# Central Queensland Coal Project

# Appendix 11c – Draft Mamelon Offset Area Management Plan

Central Queensland Coal

CQC SEIS, Version 3

October 2020

# Mamelon Offset Area Management Plan

## Central Queensland Coal Project

August 2020

# APPROVALS

| Rev | Date | Description |
|---|---|---|
| 0 | 30 July 2020 | Draft issued for review |
| 1 | 25 August 2020 | Draft revised for submission |

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# APPROVAL HOLDER DECLARATION

I declare that:

1. To the best of my knowledge, all the information contained in, or accompanying this Mamelon Offset Area Management Plan is complete, current and correct.

2. I am duly authorised to sign this declaration on behalf of the approval holder.

3. I am aware that:

a. Section 490 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth; EPBC Act) makes it an offence for an approval holder to provide information in response to an approval condition where the person is reckless as to whether the information is false or misleading.

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Signed: _____

Full name: _____

Organisation: _____

Date: ___ / ___/ _____

# EXECUTIVE SUMMARY

This offset area management plan (OAMP) has been prepared to address offset requirements for matters of national environmental significance (MNES) and matters of state environmental significance (MSES) associated with the Central Queensland Coal Project (the Project) to be undertaken by Central Queensland Coal Pty Ltd (CQC) and Fairway Coal Pty Ltd (Fairway Coal). As CQC is the senior proponent, CQC is referred to as the proponent for this Project.

The Project was deemed a controlled action (EPBC 2016/7851) and is being assessed under the bilateral agreement between the Commonwealth and the State of Queensland in accordance with section 45 of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth; EPBC Act). The Project will result in significant residual impacts on MNES and MSES for which CQC will be required to provide biodiversity offsets in accordance with the EPBC Act Environmental Offsets Policy (DSEWPC 2012) and Queensland Environmental Offsets Policy (DES 2020).

Table ES-1 presents a summary of the Project's significant residual impacts to be offset for MNES and MSES.

**Table ES-1: Summary of the Project's significant residual impacts and anticipated offsets.**

| Protected Matter | Status | Significant residual Impact (ha) | | Total impact to offset (ha) |
|---|---|---|---|---|
| **MNES – Listed threatened species and ecological communities** | **EPBC Act** | **Direct** | **Indirect** | |
| Habitat for greater glider (*Petauroides volans*) | Vulnerable | 115.7 | 165.2 | 281.0 |
| Habitat for koala (*Phascolarctos cinereus*) | Vulnerable | 159.4 | 165.2 | 324.6 |
| Habitat for squatter pigeon (southern) (*Geophaps scripta scripta*) | Vulnerable | 141.4 | 165.2 | 306.6 |
| Habitat for ornamental snake (*Denisonia maculata*) | Vulnerable | 18.8 | 0 | 18.8 |
| **MSES – Regulated vegetation** | **VM Act** | | | |
| RE 11.3.4 (BVG 16c) | Of concern | 1.4 | 39.3 | 40.7 |
| RE 11.4.2 (BVG 17a) | Of concern | 110.8 | 0 | 110.8 |
| Watercourse RE 11.3.4 (BVG 16c) | Of concern | 0.5 | 3.8 | 4.3 |
| Watercourse RE 11.3.25 (BVG 16a) | Least concern | 10.7 | 68.1 | 78.8 |
| Essential habitat for greater glider | - | 0 | 15.0 | 15.0* |
| Essential habitat for koala | - | 96.1 | 14.3 | 110.4* |
| Essential habitat for squatter pigeon | - | 14.6 | 14.3 | 28.9* |
| **MSES – Protected wildlife habitat** | **NC Act** | | | |
| Habitat for greater glider | Vulnerable | 115.7 | 165.2 | 281.0* |
| Habitat for koala | Vulnerable | 159.4 | 165.2 | 324.6* |
| Habitat for squatter pigeon | Vulnerable | 141.4 | 165.2 | 306.6* |
| Habitat for ornamental snake | Vulnerable | 18.8 | 0 | 18.8* |

| Protected Matter | Status | Significant residual Impact (ha) | | Total impact to offset (ha) |
|---|---|---|---|---|
| **MSES – Waterway fish passage** | | **Direct** | **Indirect** | |
| Waterway providing for fish passage | - | 8.35 +ha | - | 8.35 ha+ |

* To be offset as an MNES protected matter, noting that the State cannot impose an offset condition for a prescribed activity that has the 'same, or substantially the same' impact on the 'same, or substantially the same' matter as the MNES, if it has already been assessed as a 'controlled action' under the EPBC Act.
+ Based on an impact to 8.35 km of waterway providing for fish passage with an average width of 10 m.

Table ES-2 presents a summary of the Project's offsets for MNES and MSES that will be secured on the Mamelon property. Mamelon (Lot 9 MC496, Lot 10 MC493 and Lot 11 MC23) is a 6,259 ha leasehold cattle grazing property located approximately 25 km north-west of Marlborough, in Queensland's Brigalow Belt bioregion. Mamelon (and adjacent properties) is also the location of the Project , however all offset areas are outside the Project's proposed development footprint and Mining Lease Application (ML) areas (ML 80187 and ML 700022).

**Table ES-2: Summary of anticipated MNES and MSES offsets to be secured on Mamelon.**

| Protected matter | Total significant residual impact to be offset (ha) | Offset area to be secured on Mamelon (ha) | Acquittal (%)^ /minimum offset area required (ha)# | Is MNES/MSES fully acquit on Mamelon? |
|---|---|---|---|---|
| Greater glider | 281.0 | 2,428.4 | 100.03% | Yes |
| Koala | 324.6 | 2,803.4 | 100.10% | Yes |
| Squatter pigeon | 306.6 | 2,667.1 | 100.80% | Yes |
| RE 11.3.4 (BVG 16c) | 40.7 | 14.8* | 162.8 | No* |
| RE 11.4.2 (BVG 17a) | 110.8 | 443.2 | 443.2 | Yes |
| Watercourse RE 11.3.4 (BVG 16c) | 4.3 | 14.8* | 17.2 | No* |
| Watercourse RE 11.3.25 (BVG 16a) | 78.8 | 100.8* | 315.2 | No* |

^ Acquittal (%) calculated in accordance with the EPBC Act Environmental Offsets Policy and associated offsets assessment guide.
# Minimum offset area (ha) calculated in accordance with the Queensland Environmental Offsets Policy and associated land-based offset multiplier calculator.
* Balance of offset to be secured on an additional property (or other land-based offset and/or financial settlement offset for MSES in accordance with Queensland Environmental Offsets Policy).

The primary purpose of this OAMP is to address both Commonwealth and State offset requirements for the Project and guide the ongoing management and monitoring of the Mamelon offset area. The Mamelon OAMP aims to improve the quality of habitat and vegetation for MNES and MSES within the offset area. The Mamelon offset area will be managed and monitored based on an adaptive management framework, using interim performance targets and completion criteria, as set out in Table ES-3.

**Table ES-3: Interim performance targets and completion criteria for offsets on Mamelon.**

| Offset value | Interim performance targets – year 10 of management | Completion criteria – year 20 of management |
|---|---|---|
| Greater glider | ▶ Improve the quality of greater glider habitat to achieve a habitat quality score greater than 7<br>▶ Non-native plant cover – increase the score across all monitoring sites to a 5 representing between 5% to 25% of non-native plant cover at each site. | Improve the quality of greater glider habitat to achieve a habitat quality score of 8.<br>▶ Site condition – the following scores for each ecological attribute will in part or whole be achieved through the implementation of specific management actions under the OAMP:<br>– Native shrub species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25<br>– Native grass species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25<br>– Native forb species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25<br>– Tree canopy height – increase the score across all monitoring sites to a 5 representing 70% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25<br>– Shrub canopy cover – increase the score across all monitoring sites to a 5 representing between 50% and 200% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25<br>– Native perennial grass cover – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25<br>– Large trees – increase the score for all monitoring sites to a 10, representing between 50% to 100% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25<br>– Non-native plant cover – increase the score across all monitoring sites to a 10 representing <5% non-native plant cover at each site.<br>▶ Site context<br>– Average site context score for each RE is maintained or increased compared to the start quality score:<br>– RE 11.10.7 – ≥ 7.03<br>– RE 11.11.15 – ≥ 7.38<br>– RE 11.4.2 – ≥ 8.50<br>– RE 11.5.8 – ≥ 7.60<br>– RE 11.3.25 – ≥ 8.53<br>▶ Species habitat index<br>– Increase the threats to species score to a 15 through the implementation of the OAMP specifically implementation of successful pest animal control targeting wild dogs, cats and foxes, active fire management, security through a legally binding mechanism and active management of the area for conservation purposes. |
| Koala | ▶ Improve the quality of koala habitat to achieve a habitat quality score greater than 7<br>▶ Non-native plant cover – increase the score across all monitoring sites to a 5 representing between 5% to 25% of non-native plant cover at each site. | Improve the quality of koala habitat to achieve a habitat quality score of 8.<br>▶ Site condition – the following scores for each ecological attribute will in part or whole be achieved through the implementation of specific management actions under the OAMP:<br>– Native shrub species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8, RE 11.3.25, RE 11.11.1, RE 11.3.35 and RE 11.3.4<br>– Native grass species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8, RE 11.3.25, RE 11.11.1, RE 11.3.35 and RE 11.3.4<br>– Native forb species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8, RE 11.3.25, RE 11.11.1, RE 11.3.35 and RE 11.3.4<br>– Tree canopy height – increase the score across all monitoring sites to a 5 representing 70% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8, RE 11.3.25, RE 11.11.1, RE 11.3.35 and RE 11.3.4<br>– Shrub canopy cover – increase the score across all monitoring sites to a 5 representing between 50% and 200% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8, RE 11.3.25, RE 11.11.1, RE 11.3.35 and RE 11.3.4<br>– Native perennial grass cover – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8, RE 11.3.25, RE 11.11.1, RE 11.3.35 and RE 11.3.4<br>– Large trees – increase the score across all monitoring sites to a 10, representing between 50% to 100% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8, RE 11.3.25, RE 11.11.1, RE 11.3.35 and RE 11.3.4<br>– Non-native plant cover – increase the score across all monitoring sites to a 10 representing <5% non-native plant cover at each site.<br>▶ Site context<br>– Average site context score for each RE is maintained or increased compared to the start quality score:<br>– RE 11.10.7 – ≥ 7.03<br>– RE 11.11.15 – ≥ 7.38 |

| Offset value | Interim performance targets – year 10 of management | Completion criteria – year 20 of management |
|---|---|---|
| | | – RE 11.11.15 regrowth – ≥ 1.15<br>– RE 11.4.2 – ≥ 8.50<br>– RE 11.4.2 regrowth – ≥ 1.15<br>– RE 11.5.8 – ≥ 7.60<br>– RE 11.3.25 – ≥ 8.53<br>– RE 11.11.1 – ≥ 7.69<br>– RE 11.3.35 – ≥ 8.85<br>▶ Species habitat index<br>– Increase the threats to species score to a 15 through the implementation of the OAMP, specifically, implementation of successful pest animal control targeting wild dogs, active fire management, security through a legally binding mechanism and active management of the area for conservation purposes. |
| Squatter pigeon | ▶ Improve the quality of squatter pigeon habitat to achieve a habitat quality score greater than 7<br>▶ Non-native plant cover – increase the score across all monitoring sites to a 5 representing between 5% to 25% of non-native plant cover at each site. | Improve the quality of squatter pigeon habitat to achieve a habitat quality score of 8.<br>▶ Site condition – the following scores for each ecological attribute will in part or whole be achieved through the implementation of specific management actions under the OAMP:<br>– Native shrub species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2 (remnant and regrowth), RE 11.5.8 and RE 11.3.25<br>– Native grass species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2 (remnant and regrowth), RE 11.5.8 and RE 11.3.25<br>– Native forb species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2 (remnant and regrowth), RE 11.5.8 and RE 11.3.25<br>– Tree canopy height – increase the score across all monitoring sites to a 5 representing 70% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2 (remnant and regrowth), RE 11.5.8 and RE 11.3.25<br>– Shrub canopy cover – increase the score across all monitoring sites to a 5 representing between 50% and 200% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2 (remnant and regrowth), RE 11.5.8 and RE 11.3.25<br>– Native perennial grass cover – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2 (remnant and regrowth), RE 11.5.8 and RE 11.3.25<br>– Large trees – increase the score across all monitoring sites to a 10, representing between 50% to 100% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25<br>– Non-native plant cover – increase the score across all monitoring sites to a 10 representing <5% non-native plant cover at each site.<br>▶ Site context:<br>– Average site context score for each RE is maintained or increased compared to the start quality score:<br>– RE 11.10.7 – ≥ 7.03<br>– RE 11.11.15 – ≥ 7.38<br>– RE 11.4.2 – ≥ 8.50<br>– RE 11.4.2 regrowth – ≥ 1.15<br>– RE 11.5.8 – ≥ 7.60<br>– RE 11.3.25 – ≥ 8.53<br>▶ Species habitat index:<br>– Increase the threats to species score to a 15 through the implementation of the OAMP, specifically, implementation of successful pest animal control, active fire management, security through a legally binding mechanism and active management of the area for conservation purposes. |
| Of concern RE 11.3.4 (BVG 16c) | By year 10, achieve habitat quality score of 8 | By year 20, achieve habitat quality score of 9 |
| Of concern RE 11.4.2 (BVG 17a) | By year 10, achieve habitat quality score of 9 | By year 20, achieve habitat quality score of 10 |
| Watercourse RE 11.3.4 (BVG 16c) | By year 10, achieve habitat quality score of 8 | By year 20, achieve habitat quality score of 9 |
| Watercourse RE 11.3.25 (BVG 16a) | By year 10, achieve habitat quality score of 9 | By year 20, achieve habitat quality score of 10 |

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# FIGURES

# TABLES

# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| BVG | Broad Vegetation Group |
| CQC | Central Queensland Coal Pty Ltd |
| DAF | Department of Agriculture and Fisheries |
| DAWE | Commonwealth Department of Agriculture, Water and the Environment |
| DES | Queensland Department of Environment and Science |
| EIS | Environmental Impact Statement |
| EN | Endangered |
| EP Act | *Environmental Protection Act 1994* |
| EPBC Act | *Environment Protection and Biodiversity Conservation Act 1999* |
| EPC | Exploration Permit for Coal |
| GTDTHQ | Guide to Determining Terrestrial Habitat Quality |
| ha | hectare |
| hd | head |
| LC | Least concern |
| MDL | Mineral Development Licence |
| ML | Mining Lease |
| MLA | Meat and Livestock Australia |
| MNES | matters of national environmental significance |
| MSES | matters of state environmental significance |
| Mtpa | million tonnes per annum |
| OAMP | offset area management plan |
| OC | Of concern |
| RE | Regional ecosystem |
| REDD | Regional Ecosystem Description Database |
| SEIS | Supplementary Environmental Impact Statement |
| SOIC | Strategic Footprint of the Galilee Basin Strategic Offset Investment Corridor |
| The BOS | Biodiversity Offset Strategy for the Central Queensland Coal Project |
| the joint proponents | Central Queensland Coal Pty Ltd and Fairway Coal Pty Ltd |
| the Project | Central Queensland Coal Project |
| VM Act | *Vegetation Management Act 1999* |

# 1 INTRODUCTION

This offset area management plan (OAMP) has been prepared for the Central Queensland Coal Project (the Project), located in the southern Styx Basin, approximately 130 km north-west of Rockhampton (and 25 km north-west of Marlborough) in Central Queensland (Figure 1). The Project is being undertaken by Central Queensland Coal Pty Ltd (CQC) and Fairway Coal Pty Ltd (the joint proponents). As CQC is the senior proponent, CQC is referred to as the proponent for this Project, which involves the extraction of up to ten million tonnes per annum (Mtpa) of product coal for the export market over a life of approximately 20 years.

Under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth: EPBC Act) the Project was determined to be a controlled action (EPBC 2016/7851). It is being assessed under the bilateral agreement between the Commonwealth and the State of Queensland (section 45 of the EPBC Act) through an Environmental Impact Statement (EIS) process being completed under the *Environmental Protection Act 1994* (Qld: EP Act).

Subject to approval, it is likely the Project will be conditioned in relation to biodiversity offsets and CQC required to provide offsets for significant residual impacts on matters of national environmental significance (MNES) and matters of state environmental significance (MSES). As such, the *Biodiversity Offset Strategy for the Central Queensland Coal Project* (the BOS; CO2 Australia 2020) has been prepared and submitted to the Commonwealth Department of Agriculture, Water and the Environment (DAWE) and Queensland Department of Environment and Science (DES). In line with the BOS, Table 1 summarises the Project's significant residual impacts on MNES and MSES anticipated to require offsets.

**Table 1: Summary of the Project's MNES and MSES impacts anticipated to require offsets**

| Protected Matter | Status | Significant residual Impact (ha) | | Total impact to offset (ha) |
|---|---|---|---|---|
| **MNES – Listed threatened species and ecological communities** | **EPBC Act** | **Direct** | **Indirect** | |
| Habitat for greater glider (*Petauroides volans*) | Vulnerable | 115.7 | 165.2 | 281.0 |
| Habitat for koala (*Phascolarctos cinereus*) | Vulnerable | 159.4 | 165.2 | 324.6 |
| Habitat for squatter pigeon (southern) (*Geophaps scripta scripta*) | Vulnerable | 141.4 | 165.2 | 306.6 |
| Habitat for ornamental snake (*Denisonia maculata*) | Vulnerable | 18.8 | 0 | 18.8 |
| **MSES – Regulated vegetation** | **VM Act** | | | |
| RE 11.3.4 (BVG 16c) | Of concern | 1.4 | 39.3 | 40.7 |
| RE 11.4.2 (BVG 17a) | Of concern | 110.8 | 0 | 110.8 |
| Watercourse RE 11.3.4 (BVG 16c) | Of concern | 0.5 | 3.8 | 4.3 |
| Watercourse RE 11.3.25 (BVG 16a) | Least concern | 10.7 | 68.1 | 78.8 |
| Essential habitat for greater glider | - | 0 | 15.0 | 15.0* |
| Essential habitat for koala | - | 96.1 | 14.3 | 110.4* |
| Essential habitat for squatter pigeon | - | 14.6 | 14.3 | 28.9* |
| **MSES – Protected wildlife habitat** | **NC Act** | | | |
| Habitat for greater glider | Vulnerable | 115.7 | 165.2 | 281.0* |

| Protected Matter | Status | Significant residual Impact (ha) | | Total impact to offset (ha) |
|---|---|---|---|---|
| **MNES – Listed threatened species and ecological communities** | **EPBC Act** | **Direct** | **Indirect** | |
| Habitat for koala | Vulnerable | 159.4 | 165.2 | 324.6* |
| Habitat for squatter pigeon | Vulnerable | 141.4 | 165.2 | 306.6* |
| Habitat for ornamental snake | Vulnerable | 18.8 | 0 | 18.8* |
| **MSES – Waterway fish passage** | | | | |
| Waterway providing for fish passage | - | 8.35+ | - | 8.35+ |

* To be offset as an MNES protected matter, noting that the State cannot impose an offset condition for a prescribed activity that has the 'same, or substantially the same' impact on the 'same, or substantially the same' matter as the MNES, if it has already been assessed as a 'controlled action' under the EPBC Act.
+ Based on an impact to 8.35 km of waterway providing for fish passage with an average width of 10 m.

CQC are proposing to deliver the majority of anticipated offsets for MNES and MSES as direct land-based offsets, with two MSES to be delivered as a financial settlement offset:

- Watercourse RE 11.3.25 (BVG 16a) (part of impact of 33.95 ha)
- Waterway providing for fish passage (full impact of 8.35 ha).

Land-based offsets will be acquit across two offset properties: Mamelon and an additional property. OAMPs have been developed for Mamelon and the additional property, with this OAMP detailing the offset acquittal on the Mamelon property.

## 1.1 PURPOSE

A large proportion of the land-based offsets required to acquit the Project's anticipated significant residual impacts on MNES and MSES will be delivered on Mamelon as summarised below. This Mamelon OAMP has been prepared to guide the ongoing management and monitoring of the offset area, thus satisfying obligations under the EPBC Act Environmental Offsets Policy (DSEWPC 2012) and the Queensland Environmental Offsets Policy (DES 2020).

- Greater glider (*Petauroides volans*) – MNES (fully acquit on Mamelon)
- Koala (*Phascolarctos cinereus*) – MNES (fully acquit on Mamelon)
- Squatter pigeon (southern) (*Geophaps scripta scripta*) – MNES (fully acquit on Mamelon)
- Of concern RE 11.3.4 (BVG 16c) – MSES (partly acquit Mamelon)
- Of concern RE 11.4.2 (BVG 17a) – MSES (fully acquit on Mamelon)
- Watercourse RE 11.3.4 (BVG 16c) – MSES (partly acquit Mamelon)
- Watercourse RE 11.3.25 (BVG 16a) – MSES (partly acquit Mamelon).

149°30'0"E 149°40'0"E 149°50'0"E 150°0'0"E 150°10'0"E 150°20'0"E 150°30'0"E

22°20'0"S 22°30'0"S 22°40'0"S 22°50'0"S 23°0'0"S 23°10'0"S 23°20'0"S 23°30'0"S

St Lawrence
Styx River
Herbert Creek Inlet
Shoalwater Bay
Stanage
Ogmore
Marlborough
Mount Gardiner
Kunwarara
Shoalwater
Canal Creek
Canoona
Glenroy
Garnant
Morinish
Etna Creek
Goodedulla National Park
Ridgelands
Alto-a-Downs
Norman Gardens
Pink Lily
Frenchville
Dalma
Rockhampton
Allenstown
Nine Mile
The Range
Gracemere
Kabra
Stanwell
Morinish South
Balcomba

**Central Queensland Coal**

**Figure 1:**
**CQC Project context map**

Mamelon
Mining leases (ML700022 and ML80187)
Road

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Mining leases
- Roads

Date: 7/30/2020 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:400,000@A3

0 5 10 15 20
Kilometres

N

CO2 Australia

Location diagram

# 2 OFFSET PROPERTY

## 2.1 PROPERTY OVERVIEW

The Mamelon property (comprising Lot 9 MC496, Lot 10 MC493 and Lot 11 MC2) is a 6,259 ha property located in Ogmore approximately 115 km north-west of Rockhampton and 25km north-west of Marlborough in Queensland's Brigalow Belt Bioregion (Figure 2). Mamelon straddles the Marlborough Plains and Nebo-Connors Ranges subregions, with a very small area in the very south-east intersecting the Boomer Range subregion. It should be noted that the Project's offset areas on Mamelon are outside the Project's two mining lease application (MLA 80187 and MLA 700022) areas on Mamelon.

Mamelon is adjacent Tooloombah Creek Conservation Park (to the north-west of Mamelon) and flanked by Regional Significant Corridors along the east and west boundaries of the property, corresponding to Deep Creek, Tooloombah Creek and Mamelon Creek, respectively (Figure 2).

Table 2 provides an overview of the landholder details and property description for Mamelon. It should be noted that the Mamelon registered owner, QNI Metals Pty Ltd, and the joint Project proponents (CQC and Fairway Coal) are all related companies having common shareholder ownership and control. Figure 3 illustrates the resource permits located over the Mamelon offset area and property.

**Table 2: Mamelon offset landholder and property details**

| **Landholder details** | |
|---|---|
| Registered owner/s on title: | QNI Metals Pty Ltd |
| ABN/ACN: | ABN 56 066 656 175 / ACN 066 656 175 |
| Phone: | 07 4720 6422 |
| Primary contact person: | George Lukacs |
| Email: | George.Lukacs@qni.com.au |
| Postal address: | PMB 5, Townsville MC QLD 4810 |
| **Property description** | |
| Lot on plan: | 9MC496, 10MC493, 11MC23 |
| Address: | 11 St Lawrence Road, Ogmore, Qld 4706 |
| Tenure: | Freehold |
| Area: | 6,259 ha |
| Local government area: | Livingstone Shire Council |
| Zoning: | Rural |
| **Permits** | |
| Coal Exploration Permit: | EPC 1029 (expires 19/04/2021), Fairway Coal Pty Ltd |
| Mineral Development Licence | MDL 468 (expires 31/01/2024), Fairway Coal Pty Ltd |

149°30'0"E
150°0'0"E
150°30'0"E
22°30'0"S
23°0'0"S
23°30'0"S

Tooloombah Creek Conservation Park
Saint Lawrence Rd
Saint Lawrence Rd
Ogmore
A1
Stanage
Kunwarara
Canoona
Jardine
Byfield
Woodbur
Bangalee
Yeppoon
Glenroy
Garnant
Morinish
The Caves
Mulara
Glendale
Cawarral
Emu Pa
Parkhurst
Dalma
Rockhampton
Nerimbera
Nine Mile
Gracemere
Kabra
Stanwell
Midgee
Balcomba
Westwood
Gogango
Bajool
A1
Marmor
A3
Port Al
Duaringa

**Central Queensland Coal**

**Location diagram**


**Figure 2:**
**Offset context map**

- Mamelon
- Project MLs
- Protected area

***Statewide Corridors***
- State
- Regional

***Galilee Basin Offset Strategy***
- Priority 1 - High value
- Priority 2 - Key linkage
- Priority 3 - Strategic footprint

***Southern Brigalow Strategic Offset Corridors***
- Priority 1 - High value
- Priority 2 - Key linkage

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Mining leases
- Protected areas
- Statewide corridors
- Galilee Basin Offset Strategy
- Southern Brigalow Strategic Offset Corridors

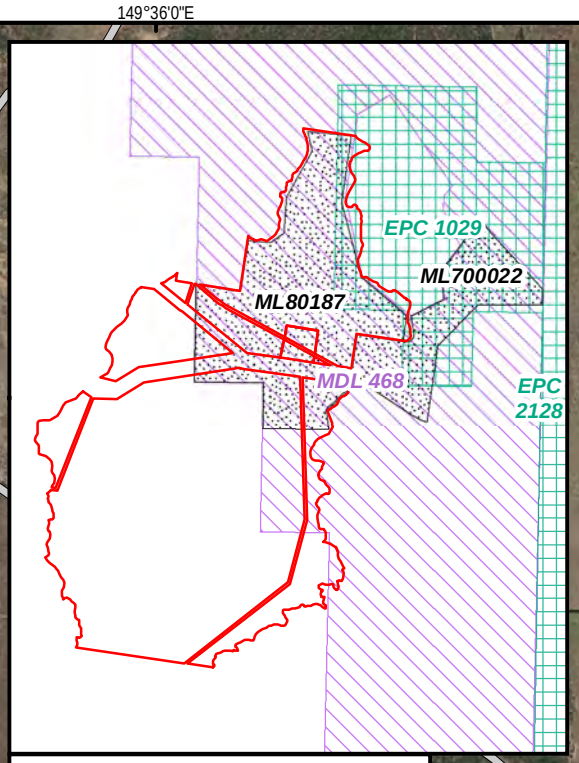
Date: 8/13/2020 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:500,000@A3

0 5 10 15 20
Kilometres

N

CO2 Australia

149°36'0"E
149°38'0"E
149°40'0"E
149°42'0"E
22°40'0"S
22°42'0"S
22°44'0"S
22°46'0"S




Mamelon
Project MLs
Exploration Permit - Coal
Mineral Development Licence

ML700022
ML80187

**Central Queensland Coal**

**Location diagram**


**Figure 3: Mamelon offset property - permits**

Mamelon
Mamelon offset area
Road
Project MLs
Project footprint (direct impact area)
Indirect impact area

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Exploration Permit - Coal
- Mineral Development Licence

The following datasets were provided by CQC
- Project MLs (amended)
- Project footprint and indirect impact area

Date: 8/13/2020 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:47,500@A3

0 0.5 1 1.5 2
Kilometres

N

CO2 Australia

## 2.2 CLIMATE

The Mamelon property is considered to have a dry-winter humid subtropical climate (Cwa) in accordance with the Köppen-Geiger climate classification system. This climate is characterised as a monsoon-influenced climate with 70% or more of the average annual precipitation received in the warmest six months. Mean monthly rainfall data from Strathmuir (the property immediately to the east of Mamelon) ranges from 16 mm in September up to 141 mm in February. Temperature records from the St Lawrence post office (~40 km north of Mamelon) show mean monthly maximum temperatures range between 24°C (June/July) and 32°C (December/January) and mean monthly minimum temperature range between 11°C (July) and 23°C (January/February).

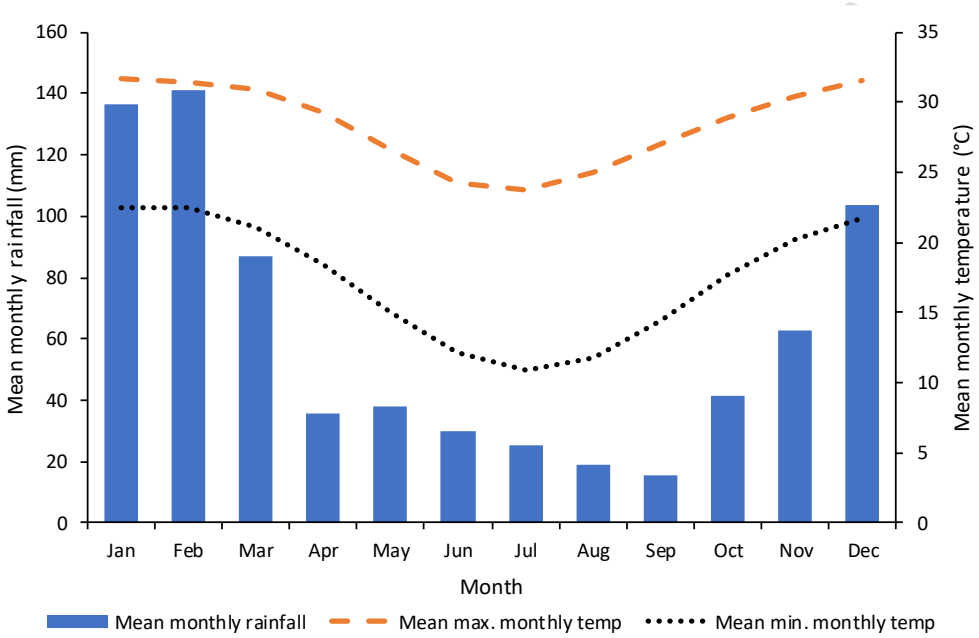



**Figure 4: Mean monthly temperature records (St Lawrence post office – station 33065) and rainfall records (Strathmuir – station 33189) (www.bom.gov.au).**

## 2.3 FIELD SURVEYS

Field assessments of terrestrial vegetation, flora and fauna of the Mamelon property have been undertaken between 2011 and 2020. Between March 2011 to July 2018, the majority of survey was restricted to the mining leases and immediate surrounds (i.e. adjacent Deep Creek) associated with the Project, with surveys after this time extending to the balance of Mamelon.

- March and September 2011
  - Systematic fauna surveys in late wet season (March 2011) and dry season (September 2011), including fauna habitat assessments, trapping (Elliot Type A & B box traps, pitfall traps, & funnel traps), bird surveys, diurnal ground searches for herpetofauna, spotlight searches, microbat call detection surveys, camera trapping, and call playback by ecological consultant Ed Meyer and Oberonia Botanical Services.
  - Flora surveys in late wet season (March) and dry season (September) by ecological consultant Ed Meyer and Oberonia Botanical Services.

- February 2012
  - Fauna surveying targeting conservation significant fauna species (i.e. those listed under NC Act and the EPBC Act) by Ed Meyer.
- February 2017
  - Systematic and targeted threatened fauna surveys by CDM Smith (led by Brett Taylor).
  - Wet season flora surveys, including tertiary and quaternary assessments as well as regional ecosystem remnant vegetation ground-truthing by CDM Smith and Terrestria (led by Dr Andrew Daniel).
- May, August, September, November 2017 and January 2018
  - Supplementary fauna surveys, including remote camera surveys, bird surveys, herpetofauna searches and spotlighting by CDM Smith.
- July/August 2018
  - Ground-truthing of regional ecosystems remnant vegetation areas within the mining lease and adjacent Deep Creek, as well as upstream reaches of Mamelon Creek in the south-west of Mamelon. Vegetation mapped in accordance with Neldner et al. (2017), including tertiary and quaternary assessments by 3D Environmental (led by David Stanton).
  - BioCondition assessments of ground-truthed regional ecosystem remnant vegetation and assessment of vegetation and habitat condition generally in accordance with the Guide to Determining Terrestrial Habitat Quality, Version 1.2 by 3D Environmental (led by David Stanton).
- October 2019
  - Ground-truthing of regional ecosystems across balance of Mamelon, including communities within non-remnant areas. Vegetation mapped in accordance with Neldner et al. (2017), including tertiary and quaternary assessments by CO2 Australia (led by Dr Jarrad Cousin).
  - BioCondition assessments in regional ecosystems and assessment of vegetation and habitat condition generally in accordance with the Guide to Determining Terrestrial Habitat Quality, Version 1.2 across balance of Mamelon and Strathmuir, representing those areas proposed to be considered for offsets by CO2 Australia (led by Dr Jarrad Cousin).
  - Targeted spotlighting surveys for koala and greater glider, as well as targeted diurnal surveying for squatter pigeon by CO2 Australia (led by Dr Jarrad Cousin).
  - Assessment of appropriateness and integrity of potential offset areas and location of current land management infrastructure (i.e. fencing, tracks, watering points) to inform offset availability and preparation of the offset area management plan by CO2 Australia.
- November 2019
  - Targeted fauna surveying (diurnal and nocturnal spotlighting) for koala and greater glider along Deep Creek and Surveyor's Creek, along with remnant vegetation communities adjacent Deep Creek by Austecology (led by Lindsay Agnew (Austecology 2020b).
- May/June 2020
  - BioCondition assessments and assessment of vegetation and habitat condition generally in accordance with the Guide to Determining Terrestrial Habitat Quality, Version 1.2 across additional regional ecosystems on Mamelon, including those indirectly impacted by ground-water drawdown,

as well as additional greater glider, koala and squatter pigeon habitat areas by CO2 Australia (led by Dr Jarrad Cousin).

- Targeted survey for squatter pigeon in southern half of Mamelon by CO2 Australia (led by Dr Jarrad Cousin).
- Assessment of appropriateness and integrity of potential offset areas and location of current land management infrastructure (i.e. fencing, tracks, watering points) to inform offset availability and preparation of the offset area management plan by CO2 Australia.

## 2.4 VEGETATION COMMUNITIES

Surveying of vegetation communities involved quaternary and tertiary assessments to ground-truth regional ecosystem (RE) mapping, including stratification of ground-truthed REs in the same general condition state. Areas ground-truthed and observed to comprise regrowth (non-mature) vegetation, were mapped separately to those mapped as remnant (largely intact, mature-like) vegetation. This terminology delineates assessment units for the purposes of assessing habitat condition, site context and species associations, and is not necessarily reflective of defined terms under the VM Act (i.e. remnant woody vegetation, high-value regrowth etc). The areas of newly mapped REs were used to randomly stratify monitoring sites throughout mapped ground-truthed REs.

Site condition assessments were undertaken at each monitoring site, generally in accordance with the *Guide to Determining Terrestrial Habitat Quality* (version 1.2; DEHP 2017). The site condition assessments included assessment of up to 13 ecological attributes, including:

- Native plant species richness of trees, shrubs, grasses and forbs
- Recruitment of woody perennial species
- Tree canopy heights and cover (canopy and subcanopy layers)
- Shrub canopy cover
- Native perennial grass cover
- Organic litter cover
- Coarse woody debris volume
- Number of large native trees over a certain size threshold (RE-specific)
- Non-native plant cover

In addition to the assessment of specific, quantitative ecological attributes assessed as part of the site condition assessments, additional information was collected from the field assessment including habitat attributes reflecting the appropriateness and integrity of potential offset areas (e.g. presence of hollow-bearing trees in areas of potential greater glider offset areas), as well as the location of existing fences to guide potential offset areas.

Ground truthed vegetation communities at Mamelon vary considerably across the property, largely influenced by the highly variable topography and complex geological history:

- Lowland areas adjacent and north of Bruce Highway
  - North of Bruce Highway within the Project ML are predominantly historically cleared areas used for grazing cattle. Many of these areas are dominated by buffel (*Cenchrus ciliaris*), with limited brigalow (*Acacia harpophylla*) regrowth present associated with gilgai on cracking clay or silty, clay

loam soils. Traversing the centre of the ML from the north to the south is Surveyor's Creek, represented by a narrow strip of RE 11.3.25. The eastern boundary of Mamelon north of the Bruce Highway corresponds to Deep Creek which is represented by *Eucalyptus tereticornis* woodland (RE 11.3.25) flanked by areas of remnant *Corymbia clarksoniana*, *C. tessellaris* and *E. platyphylla* woodland (RE 11.3.35) and small freshwater wetlands (RE 11.3.27). The southern section of these alluvial areas is anticipated to be indirectly impacted as part of the Project as shown in Figure 5. All alluvial areas are all subject to extensive (often very dense) weed invasion, particularly lantana (*Lantana camara*), rubber vine (*Cryptostegia grandiflora*), rattlepod (*Crotalaria pallida*) and starbur (*Acanthospermum hispidum*).

  - To the south of Brigalow regrowth areas, adjacent to the Bruce Highway, are areas of remnant and regrowth vegetation supporting *Eucalyptus populnea* woodland on Cainozoic clay plains (RE 11.4.2), with the lowest lying areas supporting two small (0.6 ha and 0.2 ha) wetland areas (RE 11.3.27) located either side of the Bruce Highway (Figure 5).

- Lowland areas along the west and east boundaries of Mamelon, south of the Bruce Highway (outside of the ML)
  - The western boundary of Mamelon, corresponding to Mamelon Creek is characterised by *Eucalyptus tereticornis* woodland (RE 11.3.25) grading to areas of remnant and regrowth *E. populnea/E. crebra woodland* dissected by numerous drainage lines; whether brigalow-dominated (RE 11.4.9) or dominated by *E. crebra*/*Melaleuca* sp. (RE 11.3.29).
  - The eastern boundary of Mamelon corresponds to the upper reaches of Deep Creek and is characterised by similar vegetation communities to downstream reaches of Deep Creek to the north of the Bruce Highway (i.e. RE 11.3.25, RE 11.3.35), all with similarly dense invasions of weeds. Upslope of these alluvial-influenced areas, are intact areas of *E. populnea*/*E. crebra*, often on texture contrast soils, characteristic of RE 11.4.2.
  - The southern boundary of Mamelon includes a complex mix of geologies in lowland areas, including areas of regrowth *E. crebra* woodland (RE 11.11.15) in the south-east grading down to *E. tereticornis* woodland on alluvial terraces (RE 11.3.4) adjacent Brussels Creek supporting RE 11.3.25. The south-west of Mamelon supports areas of remnant and regrowth *E. populnea* woodland on Cainozoic to Proterozoic fine-grained sedimentary rocks (RE 11.9.7) and Cainozoic clay plains (RE 11.4.2)
- Upslope areas in the centre of Mamelon (outside of the ML)
  - Upslope areas in the centre of Mamelon, associated with Mount Mamelon and Mount Bison are characterised by a mix of *Eucalytpus crebra* woodland and *Acacia catenulata* forest on coarse-grained sedimentary rocks (RE 11.10.7 and RE 11.10.3, respectively).
  - To the south of these sandstone vegetation communities, underlying metamorphic geology predominates supporting a mix of dense, remnant semi-evergreen vine thicket without emergent *Araucaria cunninghamii* (RE 11.11.5) grading down to gentle slopes dominated by remnant and regrowth *Eucalyptus crebra* woodland (RE 11.11.15).
  - The northern upslope areas are represented by a mix of geologies, resulting in a complex mix of vegetation communities from *Eucalyptus crebra* woodland on coarse-grained sandstone (RE 11.10.7) and metamorphic geologies (RE 11.11.15 and RE 11.11.1), grading to *E. crebra*, *Corymbia intermedia* and *Melaleuca* spp. on deep unconsolidated course and medium textured

Cainozoic sediments (RE 11.5.8), dissected by a drainage depression draining Mount Bison comprising a mix of *E. platyphylla*, *E. tereticornis* and *Lophostemon suaveolens* woodland (RE 11.3.9) and *E. tereticornis* woodland (RE 11.3.25), with the lowest-lying areas supporting a *Melaleuca*-dominated palustrine wetland (RE 11.3.12).

