within 100 m of operational areas) and impair photosynthesis. Given the short life of the project (dust levels will return to baseline after four years), there will be no long-term impacts of dust on watercourse vegetation.	1) Haulage between the mine and coal-processing facilities is along a sealed road. 2) Dust covers will cover coal in haulage trucks. 3) Topsoil will not be stripped on extremely windy days. 4) Topsoil stockpiles will be vegetated. 5) Water carts will be used to supress dust on haul roads. 6) Land disturbance will be restricted to that necessary for the works. 7) Progressive rehabilitation of disturbed areas will occur to reduce the potential for dust generation.	1	B	M (7)

OPERATIONAL PHASE							
MSES/MNES	**Activity**	**Hazard**	**Impact Description**	**Proposed Controls**	**Consequence**	**Likelihood**	**Risk Rating**
		Weeds	Weeds, if introduced to the site via soil, machinery or footwear, could establish in or around the edges of the Project's disturbance footprint and be carried downstream. Riparian areas on site have very high pre-project weed densities (non-native plants comprise 80-90% of the groundcover in landzone 3). Areas downstream of the project are also already highly modified by neighbouring large-scale mining projects. With appropriate controls in place, and in consideration of the current state of riparian vegetation, it is unlikely that the project will substantially worsen the weed threat to watercourse vegetation.	1) All vehicles that will enter undisturbed parts of the site are to be washed and certified prior to arrival at the Project site, to restrict the introduction of new weeds. Weed management activities will control weeds in high-traffic areas. 2) Light vehicles used for commuting between the project area and nearby towns (where they may be exposed to weeds) are to be parked in the visitor carpark. 3) Operational areas and the visitor carpark are to be inspected regularly (at least biannually) to identify new infestations of restricted weeds. These should be treated soon after detection, with follow-up treatment required until populations are eradicated. 4) Any weeds germinating on topsoil stockpiles should be treated and eradicated to maintain a source of weed-free growing medium for use post-mining. 5) Access to riparian areas is to be restricted, with signage installed to notify staff and contractors.	2	C	M (8)
Groundwater dependent Ecosystems (GDEs)	Excavation	Groundwater drawdown	Groundwater modelling suggests that any drawdown as a result of groundwater evaporation from the pit is highly localised and unlikely to occur in the vicinity of GDEs. The zone of drawdown does contain some GDEs, but only within the clearing footprint. No remnant vegetation outside the clearing footprint is found within the zone of drawdown.	N/A	3	E	M (6)