A summary of the ground-truthed REs across Mamelon is provided in Table 3, with Figure 5 illustrating these ground-truthed REs on Mamelon.

**Table 3: Ground-truthed regional ecosystems across the Mamelon**

| RE[#] | Description | VM status* | Total area (ha) on property |
|---|---|---|---|
| 11.3.4 | *Eucalyptus tereticornis* and/or *Eucalyptus* spp. woodland on alluvial plains | OC | 14.8 |
| 11.3.9 | *Eucalyptus platyphylla*, *Corymbia* spp. woodland on alluvial plains | LC | 50.2 |
| 11.3.11 | Semi-evergreen vine thicket on alluvial plains | EN | 0.8 |
| 11.3.12 | *Melaleuca viridiflora, M. argentea +/- M. dealbata* woodland on alluvial plains | LC | 4.2 |
| 11.3.25 | *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines | LC | 146.9 |
| 11.3.27 | Freshwater wetlands | LC | 4.0 |
| 11.3.29 | *Eucalyptus crebra*, *E. exserta*, *Melaleuca* spp. woodland on alluvial plains | LC | 6.4 |
| 11.3.35 | *Eucalyptus platyphylla, Corymbia clarksoniana* woodland on alluvial plains | LC | 93.2 |
| 11.4.2 | *Eucalyptus* spp. and/or *Corymbia* spp. grassy or shrubby woodland on Cainozoic clay plains | OC | 519.1 |
| 11.4.2 regrowth | | | 388.3 |
| 11.4.9 | *Acacia harpophylla* shrubby woodland with *Terminalia oblongata* on Cainozoic clay plains | EN | 34.7 |
| 11.5.8 | *Melaleuca* spp., *Eucalyptus crebra*, *Corymbia intermedia* woodland on Cainozoic sand plains and/or remnant surfaces | LC | 324.0 |
| 11.5.8 regrowth | | | 13.5 |
| 11.9.7 | *Eucalyptus populnea, Eremophila mitchellii* shrubby woodland on fine-grained sedimentary rocks | OC | 8.0 |
| 11.9.7 regrowth | | | 13.5 |
| 11.10.3 | *Acacia catenulata* or *A. shirleyi* open forest on coarse-grained sedimentary rocks. Crests and scarps | LC | 355.7 |
| 11.10.7 | *Eucalyptus crebra* woodland on coarse-grained sedimentary rocks | LC | 864.6 |
| 11.11.1 | *Eucalyptus crebra +/- Acacia rhodoxylon* woodland on old sedimentary rocks with varying degrees of metamorphism and folding | LC | 52.2 |
| 11.11.15 | *Eucalyptus crebra* woodland on deformed and metamorphosed sediments and interbedded volcanics | LC | 813.1 |
| 11.11.15 regrowth | | | 184.0 |

| RE[#] | Description | VM status* | Total area (ha) on property |
|---|---|---|---|
| 11.11.5a | Microphyll vine forest +/- *Araucaria cunninghamii* on old sedimentary rocks with varying degrees of metamorphism and folding | LC | 81.6 |
| | Non-remnant[§] | - | 2,267.3 |
| | **Total area ground-truthed (ha)** | - | 6,240.1 |

* *Vegetation Management Act 1999* (Qld); EN = Endangered, OC = Of Concern, LC = Least Concern

# Areas ground-truthed and observed to comprise regrowth (non-mature) vegetation, as distinct from remnant (largely intact, mature-like) vegetation. This terminology delineates assessment units for the purposes of assessing habitat condition, site context and species associations, and is not necessarily reflective of defined terms under the VM Act (i.e. remnant woody vegetation, high-value regrowth etc).

§ Non-remnant areas generally correspond to those areas supporting pasture; largely devoid of any remnant or regrowth vegetation.

149°36'0"E 149°38'0"E 149°40'0"E 149°42'0"E

22°40'0"S 22°42'0"S 22°44'0"S 22°46'0"S

**Ground-truthed vegetation**

- 11.10.3
- 11.10.7
- 11.11.1
- 11.11.1 regrowth
- 11.11.10
- 11.11.15
- 11.11.15 regrowth
- 11.11.2
- 11.11.5a
- 11.3.11
- 11.3.12
- 11.3.25
- 11.3.27
- 11.3.29
- 11.3.35
- 11.3.4
- 11.3.4 regrowth
- 11.3.9
- 11.4.2
- 11.4.2 regrowth
- 11.4.9
- 11.4.9 regrowth
- 11.5.8
- 11.5.8 regrowth
- 11.9.7
- 11.9.7 regrowth
- non-remnant

Tooloombah Creek
Surveyor's Creek
Deep Creek
Barrack Creek
Mamelon Creek
Brussels Creek

ML80187
ML700022

M01 M02 M03 M04 M05 M06 M08 M10 M11 M12 M13 M14 M15 M16 M17 M18 M19 M20 M21 M22 M23 M24 M25 M26 M27 M28 M29 M30 M31 M32 M33 M34 M35 M36 M37 M38 M39 M40 M41 M42 M43 M44 M45 M46 M47 M48 M49 M53 M54 M55 M56 M57 M58 M59 M60 M61 M62 M63 M64 M65 M66 M67 M68 M69 M70 M71 M72 M73 M74 M79 M80 M81 M82 M83

**Central Queensland Coal**

**Figure 5:**
**Observed regional ecosystems and survey sites on the Mamelon property**

- Mamelon
- Project MLs
- Project footprint (direct impact area)
- Indirect impact area
- Watercourses

***Survey sites***

- Impact habitat assessment site
- Offset monitoring site (discontinued)
- Offset monitoring site (existing)
- Offset monitoring site (to be established)

0 0.5 1 1.5 2
Kilometres

N

CO2 Australia

**Location diagram**

Queensland

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Watercourses

The following datasets were provided by Orange Environmental
- Ground-truthed vegetation
- Project footprint and indirect impact area

Date: 8/13/2020 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:47,500@A3

# 3 MAMELON OFFSET AREA

The proposed Mamelon offset area of approximately 2,803 ha in total is outside any areas proposed for mining activities (and associated infrastructure), as well as any areas that may potentially be impacted by groundwater drawdown. The Mamelon offset area has been identified to acquit the majority of the Project's anticipated MNES and MSES offset requirements, namely:

- Greater glider (*Petauroides volans*) – MNES (fully acquit on Mamelon)
- Koala (*Phascolarctos cinereus*) – MNES (fully acquit on Mamelon)
- Squatter pigeon (southern) (*Geophaps scripta scripta*) – MNES (fully acquit on Mamelon)
- Of concern RE 11.3.4 (BVG 16c) – MSES (partly acquit Mamelon)
- Of concern RE 11.4.2 (BVG 17a) – MSES (fully acquit on Mamelon)
- Watercourse RE 11.3.4 (BVG 16c) – MSES (partly acquit Mamelon)
- Watercourse RE 11.3.25 (BVG 16a) – MSES (partly acquit Mamelon).

The Project's remaining MNES and MSES requirements, either the full requirement or part thereof (ornamental snake - full, of concern RE 11.3.4 – part, watercourse RE 11.3.4 - part and watercourse RE 11.3.25 - part) are to be acquit on another land-based offset for the Project on an additional property.

The Project's BOS has been submitted to DAWE and DES for endorsement. The Project's BOS included an assessment of the impact habitat quality scores for all MNES and MSES, and, for the Mamelon offset area, assessments for MNES and MSES with regard to:

- Offset start and future habitat quality scoring
- Commonwealth Government's offsets assessment guide
- Queensland Government's land-based offset multiplier calculator.

These assessments are summarised in the following Sections 3.1 - 3.3, noting the same assessments were undertaken for MNES and MSES in the offset area on the additional property.

## 3.1 HABITAT QUALITY SCORING

The results of the detailed field surveys on Mamelon between 2018 and 2020 in the proposed impact and offset areas were used to calculate the habitat quality scores in Table 4 generally in accordance with the *Guide to Determining Terrestrial Habitat Quality* (version 1.2; DEHP 2017). This included an assessment, for each of the monitoring sites, of the following:

- Site condition
- Site context
- Species habitat index.

Habitat quality scores were area-weighted (where relevant) to account for the various component REs/condition states (including their corresponding habitat quality scores) contributing to the habitat area for each of the impacted and offset matters.

**Table 4: MNES and MSES habitat quality scores relevant to Mamelon offset.**

| Protected Matter | Impact habitat quality score | Start habitat quality score on Mamelon | Future habitat quality score on Mamelon |
|---|---|---|---|
| Greater glider | 7 | 7 | 8 |
| Koala | 7 | 7 | 8 |
| Squatter pigeon | 7 | 7 | 8 |
| Of concern RE 11.3.4 (BVG 16c) | 7 | 7 | 9 |
| Of concern RE 11.4.2 (BVG 17a) | 7 | 6 | 8 |
| Watercourse RE 11.3.4 (BVG 16c) | 7 | 7 | 9 |
| Watercourse RE 11.3.25 (BVG 16a) | 8 | 8 | 10 |

## 3.2 OFFSETS ASSESSMENT GUIDE

Using the habitat quality scores calculated above (Table 4), the Mamelon offset area has been assessed in accordance with the Commonwealth Government's offsets assessment guide to determine its suitability to acquit the Project's MNES offset requirements and accommodate the minimum offset area required to be secured for each MNES on Mamelon (greater glider, koala and squatter pigeon).

Table 5 presents a summary of the Mamelon offset area for the relevant MNES, including the total area to be secured for each MNES and the percent acquittal in accordance with the offsets assessment guide.

**Table 5: Mamelon offset area to be secured for MNES in accordance with the offsets assessment guide.**

| MNES | Total significant residual impact (ha) | Total offset area to be secured (ha) on Mamelon | Acquittal (%) under offsets assessment guide |
|---|---|---|---|
| Greater glider | 281.0 | 2,428.4 | 100.03% |
| Koala | 324.6 | 2,803.4 | 100.10% |
| Squatter pigeon | 306.6 | 2,667.1 | 100.80% |

## 3.3 LAND-BASED OFFSET MULTIPLIER CALCULATOR

In addition to the assessment in Section 3.2, the Mamelon offset area has also been assessed in accordance with the Queensland Government's land-based offset multiplier calculator to determine its suitability to acquit the Project's MSES offset requirements.

Table 6 presents a summary of the Mamelon offset area including the total area to be secured for MSES calculated in accordance with the land-based offset multiplier calculator. The total area to be secured on Mamelon represents either the whole area able to be offset on Mamelon, or part thereof, with the balance of the offset to be secured on another property and/or secured as a financial settlement offset.

**Table 6: Mamelon offset area to be secured for MSES in accordance with the land-based offset multiplier calculator.**

| MSES | Total significant residual impact (ha) | Offset multiplier | Minimum offset area required (ha) | Total offset area to be secured (ha) on Mamelon |
|---|---|---|---|---|
| Of concern RE 11.3.4 (BVG 16c) | 40.7 | 4.00 | 162.8 | 14.8* |

| MSES | Total significant residual impact (ha) | Offset multiplier | Minimum offset area required (ha) | Total offset area to be secured (ha) on Mamelon |
|---|---|---|---|---|
| Of concern RE 11.4.2 (BVG 17a) | 110.8 | 4.00 | 443.2 | 443.2 |
| Watercourse RE 11.3.4 (BVG 16c) | 4.3 | 4.00 | 17.2 | 14.8* |
| Watercourse RE 11.3.25 (BVG 16a) | 78.8 | 4.00 | 315.2 | 100.8* |

* Balance of offset required proposed to be secured on other land-based offset and/or financial settlement offset.

## 3.4 OFFSET PROTECTION

The Mamelon offset area is proposed to be protected by a Voluntary Declaration under section 19E and 19F of the *Vegetation Management Act 1999* (VM Act) and will be declared as an area of high nature conservation value. The Voluntary Declaration will be registered on the property's title and will be binding on current and future landowners.

A Voluntary Declaration under the VM Act is an authorised legally binding mechanism and is considered appropriate to legally secure MNES and MSES values and protect the area from vegetation clearing.

This OAMP is required to support the Voluntary Declaration process which will be commenced post approval of the Mamelon OAMP.

The Voluntary Declaration will remain in place for the life of the Project. The Voluntary Declaration may only be removed in accordance with the provisions of the VM Act or if the chief executive of the Queensland Department of Natural Resources, Mines and Energy considers it is necessary.

## 3.5 OFFSET POLICY REQUIREMENTS

The offset package proposed for the Project meets the key overarching requirements of the EPBC Act Environmental Offsets Policy and the Queensland Environmental Offsets Policy, respectively, as set out in Table 13 and Table 14 of the BOS. Table 7 and Table 8 below provide an overview of how the Mamelon offset specifically meets these requirements.

**Table 7: EPBC Act Environmental Offsets Policy requirements and Mamelon offset compliance**

| Policy requirement | Mamelon offset |
|---|---|
| Suitable offsets must deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environment law and affected by the proposed action | The Mamelon offset area (2,803 ha) will acquit a minimum of 100% of the offset requirements for MNES including greater glider, koala and squatter pigeon in accordance with the EPBC Act Environmental Offsets Policy and offsets assessment guide. An additional offset property will be used to acquit a minimum of 100% of the offset requirement for ornamental snake.<br>The Mamelon offset area will be managed to improve the condition and viability of the threatened species habitat in accordance with EPBC Act offset obligations and offsets assessment guide. This OAMP sets out specific management objectives with interim performance targets and completion criteria. Management actions are outlined with accompanying adaptive management triggers and corrective actions in the event that monitoring identifies that interim performance targets are not attained or completion criteria are not attained and/or maintained.<br>The Mamelon offset area will be managed and monitored from approval of this OAMP for a minimum of 20 years. It is anticipated that the completion criteria will be achieved within a 20 year period. |
| Suitable offsets must be built around direct offsets but may include other compensatory measures | 100% of the Project's MNES offset requirements will be acquit through the delivery of direct land-based offsets. The direct land-based offset areas proposed on Mamelon have been determined to be suitable in accordance with the EPBC Act Environmental Offsets Policy and offsets assessment guide. |
| Suitable offsets must be in proportion to the level of statutory protection that applies to the protected matter | The EPBC Act status of the MNES proposed to be offset on Mamelon has been taken into account in the offsets assessment guide in calculating the area of the offset to be provided. |
| Suitable offsets must be of a size and scale proportionate to the impacts on the protected matter | The size of the Mamelon offset area to be secured for MNES has been calculated in accordance with the offsets assessment guide. The inputs and justifications are based on the results of detailed field assessments. The Project's BOS, submitted to regulators for endorsement, includes full offsets assessment guide inputs, justifications and results for all MNES. |
| Suitable offsets must effectively account for and manage the risks of the offset not succeeding | The size of the Mamelon offset area to be secured for MNES has been calculated in accordance with the offsets assessment guide. |
| Suitable offsets must be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs (this does not preclude state or territory offsets) | The proposed Mamelon offset area is zoned rural under the Livingstone Planning Scheme 2018. The current primary land use on the offset area is cattle grazing. The proposed offset is subject to potential threats, including spread of weeds such as Parthenium (*Parthenium hysterophorus*), rubber vine (*Cryptostegia grandiflora*) and exotic pasture grasses, pest animals, inappropriate fire regimes and potential future development. |
| Suitable offsets must be efficient, effective, timely, transparent, scientifically robust and reasonable | The process used to identify, secure and establish offsets for the Project are consistent with the requirements of the EPBC Act Environmental Offsets Policy. The Mamelon offset area has been identified and deemed suitable using an evidence-based and scientifically robust approach. The Mamelon OAMP supports the efficient, effective, timely, transparent and scientifically robust approach to providing offsets. |

| Policy requirement | Mamelon offset |
|---|---|
| Suitable offsets must have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced. | The Mamelon OAMP outlines a governance framework and delivery pathway to legally secure the offset area on the property title, which will be monitored, and audited/enforced. |

**Table 8: Queensland Environmental Offsets Policy requirements and Mamelon offset compliance**

| Queensland Environmental Offsets Policy requirement | Mamelon offset |
|---|---|
| Offsets will not replace or undermine existing environmental standards or regulatory requirements, or be used to allow development in areas otherwise prohibited through legislation or policy | A detailed assessment of the significant residual impacts on MSES associated with the Project was undertaken as part of the updated SEIS (Version 3; August 2020). Since the publication of the previous SEIS (Version 2; December 2018), substantial additional ecological field surveys and technical studies have been undertaken in order to evaluate the habitat characteristics within the impact area that are specific to the respective threatened environmental values. The likely significant residual impacts on MNES and MSES have been refined and amended accordingly in the SEIS v3 and detailed in the Project's BOS and summarised in Table 1 of this OAMP. |
| Environmental impacts must first be avoided, then minimised, before considering the use of offsets for any remaining impact. | The Project has been designed to avoid and minimise environmental impacts to the greatest extent possible; however, the mine layout is dependent on the underlying geology as well as the location of the existing North Coast Rail Line which will be used to transport the Project's coal to the existing Dalrymple Bay Coal Terminal.<br>Avoidance and mitigation measures were considered as part of the impact assessment and determination of significant residual impacts on MNES and MSES for the Project. To avoid and minimise any further impacts on environmental values as part of construction and operation, a range of mitigation, management and monitoring measures will be implemented, a summary of which is provided in the Project's BOS. |
| Offsets must achieve a conservation outcome that achieves an equivalent environmental outcome | This draft OAMP includes specific management objectives and completion criteria for each of the MNES and MSES offset values in the offset area, as well as ongoing management and monitoring activities to ensure that a conservation outcome for the offset values can be achieved.<br>In accordance with the Queensland Environmental Offset Framework and the Guide to Determining Terrestrial Habitat Quality the MSES offsets will be required to achieve:<br>▶ habitat quality score at least 1 point greater than the impact site's score, and<br>▶ minimum overall habitat quality gain of at least 2 points, relative to the offset sites starting habitat quality. |
| Offsets must provide environmental values as similar as possible to those being lost. | The Mamelon offset property meets the specific criteria for the relevant MSES outlined in the Queensland Environmental Offsets Policy section 2.3.1.6 Characteristics of a land-based offset site.<br>Detailed field surveys on Mamelon have been completed in accordance with the Guide to Determining Terrestrial Habitat Quality in order to confirm the extent and condition of MSES offset values. |

| Queensland Environmental Offsets Policy requirement | Mamelon offset |
|---|---|
| Offset provision must minimise the time-lag between the impact and delivery of the offset. | The Project's BOS, in conjunction with the Project's ODP, have been prepared to outline CQC's proposed plan for the delivery of the Project's MNES and MSES offset package. The tasks and anticipated timeframes to deliver the Project's offsets, as detailed in the BOS, are proposed to minimise the time-lag between Project construction (impact) and delivery of the required offsets.<br>Following Commonwealth and Queensland Government approval of the Project, CQC will finalise this OAMP. Following approval of the OAMP CQC will implement the OAMP and proceed to legally secure the offset area through a suitable legally binding mechanism. These tasks and timeframes are subject to change due to a number of variables, including regulatory (Commonwealth and Queensland Government) approval, regulatory requirements, climatic conditions, stakeholder inactivity and other unexpected delays. |
| Offsets must provide additional protection to environmental values at risk, or additional management actions to improve environmental values. | The Mamelon offset area (2,803 ha) will be secured through a legally binding mechanism negotiated between CQC, QNI Metals Pty Ltd, the Queensland and Australian governments, and other relevant parties with a registered interest in the land.<br>Legal security of the Mamelon offset area will provide greater protection for the environmental values than what is currently afforded to remnant vegetation under the VM Act, the *Planning Act 2016* and associated policies and codes. |
| Where legal security is required, offsets must be legally secured for the duration of the impact on the prescribed environmental matter. | The Mamelon offset area will be protected by legally binding mechanisms which will remain in effect as required by the applicable State and Commonwealth legislative requirements (see section 3.4). |

# 4 MAMELON OFFSET VALUES

## 4.1 GREATER GLIDER

### 4.1.1 Species ecology

The greater glider is generally restricted to eucalypt forests and woodlands, typically found in highest abundance in taller, montane, moist eucalypt forests with relatively old trees and abundant hollows (TSSC 2016). During the day, the species shelters in tree hollows, with a particular selection for large hollows in large, old trees (TSSC 2016). In southern Queensland, greater gliders require at least 2−4 live den trees for every 2 ha of suitable forest habitat (TSSC 2016). The diet of the greater glider mainly comprises eucalypt leaves and occasionally flowers, with the species favouring forests with a diversity of eucalypt species due to seasonal variation. Home ranges are typically relatively small (1−4 ha), but are larger in lower productivity forests and more open woodlands (up to 16 ha; TSSC 2016).

### 4.1.2 Offset area

Greater glider habitat within the offset area comprises ~2,428 ha of ground-truthed remnant RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25 (Figure 6 and Figure 7). This habitat is located throughout Mamelon, including lowland areas in the vicinity of Tooloombah Creek, Mamelon Creek and Deep Creek as well as upland areas supporting eucalypt woodland. Each of these REs are considered suitable habitat; being consistent with the habitat assessment results presented in Agnew (2020), which were based on surveys undertaken in the vicinity of the offset area.

Targeted spotlighting surveys conducted in October and November 2019 by Austecology and CO2 Australia confirmed the presence of greater glider in the offset area, including foraging and denning in a variety of trees including *Eucalyptus crebra, E. platyphylla* and *E. populnea*. At least 22 greater glider were observed in November 2019 along and adjacent to Deep Creek in the east of Mamelon, with additional individuals observed along Barrack Creek in Strathmuir to the east of Mamelon (Austecology, 2020b; Figure 6, Figure 7). A survey of fauna habitat features identified numerous large, hollow-bearing trees throughout all of the offset area REs, including a diversity of eucalypt foraging and denning trees species known or observed as being used by greater glider in the area (e.g. *E. camaldulensis*, *E. tereticornis, E. crebra, E. populnea, E. platyphylla* and dead standing stags).

### 4.1.3 Threats

The following key threats to greater glider will be addressed through implementation of this OAMP:

- Habitat loss (through clearing, clearfell logging and the destruction of senescent trees due to prescribed burning) and fragmentation (TSSC 2016)
- Too intense or frequent fires (TSSC 2016).

## 4.2 KOALA

### 4.2.1 Species ecology

In Queensland, the koala's distribution extends inland from the east coast: from the Wet Tropics bioregion, into the Einasleigh Uplands bioregion in the north of the state; from the Central Mackay Coast bioregion, through the Brigalow Belt North bioregion to the Desert Uplands and Mitchell Grass Downs bioregions, and from the Southeast Queensland bioregion, through the Brigalow Belt to the Mulga Lands and Channel Country bioregions in the southwest of the state (Patterson 1996; TSSC 2012). Koalas naturally inhabit a

range of temperate, sub-tropical and tropical forest, woodland and semi-arid communities dominated by *Eucalyptus* species (Martin & Handasyde 1999).

Koala habitat can be broadly defined as any forest or woodland containing species that are known koala food trees, or shrubland with emergent food trees. The distribution of this habitat is largely influenced by land elevation, annual temperature and rainfall patterns, soil types and the resultant soil moisture availability and fertility. Preferred food and shelter trees are naturally abundant on fertile clay soils. The Koala is a leaf-eating specialist that feeds primarily during dawn, dusk or night (Crowther *et al.* 2013). Its diet is restricted mainly to foliage of *Eucalyptus* spp; however, it may also consume foliage of related genera, including *Corymbia* spp., Angophora spp. and *Lophostemon* spp.

### 4.2.2 Offset area

Koala habitat within the offset area comprises ~2,803 ha of ground-truthed remnant RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8, RE 11.3.25, RE 11.11.1, RE 11.3.35, RE 11.3.4, along with regrowth RE 11.4.2 and regrowth RE 11.11.15 (Figure 6 and Figure 7). The offset area comprises suitable foraging and breeding habitat for koala and is located throughout Mamelon, part of which is along and adjacent to Tooloombah Creek, Mamelon Creek and Deep Creek. Each of these REs are considered suitable habitat; being consistent with the habitat assessment results presented in Agnew (2020) and Melzer and Tucker (2011), which were based on surveys undertaken in the vicinity of the offset area.

These RE are considered appropriate habitat for koala, represented by a mix of *Eucalyptus tereticornis* woodland fringing Tooloombah, Mamelon and Deep Creek (RE 11.3.25) and adjacent *Eucalyptus populnea* and/or *E. platyphylla* grassy woodland on alluvial soils (RE 11.3.35) or clay plains (remnant and regrowth RE 11.4.2) and *Eucalyptus crebra* dominated woodland on remnant sand plain (RE 11.5.8) and old metamorphic sedimentary surfaces (RE 11.11.1, as well as remnant and regrowth RE 11.11.15). Areas of koala habitat offsets support known koala food trees, including *Eucalyptus crebra, E. tereticornis*, *E. populnea, E. exserta* and *C. citriodora*.

Targeted surveys conducted in October and November 2019 by Austecology and CO2 Australia confirmed the presence of no fewer than 18 koalas within the offset area; including one observed feeding within a *E. exserta* on the boundary between RE 11.11.1 and RE 11.5.8 in the north-west of Mamelon, others sheltering in *E. crebra* within an area of regrowth RE 11.4.2, with numerous records along alluvial watercourses on Mamelon (RE 11.3.25) (Austecology, 2020b; Figure 7, Figure 8). Additional evidence of their presence was confirmed throughout Mamelon in the form of characteristic scats and scratches.

### 4.2.3 Threats

The following key threats to koala will be addressed through the implementation this OAMP:

- Habitat loss and fragmentation through land clearing (DAWE 2020b).
- Mortality due vehicle strikes (DAWE 2020b).
- Predation by wild dogs (DAWE 2020b).

## 4.3 SQUATTER PIGEON

### 4.3.1 Species ecology

The squatter pigeon (southern) (*Geophaps scripta scripta*) generally inhabits grassy open forest to sparse open woodlands and scrub dominated by *Eucalyptus*, *Corymbia*, *Acacia* or *Callitris* overstorey species. The species is known to occupy habitat of varying quality, including remnant, regrowth and modified vegetation

communities, although the species is usually located within 3 km of a suitable, permanent or seasonal waterbody from which it drinks on a daily basis (DAWE 2020b).

The squatter pigeon (southern) is a ground-dwelling pigeon that forages predominantly on seeds which have fallen to the ground from low vegetation such as grasses, herbs and shrubs. Foraging habitat is generally associated with well-draining, gravelly, sandy or loamy soils containing patchy, tussock-grassy understory. Well-draining soil is also an important attribute supporting breeding habitat which typically comprises a depression scraped into the ground beneath a tussock of grass, bush, fallen tree or log (DAWE 2020b).

### 4.3.2 Offset area

Squatter pigeon habitat within the offset area comprises ~2,667 ha of ground-truthed remnant RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25 and areas of regrowth RE 11.4.2 (Figure 6 and Figure 7). The offset area comprises suitable foraging and breeding habitat for squatter pigeon and is located throughout Mamelon, in the vicinity of Tooloombah Creek, Mamelon Creek and Deep Creek as well as upslope areas with appropriate grassy woodland habitat.

These RE are considered appropriate habitat for squatter pigeon, represented by eucalypt grassy woodland (remnant and regrowth) on clay plains (RE 11.4.2), along alluvial channels (RE 11.3.25), remnant sand plain (RE 11.5.8) and old metamorphic and/or sedimentary surfaces (RE 11.10.7, RE 11.11.1 and RE 11.11.15). All areas of squatter pigeon offset habitat support eucalypt-dominated regrowth to remnant open-forest to open-woodland with a patchy, open grassy understorey. All offset areas are also within 3 km of permanent (artificial) or seasonal waterbodies, with much of the offset within 1 km.

Targeted surveys conducted in October and November 2019 by Austecology and CO2 Australia confirmed the presence of six (6) squatter pigeon on Mamelon, within the offset area, with a total of 25 confirmed records from Mamelon and adjacent Strathmuir during 2019 (Figure 6 and Figure 7). A further 58 squatter pigeon records are known from targeted surveys on those properties since March 2011 (Austecology 2020a and 2020b).

### 4.3.3 Threats

The following key threats to squatter pigeon will be addressed through the implementation of this OAMP:

- ongoing vegetation clearance and fragmentation (TSSC 2015).
- degradation of habitat by overgrazing livestock (TSSC 2015).
- trampling of nests by livestock (TSSC 2015).
- weed invasion (TSSC 2015).
- habitat degradation by rabbits (*Oryctolagus cuniculus*) (TSSC 2015).
- predation by feral cats and foxes (TSSC 2015).
- inappropriate fire regimes (TSSC 2015).
- thickening of understorey vegetation (TSSC 2015).

## 4.4 REGULATED VEGETATION

### 4.4.1 Of Concern Regional Ecosystems

**Of concern RE 11.3.4 (BVG 16c)**

Offset areas for *of concern RE 11.3.4 (BVG 16c)* comprise ~14.8 ha of ground-truthed RE 11.3.4, representing all areas of this RE on Mamelon, one in the south-east of Mamelon and the other in the south-west of Mamelon (Figure 8 and Figure 9). This offset area is wholly collocated with the *Watercourse RE 11.3.4 (BVG 16c)* offset area. The balance of the offset requirement for this MSES is located on an alternative property.

**Of concern RE 11.4.2 (BVG 17a)**

Offset areas for *of concern RE 11.4.2 (BVG 17a)* comprise ~443 ha of ground-truthed RE 11.4.2, representing a subset of the 593 ha of this RE on Mamelon. Areas of RE 11.4.2 offset are located in two areas on Mamelon; one in lowland areas along the western boundary of the site, and the other along the eastern boundary of the site (Figure 8 and Figure 9).

### 4.4.2 Watercourse Regional Ecosystems

**Watercourse RE 11.3.4 (BVG 16c)**

Offset areas for *Watercourse RE 11.3.4 (BVG 16c)* comprise ~14.8 ha of ground-truthed RE 11.3.4, representing all areas of this RE on Mamelon, one in the south-east of Mamelon and the other in the south-west of Mamelon (Figure 8 and Figure 9). This offset area is wholly collocated with the *of concern RE 11.3.4 (BVG 16c)* offset area. The balance of the offset requirement for this MSES is located on an alternative property.

**Watercourse RE 11.3.25 (BVG 16a)**

Offset areas for *Watercourse RE 11.3.25 (BVG 17a)* comprise ~100.8 ha of ground-truthed RE 11.3.25, representing all areas of this RE on Mamelon (Figure 8 and Figure 9). Areas of RE 11.3.25 are located throughout Mamelon, including ~9 ha in the very northwest of the property, associated with Deep Creek. All areas of offset for *Watercourse RE 11.3.25 (BVG 16a)* are located outside the extent of modelled water drawdown along Deep Creek. The balance of the offset requirement for this MSES is located on an alternative property.

149°38'0"E

149°40'0"E

22°40'0"S

22°42'0"S

22°44'0"S

Tooloombah Creek Conservation Park

Tooloombah Creek

Mamelon Creek

Surveyor's Creek

Deep Creek

ML80187

ML700022

Deep Creek

Central Queensland Coal

Location diagram

Queensland

Brisbane

**Figure 6:**
**Mamelon offset area – MNES fauna offset matters (north)**

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Statewide corridors
- Protected areas
- Watercourses

The following datasets were provided by Orange Environmental
- Project footprint and indirect impact area
- Threatened species records

Mamelon
Protected area
Watercourses
Project footprint (direct impact area)
Indirect impact area
Project MLs
Mamelon offset area

***MNES offset areas***
Koala, greater glider and squatter pigeon
Koala and squatter pigeon only
Koala only

***Threatened species records***
Greater glider records
Squatter pigeon records
Koala records

0 0.25 0.5 0.75 1
Kilometres

N

CO2 Australia

Date: 8/13/2020 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:27,500@A3

149°36'0"E 149°38'0"E 149°40'0"E

22°42'0"S 22°44'0"S 22°46'0"S

Tooloombah Creek Conservation Park

Tooloombah Creek

Surveyors Creek

ML80187

ML700022

Mamelon Creek

Deep Creek

Mamelon Creek

Central Queensland Coal

Location diagram

Queensland

Brisbane

**Figure 7:**
**Mamelon offset area – MNES fauna offset matters (south)**

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Statewide corridors
- Protected areas
- Watercourses

The following datasets were provided by Orange Environmental
- Project footprint and indirect impact area
- Threatened species records

- Mamelon
- Protected area
- Watercourses
- Project footprint (direct impact area)
- Indirect impact area
- Project MLs
- Mamelon offset area

***MNES offset areas***
- Koala, greater glider and squatter pigeon
- Koala and squatter pigeon only
- Koala only

***Threatened species records***
- Greater glider records
- Squatter pigeon records
- Koala records

0 0.25 0.5 0.75 1
Kilometres

N

CO2 Australia

Date: 8/13/2020 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:27,500@A3

149°38'0"E

149°40'0"E

22°40'0"S

22°42'0"S

22°44'0"S

Tooloombah Creek Conservation Park

Tooloombah Creek

Mamelon Creek

Surveyor's Creek

Deep Creek

ML80187

ML700022

Deep Creek

Central Queensland Coal

Location diagram

Queensland

Brisbane

**Figure 8:**
**Mamelon offset area – MSES regulated vegetation matters (north)**

- Mamelon
- Protected area
- Watercourses
- Project footprint (direct impact area)
- Indirect impact area
- Project MLs
- Mamelon offset area

***MSES offset areas***

- Of concern RE 11.4.2 (BVG 17a)
- Watercourse RE 11.3.25 (BVG 16a)

***Threatened species records***

- Greater glider records
- Squatter pigeon records
- Koala records

0 0.25 0.5 0.75 1
Kilometres

N

CO2 Australia

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Statewide corridors
- Protected areas
- Watercourses

The following datasets were provided by Orange Environmental
- Project footprint and indirect impact area
- Threatened species records

Date: 8/17/2020 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:27,500@A3

149°36'0"E 149°38'0"E 149°40'0"E

22°42'0"S 22°44'0"S 22°46'0"S

Tooloombah Creek Conservation Park

Tooloombah Creek

Surveyors Creek

ML80187

ML700022

Mamelon Creek

Deep Creek

Mamelon Creek

Central Queensland Coal

**Figure 9:**
**Mamelon offset area – MSES regulated vegetation matters (south)**

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Statewide corridors
- Protected areas
- Watercourses

The following datasets were provided by Orange Environmental
- Project footprint and indirect impact area
- Threatened species records

Date: 8/17/2020 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:27,500@A3

- Mamelon
- Mamelon offset area
- Protected area
- Watercourses
- Project footprint (direct impact area)
- Indirect impact area
- Project MLs

***MSES offset areas***
- Of concern and Watercourse RE 11.3.4 (BVG 16c)
- Of concern RE 11.4.2 (BVG 17a)
- Watercourse RE 11.3.25 (BVG 16a)

***Threatened species records***
- Greater glider records
- Squatter pigeon records
- Koala records

0 0.25 0.5 0.75 1
Kilometres

N

CO2 Australia

Location diagram

Queensland

# 5 ENVIRONMENTAL OUTCOMES TO BE ACHIEVED

The overall environmental outcome sought by the Mamelon OAMP is to acquit the MNES and MSES offset requirements for the Project's significant residual impacts, in accordance with the EPBC Act Environmental Offsets Policy and the Queensland Environmental Offsets Policy.

The interim performance targets and completion criteria defined in Table 9 indicate progress towards, and achievement of, the more specific environmental outcomes as per the Commonwealth Government's offsets assessments guides for relevant MNES, and the Queensland Government's Queensland Environmental Offsets Policy for relevant MSES.

Following the approval and implementation of this OAMP, the interim performance targets and completion criteria for the offset area are expected to be achieved within 10 and 20 years, respectively. The management actions outlined in Section 7 have been designed to minimise the risk of identified threats to the MNES and MSES occurring and improve habitat for offset matters across the offset area.

**Table 9: Interim performance targets and completion criteria for the Mamelon offset area.**

| Offset value | Interim performance targets – year 10 of management | Completion criteria – year 20 of management |
|---|---|---|
| Greater glider | ▶ Improve the quality of greater glider habitat to achieve a habitat quality score greater than 7<br>▶ Non-native plant cover – increase the score across all monitoring sites to a 5 representing between 5% to 25% of non-native plant cover at each site. | Improve the quality of greater glider habitat to achieve a habitat quality score of 8.<br>▶ Site condition – the following scores for each ecological attribute will in part or whole be achieved through the implementation of specific management actions under the OAMP:<br>– Native shrub species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25<br>– Native grass species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25<br>– Native forb species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25<br>– Tree canopy height – increase the score across all monitoring sites to a 5 representing 70% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25<br>– Shrub canopy cover – increase the score across all monitoring sites to a 5 representing between 50% and 200% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25<br>– Native perennial grass cover – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25<br>– Large trees – increase the score for all monitoring sites to a 10, representing between 50% to 100% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25<br>– Non-native plant cover – increase the score across all monitoring sites to a 10 representing <5% non-native plant cover at each site.<br>▶ Site context<br>– Average site context score for each RE is maintained or increased compared to the start quality score:<br>– RE 11.10.7 – ≥ 7.03<br>– RE 11.11.15 – ≥ 7.38<br>– RE 11.4.2 – ≥ 8.50<br>– RE 11.5.8 – ≥ 7.60<br>– RE 11.3.25 – ≥ 8.53<br>▶ Species habitat index<br>– Increase the threats to species score to a 15 through the implementation of the OAMP specifically implementation of successful pest animal control targeting wild dogs, cats and foxes, active fire management, security through a legally binding mechanism and active management of the area for conservation purposes. |
| Koala | ▶ Improve the quality of koala habitat to achieve a habitat quality score greater than 7<br>▶ Non-native plant cover – increase the score across all monitoring sites to a 5 representing between 5% to 25% of non-native plant cover at each site. | Improve the quality of koala habitat to achieve a habitat quality score of 8.<br>▶ Site condition – the following scores for each ecological attribute will in part or whole be achieved through the implementation of specific management actions under the OAMP:<br>– Native shrub species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8, RE 11.3.25, RE 11.11.1, RE 11.3.35 and RE 11.3.4<br>– Native grass species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8, RE 11.3.25, RE 11.11.1, RE 11.3.35 and RE 11.3.4<br>– Native forb species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8, RE 11.3.25, RE 11.11.1, RE 11.3.35 and RE 11.3.4<br>– Tree canopy height – increase the score across all monitoring sites to a 5 representing 70% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8, RE 11.3.25, RE 11.11.1, RE 11.3.35 and RE 11.3.4<br>– Shrub canopy cover – increase the score across all monitoring sites to a 5 representing between 50% and 200% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8, RE 11.3.25, RE 11.11.1, RE 11.3.35 and RE 11.3.4<br>– Native perennial grass cover – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8, RE 11.3.25, RE 11.11.1, RE 11.3.35 and RE 11.3.4<br>– Large trees – increase the score across all monitoring sites to a 10, representing between 50% to 100% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8, RE 11.3.25, RE 11.11.1, RE 11.3.35 and RE 11.3.4<br>– Non-native plant cover – increase the score across all monitoring sites to a 10 representing <5% non-native plant cover at each site.<br>▶ Site context<br>– Average site context score for each RE is maintained or increased compared to the start quality score:<br>– RE 11.10.7 – ≥ 7.03<br>– RE 11.11.15 – ≥ 7.38 |

| Offset value | Interim performance targets – year 10 of management | Completion criteria – year 20 of management |
|---|---|---|
| | | – RE 11.11.15 regrowth – ≥ 1.15<br>– RE 11.4.2 – ≥ 8.50<br>– RE 11.4.2 regrowth – ≥ 1.15<br>– RE 11.5.8 – ≥ 7.60<br>– RE 11.3.25 – ≥ 8.53<br>– RE 11.11.1 – ≥ 7.69<br>– RE 11.3.35 – ≥ 8.85<br>▶ Species habitat index<br>– Increase the threats to species score to a 15 through the implementation of the OAMP, specifically, implementation of successful pest animal control targeting wild dogs, active fire management, security through a legally binding mechanism and active management of the area for conservation purposes. |
| Squatter pigeon | ▶ Improve the quality of squatter pigeon habitat to achieve a habitat quality score greater than 7<br>▶ Non-native plant cover – increase the score across all monitoring sites to a 5 representing between 5% to 25% of non-native plant cover at each site. | Improve the quality of squatter pigeon habitat to achieve a habitat quality score of 8.<br>▶ Site condition – the following scores for each ecological attribute will in part or whole be achieved through the implementation of specific management actions under the OAMP:<br>– Native shrub species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2 (remnant and regrowth), RE 11.5.8 and RE 11.3.25<br>– Native grass species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2 (remnant and regrowth), RE 11.5.8 and RE 11.3.25<br>– Native forb species richness – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2 (remnant and regrowth), RE 11.5.8 and RE 11.3.25<br>– Tree canopy height – increase the score across all monitoring sites to a 5 representing 70% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2 (remnant and regrowth), RE 11.5.8 and RE 11.3.25<br>– Shrub canopy cover – increase the score across all monitoring sites to a 5 representing between 50% and 200% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2 (remnant and regrowth), RE 11.5.8 and RE 11.3.25<br>– Native perennial grass cover – increase the score across all monitoring sites to a 5 representing > 90% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2 (remnant and regrowth), RE 11.5.8 and RE 11.3.25<br>– Large trees – increase the score across all monitoring sites to a 10, representing between 50% to 100% of the benchmark for RE 11.10.7, RE 11.11.15, RE 11.4.2, RE 11.5.8 and RE 11.3.25<br>– Non-native plant cover – increase the score across all monitoring sites to a 10 representing <5% non-native plant cover at each site.<br>▶ Site context:<br>– Average site context score for each RE is maintained or increased compared to the start quality score:<br>– RE 11.10.7 – ≥ 7.03<br>– RE 11.11.15 – ≥ 7.38<br>– RE 11.4.2 – ≥ 8.50<br>– RE 11.4.2 regrowth – ≥ 1.15<br>– RE 11.5.8 – ≥ 7.60<br>– RE 11.3.25 – ≥ 8.53<br>▶ Species habitat index:<br>– Increase the threats to species score to a 15 through the implementation of the OAMP, specifically, implementation of successful pest animal control, active fire management, security through a legally binding mechanism and active management of the area for conservation purposes. |
| Of concern RE 11.3.4 (BVG 16c) | By year 10, achieve habitat quality score of 8 | By year 20, achieve habitat quality score of 9 |
| Of concern RE 11.4.2 (BVG 17a) | By year 10, achieve habitat quality score of 9 | By year 20, achieve habitat quality score of 10 |
| Watercourse RE 11.3.4 (BVG 16c) | By year 10, achieve habitat quality score of 8 | By year 20, achieve habitat quality score of 9 |
| Watercourse RE 11.3.25 (BVG 16a) | By year 10, achieve habitat quality score of 9 | By year 20, achieve habitat quality score of 10 |

# 6 ADAPTIVE MANAGEMENT

## 6.1 WHAT IS ADAPTIVE MANAGEMENT?

This OAMP is based on an adaptive management approach which involves 'flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood' (National Research Council 2004).

Adaptive management includes two key phases:

- Establishment of the key components of a management framework including engaging stakeholders, developing clear and measurable objectives and performance criteria, identification and selection of potential management actions and the development of monitoring protocols which enable the evaluation of progress towards achieving objectives, and which will effectively contribute to the adaptive management decision making process
- An iterative learning phase which involves utilisation of the management framework to learn about the natural resource system and iteratively adapt management strategies and approaches based on what is learned (Williams 2011).

The management of natural systems involves uncertainty which can affect the success of the management measures in achieving the objectives and performance criteria. Williams (2011) and Williams and Brown (2016) identify four kinds of uncertainty, outlined as follows, with how they have been addressed through the development of this OAMP:

- Environmental variation
  - caused by external factors that act upon natural systems, but which are not influenced by the resource conditions and dynamics, for example variation in rainfall or temperature
  - largely outside of the control of the manager (Williams 2011)
  - influence is considered in the analysis of the effectiveness of the adaptive management approach, the analysis of the ability to achieve and maintain performance criteria and when considering the need for corrective actions.
- Partial observability
  - includes potential uncertainty arising from variation in the collection of data during monitoring events, and from being unable to completely observe the natural system in its entirety (Williams and Brown 2016)
  - addressed in this OAMP through the development of a monitoring program based on scientifically tested and repeatable methods.
- Partial controllability
  - relates to the difference between the intended effect of the management measures to be implemented through this OAMP and the actual effect of their implementation on the ground (Williams and Brown 2016)
  - address through adherence to an adaptive management approach including regular monitoring of conformance with performance criteria, assessment of adaptive management triggers, the

implementation of corrective actions, review and amendments to the OAMP, and reporting to ensure that management measures are being effectively implemented on the ground.

- Structural and process uncertainty
  - concerns a lack of knowledge or understanding regarding biological and ecological processes and relationships, and differing views regarding how natural systems respond to management (Williams and Brown 2016)
  - addressed through the adaptive management approach. Following the results of ongoing management, monitoring and reporting, the OAMP will be reviewed and updated as required to incorporate learnings, updated conservation advice and best practice management techniques.

## 6.2 OAMP ADAPTIVE MANAGEMENT FRAMEWORK

### 6.2.1 Risk assessment

The adaptive management process for this OAMP is supported by a risk assessment through which the known and potential risks for each offset value have been evaluated. The relevant risks were identified based on a review of current literature (i.e. conservation advices, recovery plans etc) and identification of potential site-specific risks. As presented in Appendix B, the risk assessment included an assessment of the likelihood and consequence for each identified risk, both with and without the implementation of control strategies. The results of the risk assessment have informed the adaptive management process including the identification of threats to offset values, management objectives, performance criteria, management actions, monitoring programs, adaptive management triggers and corrective actions.

Implementation of the adaptive management process aims to reduce the risk of the identified threats occurring to ensure that the overall outcome sought by this OAMP are achieved.

### 6.2.2 Adaptive management process

The adaptive management process for this OAMP includes the following key components:

- **Identified threats to offset values** – known and potential threats to the offset values have been identified as part of the risk assessment process
- **Relevant offset values** – MNES or other offset matter for which the identified threat is relevant have been indicated
- **Management objectives** – management objectives have been developed to address each identified threat to the offset values, and to ensure that the interim performance targets and completion criteria are attained
- **Performance criteria** – assessable criteria have been defined to measure adherence to the management objectives
- **Management action** – specific management actions have been identified to ensure that the performance criteria and management objectives are satisfied, and which will ultimately result in attainment of the interim performance targets and completion criteria
- **Monitoring** – a combination of qualitative and quantitative methodologies has been included to assess whether management actions are meeting the performance criteria and management objectives, and ultimately, whether the OAMP is supporting the delivery of the interim performance targets and completion criteria

- **Adaptive management trigger** – measurable events or parameters have been identified which, when triggered, indicate that a performance criterion has not been satisfied, instigating the implementation of contingency plans and corrective actions
- **Contingency response and corrective action** – a two-step process has been established to identify the likely cause of the non-compliance with the performance criteria and allow for identification of suitable corrective actions:
  - Contingency response – a process to be instigated to investigate the cause of the non-compliance with the performance criteria and identify suitable corrective actions to be implemented.
  - Corrective actions – implementation of a feasible, appropriate and effective action to address the identified issue and ensure the performance criteria is satisfied.

Figure 10 illustrates the ongoing adaptive management cycle of implementation, learning and review, with the aim of achieving the interim performance targets and completion criteria. Through the implementation of this adaptive management process, it is anticipated that the interim performance targets and completion criteria will be attained and maintained for the life of the Project.

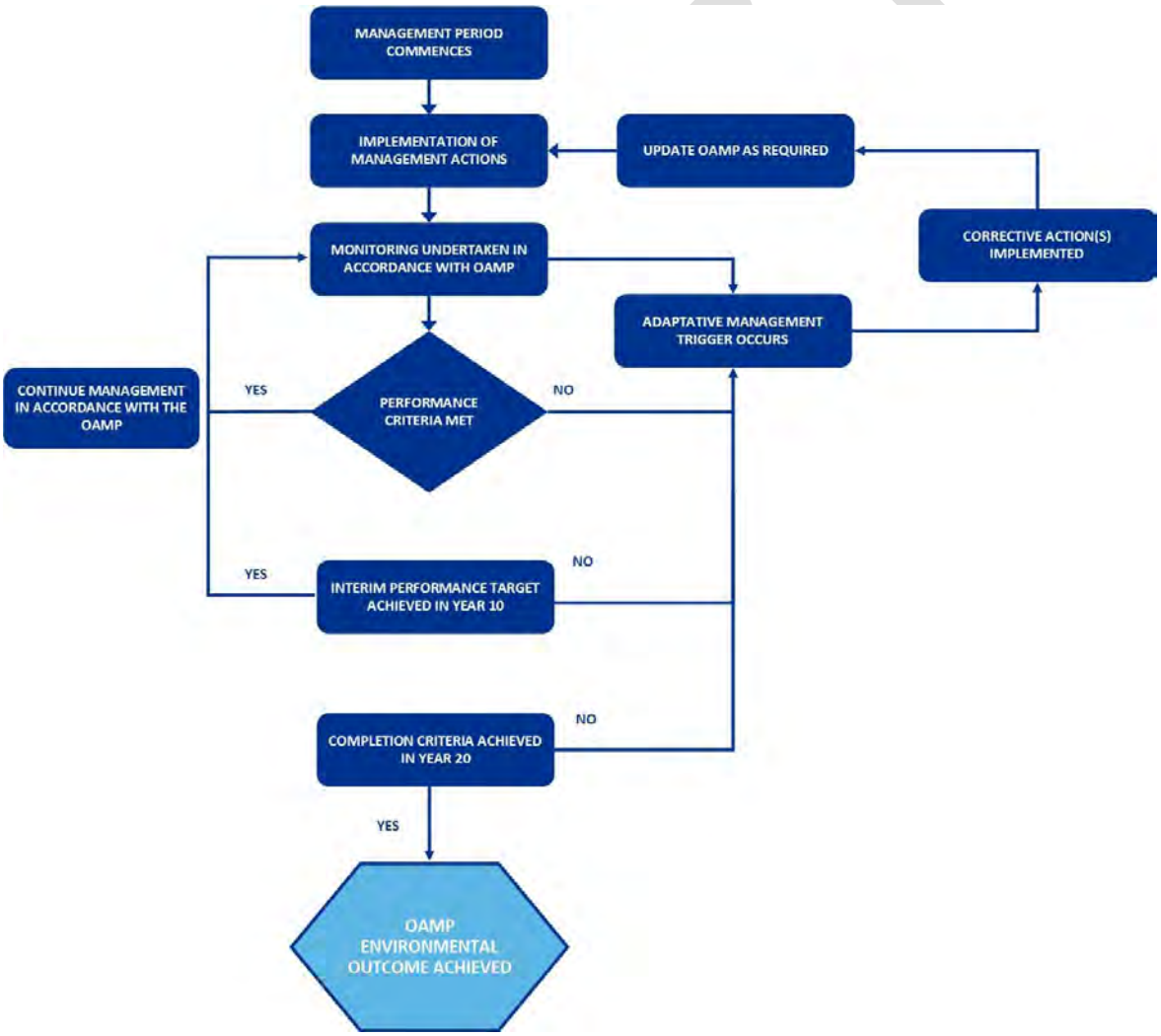



**Figure 10: Adaptive management process for implementation of the OAMP.**

### 6.2.3 Timing for implementation of the OAMP

The Mamelon offset area will be managed and monitored until the interim performance targets and completion criteria are achieved. It is anticipated that through the adaptive management approach, interim performance targets and completion criteria will be achieved within the proposed 20-year management period. However, if the interim performance targets and/or completion criteria for offset values have not been achieved within the anticipated timeframes, management and monitoring will continue beyond the 20-year management period in accordance with this OAMP until the completion criteria have been achieved.

### 6.2.4 Risk of offset failure

In the unlikely event that the interim performance targets are not achieved for one or more offset values by year 10, for those offset values, CQC will obtain advice from scientific advisory groups and/or research programs with the aim of identifying appropriate additional management interventions.

In the very unlikely event that it is considered that the completion criteria will not be achieved, the following process will be implemented:

- discuss the provision of additional offset options with DAWE and DES
- deliver offset requirements in accordance with the EPBC Act Environmental Offsets Policy and the Queensland Environmental Offsets Policy
- incorporate offset requirements in a revised BOS and submit to DAWE and DES for approval.

### 6.2.5 Management objectives

A summary of the management objectives and performance criteria for the Mamelon offset area is presented in Table 10. The complete adaptive management process for this OAMP is encapsulated in Table 11. Management actions, monitoring events, adaptive management triggers and corrective actions have been assigned to each management objective and performance criteria (Table 11).

**Table 10: Summary of the management objectives and performance criteria**

| Management objectives | Performance criteria |
|---|---|
| Achieve the completion criteria and habitat quality improvements for offset values, which include the habitat quality scores in this OAMP. | ▶ Increase the habitat quality scores within the offset area for each MNES at each habitat quality assessment site based on the results of baseline and subsequent monitoring events to achieve the scores in the completion criteria. |
| Maintain the extent of offset value habitat within the offset area. | ▶ No unapproved/intentional clearing of habitat within the offset area, with the exception of clearing that is required for fencing, access, firebreaks and public safety as outlined in Table 12.<br>▶ Minimise any clearing required within the offset area for the above purposes (i.e. for fencing, access, firebreaks and public safety). |
| Ensure that any livestock grazing for fire management and weed control maintains and enhances the ground cover attributes for offset values and does not result in the degradation of habitat. | ▶ Increase the species richness and average % cover of native perennial grasses at each habitat quality assessment site based on the results of baseline and subsequent monitoring events.<br>▶ Biomass levels of 1,500 kg/ha are retained at each of the monitoring sites at the end of the dry season.<br>▶ Livestock are only observed to be grazing in the offset management areas during strategic grazing event/s. |

| Management objectives | Performance criteria |
|---|---|
| Minimise predation risk by wild dogs to threatened fauna species. | ▶ Reduction in Catling* Index for wild dogs from year 1 and subsequent monitoring events. |
| Minimise predation risk by foxes to threatened fauna species. | ▶ Reduction in Catling* Index for foxes from year 1 and subsequent monitoring events. |
| Minimise predation risk by feral cats to threatened fauna species. | ▶ Reduction in Catling* Index for feral cats from year 1 and subsequent monitoring events. |
| Minimise degradation of offset value habitat by feral pigs. | ▶ Reduction in mean feral pig abundance score from year 1 and subsequent monitoring events. |
| Minimise degradation of offset value habitat by rabbits. | ▶ Maintain rabbit impact category as 'acceptable'. |
| Manage invasive weed species to reduce degradation of offset value habitat. | ▶ A decrease in species richness and relative abundance of weed species at 80% of monitoring sites from year 1 and subsequent monitoring events.<br>▶ No new weed species are identified at any monitoring site (based on year 1 and subsequent monitoring data). |
| Reduce the risk of adverse impacts to offset value habitat by inappropriate fire regimes or unplanned fire. | ▶ No unplanned fire within the offset area<br>▶ Increase in habitat quality scores as a result of implementation of any fire management measures. |
| Achieve the interim performance targets and completion criteria for each offset value within 10 and 20 years, respectively. | ▶ The interim performance targets are achieved for all offset values by year 10.<br>▶ The completion criteria are achieved for all offset values by year 20. |

* Catling index provides a measure of relative abundance of wild dogs, foxes and feral cats within the offset area. The Catling index will be measured as the percentage of camera nights in which the pest species was observed as part of fauna camera monitoring for the species, as outlined in Section 8.4..

**Table 11: Management objectives, performance criteria, adaptive management triggers, corrective actions.**

| Identified threats to offset values | Relevant offset values | Management objective | Performance criteria | Management action | Monitoring | Trigger for adaptive management and corrective actions | Corrective actions |
|---|---|---|---|---|---|---|---|
| ▶ Degradation of habitat | ▶ Greater glider<br>▶ Koala<br>▶ Squatter pigeon<br>▶ Of concern RE 11.3.4<br>▶ Of concern RE 11.4.2<br>▶ Watercourse RE 11.3.4<br>▶ Watercourse RE 11.3.25 | ▶ Achieve the completion criteria and habitat quality improvements for offset values, which include the habitat quality scores in this OAMP. | ▶ Increase the habitat quality scores for each offset value at each habitat quality assessment site based on the results of baseline and subsequent monitoring events so as to achieve the scores in the completion criteria. | ▶ Implementation of the management actions and adaptive management framework as outlined in this OAMP | ▶ Monitoring of offset value habitat quality scores will be undertaken in accordance with Section 8 including:<br>- Offset area inspections (Section 8.1)<br>- Habitat quality assessments to determine habitat quality scores (Section 8.5.2).<br>▶ The results of monitoring events will be compared against the habitat quality scores in the interim performance targets and completion criteria to determine the progress of the offset area and recorded as part of reporting (Section 9). | ▶ Habitat quality scores for interim performance targets are not achieved for one or more offset values by year 10.<br>▶ Habitat quality scores for completion criteria are not achieved for one or more offset values by year 20. | Step 1: Investigate cause of trigger<br>▶ Investigate reasons why the interim performance targets or the completion criteria were not achieved within the specified timeframes.<br>▶ Re-evaluate the suitability of the relevant management measures in the OAMP.<br>▶ Identify appropriate corrective actions.<br>Step 2: Implementation of corrective action/s<br>▶ The appropriate corrective actions will be implemented and may include:<br>- Third party review of the OAMP to provide input on the effectiveness of the management actions.<br>- Increasing the frequency and intensity of pest animal and weed control measures, or revising the type of measures to be implemented.<br>- Modifying the strategic grazing regime to better support enhancement of offset values.<br>– For offset values that have not achieved interim performance targets by year 15, for those offset values, CQC will obtain advice from scientific advisory groups with the aim of identifying appropriate additional management interventions.<br>▶ In the very unlikely event that it is considered that the completion criteria will not be achieved, CQC will discuss the provision of additional offset options with the Commonwealth Government. |
| ▶ Habitat loss through vegetation clearing | ▶ Greater glider<br>▶ Koala<br>▶ Squatter pigeon | ▶ Maintain the extent of offset value habitat within the offset area. | ▶ No unapproved and/or intentional clearing of habitat within the offset area, with the exception of clearing that is required for | Protection of the offset area via a Voluntary Declaration under section 19E and 19F of the VMA, as described in Section 3.4. | Reporting to the Commonwealth Government consistent with any EPBC approval. | At 12 months after approval of OAMP, no progress in legally securing the offset area. | Step 1: Investigate cause of trigger<br>▶ Discuss alternative options for legal security with the Queensland and Commonwealth Governments. |

| Identified threats to offset values | Relevant offset values | Management objective | Performance criteria | Management action | Monitoring | Trigger for adaptive management and corrective actions | Corrective actions |
|---|---|---|---|---|---|---|---|
| | ▶ Of concern RE 11.3.4<br>▶ Of concern RE 11.4.2<br>▶ Watercourse RE 11.3.4<br>▶ Watercourse RE 11.3.25 | | fencing, access, firebreaks and public safety as outlined in Table 12. | | | | ▶ Identify appropriate corrective actions.<br>Step 2: Implementation of corrective action/s<br>▶ The appropriate corrective actions will be implemented and may include:<br>- Submission of application for alternative legal security mechanism to relevant authority. |
| | | | | ▶ Comply with the restrictions outlined in Section 7.1<br>▶ Construction and maintenance of access tracks, fencing and firebreaks will be undertaken in accordance with Sections 7.2, 7.3 and 7.4.<br>▶ In the event that vegetation clearing is required for fencing, access, firebreaks or public safety, all activities will be planned, recorded and monitored. | ▶ Compliance with restrictions for vegetation clearing associated with maintenance and establishment of access tracks, fencing and firebreaks will also be assessed as part of offset area inspections (Section 8.1). | ▶ Clearing for access, fencing, firebreaks or public safety is not undertaken in accordance with the restrictions outlined in Table 12 and Sections 7.1, 7.2, 7.3 and 7.4. | Step 1: Investigate cause of trigger<br>▶ If restrictions for clearing associated with fencing, access, firebreaks or public safety are not adhered to, Origin will ensure that all clearing activities cease immediately.<br>▶ Investigate the reason for unapproved or unintentional clearing.<br>▶ Following clearing, the area is to be assessed by a suitably qualified ecologist/expert to determine the total clearing extent of offset value habitat.<br>▶ Identify appropriate corrective actions.<br>Step 2: Implementation of corrective action/s<br>▶ The appropriate corrective actions will be implemented and may include:<br>- Reviewing and modifying protocols for the establishment of fences, access tracks, and firebreaks.<br>- Prior to the establishment of fences, access tracks, and firebreaks, the area to be cleared will be clearly marked out with flagging tape and checked prior to clearing.<br>- Rehabilitation of the impacted area. |
| ▶ Degradation of habitat by livestock overgrazing. | ▶ Greater glider<br>▶ Koala<br>▶ Squatter pigeon | ▶ Ensure that any livestock grazing for fire management and weed control maintains and enhances the ground cover attributes for offset | ▶ Increase the richness and average % cover of native perennial grasses at each habitat quality assessment site based on the results of | ▶ Implementation of strategic grazing to reduce fuel loads and control exotic pasture grasses and promote the establishment of native perennial grass | ▶ Habitat quality assessments will be undertaken in accordance with Section 8.5.2. These will include assessment of % cover of native perennial grasses. | ▶ Decrease in the richness and average % cover of native perennial grasses at one or more habitat quality assessment sites based on the results of | Step 1: Investigate cause of trigger<br>▶ Investigate the reason for the decrease in richness and average % cover of native perennial grasses |

| Identified threats to offset values | Relevant offset values | Management objective | Performance criteria | Management action | Monitoring | Trigger for adaptive management and corrective actions | Corrective actions |
|---|---|---|---|---|---|---|---|
| | ▶ Of concern RE 11.3.4<br>▶ Of concern RE 11.4.2<br>▶ Watercourse RE 11.3.4<br>▶ Watercourse RE 11.3.25 | values and does not result in the degradation of habitat. | baseline and subsequent monitoring events. | species in accordance with Section 7.4. | | baseline and subsequent monitoring events. | ▶ Identify appropriate corrective actions.<br>Step 2: Implementation of corrective action/s<br>▶ The appropriate corrective actions will be implemented and may include:<br>- Modifying the strategic grazing regime to maintain a suitable ground layer cover for the squatter pigeon including modifying the frequency, intensity and/or duration of grazing events.<br>- Constructing additional fencing should the current fencing be considered insufficient to manage livestock in accordance with the grazing regime.<br>- Installing additional watering points for livestock to manage livestock in accordance with the grazing regime.<br>– Removal of stock or spelling grazing |
| | | | ▶ Biomass levels of 1,500 kg/ha are retained at each of the monitoring sites at the end of the dry season. | ▶ Implementation of a strategic grazing regime to protect and maintain environmental values in accordance with Section 7.4. | ▶ Biomass monitoring and fuel load assessments will be undertaken in accordance with Section 8.2. | ▶ Biomass monitoring results indicate less than 1,500 kg/ha of biomass is present at any of the monitoring sites at the end of the dry season. | Step 1: Investigate cause of trigger<br>▶ Investigate the reason for biomass being less than 1,500 kg/ha.<br>▶ Re-evaluate the strategic grazing regime to assess the suitability of grazing to ensure no less than an average of 1,500 kg/ha of biomass is retained at the end of the d7.3ry season.<br>▶ Identify appropriate corrective actions.<br>Step 2: Implementation of corrective action/s<br>▶ The appropriate corrective actions will be implemented and may include:<br>- Removal of stock or spelling grazing from the area of the offset in which less than 1,500kg/ha of biomass was identified.<br>- Review adherence to livestock grazing restrictions in Section 7.4. |

| Identified threats to offset values | Relevant offset values | Management objective | Performance criteria | Management action | Monitoring | Trigger for adaptive management and corrective actions | Corrective actions |
|---|---|---|---|---|---|---|---|
| | | | | | | | - Where relevant, amending livestock management practices in the OAMP, including amending stocking rates, and/or duration and/or frequency of strategic grazing events. |
| | | | ▶ Livestock are only observed to be grazing in the offset area during strategic grazing event/s. | ▶ Existing fencing is maintained at all times as outlined in Section 7.3. | ▶ Offset area inspections to be undertaken at least annually (Section 8.1) and will include monitoring to assess the:<br>- condition of fencing to identify any necessary maintenance requirements.<br>- presence of livestock within the offset area. | ▶ Livestock are observed within the offset area when not permitted within that area.<br>▶ Damaged fencing is observed. | Step 1: Investigate cause of trigger<br>▶ If livestock are identified in the offset area, remove stock immediately.<br>▶ Inspect and evaluate fencing and identify the cause of livestock within the offset area.<br>▶ Identify appropriate corrective actions.<br>Step 2: Implementation of corrective action/s<br>▶ The appropriate corrective actions will be implemented and may include:<br>- Repairing fencing where required to ensure its condition is satisfactory to exclude livestock.<br>- Constructing additional fencing should the current fencing be considered insufficient to exclude livestock. |
| Predation by wild dogs | ▶ Greater glider<br>▶ Koala<br>▶ Squatter pigeon | ▶ Minimise predation risk by wild dogs to threatened fauna species. | ▶ Reduction in Catling* Index for wild dogs from year 1 and subsequent monitoring events. | ▶ Implement control actions for wild dogs in accordance with Section 7.6. | ▶ Undertake monitoring for wild dogs in accordance with Section 8.4. | ▶ An increase in Catling* Index for wild dogs from year 1 and subsequent monitoring events. | Step 1: Investigate cause of trigger<br>▶ Investigate potential sources or reasons that may have attributed to an increase in the:<br>- Catling* index for wild dogs, feral cats and/or foxes<br>- rabbit impact category<br>- relative abundance of feral pigs.<br>▶ Review adherence to pest management control measures as outlined in Section 7.6.<br>▶ Identify appropriate corrective actions.<br>Step 2: Implementation of corrective action/s<br>▶ The appropriate corrective actions will be implemented and may include: |
| Predation by feral cats. | ▶ Squatter pigeon | ▶ Minimise predation risk by feral cats to threatened fauna species. | ▶ Reduction in Catling* Index for feral cats from year 1 and subsequent monitoring events. | ▶ Implement control actions for feral cats in accordance with Section 7.6. | ▶ Undertake monitoring for feral cats in accordance with Section 8.4. | ▶ An increase in Catling* Index for feral cats from year 1 and subsequent monitoring events. | |
| Predation by foxes. | ▶ Greater glider<br>▶ Squatter pigeon | ▶ Minimise predation risk by foxes to threatened fauna species. | ▶ Reduction in Catling* Index for foxes from year 1 and subsequent monitoring events. | ▶ Implement control actions for foxes in accordance with Section 7.6. | ▶ Undertake monitoring for foxes in accordance with Section 8.4. | ▶ An increase in Catling* Index for foxes from year 1 and subsequent monitoring events. | |
| Degradation of habitat by rabbits. | ▶ Greater glider<br>▶ Koala<br>▶ Squatter pigeon<br>▶ Of concern RE 11.3.4 | ▶ Minimise degradation of offset value habitat by rabbits. | ▶ Maintain rabbit impact category as 'acceptable'. | ▶ Implement control actions for rabbits in accordance with Section 7.6. | ▶ Undertake monitoring for rabbits in accordance with Section 8.4. | ▶ Rabbit impact category measured as 'monitor closely', or 'unacceptable'. | |
| Degradation of habitat by feral pigs. | | ▶ Minimise degradation of offset value habitat by feral pigs. | ▶ Reduction in mean feral pig abundance score from year 1 and subsequent monitoring events. | ▶ Implement control actions for feral pigs in accordance with Section 7.6. | ▶ Undertake monitoring for feral pigs in accordance with Section 8.4. | ▶ An increase in mean feral pig abundance score from year 1 and subsequent monitoring events. | |

| Identified threats to offset values | Relevant offset values | Management objective | Performance criteria | Management action | Monitoring | Trigger for adaptive management and corrective actions | Corrective actions |
|---|---|---|---|---|---|---|---|
| | ▶ Of concern RE 11.4.2<br>▶ Watercourse RE 11.3.4<br>▶ Watercourse RE 11.3.25 | | | | | | - Increasing the frequency and intensity of pest animal control.<br>- Revising methods of pest animal control in accordance with Queensland Department of Agriculture and Fisheries (DAF) guidelines, and coordinate with neighbouring land owners to ensure a consistent approach.<br>- Updating pest animal control methods in the OAMP and targeted pest animal control programs. |
| Invasion of habitat by weed species, including exotic grasses. | ▶ Greater glider<br>▶ Koala<br>▶ Squatter pigeon<br>▶ Of concern RE 11.3.4<br>▶ Of concern RE 11.4.2<br>▶ Watercourse RE 11.3.4<br>▶ Watercourse RE 11.3.25 | ▶ Manage invasive weed species to reduce degradation of offset value habitat. | ▶ A decrease in species richness and relative abundance of weed species at 80% of monitoring sites from year 1 and subsequent monitoring events.<br>▶ No new weed species are identified at any monitoring site (based on year 1 and subsequent monitoring data). | ▶ Implement weed control actions in accordance with Section 7.5.<br>▶ Adhere to weed hygiene restrictions in accordance with Section 7.1. | ▶ Undertake weed monitoring in accordance with Section 8.2. | ▶ An increase in species richness and relative abundance of weed species at more than 20% of monitoring sites from year 1 and subsequent monitoring events.<br>▶ A new weed species is identified at one or more monitoring sites. | Step 1: Investigate cause of trigger<br>▶ Investigate potential sources or reasons that may have attributed to an increase in species richness and/or relative abundance of weeds.<br>▶ Investigate potential sources or reasons for the occurrence of the new weed species.<br>▶ Review adherence to weed management control measures as outlined in Section 7.5.<br>▶ Review adherence to weed hygiene restrictions as outlined in Section 7.1.<br>▶ Identify appropriate corrective actions.<br>Step 2: Implementation of corrective action/s<br>▶ The appropriate corrective actions will be implemented and may include:<br>- Amending weed hygiene restrictions.<br>- Providing additional educational awareness training for all staff and contractors to ensure weed hygiene restrictions are adhered to.<br>- Revising weed control methods in accordance with the *Biosecurity Act 2014* (Qld).<br>- Increasing the frequency and intensity of weed control. |

| Identified threats to offset values | Relevant offset values | Management objective | Performance criteria | Management action | Monitoring | Trigger for adaptive management and corrective actions | Corrective actions |
|---|---|---|---|---|---|---|---|
| | | | | | | | - Updating weed control methods in the OAMP and targeted weed control programs. |
| Inappropriate fire regimes | ▶ Greater glider<br>▶ Koala<br>▶ Squatter pigeon<br>▶ Of concern RE 11.3.4<br>▶ Of concern RE 11.4.2<br>▶ Watercourse RE 11.3.4<br>▶ Watercourse RE 11.3.25 | ▶ Reduce the risk of adverse impacts to offset value habitat by inappropriate fire regimes or unplanned fire. | ▶ No unplanned fire within the offset area<br>▶ Increase in habitat quality scores as a result of implementation of any fire management measures. | ▶ All fire management measures to be implemented in accordance with the program outlined in Section 7.4. | ▶ Habitat quality assessments to determine habitat quality scores will be undertaken in accordance with Section 8.5.2. | ▶ As a result of fire management measures, or an unplanned fire, there is a decrease in the habitat quality score for any offset value from baseline and subsequent monitoring events. | Step 1: Investigate cause of trigger<br>▶ Investigate reasons why the fire management measures have resulted in a decrease in habitat quality scores.<br>▶ Review adherence to the fire management measures as outlined in Section 7.4.<br>▶ Identify appropriate corrective actions.<br>Step 2: Implementation of corrective action/s<br>▶ The appropriate corrective actions will be implemented and may include:<br>- Increasing the frequency of biomass and fuel load monitoring.<br>- Increasing the frequency of weed control measures.<br>- Amending the strategic grazing regime.<br>- Reviewing effectiveness of firebreaks, and establishment of additional fire breaks.<br>- Review timing and intensity of fuel hazard reduction burns in accordance with the Regional Ecosystem Description Database (REDD) fire management guidelines and conservation advice for the particular offset value. |
| ▶ Offset fails to achieve the interim performance targets and completion criteria within the anticipated 10 and 20 year timeframes, respectively. | ▶ Greater glider<br>▶ Koala<br>▶ Squatter pigeon<br>▶ Of concern RE 11.3.4<br>▶ Of concern RE 11.4.2<br>▶ Watercourse RE 11.3.4<br>▶ Watercourse RE 11.3.25 | ▶ Achieve the interim performance targets and completion criteria for each offset value within 10 and 20 years, respectively. | ▶ The interim performance targets are achieved for all offset values by year 10.<br>▶ The completion criteria are achieved for all offset values by year 20. | ▶ All management actions outlined in Section 7 will be implemented to ensure that the interim performance targets and completion criteria are achieved. | ▶ Monitoring of the offset area will be undertaken in accordance with Section 8 including:<br>- Offset area inspections (Section 8.1).<br>- Habitat quality assessments to determine habitat quality scores (Section 8.5.2).<br>▶ The results of monitoring events will be compared against the interim performance targets and completion criteria to determine the progress of offset area and | ▶ Interim performance targets are not achieved for one or more offset values by year 10.<br>▶ Completion criteria are not achieved for one or more offset values by year 20. | Step 1: Investigate cause of trigger<br>▶ Investigate reasons why the interim performance targets or the completion criteria were not achieved within the specified timeframes.<br>▶ Re-evaluate the suitability of the relevant management measures in the OAMP.<br>▶ Identify appropriate corrective actions.<br>Step 2: Implementation of corrective action/s |

| Identified threats to offset values | Relevant offset values | Management objective | Performance criteria | Management action | Monitoring | Trigger for adaptive management and corrective actions | Corrective actions |
|---|---|---|---|---|---|---|---|
| | | | | | recorded as part of reporting (Section 9). | | ▶ The appropriate corrective actions will be implemented and may include:<br>- Third party review of the OAMP to provide input on the effectiveness of the management actions.<br>- Increasing the frequency and intensity of pest animal and weed control measures, or revising the type of measures to be implemented.<br>- Modifying the strategic grazing regime, or fire management measures, to better support enhancement of offset values. |

* Catling index provides a measure of relative abundance for wild dogs, foxes and feral cats. The Catling index will be measured as the percentage of camera nights in which the pest species was observed as part of fauna camera monitoring for the species as outlined in Section 8.4.

# 7 MANAGEMENT ACTIONS

## 7.1 GENERAL RESTRICTIONS

To ensure the management objectives and completion criteria are achieved, the Mamelon offset area will be managed with general restrictions in place relating to access, weed hygiene, vehicles and vegetation clearing, as set out in Table 12.

**Table 12: Mamelon offset area restrictions.**

| Restriction | Details |
|---|---|
| Access | Access into the offset area will be restricted to authorised personnel only. Existing and new fences will be used to restrict access into the offset area. Signs will be installed in prominent locations (i.e. at access points into the offset area) which recognise that the offset areas on Mamelon are protected for conservation purposes. The signs will also advise that access into the offset area is restricted to authorised personnel only. |
| Weed hygiene | Weed hygiene measures will be implemented to prevent the movement of weed material into the offset area. All persons entering the offset area will be required to ensure vehicles and equipment are weed free. Contractors entering the offset area must hold a current weed hygiene certificate or equivalent for all vehicles and equipment. Evidence is to be provided on request to the landowner that vehicles, slashers or any machinery implementing management actions are clean prior to entry to minimise potential weed spread. |
| Vehicles | Vehicle movement will be limited to designated access tracks in the offset area and access will be restricted to authorised personnel only. Vehicles will travel to track conditions to minimise the risk of vehicle strike to fauna. |
| Vegetation clearing | Clearing of native vegetation will not be permitted within the offset area as part of any management and monitoring activities associated with the OAMP, with the exception of clearing that is required for:<br>▶ maintenance of access tracks and/or fire breaks, with any vegetation clearing required to establish new access tracks to be no more than 6 m wide (Section 7.2 and 7.4),<br>▶ fence construction and maintenance, with any vegetation clearing required for establishing or maintaining fencing to be no more than 5 m wide on each side of the fence (Section 7.3), and<br>▶ ensure public safety or as directed by emergency management response personnel in the event of unplanned fire or other emergency or other associated procedure.<br>In the event that vegetation clearing is required for fencing, access, firebreaks or public safety, all activities will be appropriately planned, recorded and monitored.<br>Machinery will not be allowed on site after heavy or prolonged rainfall events until after the site has dried to allow for safe movement of traffic. |
| Alternate land use | The offset areas will be managed for conservation purposes only, therefore no activities in contravention of this OAMP (or the eventual legally securing mechanism – see Section 3.4) can occur. |

## 7.2 ACCESS TRACKS

Existing access tracks will be utilised to facilitate management, maintenance and monitoring activities (refer to existing tracks in Figure 11). In the event that existing access tracks become impassable (through erosion or vegetation regrowth), track maintenance (e.g. grading) will be prioritised over alternative track alignments. Gully crossings are likely to be subject to periodic, ongoing maintenance as a consequence of erosion following rain events.

Existing and new access tracks will be managed to both reduce vegetation disturbance and safety risks (in accordance with Section 7.1).

## 7.3 FENCING

Fencing will be used to manage access to offset management areas as well as strategic grazing activities. Existing internal and boundary fencing will be used where they are in good condition (refer to the location of existing fences and gates Figure 11).

Where additional fencing is required to be installed, it will be constructed to be fit for purpose and fauna friendly (exact specifications will be in accordance with the executed offset agreement or any addendum to that agreement). Any access tracks into the offset area will be gated and locked to prevent unauthorised access.

## 7.4 FIRE MANAGEMENT

Unplanned fire risk will be managed through:

- establishment and regular maintenance (grading) of firebreaks
- carefully managed biomass levels
- fuel hazard reduction burns.

Firebreaks will be graded along:

- all boundaries of the offset area, except along road reserves (which will act as a firebreak) and where they correspond to waterways
- all existing/proposed fencelines within or bounding the offset area.

A comprehensive fuel load monitoring program will be undertaken (refer to section 8.2) as part of fire management activities to assess fuel loads, determine the risk of unplanned fire to the offset area and inform fire management strategies. The results of fuel load assessment monitoring will be used to inform fire management strategies, including the efficacy of any proposed fuel hazard reduction burns. The results of biomass monitoring will inform strategic grazing activities within the offset area. A strategic grazing regime will be used to reduce fuel loads and control exotic weeds and pasture grasses such as *Cenchrus ciliaris, Parthenium hysterophorus* and *Acacia farnesiana*. As increasing grazing intensity is correlated with an increase in weedy cover (Franks 2002), and a decrease in native grass species richness, grazing will be permitted in the offset area on a managed and limited basis to control weeds and reduce fuel loads. Best management practices will be employed as follows:

- minimum of 1,500 kg/ha of dry matter will be retained at the end of the dry season
- stock will only be permitted in the offset area to reduce fuel loads and reduce exotic pasture grass cover.

The suitability of conditions for undertaking a grazing event will be informed by biomass monitoring events as described in Section 8.2.2. Following a wet season spell and prior to a strategic grazing event in the offset area, a feed budgeting assessment will be undertaken. The feed budgeting assessment will determine the stocking rate based on the amount of feed available and the amount of feed desired in these areas at the end of the grazing event.

Further details of the method for undertaking fuel load assessment and the biomass monitoring are provided in Section 8.2.

### 7.4.1 Fire management guidelines

Fire management, through fuel hazard reductions burns will be guided by conservation advice documentation (e.g. for MNES) and the Regional Ecosystem Description Database (REDD; Queensland Herbarium 2019), which provides recommendations for fire management for each of the Regional ecosystems within the Mamelon offset area (Table 13).

The fire management regime will be implemented to minimise fuel loads to mitigate the risk of uncontrolled fires within the Mamelon offset area and manipulate the vegetation communities in order to improve the quality of habitat for MNES and MSES by promoting germination and recruitment of eucalypt and other species.

In addition to biomass monitoring to inform strategic grazing, fuel load assessments will be undertaken in accordance with Section 8.2.1. In conjunction with results of biomass monitoring and habitat quality assessments, the results of the fuel load assessments will be used to determine the location and timing for fuel hazard reduction burns within the offset area taking into account the REDD fire management guidelines for the vegetation community and MNES conservation advices.

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Central Queensland Coal

Location diagram


**Figure 11: Mamelon offset area infrastructure**

- Mamelon
- Mamelon offset area
- Watercourses
- Project footprint (direct impact area)
- Indirect impact area
- Project MLs

***Infrastructure***

- Access tracks
- Fence
- Gates
- Watering points

0 0.5 1 1.5 2
Kilometres

N

CO2 Australia

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Mining leases
The following datasets were provided by CQC
- Project footprint and indirect impact area

Date: 8/13/2020 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:40,000@A3

**Table 13: Fire management guidelines for regional ecosystems within offset areas based on REDD guidelines (Queensland Herbarium 2019).**

| Regional ecosystem (RE) | Strategy | Season | Intensity | Timing | Considerations | Relevant offset values |
|---|---|---|---|---|---|---|
| 11.10.7 | ▶ Burn less than 10-30% in any year. Burn surrounding vegetation under conditions of good soil moisture and when plants are actively growing throughout the year so that wildfires will be very limited in extent. Fire exclusion not necessary. | ▶ Late wet to early dry season when there is good soil moisture. Early storm season or after good spring rains. | ▶ Moderate to high. | ▶ 6 – 10 years | ▶ Best protection from wildfires is probably the creation of a multi-aged mosaic in surrounding vegetation and perimeter burning. Planned burns have traditionally been carried out in the winter dry season; further research required. | ▶ Koala<br>▶ Squatter pigeon<br>▶ Greater glider (except RE 11.11.15 regrowth) |
| 11.5.8 | ▶ Restrict to less than 30% in any year. Burn under conditions of good soil moisture and when plants are actively growing. Sometimes a small amount of wind may move the fire front quickly so that burn intensity is not too severe to destroy habitat trees. | | ▶ Low to moderate. | | ▶ Maintaining a fire mosaic will help ensure protection of habitat and mitigate against wildfires. Avoid burning riparian communities as these can be critical habitat for some species. | |
| 11.11.15<br>11.11.15 (regrowth) | ▶ Burn less than 30% in any year. Burn under conditions of good soil moisture and when plants are actively growing. All shrubby areas will carry fire after a good season | | ▶ Various. | ▶ 6 – 15 years | ▶ Management of this fire tolerant vegetation type should be based on maintaining vegetation composition, structural diversity, animal habitats and preventing extensive wildfire. Maintaining a fire mosaic will ensure protection of habitat and mitigate against wildfires. Planned burns have traditionally been carried out in the winter dry season; further research required. | |
| 11.3.25 | ▶ Protection relies on broad-scale management of surrounding country with numerous small fires throughout the year so that wildfires will be very limited in extent. | ▶ Primarily early dry season. | ▶ Low | ▶ 3 – 5 years. | ▶ Fringing communities are critical habitat. In some situations it may be best not to burn. Intense and extensive fires degrade vegetation structure and destroy fauna habitats. Restrict the extent and intensity of fires. Hollow trees are critical habitat. Green panic may be an issue and an intensive grazing regime for very short periods, may be necessary to limit potential of wildfire. Fire is an option for control of weeds (possibly in ungrazed situations). If riparian areas need to be burnt to reduce fuel loads then burning should occur when there is good soil moisture and active growth. Late wet to early dry season when there is good soil moisture. Early storm season or after good spring rains. | ▶ Koala<br>▶ Squatter pigeon<br>▶ Greater glider<br>▶ Watercourse RE 11.3.25 (BVG 16a) |
| 11.4.2<br>11.4.2 (regrowth) | ▶ Restrict to less than 30% in any year. Burn under conditions of good soil moisture and when plants are actively growing. Sometimes a small amount of wind may move the fire front quickly so that burn intensity is not too severe to destroy habitat trees. | ▶ Late wet to early dry season when there is good soil moisture. Early storm season or after good spring rains. | ▶ Low to moderate. | ▶ 6 – 10 years. | ▶ Burn interval for conservation purposes will differ from that for grazing purposes; the latter being much shorter. Management of this vegetation type should be based on maintaining vegetation composition, structural diversity, fauna habitats (in particular hollow-bearing trees and logs) and preventing extensive wildfire. Maintaining a fire mosaic will help ensure protection of habitat and mitigate against wildfires. Fire can control shrub invasives (e.g., *Eremophila* spp. and *Acacia stenophylla* in the red soil country in particular). Fire will also control cypress. Low to moderate intensity burns with good soil moisture are necessary to minimise loss of hollow trees. Avoid burning riparian communities as these can be critical habitat for some species. Culturally significant (scar) trees may need protection, such as rake removal of ground fuels. Planned burns have traditionally been carried out in the winter dry season; further research required. | ▶ Koala<br>▶ Squatter pigeon<br>▶ Greater glider (except RE 11.4.2 regrowth)<br>▶ Of concern RE 11.4.2 (BVG 17a) |
| 11.3.4 | ▶ Restrict to less than 30% in any year. Burn under conditions of good soil moisture and when plants are actively growing. Sometimes a small amount of wind may move the fire front quickly so that burn intensity is not too severe to destroy habitat trees. | | | | | ▶ Koala<br>▶ Of concern RE 11.3.4 (BVG 16c)<br>▶ Watercourse RE 11.3.4 (BVG 16c) |
| 11.3.35 | ▶ A predominance of early dry season fires is recommended, although there is value in occasional late dry season fires, or storm burns, over small areas. Burning should begin very soon after the wet season, to secure boundaries and adjacent fire-sensitive vegetation. Subsequent repeat ignitions can be used | | ▶ Primarily low to moderate, with occasional high intensity fires. | ▶ Typically 2 – 7 years, with some areas longer unburnt. | ▶ These woodlands have a diverse native grass and herb layer that is maintained and promoted by regular fire. Burning that starts immediately after the wet season, with follow up small fires ignited progressively over multiple dates can increase the availability of grass and herb seed, which is a critical food | ▶ Koala |

| Regional ecosystem (RE) | Strategy | Season | Intensity | Timing | Considerations | Relevant offset values |
|---|---|---|---|---|---|---|
| | within the same section of land weeks or months after the boundaries have been secured by early burning, to produce a mixture of burnt areas with multiple ignition dates. Use topographical features to ignite areas as soon as they dry out. This will create a mosaic of areas that were burnt at different dates and unburnt sections within the same area of woodland. Burn away from riparian communities, which can be critical habitat for some species. Approximately 25% of the grassy woodlands within a landscape should receive patchy fires in most years. | | | | source for many birds and small mammals. Recently burnt grass clumps tend to produce more seed than unburnt clumps and the earlier burnt grass usually seeds earlier than later burnt grass. Maintaining a fire mosaic will help ensure protection of habitat and mitigate against wildfires. Low to moderate intensity burns with good soil moisture minimise the risk of losing hollow trees. An occasional late season burn will promote grasses and legumes. Ensure a diverse grass layer; maintain hollow-bearing trees and vegetation structure. | |
| 11.11.1 | ▶ Manage surrounding country. Burn surrounding country only under conditions of good soil moisture and when plants are actively growing. Will be difficult to burn owing to a lack of ground fuel that normally occurs in this RE. | | | | | |

## 7.5 WEED MANAGEMENT

Offset area weed management will minimise the introduction, establishment and spread of restricted and prohibited pest plants under the *Biosecurity Act 2014* (Qld: Biosecurity Act) and other invasive species that present a threat to vegetation communities and species habitat in the offset area. Weed management within the offset area will focus on reducing the extent of existing weeds (see list below) as well as minimising the risk of introduction of additional weed species to the offset areas.

Weed species richness and cover surveys were undertaken between September 2019 and May 2020 that in combination with previous regional ecosystem surveys and BioCondition assessments on Mamelon identified 53 weed species. Maps of the species richness and cover of weeds by regional ecosystem is presented in Figure 12 and Figure 13, respectively. The results of this demonstrate high weed species richness in many lowland areas and some mid-elevation regional ecosystems. However, weed cover was markedly greater in alluvial regional ecosystems (e.g. 15 – 50% cover in RE 11.3.35, RE 11.3.4 and RE 11.3.25) compared with regional ecosystems away from alluvial influence which had weed cover as low as 1% (RE 11.4.2). The most widespread weeds, encountered at multiple regional ecosystems, included:

- lantana (*Lantana camara*)
- rubber vine (*Cryptostegia grandiflora*) – particularly in the watercourses, but also in upland areas
- Indian bluegrass (*Bothriochloa pertusa*)
- Parthenium (*Parthenium hysterophorus*)
- Guinea grass (*Megathyrsus maximus*) – mostly in disturbed alluvial lowland areas
- prickly pear (*Opuntia* spp.)
- buffel grass (*Cenchrus ciliaris*)
- flannel weed (*Sida cordifolia*).

Reductions in the extent of Parthenium are most effectively achieved by maximising the competitive advantage of native ground cover species. This requires native species richness and abundance to be maximised. In historically grazed environments the most effective way to ensure high species richness is through conservatively managed cattle grazing (Fensham 1998); however, the offset REs and offset values are considered sensitive to grazing pressure. For example, watercourse embankment habitat associated with areas of RE 11.3.25 and utilised by greater glider and koala are subject to erosion from cattle. Furthermore, adjacent areas of RE 11.3.4 are often subject to grazing pressure detrimentally impacting canopy tree and shrub species recruitment, with the additional impact of increased weed loads (e.g. buffel and Parthenium weed). This has the added effect of impacting the availability of a diverse native species richness and cover of perennial grass species characteristic of squatter pigeon breeding habitat. Similarly, grazing in areas of RE 11.10.7 and RE 11.11.1 not only impacts recruitment of canopy trees, shrubs and native perennial grasses, can result in erosion of many of these steep areas, with the additional impact of weed incursion increasing the potential impact of unplanned or uncontrolled fire.

Therefore, where identified, spraying of small isolated patches of weed species will be undertaken in consultation with the landowner, working from upslope to downslopes areas, eventually working towards core infestations.

Woody weeds will be managed through a combination of herbicide and mechanical control techniques in accordance with the recommended control measures available from the Queensland Department of Agriculture and Fisheries[1]. Spraying will occur at the end of the wet season when there is active growth. Follow-up inspection and treatment will be implemented if regrowth is evident, including mechanical removal of woody weeds.

A targeted weed survey will be conducted in year one of the implementation of this OAMP to calculate the species richness and abundance of restricted, prohibited and other weed species, including exotic pasture grasses, at each monitoring site in accordance with Section 8.3. The results of the year one surveys will inform the species-specific weed control measures, timing and location for ongoing weed management.

Species-specific control measures and timing for control activities will be reviewed based on the results of ongoing weed monitoring in the offset area.



[1] http://www.daff.qld.gov.au/plants/weeds-pest-animals-ants/weeds

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149°40'0"E
22°40'0"S
22°42'0"S
22°44'0"S
22°46'0"S

Central Queensland Coal

Location diagram


**Figure 12:**
**Distribution of weed species in the Mamelon offset area as a function of regional ecosystem**

Mamelon
Mamelon offset area

***Infrastructure***
Access tracks
Fence
Gates
Watering points

***Weed species richness***
23 - 28 species
18 - 22 species
12 - 17 species
7 - 11 species
1 - 6 species

0 0.5 1 1.5 2
Kilometres

N

CO2 Australia

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data

Date: 7/31/2020 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:40,000@A3

149°36'0"E
149°38'0"E
149°40'0"E
22°40'0"S
22°42'0"S
22°44'0"S
22°46'0"S

Central Queensland Coal

Location diagram


**Figure 13:**
**Weed species cover in the Mamelon offset area as a function of regional ecosystem**

Mamelon
Mamelon offset area

***Infrastructure***
Access tracks
Fence
Gates
Watering points

***Weed cover***
41 - 50%
31 - 40%
21 - 30%
11 - 20%
0 - 10%

0 0.5 1 1.5 2
Kilometres

N

CO2 Australia

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data

Date: 7/31/2020 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:40,000@A3

## 7.6 PEST ANIMAL MANAGEMENT

Pest animals are present or have the potential to be present within or in the immediate vicinity of the Mamelon offset area, and pose the following threats:

- Predation of fauna (including koala, greater glider and squatter pigeon) by wild dogs, foxes and cats, and
- Erosion and degradation of habitat and competition by feral pigs and rabbits.

An initial assessment of pest animals in the offset area will be undertaken in year 1 of the OAMP, consisting of a survey during the dry season and a survey post-wet season, to assess the spatial extent of pest animal presence within the offset area (see Section 8.4).

Pest animal control activities will be conducted generally in accordance with the Biosecurity Act. Table 14 provides examples of approved species-specific pest animal control measures recommended by the Queensland and Commonwealth governments. Results of pest animal assessments will be reviewed following each reporting event to inform the need for, location and timing of species-specific control measures in subsequent years.

**Table 14: Examples of species-specific control methods for pest animal species.**

| Species | Status* | Example control methods |
|---|---|---|
| Wild dog (*Canis familiaris*) | Restricted matter – category 3,4,6 | Control methods for wild dogs include (DAF 2020a):<br>▶ Ground baiting<br>▶ Foot hold traps<br>▶ Shooting |
| Fox (*Vulpes vulpes*) | Restricted matter – category 3,4,5,6 | Control methods for foxes include (DAF 2020b):<br>▶ Ground baiting<br>▶ Trapping<br>▶ Shooting |
| Feral cat (*Felis catus*) | Restricted matter – category 3,4,6 | Control methods for feral cats include (DAF 2020c):<br>▶ Night shooting<br>▶ Poisoning<br>▶ Trapping |
| Pig (*Sus scrofa*) | Restricted matter – category 3,4,6 | Pig control methods include (DAF 2020d):<br>▶ Trapping<br>▶ Shooting<br>▶ Poisoning |
| Rabbit (*Oryctolagus cuniculus*) | Restricted matter – category 3,4,5,6 | Rabbit control methods include (DAF 2020e):<br>▶ Baiting<br>▶ Fumigation<br>▶ Trapping<br>▶ Shooting |

* Status under the *Biosecurity Act 2014* (Qld).

# 8 MONITORING

The results of the monitoring program will be used to inform operational management decisions, ensure the performance criteria and management objectives, and ultimately interim performance targets and completion criteria are met.

## 8.1 OFFSET AREA INSPECTIONS

Inspections of the Mamelon offset area will provide a general assessment of the offset area to identify any potential issues that may require remedial action to be undertaken. Visual inspections will be undertaken at least annually for the duration of the 20-year management period to determine:

- condition of access tracks
- condition of fencing, gates and signs
- condition of firebreaks
- compliance with restrictions for vegetation clearing associated with maintenance and establishment of access tracks, fencing and firebreaks
- signs of damage/degradation resulting from pest animal activity
- signs of damage/degradation resulting from over-grazing
- signs of degradation from weed infestations
- exclusion of livestock
- erosion
- incidental fauna observations and any additional risks to offset values (i.e. evidence of vehicle strike).

## 8.2 FUEL LOAD MONITORING

Fuel load monitoring will be undertaken using a combination of fuel hazard assessment and biomass monitoring, in accordance with the following:

- Fuel load assessment using the Overall Fuel Hazard Assessment Guide (Hines *et al*. 2010; Appendix C), outlined in section 8.2.1
- Biomass monitoring in accordance with the feed budgeting assessment methodology, outlined in section 8.2.2.

### 8.2.1 Fuel load assessment

Fuel loads will be assessed in accordance with the Overall Fuel Hazard Assessment Guide (Hines *et al*. 2010; Appendix C). Fuel load assessment monitoring will include a baseline survey in year 1 (post-wet season), with ongoing fuel load assessment monitoring every two years thereafter for the remainder of the management period. This monitoring will focus on assessing the key structural layers of the fine fuels that burn in bushfires, specifically bark, elevated fuels, near-surface fuels and surface fuels. This will allow for a rapid assessment of each fuel layer, which in in turn is given a hazard rating and are then combined to provide an overall fuel hazard rating of low, moderate, high, very high or extreme.

The fuel hazard rating will be monitored to compare any changes from previous assessments. In conjunction with results of biomass monitoring, habitat quality assessments, and relevant fire management guidelines for corresponding regional ecosystems, the results of the fuel load

assessments will be used to determine if fuel hazard reduction burns are required to be undertaken within the offset area.

### 8.2.2 Biomass monitoring

Biomass monitoring assessments will be will also be undertaken at habitat quality monitoring sites within the offset area, to assess fuel loads, determine the risk of unplanned fire to the offset area and inform fire management strategies as well as inform strategic grazing activities. Biomass is at its greatest at the end of the wet season (around April) with fire risk greatest towards the end of the dry season (around October). Biomass monitoring will be undertaken at the end of the wet season, or at least annually during offset area inspections.

The aim of biomass monitoring is to measure fuel loads within pasture areas and manage them (where required) through an appropriately considered strategic grazing regime, as determined through a feed budgeting assessment. Note that livestock grazing will only be considered as a measure to manage fuel loads where such grazing does not conflict with OAMP management objectives and performance criteria, and is considered unlikely to trigger adaptive management and/or corrective actions. In the absence of such a determination, prior to any grazing event in the offset area, a feed budgeting assessment will be undertaken, which is a recognised method of determining the stocking rate based on the amount of feed available and the amount of feed desired at the end of the grazing event. The process for undertaking a feed budget assessment will include the following sequence of activities:

- Determine the current amount of feed present (kg/ha) using appropriate photo standards available on the Future Beef website[2].
- Determine the amount of feed desired (kg/ha) at the end of the grazing event.
- Calculate the total useable feed (kg/ha) by subtracting the feed desired from the feed present.
- Determine utilisation (i.e. the proportion of useable feed that livestock can use).
- Determine the feed available for the grazing animal (kg/ha) by multiplying the total useable feed by the utilisation rate.
- Calculate the safe stocking rate by:
  - Determining the feed consumption per day (kg/day)
  - Determining the number of days feed is required (days)
  - Calculating the feed requirement per head (kg/hd) by multiplying the feed consumption per day by the number of days
  - Calculating the stocking rate (ha/hd) by dividing the feed requirement per head by feed available
  - Calculate the number of stock (head) by dividing the area of the paddock by the stocking rate.

The amount of feed available prior to the grazing event will be estimated using the appropriate photo standards available on the Future Beef website. The Meat and Livestock Australia (MLA)

[2] See https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/grazing-pasture/sustainable-grazing/monitoring

"Stocking Rate Calculator" will then be used to calculate the required stocking rate for the grazing event[3].

At the completion of the grazing event, photo standards will be used to assess ground cover biomass. Should the grazing event be required to be extended (e.g. as a result of additional rainfall and resultant grass growth and potential weed flowering), the feed budget assessment will be recalculated using the MLA "Stocking Rate Calculator".

## 8.3 WEED MONITORING

The offset area will be monitored for weeds, including an initial baseline survey in year 1, during which the distribution and density of weed infestations will be mapped according to the methods outlined below. Ongoing weed monitoring surveys will be undertaken every two years, consisting of a survey during the dry season and a survey post-wet season.

Weed monitoring plots will be established in accordance with the following considerations:

- randomly stratified, permanent monitoring plots representative of particular offset values and incorporating natural variability such as aspect (e.g. a mix of north-, east-, south- and west-facing monitoring sites) and community type – (e.g. grassland, woodland, riparian, wetland)
- permanent weed monitoring plots at strategic trafficable areas (e.g. entry gates, creek crossings, stock watering points) to monitor potential introduction and/or irruptions of prohibited and restricted weed species.

Permanent monitoring plots provide greater confidence in monitoring changes that have occurred over time, compared with random monitoring plots which are likely to just reflect natural variation at the site level (Auld 2009). Accordingly, weed monitoring plots will be collocated at some of the habitat quality monitoring sites, with additional standalone weed monitoring plots established in strategic locations as noted above. A total of 20 weed monitoring sites will be established at the Mamelon offset area during baseline monitoring.

At each of the permanent weed monitoring plots, monitoring of weeds will be undertaken utilising two approaches:

- Plot-based weed transects – an assessment of weed species richness and relative abundance based on plot-based cover estimates along transects within 1 ha weed monitoring plots
- Photo monitoring – time series analysis of changes in vegetation composition, structure and integrity over time. In areas where active management is being undertaken, photo monitoring offers a simple and effective visual means by which to capture the response of the vegetation to management actions

In addition to permanent weed monitoring plots, incidental observations will be collated as part of general offset site monitoring (Section 8.1), noting weed infestations away from permanent weed monitoring sites.

Details of the weed monitoring methodology are presented in Table 15.

[3] See https://www.mla.com.au/extension-training-and-tools/tools-calculators/stocking-rate-calculator/

**Table 15: Weed monitoring methodology**

| Weed monitoring method | Methodology |
|---|---|
| Plot-based weed transects | An assessment of weed species richness and relative abundance, will be undertaken in accordance with the following method:<br>▶ at randomly stratified, permanent 1 ha plots (100 m x 100 m) across the offset area in environments that are more regularly impacted by weeds (e.g. drainage lines, around swamps/lagoons etc) and high traffic areas<br>▶ within each plot, mark out three 100 m transects (traversing in an east-west direction), keeping them parallel to one another, 50 m apart<br>▶ at every 10 m interval along each of the transects, centre a 2 m x 2 m quadrat and record the presence, species and cover of weeds. Weed cover within each 2 m x 2 m quadrat will be reported as one of five cover classes: 1 = 0%, 2 = 0-5%, 3 = 6-25%, 4 = 26-50% and 5 = 51-100% (Auld 2009)<br>▶ an average cover score for each weed species for each 1 ha plot will be calculated. The average cover score is calculated as the average percentage from the 30 quadrats surveyed from the three 100 m transects<br>▶ calculate the mean cover score across all weed monitoring plots in the offset site |
| Photo monitoring | A time-series photographic analysis to visually assess changes in vegetation composition (namely, weeds), will be undertaken as follows:<br>▶ at each end of the plot-based weed transects, establish photo-monitoring points<br>▶ at each of the photo monitoring points, take five photos from 1.5 m height above ground level, namely photos facing north, east, south, west and one facing the ground. The ground shot should be chosen to give a representative indication of cover and species composition for the general area. |
| Incidental observations | As part of general offset site monitoring, outside of plot-based weed transects, record details (including location, species and extent) of weeds, species not previously encountered in the offset site, new weed outbreaks and areas of significantly weed cover. |

## 8.4 PEST ANIMAL MONITORING

The Mamelon offset area will be monitored for evidence of pest animals, including a baseline survey in year 1 (post-wet season) of the distribution and abundance of pest animals, with ongoing pest animal monitoring surveys undertaken in year 3, year 5, and then every 5 years thereafter for the remainder of the management period.

Pest animal monitoring sites will be established as part of the surveying in year 1, comprising the following permanent monitoring locations:

- 15 pest animal camera trap stations along access tracks, set for a minimum of 3 nights
- 5 permanent 500 m x 300 m feral pig monitoring sites
- 10 permanent 2 ha rabbit monitoring sites.

In addition to surveys at permanent monitoring locations, pest animals will be opportunistically surveyed throughout the year outside of monitoring times. Any observed increase in the abundance or evidence of predator pest species in the offset area will trigger corrective actions (refer to Table 11).

For pest animals that are cryptic in their behaviour, it is usually impossible to take counts of individuals in order to determine their absolute abundance (Fleming *et al.* 1996). Instead, an

assessment of presence and relative abundance through signs and/or remote fauna camera captures will be used to establish a reliable estimate of relative abundance for rabbits (Cooke *et al.* 2008) and feral pigs (Hone 1988, Mitchell and Balogh 2007a). For foxes and wild dogs (Mitchell and Balogh 2007b, c) and cats (Forsyth *et al.* 2005), a measure of pest animal presence/activity will be assessed using pest animal camera traps. At each of the camera sites, a Catling Index value will be calculated for the site for each pest animal species by summing the number of operable camera trap stations with evidence of the targeted pest animal by the sum of all operable station days/nights (refer to Mitchell and Balogh 2007a). Furthermore, targeting areas of known impacts/movements (e.g. along topographic features, including creeks, pads, paths, ridge-tops and roads for wild dogs; Harden, 1985) not only maximises success at encountering pest animals, but targets monitoring in environments that are more regularly impacted (e.g. drainage lines, moist gullies and around swamps and lagoons favoured by feral pigs; Hone 1995).

Estimates of relative abundance (through signs and/or camera encounters) will provide an initial census of populations of pest animals, allowing for an evaluation of the success or otherwise of management programs (Saunders *et al.* 1995). The results of these pest animal surveys and habitat assessments will inform adaptive pest animal control, including targeting specific areas of pest animal outbreaks or impact.

Details of the pest animal monitoring methodology are presented in Table 16.

**Table 16: Pest animal monitoring methodology**

| Pest animal | Methodology to be implemented |
|---|---|
| Wild dog (*Canis familiaris, C. familiaris dingo, C. lupus familiaris, C. lupus dingo*)<br><br>Fox (*Vulpes vulpes*)<br><br>Feral cat (*Felis catus*) | An assessment of pest animal presence/activity based on a modified version of Mitchell and Balogh (2007c) and Fleming *et al.* (1996), will be undertaken as follows:<br>▶ select sites to be monitored, along access tracks. At least 15 camera trap stations are required, to be operable across the offset site for at least three nights<br>▶ record the location of camera trap stations on GPS so that future surveys can be undertaken at the same locations<br>▶ convert to indices via the percentage of station nights with confirmed photographic encounters (Catling index). |
| Feral pig (*Sus scrofa*) | An assessment of the presence or absence of feral pig signs[a] as a measure of feral pig activity in accordance with Mitchell and Balogh (2007a) and Hone (1988), will be undertaken as follows:<br>▶ nominate five randomly stratified, permanent 500 m x 300 m sites across the offset area in environments that are more regularly impacted (e.g. drainage lines, moist gullies, around swamps, lagoons etc)<br>▶ at each site, randomly select the start location of three 500 m transects, and record locations via GPS<br>▶ traverse in an east-west direction, surveying for the presence of any feral pig signs 1 m either side of the transect centreline in every 50 m section<br>▶ calculate an abundance score for each transect as the percentage of 'present' feral pig signs from the 10 sections along the 500 m transect<br>Repeat surveys will be undertaken from permanently established transects. The average frequency of occurrence across the offset site can be used as an index of abundance and change over time. Furthermore, changes to scores for individual sites/transects can point to areas to target control activities.<br>[a] Feral pig signs can include rooting, wallows, dung, footprints, travel pads, plant damage and tree rubs, as well as the physical presence of feral pigs |
| Rabbit (*Oryctolagus cuniculus*) | An assessment of rabbit impact in accordance with Cooke *et al.* (2008) (Appendix D) will be undertaken as follow. 10 randomly stratified, permanent monitoring points, a 2 ha patch of habitat is traversed over 15-20 minutes assessing:<br>▶ Rabbit abundance – a measure of the presence and number of rabbit warrens and the abundance of any faecal pellets (including 'buck-heaps' or latrines) – measured on a scale of 0 – 5<br>▶ Seedling abundance – a measure of the presence and abundance of native vegetation seedlings encountered during the 15-20-minute traverse – measured on a scale of 0 – 5<br>▶ Rabbit damage – a measure of seedlings (< 0.5 m height) with evidence of rabbit damage, identified as 45˚ 'secateurs-like' cuts through smaller stems, defoliation and gnawing of bark – measured on a scale of 0 – 5<br>From this assessment, a 'corrected regeneration score' is calculated from the seedling abundance and rabbit damage score.<br>Overall rabbit impact is assigned as one of three categories – 'acceptable', 'monitor closely' or 'unacceptable', as determined from a combination of the score for rabbit abundance and the corrected regeneration score (refer to Appendix D). |

## 8.5 OFFSET AREA MONITORING

Monitoring of MNES and MSES within the offset area will consist of:

- habitat quality assessments generally in accordance with the Guide to Determining Terrestrial Habitat Quality (Version 1.2; DEHP 2017), including targeted fauna surveys for greater glider, koala and squatter pigeon
- photo monitoring.

Specific timing for each of the monitoring activities is outlined in the sections below and is shown in the implementation schedule in Section 10.

### 8.5.1 Monitoring locations

Fixed monitoring sites within the offset areas will be established as part of the habitat quality assessments in year 1. The number and location of habitat quality assessment sites is determined in accordance with the Guide to Determining Terrestrial Habitat Quality, to assess any variation in condition across the offset area and effectively assess key habitat features for each offset value. Some habitat quality assessment sites will be used to assess habitat for more than one offset value where relevant habitat overlaps.

Habitat quality assessment sites will be largely based on the location of habitat quality assessments completed between 2018 and 2020, with additional sites proposed to be established to ensure there are the required number of assessment sites in accordance with the Guide to Determining Terrestrial Habitat Quality. Table 17 shows the number of permanent monitoring points required and Figure 14 presents the locations of habitat quality assessment sites assessed between 2018 and 2020 (New site numbers M01 – M29) as well as five additional sites to be established in year 1 (M30 – M34).

As part of habitat quality assessments in year 1, the 0 m and 50 m points of all monitoring sites will be demarcated with a capped stake and a GPS location will be recorded using a GPS in GDA94 (or GDA2020), Zone 55 projection.

**Table 17: Habitat quality monitoring sites (GDA94).**

| New site number | Existing site number | RE | Transect centre point | |
|---|---|---|---|---|
| | | | Easting | Northing |
| M01 | M01 | 11.3.4 | 767693 | 7479969 |
| M02 | M02 | 11.10.7 | 767682 | 7480779 |
| M03 | M04 | 11.4.2 RG | 768631 | 7483995 |
| M04 | M05 | 11.4.2 RG | 767914 | 7483497 |
| M05 | M06 | 11.4.2 RG | 767356 | 7482557 |
| M06 | M08 | 11.4.2 RG | 767182 | 7481716 |
| M07 | M11 | 11.10.7 | 768480 | 7483034 |
| M08 | M14 | 11.10.7 | 769497 | 7485263 |
| M09 | M15 | 11.10.7 | 770947 | 7484098 |
| M10 | M22 | 11.11.15 | 773257 | 7483109 |
| M11 | M25 | 11.4.2 | 773557 | 7482533 |
| M18 | M62 | 11.3.35 | 773747 | 7481829 |
| M19 | M63 | 11.11.1 | 769222 | 7486069 |
| M20 | M64 | 11.11.1 | 768961 | 7486299 |
| M21 | M65 | 11.10.7 | 772337 | 7483078 |
| M22 | M66 | 11.5.8 | 769804 | 7486177 |
| M23 | M67 | 11.5.8 | 769928 | 7485177 |
| M24 | M68 | 11.5.8 | 770056 | 7484529 |
| M25 | M69 | 11.5.8 | 770121 | 7486648 |
| M26 | M70 | 11.11.15 | 773050 | 7482021 |
| M27 | M71 | 11.11.15 | 772801 | 7480594 |
| M28 | M72 | 11.11.15 | 768235 | 7480432 |

| New site number | Existing site number | RE | Transect centre point | |
|---|---|---|---|---|
| | | | Easting | Northing |
| M12 | M29 | 11.4.2 | 773596 | 7480930 |
| M13 | M33 | 11.4.2 | 767872 | 7479781 |
| M14 | M34 | 11.3.25 | 767769 | 7479648 |
| M15 | M59 | 11.3.25 | 770318 | 7486804 |
| M16 | M60 | 11.3.4 | 770705 | 7478772 |
| M17 | M61 | 11.3.35 | 773750 | 7482902 |

| New site number | Existing site number | RE | Transect centre point | |
|---|---|---|---|---|
| | | | Easting | Northing |
| M29 | M73 | 11.11.15 | 769203 | 7480274 |
| M30* | M79 | 11.4.2 | 770418 | 7487159 |
| M31* | M80 | 11.11.15 RG | 772761 | 7479797 |
| M32* | M81 | 11.11.15 RG | 772816 | 7480268 |
| M33* | M82 | 11.3.25 | 774455 | 7490833 |
| M34* | M83 | 11.3.25 | 767131 | 7483443 |

* Additional monitoring sites to be established in the first year of management as part of the habitat quality assessments.

### 8.5.2 Habitat quality assessment

Habitat quality assessments will be undertaken in year 1, with subsequent assessments undertaken in year 3, year 5, and then every 5 years thereafter for the remainder of the management period.

To satisfy specific requirements of the EPBC Act Environmental Offsets Policy and offsets assessment guide, the habitat quality scores for greater glider, koala and squatter pigeon will be determined based on the methods outlined in Section 3.1 (and detailed in the Project's BOS), in accordance with the Guide to Determining Terrestrial Habitat Quality. Habitat quality scores for MSES will likewise be undertaken based on the same guide.

Data from habitat quality assessments will be recorded in survey sheets and these will be attached to the monitoring reports. Reports prepared for subsequent years will include summary data from previous reporting years and this will be presented so as to allow trend analysis of each of the measured attributes and assess progress towards achieving the interim performance targets and completion criteria.

#### Targeted fauna surveys

The species habitat index assessment will include targeted fauna surveys in the Mamelon offset area for greater glider, koala and squatter pigeon, with these surveys undertaken in year 1, year 3, year 5, and then every 5 years thereafter for the remainder of the management period.

Targeted fauna surveys will be undertaken between November and March, when species are most detectable, in accordance with the following:

- Greater glider – Victorian Department of Sustainability and Environment Approved Survey Standards for Greater Glider (DSE 2011), specifically spotlighting
- Koala – on ground survey recommendations in the EPBC Act referral guidelines for the vulnerable koala (DoE 2014)
- Squatter pigeon - Survey Guidelines for Australia's Threatened Birds (DEWHA 2010).

All methodology documents noted throughout this OAMP are referenced in Section 12 and include internet hyperlinks to PDFs of those documents.

### 8.5.3 Photo monitoring

Photo monitoring is a qualitative analysis technique that provides the opportunity for visual time series analysis of changes in vegetation composition, structure and integrity. In areas where active management is

being undertaken, photo monitoring offers a simple and effective visual means by which to capture the response of the vegetation to management actions.

Photo monitoring will be undertaken at the same time as habitat quality assessments at each of the permanent habitat monitoring points. Permanent photo monitoring points will be established at the 0 m and 50 m points along all permanent habitat quality assessment transects, providing an opportunity to visually assess the changes in habitat over time.

Five photos will be taken at each photo monitoring point (from 1.5 m height above ground level) in the direction of magnetic north, south, east and west and ground. The ground shot should be taken at such an angle (~45°) that the horizon is just visible at the top of the frame; in a direction chosen to give a representative indication of cover and species composition for the general area. A record of the photographs will be maintained, including GPS co-ordinates, date and time of each photograph, the direction in which the photograph was taken, and the height above the ground at which the photograph was taken.

Photo monitoring will also be used to monitor biomass within the offset areas (Section 8.2) by comparing to relevant photo standards[4] in order to manage grazing biomass and minimise risk of unplanned fire.



[4] See https://futurebeef.com.au/knowledge-centre/pastures-forage-crops/pasture-photo-standards/

149°36'0"E 149°38'0"E 149°40'0"E

22°40'0"S 22°42'0"S 22°44'0"S 22°46'0"S

**Ground-truthed vegetation**

- 11.10.7
- 11.11.1
- 11.11.15
- 11.11.15 regrowth
- 11.3.25
- 11.3.35
- 11.3.4
- 11.4.2
- 11.4.2 regrowth
- 11.5.8

ML80187 ML700022

M01 M02 M03 M04 M05 M06 M07 M08 M09 M10 M11 M12 M13 M14 M15 M16 M17 M18 M19 M20 M21 M22 M23 M24 M25 M26 M27 M28 M29 M30 M31 M32 M33 M34

Central Queensland Coal

**Figure 14: Mamelon offset area – monitoring sites**

- Mamelon
- Project footprint (direct impact area)
- Indirect impact area
- Project MLs

***Survey sites (new site numbers)***

- Offset monitoring site (existing)
- Offset monitoring site (to be established)

***Infrastructure***

- Access tracks
- Fence
- Gates
- Watering points

0 0.5 1 1.5 2
Kilometres

N

Location diagram

Queensland

Brisbane

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
The following datasets were provided by Orange Environmental
- Ground-truthed vegetation
- Project footprint and indirect impact area

Date: 8/13/2020 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:40,000@A3

# 9 REPORTING

## 9.1 REPORTING AGAINST OAMP

Following approval of the Mamelon OAMP, reporting against the OAMP (including the management and monitoring undertaken and progress/results) will be prepared after the management years 1, 3, 5, and then every five years of the 20-year management period (i.e. years 10, 15 and 20) to align with interim performance targets and completion criteria milestone dates. The OAMP report will contain, but may not be limited to:

- results of monitoring events
- a comparison of the monitoring results with previous monitoring results
- a description of any performance criteria which were not satisfied and, where required, describe instances where corrective actions have been implemented
- an indication of any risks or potential threats that have become apparent through monitoring and activities to be undertaken to manage these threats and risks including any corrective actions that need to be implemented
- progress towards achieving the interim performance targets and completion criteria
- proposed changes to management and monitoring activities to improve management and/or monitoring performance and attain interim performance targets and/or completion criteria.

## 9.2 UPDATE OF OAMP

In accordance with the principles of adaptive management, the Mamelon OAMP will be amended (if required) to incorporate changes identified through management actions and monitoring activities. This may include the revision of/addition to current management actions and monitoring activities, responses to adaptive management triggers and review of environmental threats.

Changes to the Mamelon OAMP will be made in consultation with the landholder, in accordance with the executed offset agreement.

# 10 IMPLEMENTATION SCHEDULE

Persons implementing management and monitoring activities described in this management plan will have appropriate skills and qualifications as required by the relevant government guidelines.

In the event that injured fauna are encountered, they will be taken to the nearest qualified veterinary practitioner or wildlife carer. Animals with a poor prognosis for survival and that are suffering must be euthanised on site in accordance with the *Code of Practice: Care of Sick, Injured or Orphaned Protected Animals in Queensland*.

A proposed implementation schedule for management actions and monitoring events is presented in Table 18 and Table 19 respectively.

Table 20 presents months of the year when monitoring events can occur and nominates months when multiple monitoring events can occur in the same month.

**Table 18: Implementation of management actions.**

| Management action and description (relevant sections) | | Timing | Related detection/monitoring activity/ies |
|---|---|---|---|
| General restrictions (Section 7.1) | Install/upgrade fencing and gates | Within 12 months of OAMP approval | Offset area inspections (Section 8.1) |
| | Erect signs on access points | | |
| | Control vehicle access/movement | At all times | |
| | Implement weed hygiene protocols | At all times | Weed monitoring (Section 8.3) |
| Access tracks (Section 7.2) | Maintain access tracks | At all times, subject to constraints in Section 7.2 | Offset area inspections (Section 8.1) |
| Fencing (Section 7.3) | Install additional fencing and gates and upgrade current fencing where required | Within 12 months of OAMP approval | Offset area inspections (Section 8.1) |
| | Maintain fencing | At all times | |
| Fire management (Section 7.4) | Implement strategic grazing regimes to maintain fuel loads | As required, subject to constraints in Section 7.4 | Fuel load monitoring (Section 8.2)<br>Weed monitoring (Section 8.3) |
| | Maintain firebreaks | Annually | Offset area inspections (Section 8.1)<br>Fuel load monitoring (Section 8.2)<br>Weed monitoring (Section 8.3) |
| | Implement fuel hazard reduction burns to maintain fuel loads | As required, subject to constraints in Section 7.4 | Fuel load monitoring (Section 8.2)<br>Weed monitoring (Section 8.3) |
| Weed management (Section 7.5) | Conduct weed assessment in year 1 of OAMP implementation | Following the first wet season after OAMP approval | Weed monitoring (Section 8.3) |
| | Implement weed control as per Section 7.5 | Timing determined following results of year 1 assessment, subject to constraints in Section 7.5 | |
| Pest animal management (Section 7.6) | Conduct pest animal assessment in year 1 of OAMP implementation | Following the first wet season after OAMP approval | Pest animal monitoring (Section 8.4) |
| | Implement pest animal control as per Section 7.6 | Timing determined following results of year 1 assessment, subject to constraints in Section 7.6 | |
| Reporting (Section 9) | Report against OAMP | Following approval OAMP, years 1, 3, 5, 10, 15 and 20 | Offset area inspections (Section 8.1)<br>Fuel load monitoring (Section 8.2)<br>Weed monitoring (Section 8.3)<br>Pest animal monitoring (Section 8.4)<br>Offset area monitoring (Section 8.5) |

**Table 19: OAMP monitoring events.**

| Survey or monitoring objective (relevant sections) | Monitoring activity | Timing | Survey/monitoring guidelines | Reliability |
|---|---|---|---|---|
| Baseline assessments (Sections 8.2, Section 8.3, Section 8.4, and Section 8.5) | Baseline monitoring sites will be established for the following:<br>▶ Fuel load monitoring<br>▶ Weed monitoring<br>▶ Pest animal monitoring<br>▶ Habitat quality assessment and photo monitoring | Year 1 | See relevant sections | Establishes fixed/repeatable location and/or baseline condition/scores from which subsequent monitoring will be compared. |
| Offset area inspections (Section 8.1) | Monitoring within the offset area to assess the following matters:<br>▶ condition of fencing, gates and signs<br>▶ condition of access tracks<br>▶ condition of firebreaks | At least annually for 20-year management period | - | Visual inspections, providing a general assessment of the offset area to identify any potential issues that may require remedial action to be undertaken |

| Survey or monitoring objective (relevant sections) | Monitoring activity | Timing | Survey/monitoring guidelines | Reliability |
|---|---|---|---|---|
| | ▶ compliance with restrictions for vegetation clearing associated with maintenance and establishment of access tracks, fencing and firebreaks<br>▶ incidence of erosion within offset area, particularly around permanent and semi-permanent water bodies or areas subject to inundation or waterlogging<br>▶ damage/degradation resulting from pest animal activity within the offset area<br>▶ signs of land degradation and over-grazing<br>▶ exclusion of livestock in accordance with the strategic grazing regime<br>▶ incidental fauna observations and any additional risks to offset values (i.e. evidence of vehicle strike) | | | |
| Habitat quality assessments (Section 8.5) | Habitat quality assessments will be undertaken at fixed/repeatable monitoring sites to determine the site condition of the vegetation communities and overall habitat quality of the offset values to assess progress towards attaining and maintaining the completion criteria. | Year 1, year 3, year 5, and then every 5 years thereafter | Guide to Determining Terrestrial Habitat Quality (DEHP 2017) | Assessment undertaken generally in accordance with method developed by the Queensland Government and also aligns with the EPBC Act Environmental Offsets Policy measure of 'habitat quality' and is intended to provide a consistent framework for environmental offsets in Queensland. The methods presented are based on the Guide to Determining Terrestrial Habitat Quality Version 1.2 (DEHP 2017). |
| Photo monitoring (Section 8.5) | Visual assessment of habitat changes over time including at habitat quality assessment sites | Year 1, year 3, year 5, and then every 5 years thereafter | Monitoring method outlined in Section 8.5.3 | Based on best practice photo monitoring techniques, see Appendix 4 of BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland. Assessment Manual. Version 2.2. (Eyre *et al.* 2015). |
| Weed monitoring (Section 8.3) | Year 1 weed survey to assess the distribution and abundance of weed infestations. | Year 1, post-wet season (~March – April) | Monitoring method outlined in Section 8.3 | Assessment methodology based on NSW Guidelines for Monitoring Weed Control and recovery of native vegetation (Auld 2009) |
| | Ongoing weed surveys to assess the effectiveness of weed control | Every two years, post-wet season (~March - April) | | |
| Pest animal monitoring (Section 8.4) | Year 1 pest animal survey to assess the presence of pest animals | Year 1, post-wet season (~March-April) | Monitoring method outlined in Section 8.4 | Assessment undertaken generally in accordance with published monitoring techniques developed by the NSW Government – Monitoring Techniques for Vertebrate Pests (Mitchell and Balogh 2007a, b, c) and Bureau of Rural Sciences methodology for assessing impacts from rabbits (Cooke *et al.* 2008). |
| | Ongoing pest animal surveys to assess the effectiveness of pest animal control | Every two years, post-wet season (~March - April) | | |
| Fuel load monitoring (Section 8.2) | Fuel load assessment | Post-wet season (~March-April) in year 1, then every 2 years | Overall Fuel Hazard Assessment Guide (Hines *et al*. 2010). | Assessment method based on the Overall Fuel Hazard Assessment Guide (Hines *et al*. 2010). |
| | Biomass monitoring for sustainable grazing | Post-wet season (~March-April), or at least annually during offset area inspections | Feed Budget assessment methodology outlined in Section 8.2<br>Appropriate Future Beef photo standards<br>Meat and Livestock Australia stocking rate calculator | Future Beef website: https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/grazing-pasture/sustainable-grazing/monitoring<br>Meat and Livestock Australia stocking rate calculator: https://www.mla.com.au/extension-training-and-tools/tools-calculators/stocking-rate-calculator/ |
| Targeted fauna surveys (Section 8.5) | Targeted fauna surveys will be undertaken to assess the presence of offset fauna species and changes in targeted fauna capture rates between sites and monitoring events. | Year 1, year 3, year 5, and then every 5 years thereafter for greater glider, koala and squatter pigeon | ▶ Koala –on ground survey recommendations in the EPBC Act referral guidelines for the vulnerable koala (DoE 2014).<br>▶ Greater glider - Victorian Department of Sustainability | Assessment undertaken generally in accordance with methods and guidelines developed by the Queensland and Commonwealth governments, or other methodologies endorsed by relevant bodies, including other State or Territory Governments. |

| Survey or monitoring objective (relevant sections) | Monitoring activity | Timing | Survey/monitoring guidelines | Reliability |
|---|---|---|---|---|
| | | | and Environment Approved Survey Standards for Greater Glider (DSE 2011) including spotlighting and surveys for hollow-bearing trees within areas of suitable habitat<br>▶ Squatter pigeon - Survey Guidelines for Australia's Threatened Birds (DEWHA 2010) | |

**Table 20: Nominal timing of months when monitoring is recommended to occur; green columns are when monitoring could most efficiently occur.**

| Monitoring | Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Offset area inspections (Section 8.1) | X | X | X | X | X | X | X | X | X | X | X | X |
| Weed monitoring (Section 8.3) – post-wet season | | | X | X | X | | | | | | | |
| Pest animal monitoring (Section 8.4) – post-wet season | | | X | X | X | | | | | | | |
| Fuel load monitoring (Section 8.2) – fuel load assessment and biomass monitoring | | | X | X | | | | | X | X | | |
| Offset area monitoring (Section 8.5) – habitat quality assessments, targeted fauna surveys, photo monitoring | X | X | X | X | | | | | | | X | X |

# 11 CONSENT

### Administering authority of *Vegetation Management Act 1999*

**SIGNED** by the to indicate approval of the OAMP

Name: Signature:

Witness name: Signature:

Date:

### Landowner

The landowner agrees:

- Any non-compliance by the Landowner with the Landowner's requirements of this OAMP shall constitute a breach of the terms and conditions of the legally binding mechanism entered into.

**SIGNED** by being the current owner/s of the abovementioned property to indicate that the terms of this OAMP including Landowner's responsibilities under the OAMP, have been read, understood and accepted.

Name: Signature:

Witness name: Signature:

Date:

Name: Signature:

Witness name: Signature:

Date:

# 12 REFERENCES


Agnew, L. (2020). *MNES and MSES Fauna – Supplementary Impact Assessments: Central Queensland Coal Project*. Prepared for Orange Environmental. Austecology, Brisbane.

Auld, B. (2009). *Guidelines for monitoring weed control and recovery of native vegetation.* NSW Department of Primary Industries, Orange NSW.

Cooke, B., McPhee, S., and Hart, Q. (2008). *Rabbits: A threat to conservation and natural resources management. How to rapidly assess a rabbit problem and take action.* Bureau of Rural Sciences, Canberra.

Crowther, M., Lunney, D., Lemon, J., Stalenberg, E. Wheeler, R., Madani, G., Ross, K. & Ellis, M. (2013). Climate-mediated habitat selection in an arboreal folivore. *Ecography*. **36:** 1-8.

Department of Agriculture and Fisheries (DAF) (2020a) *Fact Sheet: Wild dog control (Canis familiaris). Queensland*. Available from: https://www.daf.qld.gov.au/__data/assets/pdf_file/0003/74487/IPA-Dingo-Wild-Dog-Control-PA10.pdf

Department of Agriculture and Fisheries (DAF) (2020b) *Fact Sheet: European red fox (Vulpes vulpes)*. Queensland. Available from: https://www.daf.qld.gov.au/__data/assets/pdf_file/0019/73810/IPA-Fox-PA13.pdf

Department of Agriculture and Fisheries (DAF) (2020c) *Fact Sheet: Feral cat (Felis catus).* Queensland. Available from: https://www.daf.qld.gov.au/__data/assets/pdf_file/0004/61987/IPA-Feral-Cat-Ecology-PA26.pdf

Department of Agriculture and Fisheries (DAF) (2020d) *Fact Sheet: Feral pig (Sus scrofa). Queensland*. Available from: https://www.daf.qld.gov.au/__data/assets/pdf_file/0005/70925/IPA-Feral-Pigs-Qld-PP6.pdf

Department of Agriculture and Fisheries (DAF) (2020e) *Fact Sheet: Rabbit (Oryctolagus cuniculus).* Queensland. Available from: https://www.daf.qld.gov.au/__data/assets/pdf_file/0015/62700/IPA-Rabbit-PA11.pdf

Department of Agriculture, Water and the Environment (DAWE)(2020a). *Geophaps scripta scripta in Species Profile and Threats Database.* Commonwealth of Australia, Canberra. Available from: http://www.environment.gov.au/sprat

Department of Agriculture, Water and the Environment (DAWE)(2020b). *Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) in Species Profile and Threats Database.* Commonwealth of Australia, Canberra. Available from: http://www.environment.gov.au/sprat

Department of Environment and Heritage Protection (DEHP) (2017). *Guide to Determining Terrestrial Habitat Quality, Version 1.2 (April 2017).* Queensland Government, Brisbane.

Department of Environment and Science (DES) (2020). *Queensland Environmental Offsets Policy, Version 1.8 (February 2020)*. Queensland Government, Brisbane.

Department of Sustainability, Environment, Water, Populations and Communities (DSEWPC) (2011). *Survey guidelines for Australia's threatened mammals.* Commonwealth of Australia, Canberra.

Department of Sustainability, Environment, Water, Populations and Communities (DSEWPC) (2012). *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy*. Commonwealth of Australia, Canberra.

Department of Sustainability and Environment (DSE) (2011). *Approved Survey Standards: Greater Glider Petauroides volans.* Department of Sustainability and Environment, Victoria.

Department of the Environment (DoE) (2014). *EPBC Act Referral Guidelines for the vulnerable Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory).* Commonwealth of Australia, Canberra.

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2010). *Survey guidelines for Australia's threatened birds.* Commonwealth of Australia, Canberra.

Eyre, T. J., Ferguson, D. J., Hourigan, C. L., Smith, G. C., Mathieson, M. T., Kelly, A.L., Venz, M. F., Hogan, L.D. and Rowland, J. (2018). *Terrestrial Vertebrate Fauna Survey Assessment Guidelines for Queensland.* Department of Environment and Science, Queensland Government, Brisbane.

Eyre, T. J., Kelly, A. L, Neldner, V. J., Wilson, B. A., Ferguson, D. J., Laidlaw, M. J. and Franks, A. J. (2015). *BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland. Assessment Manual. Version 2.2*. Queensland Herbarium, Department of Science, Information Technology, Innovation and Arts, Brisbane.

Fensham, R. J. (1998). The grassy vegetation of the darling downs, south-eastern Queensland, Australia floristics and grazing effects. *Biological Conservation*. **84:** 301-310.

Fleming, P. J. S., Thompson, J. A., Nicol, H. I. (1996). Indices for measuring the efficacy of aerial baiting for wild dog control in north-eastern New South Wales. *Wildlife Research* **23:** 665-674.

Forsyth, D. M., Robley, A. J., and Reddiex, B. (2005). *Review of methods used to estimate the abundance of feral cats*. Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Melbourne.

Franks, A. J. (2002). The ecological consequences of Buffel Grass *Cenchrus ciliaris* establishment within remnant vegetation of Queensland. *Pacific Conservation Biology* **8:** 99 – 107.

Future Beef (2018) *Pasture photo standards*. Available from: https://futurebeef.com.au/knowledge-centre/pasture-photo-standards/

Harden, R. H. (1985). The ecology of the dingo in north-eastern New South Wales. I. Movements and home range. *Australian Wildlife Research* **12:** 25-27.

Hines, F, Tolhurst, K.G, Wilson, A.A.G and McCarthy, G.J. (2010). *Overall Fuel Hazard Assessment Guide, 4th edition July 2010*. Victorian Government Department of Sustainability and Environment, Melbourne.

Hone, J. (1988). Feral pig rooting in a mountain forest and woodland Distribution, abundance and relationships with environmental variables. *Australian Journal of Ecology* **13:** 393-400.

Hone, J. (1995). Spatial and temporal aspects of vertebrate pest damage with emphasis on feral pigs. *Journal of Applied Ecology* **32:** 311-319.

Mitchell, B. and Balogh, S. (2007a). *Monitoring techniques for vertebrate pests – feral pigs*. NSW Department of Primary Industries, Orange NSW.

Mitchell, B. and Balogh, S. (2007b). *Monitoring techniques for vertebrate pests – foxes*. NSW Department of Primary Industries, Orange NSW.

Mitchell, B. and Balogh, S. (2007c). *Monitoring techniques for vertebrate pests – wild dogs*. NSW Department of Primary Industries, Orange NSW.

National Research Council (2004). *Adaptive Management for Water Resources Project Planning*. The National Academies Press, Washington, DC.

Kehl, J., and Borsboom, A. C. (1984). *Home range, den tree use and activity patterns in the greater glider Petauroides volans.* In 'Possums and Gliders'. (Eds A. P. Smith and I. D. Hume.) pp. 229–236. Surrey Beatty & Sons, Sydney.

Martin, R. & Handasyde, K. (1999). *The Koala: Natural history, conservation and management*. UNSW Press, Sydney.

Melzer, A. and Tucker, G. (2011). *Koalas of the St Lawrence Region of Central Queensland. Report 1: Defining the population.* Report prepared for the Queensland Department of Transport and Main Roads by Central Queensland Environmental Surveys, Rockhampton.

Neldner, V.J., Wilson, B.A., Dillewaard H.A., Ryan, T.S., Butler, D. W., McDonald, W.J.F., Addicott, E.P. and Appelman, C.N. 2017, *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland*. Version 4.0. Queensland Herbarium, Queensland. Department of Environment and Science, Brisbane.

Patterson, R. (1996). The distribution of the koala in Queensland 1986-1989. In: Gordon, G., ed. Koalas, *Research for Management: Proceedings of the Brisbane Koala Symposium.* pp 75-81. World Koala Research Inc., Brisbane.

Queensland Herbarium (2019) Regional Ecosystem Description Database (REDD). Version 11.1 (April 2019) (DES: Brisbane). Available from: https://www.qld.gov.au/environment/plantsanimals/plants/ecosystems/descriptions/download

Saunders, G. Coman, B. Kinnear, J. & Braysher, M. (1995). *Managing vertebrate pests: foxes.* Australian Government Publishing Service, Canberra.

Smith, G.C., Mathieson, M., and Hogan, L. (2007). Home range and habitat use of a low-density population of greater gliders, *Petauroides volans* (Pseudocheiridae: Marsupialia), in a hollow-limiting environment. *Wildlife Research* **34:** 472-483.

Threatened Species Scientific Committee (TSSC) (2012). *Listing advice for Phascolarctos cinereus (Koala).* Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/197-listing-advice.pdf.

Threatened Species Scientific Committee (TSSC) (2015). *Conservation Advice Geophaps scripta scripta squatter pigeon (southern).* Commonwealth of Australia, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/64440-conservation-advice-31102015.pdf

Threatened Species Scientific Committee (TSSC) (2016). *Conservation Advice Petauroides volans greater glider.* Commonwealth of Australia, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/254-conservation-advice-20160525.pdf

Williams, B. K. (2011). Adaptive management of natural resources-framework and issues. *Journal of Environmental Management* **92:** 1346-1353.

Williams, B. K. and Brown, E. D. (2016). Technical challenges in the application of adaptive management. *Biological Conservation* **195:** 255–263.

# APPENDIX A OFFSET AREA COORDINATES

### Table A-1: Offset area coordinates – 1–560 (GDA94).

| | Easting | Northing | | Easting | Northing | | Easting | Northing | | Easting | Northing | | Easting | Northing | | Easting | Northing | | Easting | Northing | | Easting | Northing |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 770191 | 7488301 | 71 | 770363 | 7485614 | 141 | 771946 | 7483386 | 211 | 772079 | 7483878 | 281 | 773961 | 7480950 | 351 | 773824 | 7480278 | 421 | 771748 | 7481797 | 491 | 771601 | 7479710 |
| 2 | 770160 | 7488102 | 72 | 770415 | 7485331 | 142 | 771870 | 7483427 | 212 | 772096 | 7483817 | 282 | 773943 | 7480976 | 352 | 773849 | 7480261 | 422 | 772010 | 7481750 | 492 | 771402 | 7479699 |
| 3 | 770539 | 7488043 | 73 | 770240 | 7484668 | 143 | 771700 | 7483422 | 213 | 772009 | 7483724 | 283 | 773909 | 7480944 | 353 | 773823 | 7480242 | 423 | 772067 | 7481810 | 493 | 771283 | 7479728 |
| 4 | 770547 | 7488010 | 74 | 770415 | 7484591 | 144 | 771688 | 7483507 | 214 | 771966 | 7483617 | 284 | 773885 | 7480893 | 354 | 773807 | 7480137 | 424 | 772010 | 7481911 | 494 | 771290 | 7479774 |
| 5 | 770399 | 7487553 | 75 | 770498 | 7484508 | 145 | 771670 | 7483525 | 215 | 772059 | 7483583 | 285 | 773643 | 7481140 | 355 | 773845 | 7480082 | 425 | 772134 | 7482012 | 495 | 771240 | 7479940 |
| 6 | 769800 | 7488040 | 76 | 770553 | 7484406 | 146 | 771603 | 7483531 | 216 | 771975 | 7483554 | 286 | 773691 | 7481154 | 356 | 773880 | 7480034 | 426 | 772273 | 7481923 | 496 | 771263 | 7480130 |
| 7 | 769893 | 7488069 | 77 | 770565 | 7484365 | 147 | 771597 | 7483456 | 217 | 771908 | 7483567 | 287 | 773723 | 7481177 | 357 | 773858 | 7479985 | 427 | 772308 | 7481943 | 497 | 771212 | 7480192 |
| 8 | 770125 | 7488224 | 78 | 770548 | 7484316 | 148 | 771613 | 7483394 | 218 | 771796 | 7483531 | 288 | 773732 | 7481240 | 358 | 773820 | 7479998 | 428 | 772258 | 7482024 | 498 | 771158 | 7480200 |
| 9 | 770609 | 7488004 | 79 | 770517 | 7485758 | 149 | 771539 | 7483389 | 219 | 771697 | 7483559 | 289 | 773694 | 7481295 | 359 | 773750 | 7480071 | 429 | 772251 | 7482095 | 499 | 770991 | 7480244 |
| 10 | 770652 | 7487996 | 80 | 770612 | 7485773 | 150 | 771474 | 7483359 | 220 | 771591 | 7483613 | 290 | 773664 | 7481267 | 360 | 773668 | 7480100 | 430 | 772321 | 7482141 | 500 | 770918 | 7480385 |
| 11 | 770640 | 7487357 | 81 | 770609 | 7485614 | 151 | 770916 | 7483919 | 221 | 771387 | 7483656 | 291 | 773614 | 7481274 | 361 | 773378 | 7480033 | 431 | 772324 | 7482205 | 501 | 770868 | 7480322 |
| 12 | 770578 | 7487408 | 82 | 771175 | 7485596 | 152 | 770936 | 7483929 | 222 | 771357 | 7483743 | 292 | 773583 | 7481207 | 362 | 773337 | 7480048 | 432 | 772363 | 7482249 | 502 | 770558 | 7480372 |
| 13 | 770595 | 7487960 | 83 | 771183 | 7485369 | 153 | 770925 | 7483950 | 223 | 771353 | 7483863 | 293 | 773535 | 7481243 | 363 | 773319 | 7480079 | 433 | 771491 | 7482742 | 503 | 770330 | 7480431 |
| 14 | 770541 | 7487794 | 84 | 771024 | 7485246 | 154 | 770975 | 7483995 | 224 | 771408 | 7483939 | 294 | 773238 | 7481545 | 364 | 773249 | 7480063 | 434 | 771554 | 7482655 | 504 | 770274 | 7480349 |
| 15 | 770530 | 7487446 | 85 | 771094 | 7485123 | 155 | 770887 | 7483967 | 225 | 771459 | 7483950 | 295 | 773406 | 7482175 | 365 | 773171 | 7480010 | 435 | 771572 | 7482522 | 505 | 770240 | 7480322 |
| 16 | 770449 | 7487512 | 86 | 771143 | 7485118 | 156 | 770757 | 7484122 | 226 | 771463 | 7484034 | 296 | 773387 | 7482852 | 366 | 773056 | 7479996 | 436 | 771730 | 7482432 | 506 | 770265 | 7480257 |
| 17 | 769315 | 7487950 | 87 | 771709 | 7484520 | 157 | 770735 | 7484236 | 227 | 771591 | 7484070 | 297 | 773429 | 7482811 | 367 | 772945 | 7479962 | 437 | 771866 | 7482295 | 507 | 770225 | 7480159 |
| 18 | 769627 | 7487904 | 88 | 771240 | 7484012 | 158 | 770647 | 7484349 | 228 | 771669 | 7484006 | 298 | 773399 | 7482903 | 368 | 772840 | 7479961 | 438 | 771977 | 7482286 | 508 | 770241 | 7480040 |
| 19 | 770522 | 7487171 | 89 | 771290 | 7484020 | 159 | 770609 | 7484495 | 229 | 771722 | 7484049 | 299 | 773477 | 7482939 | 369 | 772810 | 7479919 | 439 | 771964 | 7482122 | 509 | 770206 | 7479896 |
| 20 | 770493 | 7486202 | 90 | 771763 | 7484505 | 160 | 770643 | 7484532 | 230 | 771871 | 7484068 | 300 | 773475 | 7483027 | 370 | 772840 | 7479838 | 440 | 771962 | 7482075 | 510 | 770127 | 7479888 |
| 21 | 770485 | 7486145 | 91 | 771812 | 7484524 | 161 | 770622 | 7484633 | 231 | 771890 | 7484131 | 301 | 773457 | 7483056 | 371 | 772873 | 7479772 | 441 | 771914 | 7482022 | 511 | 769813 | 7480037 |
| 22 | 769238 | 7485959 | 92 | 771959 | 7484467 | 162 | 770578 | 7484619 | 232 | 773499 | 7483786 | 302 | 773461 | 7483149 | 372 | 772912 | 7479718 | 442 | 771915 | 7481972 | 512 | 769673 | 7480075 |
| 23 | 769049 | 7485844 | 93 | 772840 | 7483340 | 163 | 770483 | 7484829 | 233 | 773566 | 7483666 | 303 | 773477 | 7483181 | 373 | 772924 | 7479671 | 443 | 771810 | 7481927 | 513 | 769300 | 7480111 |
| 24 | 768903 | 7485980 | 94 | 773204 | 7483647 | 164 | 770551 | 7484856 | 234 | 773742 | 7483637 | 304 | 773506 | 7483355 | 374 | 772882 | 7479615 | 444 | 771789 | 7481869 | 514 | 769200 | 7480195 |
| 25 | 768909 | 7485995 | 95 | 773308 | 7483445 | 165 | 770526 | 7485080 | 235 | 773822 | 7483601 | 305 | 773534 | 7483393 | 375 | 772868 | 7479581 | 445 | 771722 | 7481823 | 515 | 769122 | 7480186 |
| 26 | 768842 | 7486065 | 96 | 773319 | 7483095 | 166 | 770616 | 7485173 | 236 | 773827 | 7483573 | 306 | 773509 | 7483391 | 376 | 772806 | 7479554 | 446 | 771710 | 7481851 | 516 | 769070 | 7480115 |
| 27 | 768823 | 7486073 | 97 | 773309 | 7483083 | 167 | 770643 | 7485245 | 237 | 773771 | 7483447 | 307 | 773441 | 7483368 | 377 | 772689 | 7479590 | 447 | 771474 | 7481904 | 517 | 769131 | 7479734 |
| 28 | 768768 | 7486130 | 98 | 773306 | 7483004 | 168 | 770540 | 7485595 | 238 | 773699 | 7483338 | 308 | 773432 | 7483376 | 378 | 772595 | 7479594 | 448 | 771486 | 7481980 | 518 | 769086 | 7479675 |
| 29 | 768777 | 7486171 | 99 | 773320 | 7482944 | 169 | 771848 | 7485017 | 239 | 773717 | 7483209 | 309 | 773488 | 7483420 | 379 | 772475 | 7479558 | 449 | 771426 | 7482133 | 519 | 768992 | 7479644 |
| 30 | 768759 | 7486187 | 100 | 773348 | 7482190 | 170 | 771930 | 7485000 | 240 | 773835 | 7483135 | 310 | 773470 | 7483463 | 380 | 772375 | 7479494 | 450 | 771352 | 7482215 | 520 | 768963 | 7479743 |
| 31 | 768738 | 7486163 | 101 | 773191 | 7481602 | 171 | 772001 | 7484802 | 241 | 773889 | 7483048 | 311 | 773494 | 7483538 | 381 | 772296 | 7479475 | 451 | 771311 | 7482331 | 521 | 768973 | 7479845 |
| 32 | 768595 | 7486313 | 102 | 772794 | 7482009 | 172 | 772037 | 7484772 | 242 | 773957 | 7482985 | 312 | 773506 | 7483584 | 382 | 772317 | 7479507 | 452 | 771317 | 7482426 | 522 | 768940 | 7479847 |
| 33 | 768586 | 7486305 | 103 | 772798 | 7482053 | 173 | 772078 | 7484760 | 243 | 773975 | 7482907 | 313 | 773500 | 7483636 | 383 | 772196 | 7479595 | 453 | 771385 | 7482695 | 523 | 768896 | 7479766 |
| 34 | 768420 | 7486475 | 104 | 772722 | 7482129 | 174 | 772097 | 7484742 | 244 | 773940 | 7482822 | 314 | 773492 | 7483747 | 384 | 772197 | 7479631 | 454 | 772496 | 7480478 | 524 | 768784 | 7479748 |
| 35 | 768433 | 7486531 | 105 | 772734 | 7482182 | 175 | 771983 | 7484557 | 245 | 773883 | 7482841 | 315 | 774319 | 7481004 | 385 | 772378 | 7479530 | 455 | 772518 | 7480460 | 525 | 768659 | 7480088 |
| 36 | 768540 | 7486788 | 106 | 772741 | 7482510 | 176 | 771978 | 7484514 | 246 | 773756 | 7482767 | 316 | 774326 | 7480989 | 386 | 772457 | 7479577 | 456 | 772545 | 7480457 | 526 | 768646 | 7480035 |
| 37 | 768699 | 7486960 | 107 | 772773 | 7482658 | 177 | 771947 | 7484497 | 247 | 773669 | 7482660 | 317 | 774300 | 7480960 | 387 | 772439 | 7479623 | 457 | 772543 | 7480414 | 527 | 768585 | 7480021 |
| 38 | 768983 | 7487241 | 108 | 772693 | 7482665 | 178 | 771874 | 7484532 | 248 | 773666 | 7482632 | 318 | 774315 | 7480835 | 388 | 772464 | 7479648 | 458 | 772503 | 7480383 | 528 | 768499 | 7480037 |
| 39 | 768961 | 7487390 | 109 | 772704 | 7482793 | 179 | 771836 | 7484575 | 249 | 773647 | 7482626 | 319 | 774306 | 7480795 | 389 | 772502 | 7479644 | 459 | 772467 | 7480376 | 529 | 768399 | 7480002 |
| 40 | 769044 | 7487604 | 110 | 772501 | 7482751 | 180 | 771814 | 7484635 | 250 | 773640 | 7482569 | 320 | 774307 | 7480816 | 390 | 772559 | 7479666 | 460 | 772449 | 7480384 | 530 | 768372 | 7479965 |
| 41 | 769093 | 7487708 | 111 | 772437 | 7482676 | 181 | 772186 | 7484227 | 251 | 773702 | 7482472 | 321 | 774276 | 7480690 | 391 | 772624 | 7479640 | 461 | 772445 | 7480409 | 531 | 768301 | 7479962 |
| 42 | 769186 | 7487841 | 112 | 772386 | 7482686 | 182 | 772249 | 7484262 | 252 | 773710 | 7482410 | 322 | 774255 | 7480671 | 392 | 772657 | 7479636 | 462 | 772466 | 7480464 | 532 | 768299 | 7480011 |
| 43 | 770570 | 7487132 | 113 | 772322 | 7482671 | 183 | 772265 | 7484287 | 253 | 773664 | 7482303 | 323 | 774207 | 7480682 | 393 | 772651 | 7479671 | 463 | 770926 | 7481798 | 533 | 768258 | 7479962 |
| 44 | 770635 | 7487079 | 114 | 772241 | 7482599 | 184 | 772293 | 7484295 | 254 | 773716 | 7481977 | 324 | 774177 | 7480678 | 394 | 772720 | 7479673 | 464 | 771074 | 7481665 | 534 | 768259 | 7479901 |
| 45 | 770619 | 7486165 | 115 | 772164 | 7482673 | 185 | 772313 | 7484350 | 255 | 773790 | 7481961 | 325 | 774162 | 7480657 | 395 | 772680 | 7480028 | 465 | 771166 | 7481513 | 535 | 768022 | 7479847 |
| 46 | 770541 | 7486153 | 116 | 772188 | 7482725 | 186 | 772332 | 7484352 | 256 | 773824 | 7481949 | 326 | 774173 | 7480589 | 396 | 772545 | 7480202 | 466 | 771317 | 7481352 | 536 | 767994 | 7479844 |
| 47 | 768731 | 7486061 | 117 | 772169 | 7482751 | 187 | 772314 | 7484271 | 257 | 773867 | 7481873 | 327 | 774159 | 7480613 | 397 | 772595 | 7480236 | 467 | 771523 | 7481204 | 537 | 767969 | 7479854 |
| 48 | 768824 | 7485962 | 118 | 772148 | 7482890 | 188 | 772220 | 7484200 | 258 | 773875 | 7481781 | 328 | 774162 | 7480671 | 398 | 772646 | 7480247 | 468 | 771656 | 7481138 | 538 | 767958 | 7479869 |
| 49 | 768837 | 7485970 | 119 | 772102 | 7482990 | 189 | 772189 | 7484208 | 259 | 773859 | 7481700 | 329 | 774182 | 7480697 | 399 | 772700 | 7480372 | 469 | 771958 | 7481116 | 539 | 767923 | 7479866 |
| 50 | 768993 | 7485809 | 120 | 771946 | 7483048 | 190 | 772315 | 7484039 | 260 | 773807 | 7481630 | 330 | 774213 | 7480695 | 400 | 772986 | 7480599 | 470 | 772186 | 7480678 | 540 | 767955 | 7479811 |
| 51 | 768829 | 7485709 | 121 | 771843 | 7483056 | 191 | 772366 | 7484077 | 261 | 773940 | 7481607 | 331 | 774250 | 7480678 | 401 | 772381 | 7482344 | 471 | 772190 | 7480740 | 541 | 767932 | 7479749 |
| 52 | 768480 | 7485824 | 122 | 771807 | 7483024 | 192 | 772387 | 7484081 | 262 | 774129 | 7481512 | 332 | 773219 | 7481474 | 402 | 773168 | 7481519 | 472 | 772249 | 7480658 | 542 | 767897 | 7479720 |
| 53 | 768504 | 7485858 | 123 | 771561 | 7483269 | 193 | 772474 | 7484190 | 263 | 774163 | 7481415 | 333 | 773454 | 7481245 | 403 | 772933 | 7480634 | 473 | 772282 | 7480594 | 543 | 767900 | 7479690 |
| 54 | 768532 | 7485927 | 124 | 771633 | 7483258 | 194 | 772478 | 7484209 | 264 | 774170 | 7481294 | 334 | 774178 | 7480483 | 404 | 772668 | 7480429 | 474 | 772351 | 7480540 | 544 | 767957 | 7479610 |
| 55 | 768545 | 7485926 | 125 | 771702 | 7483335 | 195 | 772489 | 7484214 | 265 | 774257 | 7481116 | 335 | 774121 | 7480452 | 405 | 772315 | 7480578 | 475 | 772426 | 7480514 | 545 | 767975 | 7479569 |
| 56 | 768607 | 7486069 | 126 | 771788 | 7483364 | 196 | 772491 | 7484187 | 266 | 774225 | 7481109 | 336 | 774066 | 7480528 | 406 | 772040 | 7481072 | 476 | 772458 | 7480493 | 546 | 767982 | 7479522 |
| 57 | 768618 | 7486061 | 127 | 771845 | 7483314 | 197 | 772479 | 7484144 | 267 | 774199 | 7481126 | 337 | 774063 | 7480582 | 407 | 771973 | 7481160 | 477 | 772424 | 7480384 | 547 | 767973 | 7479485 |
| 58 | 768724 | 7486047 | 128 | 771922 | 7483286 | 198 | 772451 | 7484126 | 268 | 774156 | 7481118 | 338 | 774014 | 7480590 | 408 | 771729 | 7481160 | 478 | 772348 | 7480388 | 548 | 767967 | 7479440 |
| 59 | 768462 | 7485802 | 129 | 771987 | 7483314 | 199 | 772440 | 7484082 | 269 | 774129 | 7481138 | 339 | 773953 | 7480573 | 409 | 771325 | 7481375 | 479 | 772327 | 7480371 | 549 | 767987 | 7479404 |
| 60 | 768566 | 7485757 | 130 | 772052 | 7483267 | 200 | 772363 | 7484033 | 270 | 774087 | 7481134 | 340 | 773872 | 7480581 | 410 | 771184 | 7481527 | 480 | 772262 | 7480282 | 550 | 767993 | 7479362 |
| 61 | 768788 | 7485684 | 131 | 772125 | 7483290 | 201 | 772337 | 7484026 | 271 | 774079 | 7481095 | 341 | 773800 | 7480602 | 411 | 771105 | 7481656 | 481 | 772191 | 7480239 | 551 | 767961 | 7479339 |
| 62 | 768681 | 7485619 | 132 | 772111 | 7483335 | 202 | 773693 | 7484193 | 272 | 774081 | 7481039 | 342 | 773714 | 7480579 | 412 | 770949 | 7481816 | 482 | 772062 | 7480230 | 552 | 767941 | 7479304 |
| 63 | 768342 | 7485699 | 133 | 772172 | 7483381 | 203 | 773787 | 7484273 | 273 | 774044 | 7481005 | 343 | 773680 | 7480581 | 413 | 771070 | 7481783 | 483 | 771979 | 7480181 | 553 | 767951 | 7479270 |
| 64 | 768410 | 7485770 | 134 | 772185 | 7483421 | 204 | 773993 | 7484388 | 274 | 774007 | 7480990 | 344 | 773638 | 7480534 | 414 | 771172 | 7481710 | 484 | 771983 | 7480045 | 554 | 767983 | 7479243 |
| 65 | 768289 | 7485711 | 135 | 772164 | 7483451 | 205 | 773950 | 7484317 | 275 | 773983 | 7480943 | 345 | 773665 | 7480483 | 415 | 771270 | 7481730 | 485 | 772076 | 7479967 | 555 | 768029 | 7479242 |
| 66 | 768367 | 7485747 | 136 | 772130 | 7483454 | 206 | 771973 | 7484148 | 276 | 774002 | 7480886 | 346 | 773708 | 7480495 | 416 | 771364 | 7481782 | 486 | 771903 | 7479832 | 556 | 768091 | 7479187 |
| 67 | 768314 | 7485705 | 137 | 772085 | 7483424 | 207 | 772017 | 7484120 | 277 | 774008 | 7480813 | 347 | 773786 | 7480444 | 417 | 771406 | 7481867 | 487 | 771818 | 7479875 | 557 | 768130 | 7479143 |
| 68 | 769324 | 7485553 | 138 | 772026 | 7483480 | 208 | 771929 | 7484054 | 278 | 773998 | 7480770 | 348 | 773786 | 7480413 | 418 | 771576 | 7481717 | 488 | 771756 | 7479829 | 558 | 768121 | 7479069 |
| 69 | 769376 | 7485585 | 139 | 771995 | 7483466 | 209 | 771888 | 7483909 | 279 | 773915 | 7480862 | 349 | 773758 | 7480402 | 419 | 771613 | 7481768 | 489 | 771655 | 7479820 | 559 | 768120 | 7479012 |
| 70 | 770369 | 7485736 | 140 | 771978 | 7483405 | 210 | 771970 | 7483822 | 280 | 773925 | 7480909 | 350 | 773760 | 7480285 | 420 | 771760 | 7481746 | 490 | 771619 | 7479786 | 560 | 768122 | 7478984 |

## Table A-2: Offset area coordinates – 561–1120 (GDA94).

| | Easting | Northing | | Easting | Northing | | Easting | Northing | | Easting | Northing | | Easting | Northing | | Easting | Northing | | Easting | Northing | | Easting | Northing |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 561 | 768145 | 7478952 | 631 | 767048 | 7481109 | 701 | 768121 | 7482837 | 771 | 769725 | 7483676 | 841 | 771142 | 7483225 | 911 | 769420 | 7480754 | 981 | 767430 | 7481475 | 1051 | 768855 | 7484542 |
| 562 | 767686 | 7479017 | 632 | 766942 | 7481226 | 702 | 768063 | 7482851 | 772 | 769769 | 7483637 | 842 | 771196 | 7483195 | 912 | 769521 | 7480760 | 982 | 767484 | 7481455 | 1052 | 768792 | 7484518 |
| 563 | 767729 | 7479089 | 633 | 766941 | 7481263 | 703 | 768001 | 7482915 | 773 | 769825 | 7483617 | 843 | 771203 | 7483164 | 913 | 769454 | 7480853 | 983 | 767532 | 7481471 | 1053 | 768730 | 7484533 |
| 564 | 767727 | 7479148 | 634 | 767008 | 7481297 | 704 | 767951 | 7483009 | 774 | 769893 | 7483616 | 844 | 771187 | 7483120 | 914 | 769436 | 7480971 | 984 | 767562 | 7481456 | 1054 | 768670 | 7484573 |
| 565 | 767704 | 7479212 | 635 | 767030 | 7481346 | 705 | 767960 | 7483048 | 775 | 770131 | 7483634 | 845 | 771192 | 7483099 | 915 | 769491 | 7481139 | 985 | 767223 | 7482349 | 1055 | 768550 | 7484577 |
| 566 | 767714 | 7479281 | 636 | 766968 | 7481572 | 706 | 768073 | 7483164 | 776 | 770171 | 7483652 | 846 | 771242 | 7483097 | 916 | 769498 | 7481328 | 986 | 767342 | 7482305 | 1056 | 768529 | 7484683 |
| 567 | 767773 | 7479262 | 637 | 766976 | 7481626 | 707 | 768119 | 7483092 | 777 | 770145 | 7483691 | 847 | 771311 | 7483151 | 917 | 769318 | 7481473 | 987 | 767326 | 7482265 | 1057 | 768496 | 7484756 |
| 568 | 767807 | 7479272 | 638 | 767046 | 7481721 | 708 | 768139 | 7483110 | 778 | 770066 | 7483727 | 848 | 771359 | 7483096 | 918 | 769327 | 7481559 | 988 | 767233 | 7482268 | 1058 | 768420 | 7484804 |
| 569 | 767828 | 7479307 | 639 | 767060 | 7481810 | 709 | 768118 | 7483221 | 779 | 770083 | 7483783 | 849 | 771425 | 7483085 | 919 | 769153 | 7481663 | 989 | 767206 | 7482304 | 1059 | 768386 | 7484872 |
| 570 | 767811 | 7479491 | 640 | 767035 | 7481884 | 710 | 768098 | 7483281 | 780 | 770076 | 7483823 | 850 | 771422 | 7482929 | 920 | 769354 | 7481699 | 990 | 769755 | 7483395 | 1060 | 768390 | 7484957 |
| 571 | 767768 | 7479574 | 641 | 767003 | 7481913 | 711 | 768096 | 7483413 | 781 | 770037 | 7483854 | 851 | 771322 | 7482884 | 921 | 769392 | 7481751 | 991 | 769835 | 7483372 | 1061 | 767867 | 7485364 |
| 572 | 767769 | 7479703 | 642 | 767018 | 7482057 | 712 | 768105 | 7483471 | 782 | 770049 | 7483922 | 852 | 771221 | 7482932 | 922 | 769514 | 7481861 | 992 | 769887 | 7483286 | 1062 | 767927 | 7485322 |
| 573 | 767704 | 7479739 | 643 | 766996 | 7481979 | 713 | 768184 | 7483633 | 783 | 770021 | 7483981 | 853 | 771069 | 7482964 | 923 | 769596 | 7481853 | 993 | 769843 | 7483200 | 1063 | 767864 | 7485142 |
| 574 | 767683 | 7479773 | 644 | 767022 | 7482109 | 714 | 768184 | 7483659 | 784 | 770026 | 7484039 | 854 | 770934 | 7482925 | 924 | 769790 | 7481898 | 994 | 769843 | 7483200 | 1064 | 767880 | 7485031 |
| 575 | 767661 | 7479872 | 645 | 767014 | 7482179 | 715 | 768209 | 7483697 | 785 | 769925 | 7484140 | 855 | 770890 | 7482863 | 925 | 769870 | 7481742 | 995 | 769743 | 7483234 | 1065 | 767814 | 7485026 |
| 576 | 767661 | 7479937 | 646 | 767108 | 7482194 | 716 | 768271 | 7483706 | 786 | 769928 | 7484204 | 856 | 770887 | 7482818 | 926 | 770208 | 7481687 | 996 | 769741 | 7483323 | 1066 | 767699 | 7485110 |
| 577 | 767678 | 7480006 | 647 | 767141 | 7482230 | 717 | 768287 | 7483689 | 787 | 769813 | 7484268 | 857 | 770931 | 7482755 | 927 | 770259 | 7481622 | 997 | 769922 | 7482813 | 1067 | 767719 | 7485172 |
| 578 | 767671 | 7480082 | 648 | 767137 | 7482343 | 718 | 768308 | 7483693 | 788 | 769793 | 7484301 | 858 | 770929 | 7482663 | 928 | 770330 | 7481582 | 998 | 769967 | 7482782 | 1068 | 767602 | 7485156 |
| 579 | 767520 | 7480234 | 649 | 767099 | 7482406 | 719 | 768371 | 7483658 | 789 | 769868 | 7484349 | 859 | 770978 | 7482639 | 929 | 770389 | 7481497 | 999 | 769923 | 7482732 | 1069 | 767687 | 7485193 |
| 580 | 767475 | 7480255 | 650 | 767091 | 7482498 | 720 | 768422 | 7483684 | 790 | 769877 | 7484383 | 860 | 771020 | 7482385 | 930 | 770455 | 7481522 | 1000 | 769900 | 7482655 | 1070 | 767734 | 7484889 |
| 581 | 767437 | 7480248 | 651 | 767015 | 7482620 | 721 | 768453 | 7483690 | 791 | 769758 | 7484510 | 861 | 770921 | 7482332 | 931 | 770521 | 7481596 | 1001 | 769761 | 7482564 | 1071 | 767824 | 7484812 |
| 582 | 767380 | 7480218 | 652 | 766994 | 7482711 | 722 | 768492 | 7483722 | 792 | 769703 | 7484531 | 862 | 770929 | 7482532 | 932 | 770569 | 7481580 | 1002 | 769714 | 7482627 | 1072 | 767880 | 7484846 |
| 583 | 767348 | 7480300 | 653 | 767014 | 7482783 | 723 | 768560 | 7483725 | 793 | 769627 | 7484536 | 863 | 770856 | 7482809 | 933 | 770606 | 7481503 | 1003 | 769710 | 7482732 | 1073 | 767898 | 7484776 |
| 584 | 767344 | 7480358 | 654 | 766972 | 7482833 | 724 | 768568 | 7483756 | 794 | 769568 | 7484674 | 864 | 770825 | 7482801 | 934 | 770737 | 7481465 | 1004 | 769743 | 7482761 | 1074 | 767851 | 7484657 |
| 585 | 767401 | 7480315 | 655 | 766980 | 7482845 | 725 | 768581 | 7483775 | 795 | 769507 | 7484674 | 865 | 770859 | 7482736 | 935 | 770841 | 7481522 | 1005 | 770709 | 7479327 | 1075 | 767755 | 7484713 |
| 586 | 767429 | 7480265 | 656 | 767072 | 7482923 | 726 | 768589 | 7483850 | 796 | 769470 | 7484705 | 866 | 770908 | 7482529 | 936 | 770683 | 7481074 | 1006 | 770752 | 7479316 | 1076 | 767752 | 7484805 |
| 587 | 767509 | 7480263 | 657 | 767155 | 7482911 | 727 | 768655 | 7483918 | 797 | 769463 | 7484833 | 867 | 770895 | 7482288 | 937 | 770730 | 7481151 | 1007 | 770877 | 7479232 | 1077 | 767949 | 7484741 |
| 588 | 767544 | 7480243 | 658 | 767158 | 7482861 | 728 | 768655 | 7483980 | 798 | 769422 | 7484888 | 868 | 770726 | 7482394 | 938 | 770885 | 7481164 | 1008 | 770897 | 7479176 | 1078 | 768008 | 7484659 |
| 589 | 767577 | 7480217 | 659 | 767259 | 7482777 | 729 | 768598 | 7483960 | 799 | 769425 | 7484999 | 869 | 770643 | 7482382 | 939 | 770876 | 7481057 | 1009 | 770841 | 7479004 | 1079 | 768010 | 7484615 |
| 590 | 767602 | 7480162 | 660 | 767273 | 7482858 | 730 | 768537 | 7483886 | 800 | 769458 | 7485047 | 870 | 770572 | 7482469 | 940 | 770826 | 7480985 | 1010 | 770362 | 7478631 | 1080 | 767906 | 7484632 |
| 591 | 767642 | 7480144 | 661 | 767265 | 7482939 | 731 | 768469 | 7483758 | 801 | 769431 | 7485124 | 871 | 770521 | 7482364 | 941 | 770776 | 7480981 | 1011 | 770013 | 7478682 | 1081 | 768236 | 7484255 |
| 592 | 767661 | 7480105 | 662 | 767338 | 7482957 | 732 | 768352 | 7483800 | 802 | 769251 | 7485406 | 872 | 770426 | 7482332 | 942 | 768288 | 7481095 | 1012 | 769898 | 7478793 | 1082 | 768508 | 7484143 |
| 593 | 767706 | 7480081 | 663 | 767589 | 7482867 | 733 | 768482 | 7483953 | 803 | 769246 | 7485445 | 873 | 770365 | 7482368 | 943 | 768371 | 7481034 | 1013 | 769834 | 7478891 | 1083 | 768515 | 7484101 |
| 594 | 767738 | 7480049 | 664 | 767582 | 7482799 | 734 | 768508 | 7484012 | 804 | 769281 | 7485467 | 874 | 770521 | 7482550 | 944 | 768395 | 7480980 | 1014 | 769814 | 7478984 | 1084 | 768227 | 7483812 |
| 595 | 767748 | 7479993 | 665 | 767505 | 7482801 | 735 | 768586 | 7484093 | 805 | 769332 | 7485462 | 875 | 770602 | 7482546 | 945 | 768309 | 7480953 | 1015 | 769693 | 7478942 | 1085 | 768016 | 7483452 |
| 596 | 767733 | 7479967 | 666 | 767463 | 7482783 | 736 | 768858 | 7484020 | 806 | 770573 | 7484187 | 876 | 770701 | 7482567 | 946 | 768259 | 7480967 | 1016 | 769660 | 7478978 | 1086 | 768005 | 7483365 |
| 597 | 767771 | 7479957 | 667 | 767448 | 7482681 | 737 | 768918 | 7483945 | 807 | 770545 | 7484004 | 877 | 770786 | 7482643 | 947 | 768166 | 7480924 | 1017 | 769743 | 7479035 | 1087 | 767963 | 7483325 |
| 598 | 767803 | 7479984 | 668 | 767481 | 7482601 | 738 | 768953 | 7483881 | 808 | 770592 | 7483926 | 878 | 770742 | 7482706 | 948 | 768109 | 7480874 | 1018 | 769715 | 7479119 | 1088 | 767939 | 7483339 |
| 599 | 767912 | 7479977 | 669 | 767523 | 7482544 | 739 | 768938 | 7483818 | 809 | 770593 | 7483848 | 879 | 770663 | 7482665 | 949 | 768027 | 7480878 | 1019 | 769761 | 7479133 | 1089 | 767914 | 7483308 |
| 600 | 767928 | 7479919 | 670 | 767497 | 7482430 | 740 | 768946 | 7483741 | 810 | 770566 | 7483783 | 880 | 770517 | 7482899 | 950 | 767967 | 7480845 | 1020 | 769915 | 7478975 | 1090 | 767938 | 7483280 |
| 601 | 767991 | 7479923 | 671 | 767523 | 7482190 | 741 | 769078 | 7483727 | 811 | 770573 | 7483716 | 881 | 770455 | 7482843 | 951 | 767820 | 7480698 | 1021 | 770191 | 7478995 | 1091 | 767950 | 7483299 |
| 602 | 768048 | 7479975 | 672 | 767437 | 7482189 | 742 | 768990 | 7483823 | 812 | 770508 | 7483660 | 882 | 770311 | 7482894 | 952 | 767789 | 7480656 | 1022 | 770329 | 7479098 | 1092 | 767983 | 7483288 |
| 603 | 768051 | 7479921 | 673 | 767323 | 7482104 | 743 | 768990 | 7483922 | 813 | 770368 | 7483497 | 883 | 770264 | 7482832 | 953 | 767713 | 7480577 | 1023 | 770336 | 7479235 | 1093 | 768013 | 7483246 |
| 604 | 768229 | 7479980 | 674 | 767260 | 7482137 | 744 | 768958 | 7484043 | 814 | 770322 | 7483362 | 884 | 770212 | 7482855 | 954 | 767706 | 7480597 | 1024 | 770494 | 7479070 | 1094 | 768047 | 7483270 |
| 605 | 768117 | 7480071 | 675 | 767228 | 7482116 | 745 | 768929 | 7484057 | 815 | 770223 | 7483241 | 885 | 770136 | 7482792 | 955 | 767680 | 7480606 | 1025 | 770547 | 7479150 | 1095 | 768069 | 7483217 |
| 606 | 768144 | 7480162 | 676 | 767109 | 7482111 | 746 | 769031 | 7484067 | 816 | 770233 | 7483201 | 886 | 770083 | 7482818 | 956 | 767698 | 7480635 | 1026 | 770638 | 7479213 | 1096 | 768058 | 7483182 |
| 607 | 768094 | 7480266 | 677 | 767164 | 7482029 | 747 | 769115 | 7484113 | 817 | 770306 | 7483286 | 887 | 770015 | 7482643 | 957 | 767741 | 7480665 | 1027 | 770663 | 7479280 | 1097 | 767969 | 7483083 |
| 608 | 767927 | 7480428 | 678 | 767209 | 7482004 | 748 | 769191 | 7484184 | 818 | 770426 | 7483186 | 888 | 769809 | 7482485 | 958 | 767784 | 7480718 | 1028 | 770836 | 7478924 | 1098 | 767913 | 7483038 |
| 609 | 767733 | 7480437 | 679 | 767267 | 7482012 | 749 | 769243 | 7484269 | 819 | 770548 | 7483125 | 889 | 769563 | 7482386 | 959 | 767857 | 7480856 | 1029 | 770935 | 7478836 | 1099 | 767896 | 7483046 |
| 610 | 767683 | 7480557 | 680 | 767292 | 7482035 | 750 | 769333 | 7484312 | 820 | 770471 | 7483099 | 890 | 769451 | 7482265 | 960 | 767999 | 7480944 | 1030 | 771137 | 7478819 | 1100 | 767856 | 7483186 |
| 611 | 767667 | 7480549 | 681 | 767422 | 7482076 | 751 | 769397 | 7484397 | 821 | 770651 | 7482927 | 891 | 769381 | 7482236 | 961 | 768136 | 7480983 | 1031 | 771147 | 7478764 | 1101 | 767773 | 7483195 |
| 612 | 767635 | 7480568 | 682 | 767446 | 7482119 | 752 | 769459 | 7484381 | 822 | 770770 | 7482845 | 892 | 769336 | 7482159 | 962 | 768222 | 7481074 | 1032 | 771090 | 7478686 | 1102 | 767774 | 7483301 |
| 613 | 767610 | 7480564 | 683 | 767510 | 7482116 | 753 | 769478 | 7484362 | 823 | 770848 | 7482859 | 893 | 769334 | 7482108 | 963 | 767600 | 7481463 | 1033 | 771116 | 7478588 | 1103 | 767757 | 7483349 |
| 614 | 767586 | 7480581 | 684 | 767719 | 7482224 | 754 | 769476 | 7484304 | 824 | 770818 | 7482984 | 894 | 769213 | 7481954 | 964 | 767672 | 7481410 | 1034 | 771122 | 7478566 | 1104 | 767705 | 7483369 |
| 615 | 767523 | 7480599 | 685 | 767789 | 7482215 | 755 | 769536 | 7484307 | 825 | 770742 | 7483110 | 895 | 768838 | 7481963 | 965 | 767749 | 7481427 | 1035 | 771076 | 7478533 | 1105 | 767669 | 7483361 |
| 616 | 767512 | 7480589 | 686 | 767805 | 7482231 | 756 | 769580 | 7484273 | 826 | 770626 | 7483212 | 896 | 768761 | 7481889 | 966 | 767830 | 7481424 | 1036 | 770447 | 7478621 | 1106 | 767618 | 7483365 |
| 617 | 767537 | 7480564 | 687 | 767920 | 7482196 | 757 | 769614 | 7484203 | 827 | 770518 | 7483418 | 897 | 768695 | 7481975 | 967 | 767861 | 7481403 | 1037 | 769223 | 7484460 | 1107 | 767544 | 7483335 |
| 618 | 767523 | 7480508 | 688 | 767917 | 7482114 | 758 | 769635 | 7484098 | 828 | 770506 | 7483524 | 898 | 768645 | 7482098 | 968 | 767862 | 7481344 | 1038 | 769361 | 7484491 | 1108 | 767476 | 7483378 |
| 619 | 767539 | 7480466 | 689 | 768044 | 7482155 | 759 | 769635 | 7484033 | 829 | 770652 | 7483771 | 899 | 768510 | 7482178 | 969 | 767741 | 7481382 | 1039 | 769361 | 7484431 | 1109 | 767434 | 7483431 |
| 620 | 767491 | 7480432 | 690 | 768020 | 7482279 | 760 | 769690 | 7484018 | 830 | 770729 | 7483809 | 900 | 768429 | 7482168 | 970 | 767655 | 7481387 | 1040 | 769324 | 7484342 | 1110 | 767586 | 7483818 |
| 621 | 767435 | 7480383 | 691 | 767947 | 7482304 | 761 | 769879 | 7484116 | 831 | 770818 | 7483784 | 901 | 768423 | 7482095 | 971 | 767641 | 7481357 | 1041 | 769289 | 7484335 | 1111 | 767648 | 7483780 |
| 622 | 767422 | 7480380 | 692 | 767766 | 7482252 | 762 | 769894 | 7484067 | 832 | 770887 | 7483812 | 902 | 768388 | 7482039 | 972 | 767618 | 7481365 | 1042 | 768389 | 7485179 | 1112 | 767769 | 7483753 |
| 623 | 767382 | 7480421 | 693 | 767710 | 7482265 | 763 | 769880 | 7484001 | 833 | 770906 | 7483852 | 903 | 768395 | 7481688 | 973 | 767614 | 7481385 | 1043 | 768707 | 7485173 | 1113 | 767946 | 7483786 |
| 624 | 767346 | 7480391 | 694 | 767644 | 7482256 | 764 | 769849 | 7483966 | 834 | 771087 | 7483668 | 904 | 768480 | 7481410 | 974 | 767581 | 7481385 | 1044 | 768798 | 7485229 | 1114 | 768024 | 7483839 |
| 625 | 767350 | 7480431 | 695 | 767586 | 7482363 | 765 | 769850 | 7483934 | 835 | 771096 | 7483641 | 905 | 768633 | 7481292 | 975 | 767558 | 7481346 | 1045 | 768798 | 7485143 | 1115 | 767901 | 7483906 |
| 626 | 767386 | 7480519 | 696 | 767981 | 7482387 | 766 | 769830 | 7483921 | 836 | 771250 | 7483500 | 906 | 768782 | 7481265 | 976 | 767521 | 7481365 | 1046 | 768934 | 7485117 | 1116 | 767820 | 7483892 |
| 627 | 767404 | 7480623 | 697 | 768090 | 7482484 | 767 | 769775 | 7483917 | 837 | 771228 | 7483442 | 907 | 768992 | 7481138 | 977 | 767510 | 7481415 | 1047 | 768942 | 7485044 | 1117 | 767730 | 7483890 |
| 628 | 767374 | 7480698 | 698 | 767991 | 7482606 | 768 | 769726 | 7483886 | 838 | 771180 | 7483407 | 908 | 769073 | 7481043 | 978 | 767477 | 7481418 | 1048 | 769019 | 7484802 | 1118 | 767675 | 7483883 |
| 629 | 767306 | 7480778 | 699 | 768020 | 7482706 | 769 | 769695 | 7483830 | 839 | 771090 | 7483397 | 909 | 769104 | 7480979 | 979 | 767388 | 7481456 | 1049 | 768956 | 7484574 | 1119 | 767623 | 7483912 |
| 630 | 767241 | 7480932 | 700 | 768046 | 7482713 | 770 | 769694 | 7483725 | 840 | 771118 | 7483248 | 910 | 769337 | 7480733 | 980 | 767391 | 7481467 | 1050 | 768881 | 7484589 | 1120 | 767761 | 7484264 |

## Table A-3: Offset area coordinates – 1121–1235 (GDA94).

| | Easting | Northing | | Easting | Northing | | Easting | Northing | | Easting | Northing | | Easting | Northing | | Easting | Northing | | Easting | Northing | | Easting | Northing |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1121 | 767790 | 7484153 | 1136 | 767479 | 7484091 | 1151 | 767455 | 7484696 | 1166 | 767233 | 7483263 | 1181 | 767100 | 7483515 | 1196 | 767045 | 7484646 | 1211 | 774592 | 7490661 | 1226 | 774479 | 7491444 |
| 1122 | 767884 | 7484112 | 1137 | 767487 | 7484170 | 1152 | 767334 | 7484560 | 1167 | 767236 | 7483249 | 1182 | 767082 | 7483625 | 1197 | 767227 | 7484758 | 1212 | 774597 | 7490592 | 1227 | 774461 | 7491464 |
| 1123 | 767914 | 7484072 | 1138 | 767525 | 7484218 | 1153 | 767028 | 7484288 | 1168 | 767282 | 7483211 | 1183 | 767045 | 7483688 | 1198 | 774583 | 7491692 | 1213 | 774529 | 7490441 | 1228 | 774490 | 7491629 |
| 1124 | 768147 | 7484121 | 1139 | 767589 | 7484230 | 1154 | 767015 | 7484168 | 1169 | 767267 | 7483171 | 1184 | 766940 | 7483767 | 1199 | 774621 | 7491687 | 1214 | 774377 | 7490146 | 1229 | 774526 | 7491594 |
| 1125 | 768170 | 7484102 | 1140 | 767628 | 7484260 | 1155 | 767115 | 7484115 | 1170 | 767222 | 7483187 | 1185 | 766770 | 7483826 | 1200 | 774639 | 7491653 | 1215 | 774335 | 7490144 | 1230 | 774553 | 7491591 |
| 1126 | 768202 | 7484147 | 1141 | 767638 | 7484330 | 1156 | 767238 | 7483948 | 1171 | 767198 | 7483136 | 1186 | 766780 | 7483851 | 1201 | 774948 | 7491449 | 1216 | 774311 | 7490123 | 1231 | 774615 | 7491551 |
| 1127 | 768134 | 7484174 | 1142 | 767627 | 7484398 | 1157 | 767408 | 7483875 | 1172 | 767192 | 7483094 | 1187 | 766767 | 7483885 | 1202 | 774968 | 7491396 | 1217 | 774282 | 7490151 | 1232 | 774629 | 7491555 |
| 1128 | 767695 | 7484554 | 1143 | 767642 | 7484453 | 1158 | 767515 | 7483861 | 1173 | 767213 | 7483036 | 1188 | 766776 | 7484015 | 1203 | 774953 | 7491349 | 1218 | 774285 | 7490269 | 1233 | 774614 | 7491602 |
| 1129 | 767730 | 7484527 | 1144 | 767462 | 7485095 | 1159 | 767534 | 7483850 | 1174 | 767185 | 7482967 | 1189 | 766724 | 7484071 | 1204 | 774915 | 7491319 | 1219 | 774311 | 7490276 | 1234 | 774614 | 7491634 |
| 1130 | 767718 | 7484444 | 1145 | 767363 | 7484989 | 1160 | 767432 | 7483591 | 1175 | 767082 | 7482981 | 1190 | 766675 | 7484142 | 1205 | 774753 | 7491297 | 1220 | 774313 | 7490331 | 1235 | 774587 | 7491659 |
| 1131 | 767758 | 7484421 | 1146 | 767378 | 7485021 | 1161 | 767374 | 7483584 | 1176 | 767147 | 7483100 | 1191 | 766690 | 7484229 | 1206 | 774609 | 7491216 | 1221 | 774302 | 7490353 | | | |
| 1132 | 767572 | 7483948 | 1147 | 767360 | 7484983 | 1162 | 767230 | 7483498 | 1177 | 767168 | 7483206 | 1192 | 766742 | 7484319 | 1207 | 774518 | 7491120 | 1222 | 774309 | 7490431 | | | |
| 1133 | 767519 | 7483961 | 1148 | 767300 | 7484811 | 1163 | 767182 | 7483513 | 1178 | 767146 | 7483287 | 1193 | 766746 | 7484583 | 1208 | 774468 | 7491019 | 1223 | 774369 | 7490533 | | | |
| 1134 | 767496 | 7483994 | 1149 | 767350 | 7484811 | 1164 | 767161 | 7483496 | 1179 | 767104 | 7483342 | 1194 | 766778 | 7484625 | 1209 | 774467 | 7490932 | 1224 | 774331 | 7490580 | | | |
| 1135 | 767499 | 7484039 | 1150 | 767418 | 7484790 | 1165 | 767161 | 7483402 | 1180 | 767090 | 7483403 | 1195 | 766890 | 7484648 | 1210 | 774510 | 7490781 | 1225 | 774456 | 7491433 | | | |

149°36'0"E
149°38'0"E
149°40'0"E
22°40'0"S
22°42'0"S
22°44'0"S
22°46'0"S

Figure A-2
(inset)

Figure A-2

Figure A-3

Figure A-4

**Central Queensland Coal**

**Figure A-1:**
**Offset area boundary overview**

- Mamelon
- Mamelon offset area
- Reference co-ordinates

Location diagram


DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data

Date: 8/24/2020 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:40,000@A3

0 0.5 1 1.5 2
Kilometres

N

CO2 Australia

149°37'0"E

149°38'0"E

22°41'0"S

22°42'0"S

22°43'0"S

22°44'0"S

0 100 200 300 400

Metres

1:15,000@A3

Central Queensland Coal

Location diagram

**Figure A-2:**
**Offset area boundary**

Mamelon

Mamelon offset area

Reference co-ordinates

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data

Date: 8/24/2020 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:17,500@A3

0 0.25 0.5 0.75 1

Kilometres

N

CO2 Australia

Queensland

149°36'0"E

149°37'0"E

149°38'0"E

22°44'0"S

22°45'0"S

22°46'0"S

Central Queensland Coal

Location diagram

**Figure A-3:**
**Offset area boundary**

- Mamelon
- Mamelon offset area
- Reference co-ordinates


DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data

Date: 8/24/2020 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:17,500@A3

0 0.25 0.5 0.75 1
Kilometres

N

CO2 Australia

149°38'0"E
149°39'0"E
149°40'0"E
22°44'0"S
22°45'0"S
22°46'0"S

Central Queensland Coal

Location diagram

**Figure A-4:**
**Offset area boundary**

- Mamelon
- Mamelon offset area
- Reference co-ordinates

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data

Date: 8/24/2020 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:17,500@A3

0 0.25 0.5 0.75 1
Kilometres

N

CO2 Australia

# APPENDIX B RISK ASSESSMENT

The following risk assessment assesses the risk of failure to achieve the OAMP's objectives for the offset values. For each risk identified, the potential consequence of the risk (rated from minor to critical; Table B-1) was assessed against the likelihood of that risk occurring (rated from very unlikely to almost certain; Table B-2) to determine a risk rating. The risk rating was evaluated by using the matrix in Table B-3.

The consequence and likelihood of each risk was first considered without the management measures in place to provide an initial risk rating. The consequence and likelihood of each risk occurring was then reassessed following the implementation of the management measures to provide a residual risk rating.

Table B-4 provides the risk register which was used to document the findings of the risk assessment process.

**Table B-1: Consequence classification**

| Classification | Description |
|---|---|
| Minor | Minor risk of failure to achieve the plan's objectives. Results in short term delays to achieving plan objectives, implementing low cost, well characterised corrective actions. |
| Moderate | Moderate risk of failure to achieve the plan's objectives. Results in short term delays to achieving plan objectives, implementing well characterised, high cost/effort corrective actions. |
| High | High risk of failure to achieve the plan's objectives. Results in medium-long term delays to achieving plan objectives, implementing uncertain, high cost/effort corrective actions. |
| Major | The plan's objectives are unlikely to be achieved, with significant legislative, technical, ecological and/or administrative barriers to attainment that have no evidenced mitigation strategies. |
| Critical | The plan's objectives are unable to be achieved, with no evidenced mitigation strategies. |

**Table B-2: Likelihood classification**

| Classification | Description |
|---|---|
| Highly likely | Is expected to occur in most circumstances |
| Likely | Will probably occur during the life of the Project |
| Possible | Might occur during the life of the Project |
| Unlikely | Could occur but considered unlikely or doubtful |
| Very unlikely | May occur in exceptional circumstances |

**Table B-3: Risk framework**

| | Consequence | | | | |
|---|---|---|---|---|---|
| **Likelihood** | **Minor** | **Moderate** | **High** | **Major** | **Critical** |
| **Highly likely** | Medium | High | High | Severe | Severe |
| **Likely** | Low | Medium | High | High | Severe |
| **Possible** | Low | Medium | Medium | High | Severe |
| **Unlikely** | Low | Low | Medium | High | High |
| **Very unlikely** | Low | Low | Low | Medium | High |

A brief description of each overall possible risk rating is provided below.

- Severe:

- A ranking of extreme represents an unacceptable risk, which is usually critical in nature in terms of consequences and is considered possible to almost certain to occur. Such risks significantly exceed the risk acceptance threshold and require comprehensive control measures, and additional urgent and immediate attention towards the identification and implementation of measures necessary to reduce the level of risk.

- High:
  - High risks typically relate to moderate to critical consequences that are rated as possible to almost certain to occur. These are also likely to exceed the risk acceptance threshold, and although proactive control measures are usually planned or implemented, a very close monitoring regime and additional actions towards achieving further risk reduction is required.
- Medium:
  - As suggested by the classification, medium level risks span a group of risk combinations varying from relatively minor consequence/likely likelihood to mid-level consequence/likelihood to relatively major consequence/very unlikely likelihood scenarios. These risks are likely to require active monitoring as they are effectively positioned on the risk acceptance threshold.
- Low:
  - Low risks are below the risk acceptance threshold and although they may require additional monitoring in certain cases, are not considered to require active management. In general, such risks represent relatively low likelihood, and low to mid-level consequence scenarios.

**Table B-4: Risk assessment**

| Management objective | Risk | Initial risk rating | | | Control strategies | Residual risk rating | | |
|---|---|---|---|---|---|---|---|---|
| | | Likelihood | Consequence | Overall Risk Rating | | Likelihood | Consequence | Overall Risk Rating |
| Achieve the completion criteria and habitat quality improvements for offset values, which include the habitat quality scores in this OAMP. | Completion criteria and habitat quality improvements are not achieved | 3 | 4 | H | ▶ Implement the OAMP, including the monitoring programs and management actions outlined in Section 8 and Section 7, respectively.<br>▶ Implementation of the adaptive management process outlined in Section 6<br>▶ Obtain advice from scientific advisory groups with the aim of identifying appropriate additional management interventions if interim performance targets are not achieved for one or more offset values by year 15.<br>▶ Discuss with the Commonwealth Government regarding the provision of additional offset options if it is considered that the completion criteria will not be achieved. | 2 | 3 | M |
| Maintain the extent of offset value habitat within the Mamelon offset area. | Habitat or vegetation loss through land clearing. | 3 | 4 | H | ▶ Declaration of Mamelon offset area as a Voluntary Declaration under the *Vegetation Management Act 1999* or other security mechanism.<br>▶ No clearing of native vegetation is permitted within the Mamelon offset area as part of any management and monitoring activities associated with the OAMP, except for clearing that is required:<br>- to realign, construct or maintain access tracks up to 6 m width<br>- for fence construction and maintenance (up to 5 m width on each side of the fence)<br>- ensure public safety or as directed by emergency management response personnel in the event of uncontrolled bushfire or other emergency procedure.<br>▶ Any clearing required for fencing, access, firebreaks or public safety is undertaken in accordance with the restrictions outlined in Sections 7.1, 7.2 and 7.3. | 1 | 4 | M |
| Minimise predation risk by wild dogs to threatened fauna species. | Predation of threatened fauna by wild dogs. | 3 | 2 | M | ▶ Regular monitoring for pest animals will be undertaken in accordance with the methods detailed in Section 8.4 and pest animal control will be implemented following the results of monitoring in accordance with Section 7.6. | 2 | 2 | L |
| Minimise predation risk by foxes to threatened fauna species. | Predation of threatened fauna by foxes. | 3 | 2 | M | | 2 | 2 | L |
| Minimise predation risk by feral cats to threatened fauna species. | Predation of threatened fauna by cats. | 3 | 2 | M | | 2 | 2 | L |
| Minimise degradation of offset value habitat by feral pigs. | Degradation of habitat by feral pigs. | 3 | 2 | M | | 2 | 2 | L |
| Minimise degradation of offset value habitat by rabbits. | Degradation of habitat by rabbits. | 3 | 2 | M | | 2 | 2 | L |
| Manage invasive weed species to reduce degradation of offset value habitat. | Invasion of habitat by weed species, including exotic grasses. | 3 | 3 | M | ▶ Regular inspections in accordance with the methods in Section 8.3, will be undertaken to monitor the presence of weeds.<br>▶ Based on the results of monitoring events, weed control will be implemented in accordance with Section 7.5 and the recommended control measures available from the Queensland Department of Agriculture and Fisheries. | 2 | 3 | M |

| Management objective | Risk | Initial risk rating | | | Control strategies | Residual risk rating | | |
|---|---|---|---|---|---|---|---|---|
| | | Likelihood | Consequence | Overall Risk Rating | | Likelihood | Consequence | Overall Risk Rating |
| Reduce the risk of adverse impacts to offset value habitat by inappropriate fire regimes or unplanned fire. | Decrease in the habitat quality score for any offset value from baseline and subsequent monitoring events as a result of fire management measures, or an unplanned fire. | 4 | 4 | H | ▶ Fuel loads within the offset area will be managed through strategic grazing and/or fuel hazard reduction burns (see Section 7.4).<br>▶ Firebreaks will be maintained to be no wider than 6 m along all boundaries of the offset area, except along the road reserve (which will act as a firebreak) and where they correspond with waterways; all existing/proposed fence lines. | 2 | 3 | M |
| Achieve the interim performance targets and completion criteria for each offset value within 10 and 20 years, respectively. | Offset fails to achieve the interim performance targets and completion criteria within the anticipated 10 and 20 year timeframes, respectively. | 3 | 4 | H | ▶ Monitoring of the offset area will be undertaken in accordance with Section 8, including:<br>- Offset area inspections (Section 8.1).<br>- Habitat quality assessments to determine habitat quality scores (Section 8.5.2).<br>▶ The results of monitoring events will be compared against the interim performance targets and completion criteria to determine the progress of offset area and recorded as part of reporting (Section 9).<br>▶ Third party review of the OAMP to provide input on the effectiveness of the management actions.<br>▶ Increasing the frequency and intensity of pest animal and weed control measures or revising the type of measures to be implemented.<br>▶ Modifying fire management measures to better support enhancement of offset values. | 2 | 3 | M |

# APPENDIX C OVERALL FUEL HAZARD ASSESSMENT GUIDE

Department of Sustainability and Environment

# Overall fuel hazard assessment guide

4th edition July 2010

## Fire and adaptive management

report no. 82

State Government Victoria

**Overall fuel hazard assessment guide**

4th edition July 2010

Fire and adaptive management, report no. 82

By Francis Hines, Kevin G Tolhurst, Andrew AG Wilson and Gregory J McCarthy

This publication was produced with the support of the Attorney-General's Department of the Australian Government, who part funded this project through the Natural Disaster Resilience Grants Program.


Images have been provided by Department of Sustainability and Environment – Victoria, Department of Environment and Heritage – South Australia, Country Fire Service – South Australia, Department of Conservation and Environment – Western Australia and Christian Pearson – Misheye. Katy Friend drew the illustrations.

**Cover image**: Elaine – Atchison Rd Fire, Victoria, January 2008. Bark Hazard – Extreme, Elevated Fuel Hazard – Moderate, Near-surface Fuel Hazard – Low, Surface Fuel Hazard – Very High. Overall Fuel Hazard – Extreme. Fire burning under FFDI 17 – High.

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Melbourne, July 2010



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# Contents

# 1. About this guide

## 1.1 Purpose

The main purpose of this guide is to allow people to:

- make a rapid, visual assessment of fuel arrangement, and
- gain an understanding of how this will affect the chances of controlling a bushfire.

## 1.2 Audience

This guide has been principally designed to provide information on fuel arrangement to be used by:

- firefighters to assess the difficulty of controlling a bushfire.

Information on fuel arrangement may also be used by:

- asset owners and managers to assess potential bushfire risks to assets
- land and fire managers to provide a measurable objective and trigger for fuel management in fire management plans
- personnel to identify which key attributes and fuel layers are contributing the most to the hazard
- personnel to plan and conduct planned burns
- personnel to assess the effectiveness of planned burning or mechanical hazard reduction
- fire behaviour analysts to produce fire-spread predictions and community warnings.

Those who use the guide for these other purposes need to be mindful of its limitations and how the results are applied and interpreted.

## 1.3 What fuel is assessed

This guide is for assessing fine fuels that burn in bushfires. Fine fuels are the fuels that burn in the continuous flaming zone at the fire's edge. They contribute the most to the fire's rate of spread and flame height. Typically, they are dead plant material, such as leaves, grass, bark and twigs thinner than 6mm thick, and live plant material thinner than 3mm thick. Once ignited, these fine fuels generally burn out within two minutes.

This guide focuses on assessing the key structural layers of the fine fuel complex, in particular those of bark, elevated, near-surface and surface fuels.

## 1.4 How the fuel is assessed

Each fuel layer is assessed simply and visually. Assessing the fuel takes only a few minutes and is based on the premise that the eye is better able to integrate local variations in fuel than systematic measurement. Each fuel layer is assessed in turn and given a hazard rating. Particular emphasis is placed on how the fuel is arranged within each of these layers. The hazard ratings are then combined to produce an Overall Fuel Hazard Rating that ranges from Low to Extreme.

## 1.5 Why fuel arrangement is more important than fuel load

The image below highlights the effect that changing the arrangement of the fuel can have on fire behaviour. Both fires were ignited at the same time in the same way. Both fires are burning in the same fuel load, approximately two broadsheets of newspaper over a 20cm diameter area. The fuel on the right was laid flat and has little vertical orientation. The fuel on the left was crumpled up, which gave it more vertical orientation and exposed more of the surface to the air. As a result, the fire on the left shows significantly greater flame height and the fuel is consumed much faster.

The simple difference in the arrangement of the fuel significantly affects the resulting fire behaviour. The effect would not be discerned if the fuel assessment was based purely on fuel load. An assessment of fuel hazard takes into account the fuel arrangement. It gives a better indication of potential fire behaviour and suppression difficulty.

## 1.6 Suppression difficulty is not just about fire behaviour

This guide has been mainly developed to allow people to assess the impact of fuel arrangement on suppression difficulty. An assessment of suppression difficulty (how hard it is to control a bushfire) is not based solely on the anticipated fire behaviour. Many other factors affect the chances of a firefighting operation succeeding, including resources, fire size and terrain.

In order to consider the impact of fuels, the other factors need to be treated as if they are constant. The factors that have been held constant are referred to as the Reference Extended First Attack Conditions. Further detail on these conditions is contained in Appendix 1.

## 1.7 Basis of the Overall Fuel Hazard classification

A comprehensive explanation of this guide is contained in DSE's *Overall fuel hazard assessment guide: a rationale report – fire and adaptive management report no. 83* (in prep.).

This assessment guide updates and builds on work previously published by Wilson (1992a, 1992b, 1993), McCarthy *et al*. (1998a, 1998b, 1998c, 1999, 2001), the Department of Environment and Heritage (2006) and Gould *et al*. (2007a, 2007b).

Classifying Overall Fuel Hazard is complex, with few available measurements. Therefore, we have relied on the perceptions of experienced fire personnel (e.g. fire behaviour specialists, fire managers and firefighters). The collective experience of these personnel is vast, with a broad geographic base across Australia.

## 1.8 Need for continual learning and development

Although our knowledge about fuels has many gaps, this guide is based on the best available information and experience. The authors acknowledge that this guide will need to change and improve as more information is obtained.

Observers of firefighting operations can improve future editions of this guide by carefully recording what they see. Observations, comments and feedback can be emailed to fire.monitoring@dse.vic.gov.au.

# 2. How to use the guide

This guide has been kept concise and should not be considered as a standalone document. To produce reliable and consistent results requires extra knowledge which may be gained through local hands-on training in fuel assessment.

## 2.1 Application

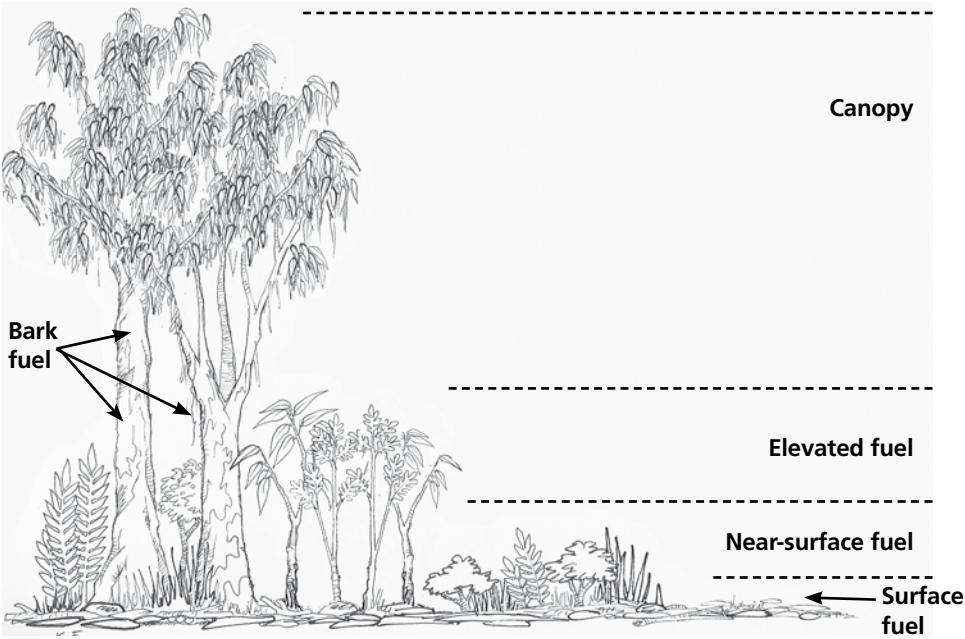
This guide is a tool for rapidly assessing fuel arrangement and its effect on the chances of controlling a bushfire. It may also be used for a range of other fire management purposes, as shown in the table below. Users of this guide should understand the underlying assumptions and limitations before applying it, particularly if applying it for purposes other than the assessment of suppression difficulty.

| Application | Methodology |
|---|---|
| Assess suppression difficulty | Assess the fuels in which the fire may occur or is actually occurring. |
| Assess fuels for predicting potential risk to assets | Assess the fuels immediately adjacent to the asset as part of an assessment of possible radiant heat loads and defendable space.<br><br>Assess the fuels further away from the asset; paying particular attention to areas that may generate spotting, such as ridges. Assessments should be focused, particularly in the direction of likely fire attack. |
| Assess the need for, or success of, fuel management activities | Assess the average fuels across the nominated area by sampling within major vegetation types, slopes and aspects. |
| Plan and conduct planned burns | Assess the variability in fuels across the nominated area by sampling within major vegetation types, slopes and aspects. Pay particular attention to areas where the burn may escape, such as the tops of gullies, ridge tops and areas adjacent to planned burn boundaries. |
| Assess fuels for predicting fire behaviour | Assess the fuel values needed as inputs for the appropriate fire behaviour model. |

## 2.2 Fuel layers

Fuel in forests, woodlands and shrublands can be divided into four layers, each based on its position in the vegetation profile (Fig 2.1). This guide focuses on assessing the key structural layers of the fine fuel complex, those of bark, elevated, near-surface and surface fuels.

**Figure 2.1 Fuel layers and bark**



Use the following descriptions to determine how to separate vegetation into fuel layers.

| Layer | Description | Contribution to suppression difficulty |
|---|---|---|
| Canopy | • Crowns of the tallest layer of trees.<br>• Under some conditions canopy fuels can play a significant role in fire behaviour and suppression difficulty. Currently, however, these fuels are not assessed as part of Overall Fuel Hazard. | |
| Bark fuel | • Bark on tree trunks and branches, from ground level to canopy. | Spotting |
| Elevated fuel | • Fuels are mainly upright in orientation.<br>• Generally most of the plant material is closer to the top of this fuel layer.<br>• Sometimes contains suspended leaves, bark or twigs.<br>• Fuels that have a clear gap between them and the surface fuels.<br>• Can be highly variable in ground coverage.<br>• Low-intensity fire (flame height of less than 0.5m) may pass beneath this layer without consuming much, if any, of it. | Influences the flame height and rate of spread of a fire. |
| Near-surface fuel | • Live and dead fuels, effectively in touch with the ground, but not lying on it.<br>• Fuel has a mixture of vertical and horizontal orientation.<br>• Bulk of the fuels are closer to the ground than to the top of this layer, or are distributed fairly evenly from the ground up.<br>• Sometimes contains suspended leaves, bark or twigs.<br>• Coverage may range from continuous to having gaps many times the size of the fuel patch.<br>• Low-intensity fire (flame height of less than 0.5m) will consume most or all of this fuel.<br>• Fuel in this layer will always burn when the surface fuel layer burns. | Influences the rate of spread and flame height of a fire. |
| Surface fuel (litter) | • Leaves, twigs, bark and other fine fuel lying on the ground.<br>• Predominantly horizontal in orientation. | Influences the rate of spread of a fire. |

This guide is for assessing fine fuels only. Coarse fuels including logs are not considered. See Section 1.3 for further details.

The descriptions of the fuel layers exclude references to species' names or common vegetation forms, such as shrubs. During a plant's life it may transition back and forth between different layers. For example, juvenile bracken fern can be classified as near-surface fuel before becoming elevated fuel as it matures. Once it dies and collapses it may become near-surface fuel again.

## 2.3 Assessment based on key attributes of fuel hazard

A fuel hazard rating of Low, Moderate, High, Very High or Extreme is assigned to each fuel layer by assessing it against the key attributes listed below.

| Key attribute | |
|---|---|
| Horizontal continuity of the layer | Determines how readily a piece of burning fuel may ignite the fuel beside it.<br>Identifies which of surface, near-surface or elevated fuels will determine the average flame height. |
| Vertical continuity of the layer | Determines how readily a piece of burning fuel may ignite the fuel above it. |
| Amount of dead material in the layer | Determines how much dead material is present to burn and thus help with igniting the live (green) fuels. |
| Thickness of the fuel pieces | Determines whether the fuel pieces will burn in the flaming front of the fire. |
| Total weight of fine fuel | Determines the weight of fine fuel contributing to the flaming front of the fire. |

The descriptions in the hazard assessment tables do not cover all possible combinations of the key attributes. Users will need to exercise judgement and make an assessment using all key attributes when actual conditions fit between the descriptions.

## 2.4 Using the descriptions and photographs

This is **not** a photographic guide for assessing fuels. The **descriptions** for each of the key attributes should be used as the basis for determining the fuel hazard rating. Photographs cannot adequately show all of the key attributes that are important in determining fuel hazard. The photographs are provided to illustrate **some** of the key attributes for each fuel hazard rating. They do not represent all possible variations of that particular hazard rating.

## 2.5 Area of assessment

Within an area of interest fuels are assessed in small patches or plots. The size and number of plots depends on the reason for assessing the fuels. Some applications (such as for input into fire behaviour models) may require a more rigorous and systematic approach to sampling. Other applications (such as assessing fuel hazard during firefighting operations) will necessitate a more rapid informal approach. For whatever purpose the guide is being used it is recommended that the following principles be applied:

- Any assessment of fuels should try to assess the variability in fuels across an area by assessing the fuels at multiple plots.
- The size and number of plots should reflect the level of reliability required of the results.
- For surface, near-surface and elevated fuel layers the result of assessing the plot should reflect the average state of that fuel layer.
- For bark hazard the result of assessing the plot should be based on the trees with the highest rating.
- Always record with the result the name and the version of the guide used.

## 2.6 Tips for assessing fuel hazard

The process of assessing fuel hazard using this guide is largely subjective. Implementing the following techniques will help to improve accuracy and reliability:

- Identify and agree on examples of the highest rating of fuel hazard for each layer that occur locally. These examples should be used as benchmarks.
- Conduct assessments in pairs of observers and regularly change assessment pairs.
- Assessors should be no more than one hazard rating apart when assessing each layer (e.g. Low or Medium, not Low or High).
- Use different assessors to re-assess completed work and provide feedback.

## 2.7 Vesta fire behaviour predictions

In dry eucalypt forest with a litter and shrub understorey the *Field guide – fuel assessment and fire behaviour prediction in dry eucalypt forest* (Gould *et al.* 2007b) provides a systematic method for assessing fuel and predicting fire behaviour (rate of spread, flame height, and spotting). The Project Vesta fuel hazard scoring system is similar to the Victorian system developed by Wilson (1992a, 1992b, 1993) and revised by McCarthy *et al*. (1999). The scale that underlies the Vesta fuel hazard scores is directly related to fire behaviour. These scores, along with height measurements of various fuel layers, are needed as inputs into the fire behaviour prediction tables in Gould *et al*. (2007b). Section 9.3 contains a table for translating the fuel hazard rating for each fuel layer into Vesta fuel hazard scores.

## 2.8 Effect on fire behaviour

Each table for assessing fuel hazard contains information on the effect that the fuel arrangement is likely to have on fire behaviour. This effect is for weather conditions equivalent to a Forest Fire Danger Index (FFDI) of 25 (McArthur 1973). An FFDI of 25 can be achieved in many ways. For the purposes of this guide the specific conditions required to achieve this are:

| | | |
|---|---|---|
| Temperature: 33°C | Relative Humidity: 25% | Wind Speed: 20km/h |
| Drought Factor: 10 | Slope: 0° | |

If weather conditions vary from those listed above the effect on fire behaviour will also vary.

## 2.9 Fuel assessment data sheet

Appendix 2 contains a sample field data sheet that can be used when assessing fuels.

# 3. Bark fine fuel

## 3.1 Identification

Bark fuel is the bark on tree trunks and branches. Bark lying on or near the ground or draped over understorey plants is considered to be surface, near-surface or elevated fuel.

## 3.2 Identifying bark types

The key attributes for assessing the effect of bark on suppression difficulty are shown below:

| Key attribute | Determines | How it is assessed |
|---|---|---|
| Ease of ignition | • How readily the bark will ignite.<br>• Whether the fire will burn up the trunk and into the branches of the tree. | Thickness, size and shape of bark pieces. |
| How bark is attached | • How likely the bark is to break off the tree. | How easily the bark breaks off the tree. |
| Quantity of combustible bark | • Volume of potential embers that a fire may generate. | Relative quantity of combustible bark. |
| Size-to-weight ratio of the bark pieces | • How far the wind is likely to carry bark pieces once they break off the tree. | Thickness, size and shape of bark pieces. |
| Burn out time | • Length of time a piece of bark will stay ignited once it breaks off the tree. | Thickness, size and shape of bark pieces. |

Descriptions of trees have been separated into three broad bark types using three of these key attributes – ease of ignition, burn out time and size-to-weight ratio:

1. Fine fibrous barks, including stringybarks
2. Ribbon or candle barks
3. Other bark types, including smooth, platy, papery and coarsely fibrous. The reason for describing these types in some detail is to help observers distinguish them from the above two types.

## 3.3 Identifying Stringybark and other fine fibrous bark types

| | |
|---|---|
| **Contribution to suppression difficulty** | • Bark types that can produce massive quantities of embers and short distance spotting. |
| **Physical description** | • Bark is fine fibrous material with easily visible fibres less than 1mm thick covering the whole trunk.<br>• Bark fibres resemble the fine fibres that are twisted together to form natural string.<br>• Old bark is retained on the trunk of the tree for decades, forming a relatively spongy fibrous mass with deep vertical fissures.<br>• Outer bark may weather to a greyish colour, while underlying bark retains its original colour.<br>• Bark may form large strands when peeled off.<br>• Fine, hairlike pieces also break off from the tree when it is rubbed. |
| **Ease of ignition** | • Bark is very flammable (can be easily lit with a match when dry).<br>• Fires will readily climb the tree and branches. |
| **How bark is attached** | • Young or new bark is held tightly to the trunk.<br>• As bark ages it becomes less tightly held.<br>• Old, long-unburnt bark is held very loosely. |
| **Quantity of combustible bark** | • Bark on old, long-unburnt stringybarks can be more than 10cm in depth. During fires it can produce massive quantities of embers. |
| **Size-to-weight ratio** | Burning pieces of bark tend to be either:<br>• Very fine lightweight fibres that will be carried for less than 100m.<br>• Small lightweight wads (about the size of a thumb) that will be carried for less than 300m.<br>• Very large wads (bigger than a fist) that fall close to the tree. |
| **Burn out time** | • Very fine fibres of bark that will burn out within one minute.<br>• Small wads of bark that will burn out within 2–3 minutes.<br>• Very large wads of bark that will burn for up to 10 minutes. |
| **Hazard accumulation** | • Bark hazard can reach Extreme.<br>• Bark hazard increases over time as the thickness and looseness of the old bark increases.<br>• Repeated low intensity fires (<0.5m flame height) may produce a 'black sock' effect on the base of the trunk, but this may have limited effect in reducing the overall quantity of bark and the hazard. |

**Examples**

**Table 3.1 Assessing the hazard of fine fibrous bark types including stringybarks**

Only use this table if at least 10% of the trees in a forest have fine fibrous bark. To achieve a given hazard rating a best fit of both key attributes should be sought. Choices for the hazard rating of fuels that fit across several descriptions may be informed by the effect that different levels of key attributes have on fire behaviour.

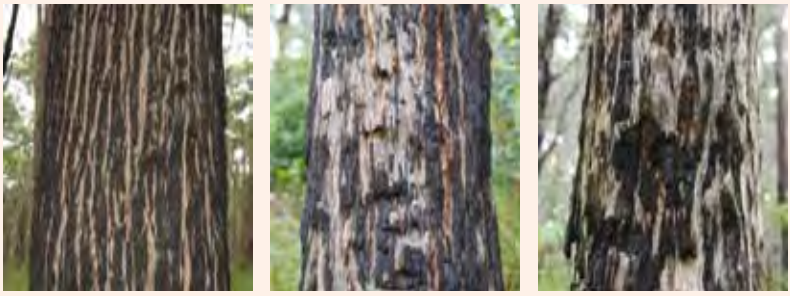
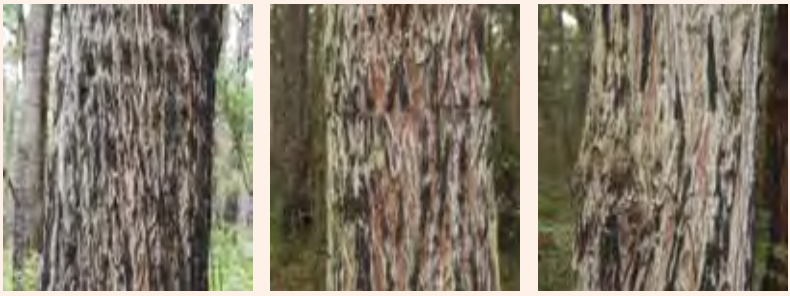
| Key attributes | | Hazard rating | Effect on fire behaviour (at FFDI 25)[1] |
|---|---|---|---|
| **How bark is attached** | **Quantity of combustible bark** | | |
| This hazard rating cannot occur when only this bark type is present. | | Low | |
| Bark tightly held.<br>Requires substantial effort to break off bark by hand. | Very little combustible bark.<br>Entire trunk almost completely black or charred. | Moderate | Spotting generally does not hinder fire control.<br>Fires will not climb these trees. |
| Bark is mostly tightly held with a few pieces loosely attached. | Limited amount of combustible bark.<br>50–90% of trunk charred.<br>Most of the bark is charred, especially on the lower part of the trunk. | High | Infrequent spotting.<br>Fires will climb some of these trees. |
| Many pieces of bark loosely held.<br>Deep fissures present in bark. | Large amounts of combustible bark.<br>10–50% of trunk charred.<br>Upper parts of the tree may not be charred at all. | Very High | Substantial spotting.<br>Fires will climb most of these trees. |
| Outer bark on trees is weakly attached.<br>Light hand pressure will break off large wads of bark.<br>Deep fissures present in bark. | Huge amounts of combustible bark.<br><10% of trunk charred.<br>Minimal evidence of charring. | Extreme | Quantity of spotting generated makes fire control very difficult or impossible.<br>Fires will climb virtually all these trees. |

Assess bark hazard over a plot 20m in radius. Assessing multiple plots will give better results. Trunk is defined as being the part of the tree between the ground and the branches.

See Section 9.3 for application of bark hazard ratings for the Vesta fire behaviour tables.

1 FFDI 25 is a Forest Fire Danger Index of 25 (McArthur 1973). Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

**Table 3.2 Examples of Stringybarks and other fine fibrous bark hazard**

| | |
|---|---|
| **Low** | This hazard rating cannot occur when only this bark type is present. |
| **Moderate** |  |
| **High** |  |
| **Very High** |  |
| **Extreme** |  |

The photos above show some of the variation possible within each bark hazard rating.

# 3

## 3.4 Identifying ribbon or candle bark types

| | |
|---|---|
| **Effect on suppression difficulty** | • Bark types that can produce substantial quantities of spotting at distances greater than 2km. Will also produce short distance spotting. |
| **Physical description** | • Trees characterised by the annual shedding of old bark layers, exposing the smooth new bark underneath.<br>• Bark is shed in the form of long strips or ribbons of bark.<br>• Long strips of bark curl tightly inwards to form a candle-like shape (see image lower right).<br>• Bark strips 50cm or more in length fall off and often drape around the trunk and over branches and surrounding shrubs.<br>• Strips of bark are usually less than 2mm thick.<br>• Bark is shed at various times of the year so that the trunk may have a mottled appearance. |
| **Ease of ignition** | • Bark is moderately flammable (can be lit with a cigarette lighter when dry).<br>• Fires will climb up ribbons of bark. |
| **How bark is attached** | • Bark strips may drape over, or be weakly attached to, the trunk and branches. |
| **Quantity of combustible bark** | • Large quantities of bark can be retained in upper trunk and head of the tree. |
| **Size-to-weight ratio** | • Bark pieces are relatively light for their large size.<br>• Easily transported by strong updrafts – may travel up to 30km downwind. |
| **Burn out time** | • Bark can burn and smoulder within the curled up ribbons for longer than 10 minutes. |
| **Hazard accumulation** | • Bark hazard never exceeds Very High.<br>• Bark hazard tends to increase over the long term as ribbons accumulate on the tree.<br>• A low intensity fire (flame height of less than 0.5m) may not reduce the hazard in this bark type. |

**Example**

**Note:** Loose ribbon or candle-like bark that is retained on the trunk near ground level is not included in the assessment of ribbon or candle bark types. It is usually:
- firmly attached to the trunk of the tree
- consumed in place by a surface fire.

This bark is considered in 'Other bark types' and can also be considered as near-surface fuel.

Smooth-bark trees also shed bark as slabs or flakes. These bark types are considered in 'Other bark types'.

**Table 3.3 Assessing the hazard of ribbon or candle bark types**

If more than 10% of the trees in a forest are fine fibrous bark trees use Table 3.1 (Assessing the hazard of fine fibrous bark types) to determine the bark hazard for a site.

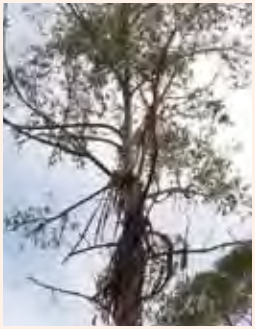
| Key attribute<br>Amount of combustible bark | Hazard rating | Effect on fire behaviour (at FFDI 25)[2] |
|---|---|---|
| This hazard rating cannot occur when only this bark type is present. | Low | |
| No long ribbons of bark present.<br>Trunk and branches of trees almost entirely smooth. | Moderate | Spotting generally does not hinder fire control.<br>Fires will not climb these trees. |
| Long ribbons of bark present on upper trunk (>4m above ground) and in head of trees.<br>Lower trunk mainly smooth. | High | Infrequent spotting.<br>Fires will climb some of these trees. |
| Long ribbons of bark in the head and upper trunk with:<br>• ribbons hanging down to ground level or,<br>• flammable bark covers trunk. | Very High | Substantial spotting.<br>Fires will climb most of these trees. |
| This hazard rating cannot occur when only this bark type is present. | Extreme | |

Assess bark hazard over a plot 20m in radius. Assessing multiple plots will give better results. Trunk is defined as the part of the tree between the ground and the branches.

See Section 9.3 for application of bark hazard ratings for the Vesta fire behaviour tables.

2 Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

**Table 3.4 Examples of ribbon or candle bark hazard**

| | |
|---|---|
| **Low** | This hazard rating cannot occur when only this bark type is present. |
| **Moderate** |    |
| **High** |    |
| **Very High** |    |
| **Extreme** | This hazard rating cannot occur when only this bark type is present. |

## 3.5 Identifying other bark types

This bark type includes all other bark types not included in the previous two types. As a result, many different tree species are grouped together. This grouping is based on the ease of ignition, burn out time and size-to-weight ratio of the bark, rather than on botanical values. These other bark types can produce limited quantities of short distance spotting.

This bark type group has been divided into several subgroups. These subgroups are described in some detail to help observers distinguish them from the other two main bark types.

### 3.5.1 Ironbarks and Platy barks

| | |
|---|---|
| **Physical description** | • Trees characterised by layers of old, coarse bark retained on the trunk and branches.<br>• Bark becomes rough, compacted and furrowed with age<br>• Bark feels very abrasive when rubbed by hand.<br>• Bark pieces tend to be more than 2mm thick when they break off.<br>• There may be little or no evidence of charring on the bark following planned burns. |
| **Hazard accumulation** | • Bark hazard never exceeds Moderate. |

**Example**

### 3.5.2 Coarsely fibrous barks

| | |
|---|---|
| **Physical description** | • Trees characterised by short strand fibrous bark.<br>• Layers of old dead bark are retained on the trunk and branches.<br>• Unlike stringybark trees, the bark on these trees forms only short strands or chunks when peeled off.<br>• Evidence of charring on the bark may last for up to 10 years. |
| **Hazard accumulation** | • Bark hazard never exceeds High.<br>• Bark hazard increases over the long term as the thickness and looseness of the old bark increases. |

**Example**

### 3.5.3 Papery barks

**Physical description**

- Shrubs and trees growing from 2m to 30m tall, often with flaky shedding bark.
- Old bark is retained on the trunk and branches and builds up into a thick spongy mass.
- Bark layers tend to split allowing sheets of bark to become loose and eventually peel off.
- Evidence of charring on the bark may last for up to 10 years.

**Hazard accumulation**

- Bark hazard never exceeds High.
- Bark hazard increases over the long term as the thickness and looseness of the old bark increases.

**Example**

### 3.5.4 Slab bark, smooth bark and small flakes

**Physical description**

- Trees characterised by the annual shedding of old bark layers, exposing the smooth living bark underneath.
- Bark shed is often seasonal and often annual.
- Species where the old bark tends to peel into large slabs (<50cm in length) or small flakes when shed.
- Most of the bark falls off the tree soon after it is shed.
- Some small amounts of bark may be retained on the stem or branches for several months before falling off, leading to a mottled effect.
- The mottled effect leads to discontinuous bark fuel up the tree.

**Hazard accumulation**

- Bark hazard never exceeds Moderate.
- Bark hazard tends to be seasonal.

**Example**

**Table 3.5 Assessing the hazard of other bark types**

If more than 10% of the trees in a forest are fine fibrous bark trees use Table 3.1 (Assessing the hazard of fine fibrous bark types) to determine the bark hazard for a site. To achieve a given hazard rating a best fit of both key attributes should be sought. Choices for the hazard rating of fuels that fit across several descriptions may be informed by the effect that different levels of key attributes have on fire behaviour.

| Key attributes | | Hazard rating | Effect on fire behaviour (at FFDI 25)[3] |
|---|---|---|---|
| **How bark is attached** | **Quantity of combustible bark** | | |
| No trees present.<br>or<br>Trunk and branches of tree entirely smooth or free from loose bark. | | Low | No bark present that could contribute to fire behaviour. |
| Bark rubs off by hand with firm pressure. | Limited amount of combustible bark. | Moderate | Spotting generally does not hinder fire control.<br>Fires will climb some of these trees. |
| Light hand pressure will break bark off. | Large amounts of combustible bark. | High | Infrequent spotting.<br>Fires will climb most of these trees. |
| This hazard rating cannot occur when only this bark type is present. | | Very High | |
| This hazard rating cannot occur when only this bark type is present. | | Extreme | |

Assess bark hazard over a plot 20m in radius. Assessing multiple plots will give better results. Trunk is defined as the part of the tree between the ground and the branches.

See Section 9.3 for application of bark hazard ratings for the Vesta fire behaviour tables.

3 Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

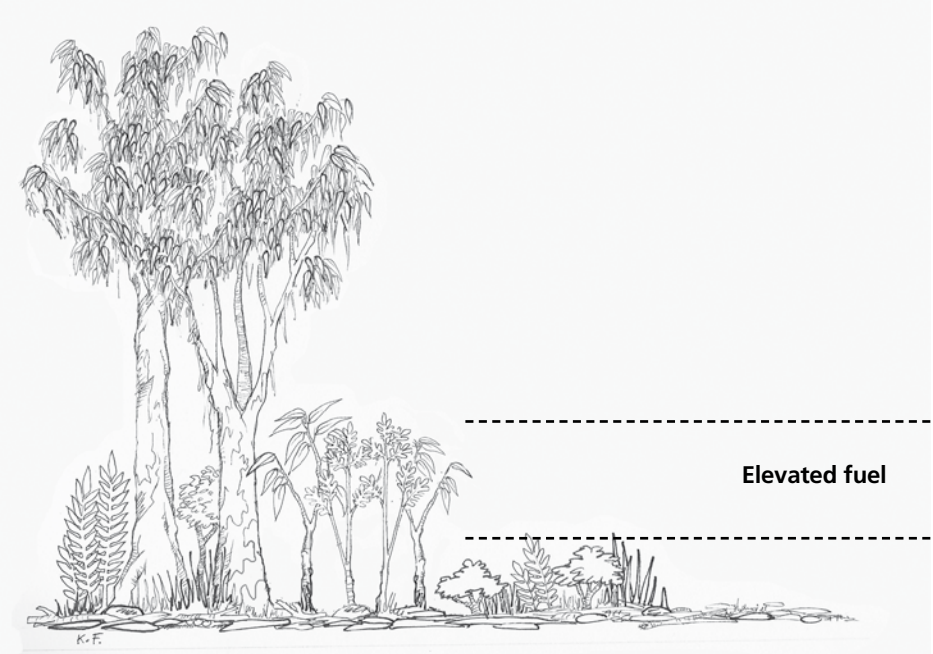
**Table 3.6 Examples of other bark types**

| | | |
|---|---|---|
| **Low** | No trees present.<br><br>or<br><br>Trunk and branches of tree entirely smooth or free from loose bark. |  |
| **Moderate** |  |   |
| **High** |  |   |
| **Very High** | Does not occur when this is the only bark type present on a site. | |
| **Extreme** | Does not occur when this is the only bark type present on a site. | |

# 4. Elevated fine fuel

## 4.1 Identification

- Fuels are mainly upright in orientation
- Generally most of the plant material is closer to the top of this layer
- Sometimes contains suspended leaves, bark or twigs
- Fuels that have a clear gap between them and the surface fuels
- Elevated fuel can be highly variable in ground coverage
- A low intensity fire (flame height of less than 0.5m) may pass beneath this layer without consuming much, if any, of it.




## 4.2 Assessment

The elevated fuel hazard is highest when the:

- foliage, twigs and other fuel particles are very fine (maximum thickness 1–2mm)
- proportion of dead material is high
- fuels are arranged with a high level of density and/or horizontal and vertical continuity that promotes the spread of flames
- live foliage has low fuel moisture content.

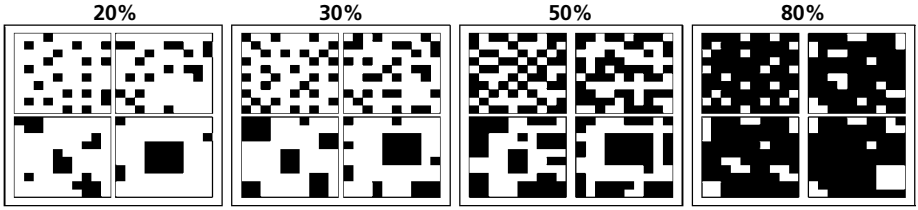
**Table 4.1 Assessing elevated fine fuel hazard**

To achieve a given hazard rating a best fit of all key attributes should be sought. Choices for the hazard rating of fuels that fit across several descriptions may be informed by the effect that different levels of key attributes have on fire behaviour.

| Key attributes | | | | | Fuel hazard rating | Effect on fire behaviour (at FFDI 25)[4] |
|---|---|---|---|---|---|---|
| Plant Cover | % dead | Vertical continuity | Vegetation density | Thickness of fuel pieces | | |
| <20% or low flammability species | <20% | | Easy to walk in any direction without needing to choose a path between shrubs. | | Low | Little or no effect. |
| 20–30% | <20% | Most of the fine fuel is at the top of the layer. | Easy to choose a path through but brush against vegetation occasionally. | | Moderate | Does not sustain flames readily. |
| 30–50% | <20% | Most of the fine fuel is at the top of the layer. | Moderately easy to choose a path through, but brush against vegetation most of the time. | | High | Causes some patchy increases in the flame height and/or rate of spread of a fire. |
| 50–80% | 20–30% | Continuous fine fuel from the bottom to the top of the layer. | Need to carefully select path through. | Mostly less than 1–2mm thick. | Very High | Elevated fuels mostly dictate flame height and rate of spread of a fire. |
| >70% | >30% | Continuous fine fuel from the bottom to the top of the layer. | Very difficult to select a path through. Need to push through vegetation. | Large amounts of fuel <2mm thick. | Extreme | Elevated fuels almost entirely determine the flame height and rate of spread of a fire. |

## Assessing plant cover

For the purpose of this guide, plant cover is defined as the amount of ground blocked out by that fuel layer if viewed while looking straight down from above. Each plant is considered opaque – any ground within the perimeter of the plant cannot be seen. The following visual guide can be used to assist in assessing plant cover. Each quarter of any one square has the same percent cover.




4 Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

**Table 4.2 Examples of elevated fine fuel hazard**

| | | |
|---|---|---|
| **Low** | Elevated fuel absent or virtually absent | |
| **Moderate** |  |  |
| **High** |  |  |
| **Very High** |  |  |
| **Extreme** |  |  |

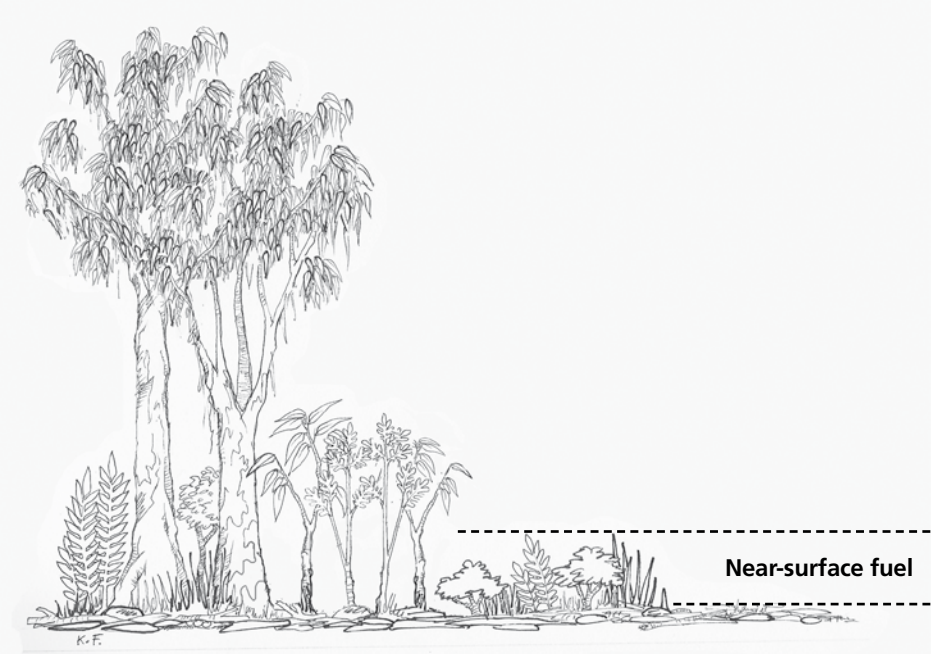
Assess elevated hazard over a plot 10m in radius. Assessing multiple plots will give better results.

See Section 9.3 for application of elevated fuel hazard ratings for the Vesta fire behaviour tables. For the Vesta fire behaviour tables the elevated fuel height (m) should be the average of 10 measurements taken along a 300m walk-through. Measure the typical height from ground level.

# 5. Near-surface fine fuel

## 5.1 Identification

- Live and dead fuels effectively in touch with the ground but not lying on it
- Fuel has a mixture of vertical and horizontal orientation
- Either the bulk of the fuels is closer to the ground than the top of this layer, or is distributed fairly evenly from the ground up
- Sometimes contains suspended leaves, bark or twigs
- Coverage may range from continuous to having gaps many times the size of the fuel patch
- A low intensity fire (flame height of less than 0.5m) will consume most or all of this fuel
- Fuel in this layer will always burn when the surface fuel layer burns.




## 5.2 Assessment

The near-surface fuel hazard is highest when the:

- foliage, twigs and other fine fuel particles are very fine (maximum thickness 1–2mm)
- proportion of dead material is high
- fuels are arranged with a high level of density and /or horizontal and vertical continuity, that promotes the spread of flames
- live foliage has low fuel-moisture content.

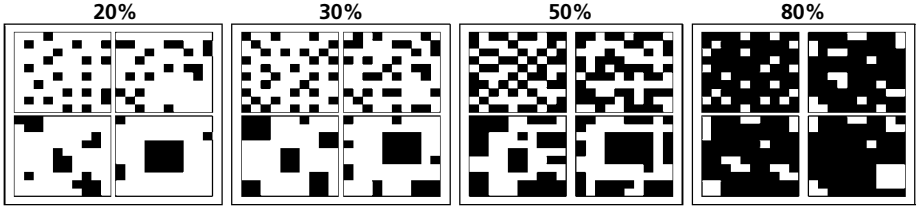
### Table 5.1 Assessing near-surface fine fuel hazard

To achieve a given hazard rating a best fit of all key attributes should be sought. Choices for the hazard rating of fuels that fit across several descriptions may be informed by the effect that different levels of key attributes have on fire behaviour.

| Key attributes | | | Fuel hazard rating | Effect on fire behaviour (at FFDI 25)[5] |
|---|---|---|---|---|
| Plant cover | % dead | Horizontal connectivity | | |
| <10% | <10% | Near-surface fuel is absent or virtually absent. | Low | Little or no effect. |
| 10–20% | <20% | Gaps many times the size of fuel patches. | Moderate | Occasionally increases flame height. |
| 20–40% | >20% | Gaps between fuel patches are greater than the size of fuel patches.<br>Starting to obscure logs and rocks. | High | Contributes to surface fire spread and causes patchy increase to flame height. |
| 40–60% | >30% | Fuel patches are equal to or larger than the gaps between the fuel patches. | Very High | Contributes significantly to fire spread and flame height.<br>A fire will spread readily in this layer without having to consume the surface layer. |
| >60% | >50% | Very small gaps between fuel patches.<br>Logs and rocks obscured. | Extreme | Contributes significantly to fire spread and flame height.<br>A fire will spread readily in this layer without having to consume the surface layer. |

## Assessing plant cover

For the purpose of this guide, plant cover is defined as the amount of ground blocked out by that fuel layer if viewed while looking straight down from above. Each plant is considered opaque – any ground within the perimeter of the plant cannot be seen. The following visual guide can be used to assist in assessing plant cover. Each quarter of any one square has the same percent cover.




5 Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

**Table 5.2 Examples of near-surface fine fuel hazard**

| | | |
|---|---|---|
| **Low** | Near-surface fuel is absent or virtually absent | |
| **Moderate** |  |  |
| **High** |  |  |
| **Very High** |  |  |
| **Extreme** |  |  |

Assess near-surface hazard over a plot 10m in radius. Assessing multiple plots will give better results.

See Section 9.3 for application of near-surface fuel hazard ratings for the Vesta fire behaviour tables. For the Vesta fire behaviour tables the near-surface fuel height (cm) should be the average of 10 measurements taken over a 300m walk through. Measure the typical height from ground level.

# 6. Surface fine fuel

## 6.1 Identification

- Leaves, twigs, bark and other fine fuel lying on the ground
- Predominantly horizontal in orientation
- Usually contributes the most to fuel load or quantity
- Includes the partly decomposed fuel (duff) on the soil surface.

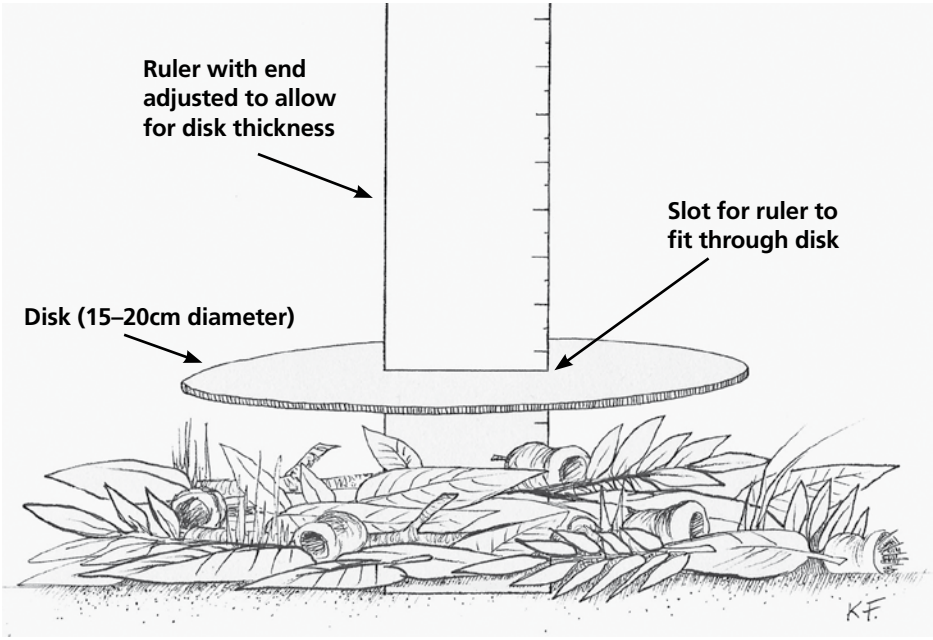

## 6.2 Assessment

The surface fine fuel hazard is highest when the:

- litter pieces are well connected
- surface litter cover is high, with minimal interruption from rocks, logs or patches of bare soil
- surface litter has substantial depth (greater than 30mm).

## 6.3 Measurement

Surface litter-bed depth should be measured using a simple depth gauge, as pictured below. This follows the methodology described in McCarthy (2004) and McCarthy *et al*. (1999).




Litter depth should be measured in areas where near-surface fuels do not obscure the litter. Fuel depth is measured using a 15cm circular disk with a ruler through a slot in its centre. To use this gauge, a small gap is made in the litter bed down to mineral soil, then the end of the ruler is placed resting on the mineral soil surface. The disk is pushed down with light pressure until its whole perimeter is in contact with the fuel. Light pressure can be described as 'enough pressure to hold a tennis ball under water'. The ruler is read off level with the top of the disk. Note that the end of the ruler needs to be adjusted to match the thickness of the disk.

Five measurements of litter bed depth should be made at each site. The average of these measurements is one of the attributes that can be used to determine the surface fine fuel hazard.

**Table 6.1 Assessing surface fine fuel hazard**

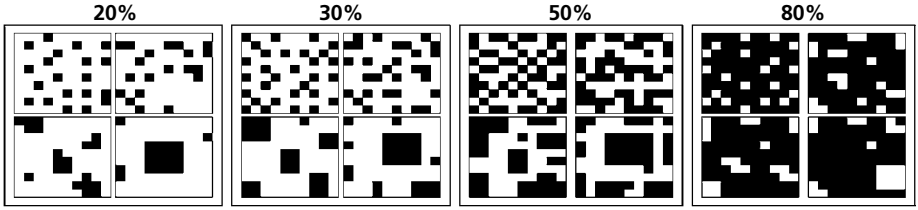
To achieve a given hazard rating a best fit of all key attributes should be sought. Choices for the hazard rating of fuels that fit across several descriptions may be informed by the effect that different levels of key attributes have on fire behaviour.

| Key attributes | | | Fuel hazard rating | Effect on fire behaviour (at FFDI 25)[6] |
|---|---|---|---|---|
| Horizontal connectivity | Surface litter cover | Litter-bed depth | | |
| Litter poorly interconnected.<br>Large areas of bare soil or rock. More soil than litter.<br>Soil surface readily visible through litter bed. | <60% | Very thin litter layer<br><10mm | Low | Surface fires will not spread. |
| Litter well connected.<br>Some areas of bare soil or rock.<br>Soil surface occasionally visible through litter bed. | 60–80% | Thin litter layer<br>10–25mm | Moderate | Litter connected well enough to allow fire spread to overcome bare patches. |
| Litter well connected.<br>Little bare soil. | 80–90% | Established litter with layers of leaves ranging from freshly fallen to decomposing.<br>20–30mm | High | Surface fires spread easily with a continuous fire edge. |
| Litter completely connected. | >90% | Thick litter layer<br>25–45mm | Very High | Surface fires spread easily.<br>Increasing flame depth and residence time. |
| Litter completely connected. | >95% | Very thick layer of litter<br>>35mm | Extreme | Surface fires spread easily.<br>Increasing flame depth and residence time. |

Assess surface hazard over a plot 10m in radius. Assessing multiple plots will give better results. For each plot litter bed depth should be an average of five measurements (McCarthy 2004) or more.

See Section 9.3 for application of surface fuel hazard ratings for the Vesta fire behaviour tables.

The following visual guide can be used to assist in assessing surface litter cover. Each quarter of any one square has the same percent cover.




6 Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

**Table 6.2 Examples of surface fine fuel hazard**

| | | |
|---|---|---|
| **Low** |  |  |
| **Moderate** |  |  |
| **High** |  |  |
| **Very High** |  |  |
| **Extreme** |  |  |

# 7. Determining the combined surface and near-surface fine fuel hazard rating

Assessments of surface and near-surface fuels must be combined together before an Overall Fuel Hazard rating can be determined. The near-surface fuel rating is used to adjust the surface fine fuel hazard rating, according to Table 7.1.

To determine the effect of near-surface fine fuel hazard:

1. Select the **surface fuel hazard rating** from column 1
2. Select the **near-surface fuel hazard rating** from column 2
3. Select the resulting **combined rating** value 3
4. Use this value to determine the Overall Fuel Hazard rating using the Table 8.1.

**Table 7.1 Determining the combined surface and near-surface fine fuel hazard rating**

| 1 Surface fine fuel hazard rating | 2 Near-surface fine fuel hazard rating | | | | |
|---|---|---|---|---|---|
| | Low | Moderate | High | Very High | Extreme |
| | 3 Combined surface and near-surface fine fuel hazard rating | | | | |
| Low | L | L | M | H | VH |
| Moderate | M | M | H | VH | E |
| High | H | VH | VH | VH | E |
| Very High | VH | VH | E | E | E |
| Extreme | E | E | E | E | E |

# 8. Determining Overall Fuel Hazard

Overall Fuel Hazard = (sum of the influences of) Bark Hazard + Elevated Fine Fuel Hazard + Combined Surface and Near-surface Fine Fuel Hazard.

The following table is used to combine the assessed levels of Bark, Elevated and Combined Surface and Near-surface Fuel Hazard to give an Overall Fuel Hazard rating.

To determine the Overall Fuel Hazard rating:

1. Select the row that corresponds to the **Bark Hazard** ❶
2. Select the row that corresponds to the **Elevated Fine Fuel Hazard** ❷
3. Select the column that corresponds to the assessed level of **Combined Surface and Near-surface Fine Fuel Hazard** ❸
4. Identify where these two intersect and this will provide you with the corresponding Overall Fuel Hazard rating.

**Table 8.1 Determining the Overall Fuel Hazard rating**

| ❶ Bark Hazard | ❷ Elevated Fine Fuel Hazard | ❸ Combined Surface and Near-surface Fine Fuel Hazard * | | | | |
|---|---|---|---|---|---|---|
| | | L | M | H | VH | E |
| Low or Moderate | L | L | M | M | H | H |
| | M | L | M | M | H | H |
| | H | L | M | H | VH | VH |
| | VH | VH | VH | VH | VH | VH |
| | E | E | E | E | E | E |
| High | L | L | M | H | H | H |
| | M | L | M | H | H | H |
| | H | L | H | H | VH | VH |
| | VH | VH | VH | VH | VH | E |
| | E | E | E | E | E | E |
| Very High or Extreme | L | L | VH | VH | VH | E |
| | M | M | VH | VH | E | E |
| | H | M | VH | E | E | E |
| | VH | E | E | E | E | E |
| | E | E | E | E | E | E |

* Combined Surface and Near-surface Fine Fuel Hazard is a measure of the Surface Fine Fuel Hazard adjusted to account for the level of near-surface fine fuel (see Table 7.1).

# 9. Interpreting and applying Overall Fuel Hazard

## 9.1 Chances of extended first attack success

The chances of extended first attack being successful[1] for a fire ignited in these fuels under the reference extended first attack conditions (Appendix 1) is approximately as follows:

**Table 9.1 Chances of extended first attack success**

| GFDI[2] | FFDI[3] | Overall Fuel Hazard rating[4] | | | | |
|---|---|---|---|---|---|---|
| | | Low | Moderate | High | Very High | Extreme |
| 0–2 | 0–5 | | | | | |
| 3–7 | 6–11 | | | | | |
| 8–20 | 12–24 | | | | | |
| 20–49 | 25–49 | | | | | |
| 50–74 | 50–74 | | | | | |
| 75–99 | 75–99 | | | | | |
| 100+ | 100+ | | | | | |

Chance of extended first attack success is greater than 95% (almost always succeeds)

Chance of extended first attack success is between 95% and 50% (succeeds most of the time)

Chance of extended first attack success is between 49% and 10% (fails most of the time)

Chance of extended first attack success is less than 10% (almost always fails)

**Notes**:

1. Extended first attack is deemed successful when a fire is controlled by 0800hrs the day after ignition and at less than 400 hectares.
2. GFDI is the Grass Fire Danger Index at the time of ignition and is assumed to be the highest GFDI expected before 0800hrs the next day.
3. FFDI is the Forest Fire Danger Index at the time of ignition and is assumed to be the highest FFDI expected before 0800hrs the next day.
4. Chance of success is for a fire ignited in fuels with this Overall Fuel Hazard rating.
5. Predicted outcomes will differ if the conditions vary from those listed in the reference extended first attack conditions.
6. Predicted outcomes based on expert opinion and informed by work carried out by Wilson (1992b, 1993), McCarthy *et al*. (1998a, 2001) and Plucinski *et al*. (2007).

## 9.2 Indicative fuel loads (t/ha)

In the absence of local data obtained by sampling fuel loads destructively the following table of indicative fuel load data from Project Vesta and Victorian studies may be useful. These tonnes per hectare figures may be applied to the Forest Fire Danger Meter Mark V (McArthur 1973) for predicting forward rate of spread and flame height for forest fires.

**Table 9.2 Indicative fuel loads (t/ha)**

| Fuel | Fuel hazard rating | | | | |
|---|---|---|---|---|---|
| | Low | Moderate | High | Very High | Extreme |
| **Bark** | 0 | 1 | 2 | 5 | 7 |
| **Elevated** | 0–1 | 1–2 | 2–3 | 3–5 | 5–8 |
| **Near-surface** | 1–2 | 2–3 | 3–4 | 4–6 | 6–8 |
| **Surface** | 2–4 | 4–10 | 8–14 | 12–20 | 16–20+ |

## 9.3 Determining Vesta fuel hazard scores

The following table translates fuel hazard ratings for each fuel layer into Project Vesta fuel hazard scores. These scores can be used with the fire behaviour prediction tables in publications such as Gould *et al*. (2007b).

To determine the Vesta fuel hazard score:

1. Select the row that corresponds to the fuel hazard rating for required fuel layer (1)
2. Select the Vesta fuel hazard score column that corresponds to the same layer (2)
3. Identify where these two intersect and this will provide you with the corresponding Vesta fuel hazard score.

**Table 9.3 Determining Vesta fuel hazard scores**

| | Vesta fuel hazard score (2) | | | |
|---|---|---|---|---|
| **Fuel hazard rating (1)** | **Surface** | **Near-surface** | **Elevated** | **Bark** |
| Low | 1 | 1 | 1 | 0 |
| Moderate | 2 | 2 | 2 | 1 |
| High | 3 | 3 | 3 | 2 |
| Very High | 3.5 | 3.5 | 3.5 | 3 |
| Extreme | 4 | 4 | 4 | 4 |

**Notes**:

- Surface and near-surface hazard score and near-surface height (cm) is required for fire spread prediction.
- Rate of spread and elevated fuel height (m) is required for flame height prediction.
- Rate of spread, surface and bark fuel hazard scores are required for prediction of spotting distance.

# Acknowledgements

This Fuel Hazard Assessment Guide updates and continues to develop work previously conducted by a number of authors. Andrew Wilson laid the foundations for this guide, with the conceptual framework presented in Research Report No. 31; and the visual guides for assessing the influence of bark and elevated fuels on suppression difficulty in the *Eucalypt Bark Hazard Guide and Elevated Fuel Guide* (Reports 32 and 35, respectively). Greg McCarthy (2004) detailed a method for rapidly assessing surface fine fuels in Research Report No. 44.

These three techniques were brought together in the first three editions of the *Overall Fuel Hazard Guide* (McCarthy, Tolhurst and Chatto, 1998b, 1998c, 1999). A subsequent unpublished edition of the guide, produced by Kevin Tolhurst (2005), provided greater detail on the assessment of near-surface fuels. In 2006, Mike Wouters adapted the guide for South Australian conditions, and incorporated the preliminary results from Project Vesta (CSIRO and Department of Conservation and Environment, Western Australia). Further information and results from the final Project Vesta report (Gould *et al.* 2007a) have also been incorporated.

Thanks to Lachie McCaw (Department of Environment and Conservation, Western Australia), Mike Wouters (Department of Environment and Heritage, South Australia), Jim Gould and Miguel Cruz (CSIRO) for their advice and comments during the production of this guide. Thanks must also go to the many other people across Australia who have provided comments and feedback during the production of the guide.

# References


Department of Environment and Heritage 2006, *Overall fuel hazard guide for South Australia*, 1st edn, Government of South Australia.

Gould, JS McCaw, WL Cheney, NP Ellis, PF Knight, IK & Sullivan, AL 2007a, *Project VESTA. Fire in dry eucalypt forest: fuel structure, fuel dynamics and fire behaviour*, Ensis-CSIRO, Canberra, ACT & Department of Environment and Conservation, Perth, WA.

Gould, JS McCaw, WL Cheney, NP Ellis, PF & Matthews, S 2007b, *Field guide – fuel assessment and fire behaviour prediction in dry eucalypt forest*, Ensis-CSIRO, Canberra, ACT & Department of Environment and Conservation, Perth, WA.

McArthur, AG 1973, *Forest fire danger meter Mk5*, Forestry and Timber Bureau, Forest Research Institute, Commonwealth of Australia.

McCarthy, GJ & Tolhurst, KG 1998a, *Effectiveness of firefighting operations by the Department of Natural Resources and Environment from 1991/2–1994/5*, research report no. 45, Fire Management Branch, Department of Natural Resources and Environment, Victoria.

McCarthy, GJ Tolhurst, KG & Chatto, K 1998b, *Overall fuel hazard guide*, research report no. 47, Fire Management Branch, Department of Natural Resources and Environment, Victoria.

McCarthy, GJ Tolhurst, KG & Chatto, K 1998c, *Overall fuel hazard guide*, 2nd edn, research report no. 47, Fire Management Branch, Department of Natural Resources and Environment, Victoria.

McCarthy, GJ Tolhurst, KG & Chatto, K 1999, *Overall fuel hazard guide*, 3rd edn, research report no. 47, Fire Management Branch, Department of Natural Resources and Environment, Victoria.

McCarthy, GJ & Tolhurst, KG 2001, *Effectiveness of broadscale fuel reduction burning in assisting with wildfire control in parks and forest in Victoria*, research report no. 51, Fire Management, Department of Natural Resources and Environment, Victoria.

McCarthy, GJ 2004, *Surface fine fuel hazard rating – forest fuels in East Gippsland*, research report no. 44, Fire Management Branch, Department of Sustainability and Environment, Victoria.

Plucinski M, Gould, J, McCarthy, G, Hollis J (2007) The effectiveness and efficiency of aerial fire fighting in Australia, Part 1, Bushfire CRC Technical Report Number A0701

Sneeuwjagt, RJ & Peet, GB 1998, *Forest fire behaviour tables for Western Australia*, Department of Conservation and Land Management, Perth, Western Australia.

Wilson, AAG 1992a, *Assessing the fire hazard on public lands in Victoria: fire management needs, and practical research objectives*, research report no. 31, Fire Management Branch, Department of Conservation and Environment, Victoria.

Wilson, AAG 1992b, *Eucalypt bark hazard guide*, research report no. 32, Fire Management Branch, Department of Conservation and Environment, Victoria.

Wilson, AAG 1993, *Elevated fuel guide*, research report no. 35, Fire Management Branch, Department of Conservation and Environment, Victoria.

# Appendix 1. Reference extended first attack conditions

This guide assesses the impact of fuels in suppressing a fire during extended first attack, using local resources. Several factors affect the success of an extended first attack. Therefore, to consider the impact of fuels alone, the other factors must be treated as if they were constant. Table A1 below adapted from Wilson (1993) summarises reference extended first attack conditions for four fuel types.

**Table A1. Revised reference extended first attack conditions**

| Fuel type | Forest fuels | Grass fuels | Mallee and scrub fuels | Heath fuels |
|---|---|---|---|---|
| **Examples of typical resources (on scene within the designated arrival time)** | Small dozer (D4)<br><br>1 to 2 small 4WD tankers (400l)<br><br>6 firefighters | 5 x 4WD heavy tankers (4000l) each with 5 firefighters | Small dozer (D4) or tractor with scrub roller<br><br>1 to 2 small 4WD tankers (400l)<br><br>6 firefighters | Small dozer (D4)<br><br>1 to 2 small 4WD tankers (400l)<br><br>6 firefighters |
| **Extended attack resources** | Potential additional resources deployed to the fire during extended first attack may include heavy tankers, large plant (dozers, graders or tractors) and fire bombing aircraft. | | | |
| **Arrival time** | Within 60 minutes of detection | | | |
| **Suppression workload** | A single fire | | | |
| **Topography and terrain** | Burning on level ground with good access | | | |
| **Fuel availability[1]** | MDF is 10 or AFF is 1.0 | 100% grass curing | MDF is 10 or AFF is 1.0 | |
| **Wind speed[2]** | 20km/h | 30km/h | | 20km/h |
| **Fire danger rating system[3]** | McArthur FFDI | McArthur GFDI | McArthur FFDI | |

**Notes:**

1. MDF (McArthur Drought Factor) is calculated using the Forest Fire Danger Meter (McArthur 1973) and is a measure of the short-term availability of forest fuels. AFF (Available Fuel Factor) is used in Western Australia to define the proportion of litter fuel available for burning (Sneeuwjagt & Peet 1998).
2. Wind speed is measured at 10m height in the open above ground level.
3. FFDI is the McArthur Forest Fire Danger Index, GFDI is the McArthur Grass Fire Danger Index.

The rationale for the reference first attack conditions is documented in DSE's *Overall fuel hazard assessment guide: a rationale report – fire and adaptive management report no. 83* (in prep).

# Appendix 2. Sample fuel assessment field work form v3

| | |
|---|---|
| Date Assessed: | Assessors: |
| Sampling Location: | Veg Type: |

| **Plot Information** | | | |
|---|---|---|---|
| Plot No. | | | |
| Zone: | | | |
| Easting (GDA94 MGA UTM): | | | |
| Northing (GDA94 MGA UTM): | | | |

| **Canopy height (Assess over a 20m radius)** | | | |
|---|---|---|---|
| Average Height to Top of Canopy: | m | m | m |
| Average Height to Base of Canopy: | m | m | m |

| **Bark fuel (Assess over a 20m radius)** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stringybark Fuel Hazard: | NP | M | H | VH | E | NP | M | H | VH | E | NP | M | H | VH | E |
| Ribbon Bark Fuel Hazard: | NP | M | H | VH | | NP | M | H | VH | | NP | M | H | VH | |
| Other Bark Fuel Hazard: | L | M | H | | | L | M | H | | | L | M | H | | |

Select the Bark Hazard rating from above that will be used to determine Overall Fuel Hazard. (Only use the Stringybark hazard rating if more than 10% of the trees are Stringybark **AND** it has the highest rating. Otherwise use the bark with next highest rating.)

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bark Fuel Hazard: | L | M | H | VH | E | L | M | H | VH | E | L | M | H | VH | E |

| **Elevated fuel layer (Assess over a 10m radius)** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Elevated % Cover: | % | | | | | % | | | | | % | | | | |
| Elevated % Dead | % | | | | | % | | | | | % | | | | |
| Elevated Fuel Ave Height (m) | m | | | | | m | | | | | m | | | | |
| Elevated Fuel Hazard: | L | M | H | VH | E | L | M | H | VH | E | L | M | H | VH | E |

| **Near-surface fuel layer (Assess over a 10m radius)** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Near-surface % Cover: | % | | | | | % | | | | | % | | | | |
| Near-surface % Dead | % | | | | | % | | | | | % | | | | |
| NS Average Height (cm): | cm | | | | | cm | | | | | cm | | | | |
| NS Fuel Hazard: | L | M | H | VH | E | L | M | H | VH | E | L | M | H | VH | E |

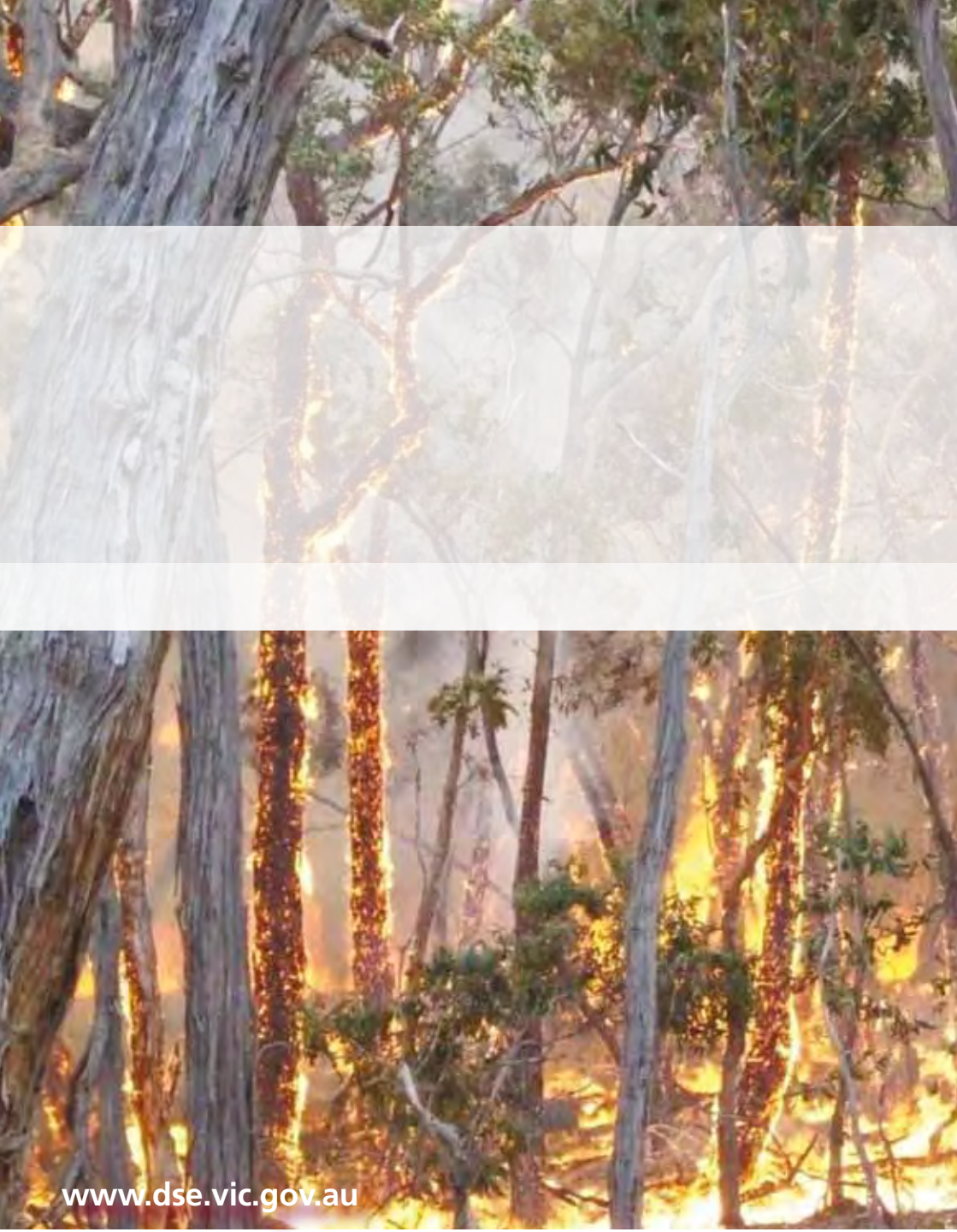
| **Surface fuel layer (Assess over a 10m radius)** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface Litter % Cover: | % | | | | | % | | | | | % | | | | |
| Average Litter Depth (mm): | mm | | | | | mm | | | | | mm | | | | |
| Surface Fuel Hazard | L | M | H | VH | E | L | M | H | VH | E | L | M | H | VH | E |

| **Combined Surface and Near-surface Fine Fuel Hazard calculation (refer Section 7)** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Combined Hazard | L | M | H | VH | E | L | M | H | VH | E | L | M | H | VH | E |

| **Overall Fuel Hazard calculation (refer Section 8)** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Overall Fuel Hazard | L | M | H | VH | E | L | M | H | VH | E | L | M | H | VH | E |

| **Are the plots representative of the average fuels across the sampling location?** | Yes | No |
|---|---|---|

If no, explain any significant difference between plots. For example, wet gully runs through the sampling area, no plots were located in this gully.



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# APPENDIX D RABBIT IMPACT ASSESSMENT (COOKE ET AL. 2008)

# Rabbits:

## A threat to conservation & natural resource management

### How to rapidly assess a rabbit problem and take action

## The problem

It takes less than one rabbit per hectare to prevent the successful regeneration of many of our common native trees and shrubs. This means that many rabbit-infested patches of remnant native vegetation can't sustain themselves naturally and are in slow decline - but unfortunately this often goes unnoticed. Whether you are a land-owner who conserves some uncleared woodland on the farm or belong to a Landcare group managing vegetation along a roadside, this quick assessment method will help you decide if rabbits are a problem and what action you need to take. National Park managers will also find this a useful tool for alerting them to problems.

## How to monitor

Take 15 – 20 minutes to walk through the patch of native vegetation of interest. You should cover about 2 – 3 hectares in this time. Observe carefully but don't stop too long at any given point.

Use this guide to help you fill in the data sheet on pages 14-15.

# STEP 1:
# Rabbit abundance score

Record evidence of rabbits as you walk; it will help form an 'average' picture of the whole area in your mind. Rabbit warrens may be present as well as scratches and 'buck-heaps' or latrines but the abundance of rabbit pellets (faeces) is the best measure to use (see **Figure 1**). Score these as follows:

0 - none found in the 15 minute search
1 - isolated pellets and small clumps of 5 - 10 pellets 10 metres or more apart
2 - scattered pellets and clumps less than 10 metres apart
3 - common, pellets in larger clumps and occasional buck-heaps on about half the areas you scan closely during the search
4 - abundant, pellets often in large clumps and buck-heaps obvious but not present across whole area
5 - very abundant, pellets and buck-heaps always apparent

**FIGURE 1: Typical small clump of rabbit pellets (faeces) in grassland.**

# Rabbit 'score' and population density

The score for rabbits (0 – 5 scale) is not a direct measure of rabbit abundance or population density. However, an approximate conversion is as follows:

| Rabbit abundance score | Approximate density (adult rabbits/hectare) |
|---|---|
| 0 | 0 |
| 1 | 0.5 |
| 2 | 1 |
| 3 | 2 |
| 4 | 5 |
| 5 | 10 or more |

# STEP 2:
# Seedling abundance score

Once you are beginning to get the picture on rabbit abundance, look around to see if there are seedlings of the common native trees and shrubs present in the area. They can be 'scored' in a similar way to the rabbits:

0 - none found during 15 minute search

1 - very few, only 1 - 5 individual seedlings encountered

2 - uncommon, 6 - 20 seedlings encountered

3 - common, 20 - 100 seedlings encountered

4 - abundant, 100 - 200 seedlings encountered

5 - very abundant, many hundreds of seedlings encountered

The presence of seedlings is a measure of the health of the vegetation community and a mix of seedlings of different tree or shrub species indicates broad community health.

# Common trees and shrubs damaged by rabbits

**These can be useful 'indicators' of rabbit browsing but you will find many other examples.**

- Acacia (Wattles):
  *Acacia ligulata, A. oswaldii*
- Bursaria (Sweet Bursaria):
  *Bursaria spinosa*
- Casuarina (Sheokes and Bulokes):
  *Allocasuarina verticilliata*
- Callitris (Native Pines):
  *Callitris glaucophylla* and *C. gracilis*
- Dodonea (Turpentines):
  *Dodonea viscosa*
- Hakea (Needlebush):
  *Hakea leucoptera*
- Myoporum (Boobialas):
  *Myoporum insulare*

# STEP 3:
# Rabbit damage score

Closely inspect smaller seedlings, less than 0.5 metres high, for evidence of rabbit damage. Oblique 45˚ 'secateurs-like' cuts through smaller stems, defoliation and gnawing of bark are tell-tale signs (see **Figure 2**). Another sign can be twigs cut from seedlings and then discarded without being eaten – and again look for the 'secateurs-like' cut to confirm that rabbits were responsible. The severity of rabbit damage should be ranked as follows:

0 - no evidence of rabbit damage

1 - slight damage to some seedlings

2 - obvious damage but confined to some seedlings

3 - many seedlings moderately damaged

4 - heavy general damage, some seedlings retain foliage

5 - foliage, twigs and bark stripped from all seedlings

**FIGURE 2: Rabbit damage showing stripping of bark and 45º 'secateurs-like' cuts through twigs.**

In some instances rabbits may have eaten all of the seedlings but the severity of grazing can still be ranked at '5' from the presence of a distinct 'browse-line' 500 millimetres above the ground on older saplings or mature shrubs with lower foliage within reach of the rabbits (see **Figure 3**).

**FIGURE 3: Absence of small seedlings and a distinct 'browse-line' 500 millimetres above the ground on older saplings indicates severe rabbit impact (Damage score = 5).**

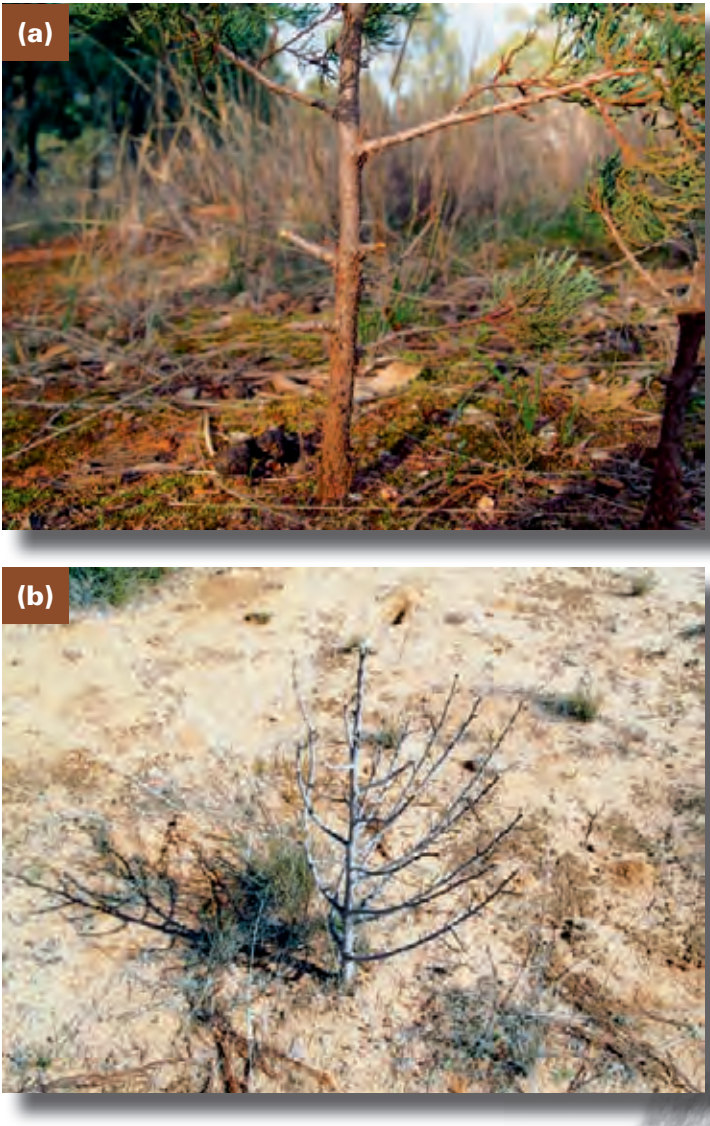



**FIGURE 4: Native pines with: (a) little damage (score 1); or (b) complete defoliation (score 5).**

# STEP 4:
# Corrected regeneration score

Use the **Table** below to work out a 'corrected regeneration score' from the seedling abundance and rabbit damage scores you have obtained.

Two examples are provided:

- Example 1: Seedlings were abundant (score 4) and very little rabbit damage was noted (score 1); the corrected regeneration score is 2.
- Example 2: Seedlings were again abundant (score 4) but rabbit damage was very heavy (score 5); the corrected regeneration score is 0.7 (which can be rounded up to 1).

| | Seedling abundance | | | | | |
|---|---|---|---|---|---|---|
| **Rabbit damage** | **0** | **1** | **2** | **3** | **4** | **5** |
| **0** | 0.20 | 1.00 | 2.00 | 3.00 | 4.00 | 5.00 |
| **1** | 0.20 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 |
| **2** | 0.20 | 0.34 | 0.70 | 1.00 | 1.30 | 1.70 |
| **3** | 0.20 | 0.28 | 0.50 | 0.80 | 1.00 | 1.30 |
| **4** | 0.20 | 0.20 | 0.40 | 0.60 | 0.80 | 1.00 |
| **5** | 0.20 | 0.20 | 0.30 | 0.50 | 0.70 | 0.80 |

Use the corrected regeneration score obtained from the **Table** for the next Step.

# STEP 5:
# Assessing overall rabbit impact

Where does the site you have assessed fit on **Figure 5** below? Use your corrected regeneration score and the score you obtained for rabbit abundance to do this.

Again, two examples are given:

- Example 1: Corrected regeneration score about 3 and rabbit abundance score 1.
- Example 2: Corrected regeneration score about 1 and rabbit abundance score 4.

Most assessments should fall roughly around the *dotted black line* which is based on observations from over 200 sites assessed in south-eastern Australia.

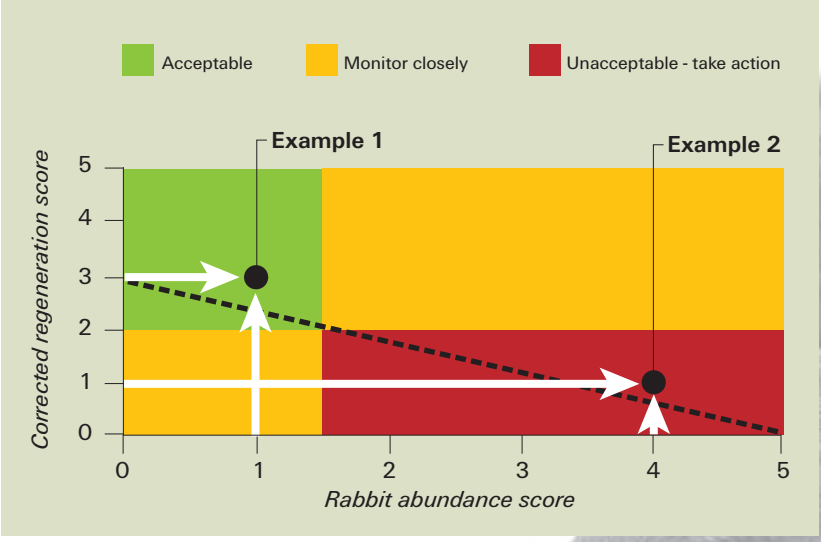



**FIGURE 5: Assessing overall rabbit impact.**

If your assessment falls within the green zone, rabbits are not having a significant impact on native vegetation regeneration. The yellow zones indicate where rabbits should be watched more closely and the red zone indicates that rabbits must be controlled to avoid serious biodiversity losses.

## Removing rabbits

Where rabbits are damaging vegetation, and action to reduce their impact is needed, it is important to remember that the '*cure should not be worse than the disease*'. Where rabbits are living amongst thick remnant native vegetation, the control methods chosen should not irreparably damage trees, shrubs and native herbage.

Several different methods of control often need to be combined to achieve the best results among roadside vegetation:

- poison in summer or autumn to eliminate most rabbits;
- destroy readily accessible warrens by ripping with a suitable small tractor or back-hoe, preferably while soil remains dry;
- fumigate inaccessible rabbit holes and any that re-open after ripping.

This combination of techniques means more work and initial expense, but the low costs of keeping rabbits down in subsequent years quickly brings accumulated costs below those of repeated annual treatments. Treating re-opened rabbit holes by fumigation 'on the spot' during annual inspections will keep costs down and ensure that rabbits do not regain damaging numbers. Ask your local Natural Resource Management Board, Catchment

Management Authority or Rural Lands Protection Board for advice on availability and use of poisons and fumigation equipment.

More information on rabbit management is available at: **www.feral.org.au**

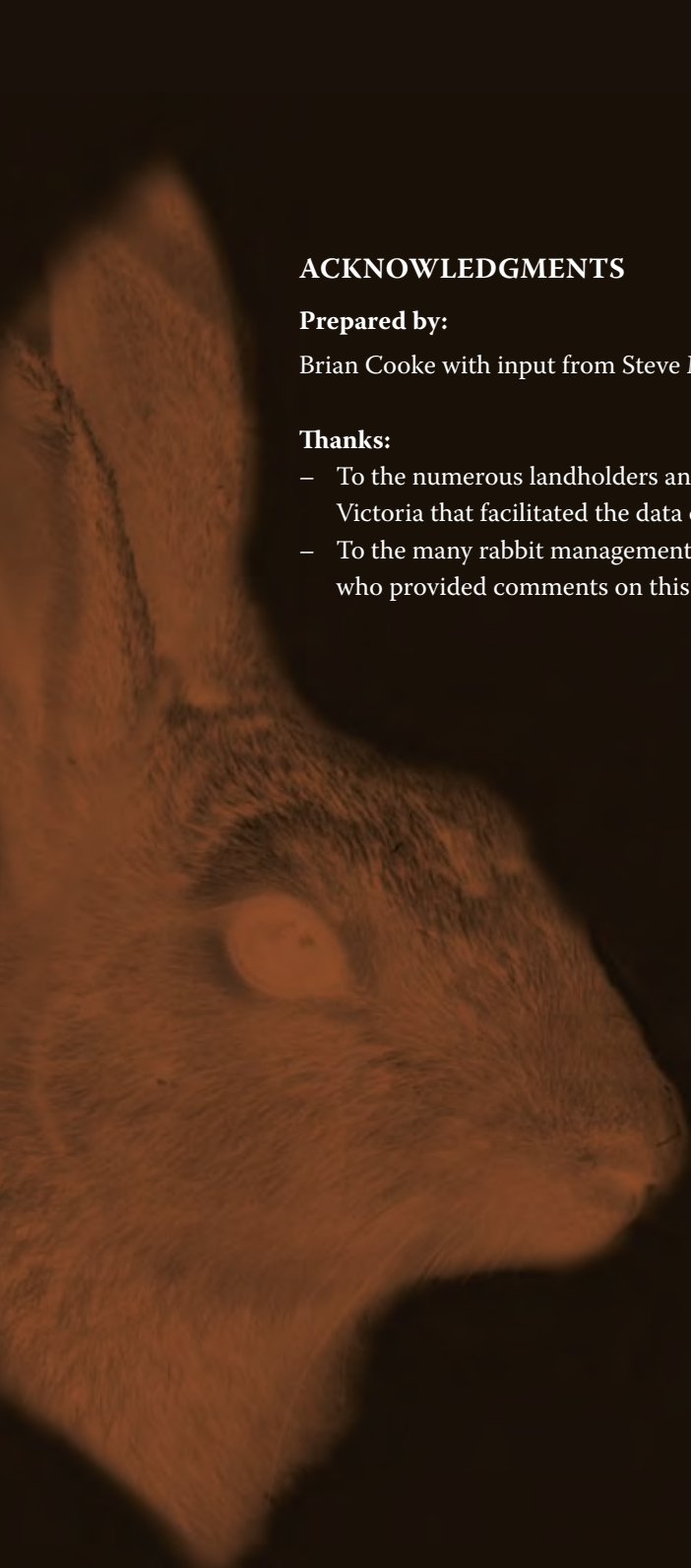
## Measuring achievement

This simple method of assessing rabbits can be useful for measuring progress in rabbit control. Note the results in your diary so that you can measure progress by repeating the assessment again a year from now. Success should not be measured in terms of reduced rabbit numbers alone. The health of the native vegetation — measured in terms of its ability to regenerate — is the main aim.

# Rabbit and vegetation data sheet

| | | | |
|---|---|---|---|
| **Site name or reference:** *(e.g. local name, owner's name details)* | | | |
| **Name of assessor:** | | | |
| **Date:** | | **Inspection time:** | am/pm |
| **Location:** *(e.g. nearest town)* | | | |
| **Latitude:** *(from GPS)* | o S | **Longitude:** | o E |
| **Altitude:** *(from GPS)* | metres | | |
| **Approximate area inspected:** ha.<br>**Total area of land if known:** ha. | | | |
| **Land use(s):** *(e.g. grazing, cropping, rail reserve)* | | | |

| **General description of site:** *(e.g. remnant native vegetation adjacent to cropland)* | |
|---|---|
| Rabbit Abundance | Score |
| 0 = none found in 15 minute search; 1 = small, isolated clumps >10m apart;<br>2 = clumps <10 m apart; 3 = common; 4 = abundant, still patchy;<br>5 = very abundant, faeces always apparent. | |
| Seedling Abundance | Score |
| 0 = none; 1 = very few; 2 = uncommon; 3 = common;<br>4 = abundant; 5 = very abundant. | |
| Rabbit Damage | Score |
| 0 = no damage; 1 = slight damage; 2 = obvious damage confined to some seedlings;<br>3 = many seedlings moderately damaged; 4 = heavy general damage; 5 = foliage and small twigs and bark stripped from almost all seedlings. If there are no seedlings and there is a browse-line on low foliage, score as 5. | |
| Corrected Damage Score | Score |
| | |
| **Final decision on rabbit control:** | |




## ACKNOWLEDGMENTS

**Prepared by:**

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