

**Moolarben UG4 – Longwall 401-408
Biodiversity Technical Report**

Prepared for Yancoal Moolarben Coal | 4 November 2021



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Glossary and list of abbreviations

Term or abbreviation	Definition
BAM	NSW Biodiversity Assessment Method
BC Act	NSW <i>Biodiversity Conservation Act 2016</i>
BVT	Biometric Vegetation Type
DBH	Diameter at Breast Height
EIA	Ecological Impact Assessment
EPBC Act	Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>
LW	Longwall
MCO	Moolarben Coal Operations Pty Ltd
PCT	Plant Community Type
TSU	Terrestrial Stratification Unit
UG	Underground

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1. Introduction

1.1 Background

Moolarben Coal Operations Pty Ltd. (MCO) received approval for Moolarben Coal Project Stage 1 (the project) under Project Approval 05_0117, which includes the No. 4 Underground Area (UG4). The Moolarben Coal Mine is located at 12 Ulan-Wollar Road, Ulan, New South Wales (NSW). MCO is currently seeking approval for secondary extraction of Longwalls 401 to 408 within UG4 (the study area) (Figure 1).

Project Approval 05_0117 Condition 77 requires the proponent to prepare and implement an Extraction Plan for all second workings on site to the satisfaction of the Secretary.

Condition 77 (i) states that the proponent is to:

Include a Biodiversity Management Plan which has been prepared in consultation with BCD, which provides for the management of the potential and/or environmental consequences of the proposed second workings on aquatic and terrestrial flora and fauna, with a specific focus on threatened species, populations and their habitats; endangered ecological communities and water dependent ecosystems.

MCO is currently in the process of developing an Extraction Plan for Longwalls 401 to 408 (UG4 LW401-408) to progress secondary extraction operations which are expected to commence in 2022. As such, this Biodiversity Technical Report has been prepared to support the Extraction Plan and to inform the subsequent preparation of a Biodiversity Management Plan to manage the potential risks of secondary extraction on threatened and non-threatened species, populations and ecological communities (biota).

Since the Stage 1 Approval (05_0117) in 2007, extensive additional environmental monitoring and studies have been undertaken in the Ulan Coalfields, including MCO's Underground 1 (UG1) and neighbouring mining operations. The additional studies and monitoring data associated with the inter-mine data sharing have improved the understanding of the predicted underground mining impacts. This contemporary knowledge, supplemented with targeted site surveys, underpins this technical report and the refined impact predictions, performance indicators, management and monitoring measures for the UG4 LW401-408 extraction plan.

This Biodiversity Technical Report includes:

- A brief description of previous ecological surveys relevant to the study area
- A summary of the field validation and baseline assessment results in addition to any threatened ecological communities (TECs) and/or threatened species, populations and their habitats (threatened biota) recorded or likely to occur in the study area
- A summary of existing vegetation condition within the study area
- A review of subsidence predictions for UG4 LW401-408 secondary extraction and an assessment of potential environmental impacts relevant to threatened and non-threatened biota
- Review of Environmental Assessment Biodiversity commitments and performance measures and the likelihood of achieving these targets
- Monitoring methodology designed to target biodiversity values vulnerable to subsidence impacts including monitoring site locations
- Conclusion and recommendations.

2. Biodiversity values

2.1 Native vegetation

The study area has undergone extensive ecological survey, including vegetation mapping and targeted threatened species survey, during the preparation of the Stage 1 EIS (Moolarben Biota 2006) in addition to numerous subsequent mapping revisions (ELA 2015, 2019, 2020). Mapping revisions were undertaken to ensure project biodiversity data remains current with changes to the NSW Vegetation Classification System (VCS).

A baseline assessment to collect biodiversity data for monitoring purposes as part of the vegetation validation and baseline assessment report was undertaken by Niche Ecologists, Nicola Trulock (Senior Ecology Consultant) and Isabel Lyons (Ecologist), between 17 and 21 May 2021. Vegetation validation and mapping was undertaken in the field to address gaps in the existing vegetation mapping and update vegetation community identities in accordance with the NSW VCS (DPIE 2021).

Vegetation within the study area has been stratified by Plant Community Type (PCT) and condition, to allow for conformity with the NSW Vegetation Information System Classification Database (Figure 2). The field validated vegetation mapping allows for consistency between the UG4 LW401-408 extraction plan (in preparation) and reporting/mapping previously undertaken for UG1 and biodiversity offset sites relevant to the project.

The field validated vegetation mapping determined that six PCTs in various condition states (low, medium, high and derived native grassland [DNG]) are present in the study area (as shown in Figure 2), consisting of the following:

- PCT 281: *Rough-Barked Apple - Red Gum - Yellow Box woodland on alluvial clay to loam soils on valley flats in the northern NSW South Western Slopes Bioregion and Brigalow Belt South Bioregion*
- PCT 477: *Inland Scribbly Gum - Red Stringybark - Black Cypress Pine - Red Ironbark open forest on sandstone hills in the southern Brigalow Belt South Bioregion and northern NSW South Western Slopes Bioregion*
- PCT 479: *Narrow-leaved Ironbark- Black Cypress Pine - stringybark +/- Grey Gum +/- Narrow-leaved Wattle shrubby open forest on sandstone hills in the southern Brigalow Belt South Bioregion and Sydney Basin Bioregion*
- PCT 1656: *Narrow-leaved Ironbark - Black Pine - Narrow-leaved Wattle shrub - grass open forest on sandstone slopes of the upper Hunter and Sydney Basin*
- PCT 1672: *Red Ironbark - Grey Gum - Black Pine heathy woodland on sandstone ranges of the Sydney Basin*
- PCT 1711: *Tantoon - Lepyrodia leptocaulis shrubland on sandstone drainage lines of the Sydney Basin.*

2.2 Threatened Ecological Communities

One threatened community occurs within the study area (Figure 4) consisting of PCT 281 which is consistent with the threatened ecological community (TEC), *White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions*. This TEC is listed as a Critically Endangered Ecological Community (CEEC) under the NSW *Biodiversity Conservation Act 2016* (BC Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). All patches of PCT 281 within the study area

meet the criteria for listing under the BC Act whereas only patches of moderate and high condition PCT 281 meet the criteria for inclusion under the Commonwealth listing.

2.3 Groundwater Dependent Ecosystems

No Groundwater Dependent Ecosystems (GDE) were detected within the study area during the Stage 1 EIS (Moolarben Biota 2006) or the surveys undertaken for the *Moolarben Coal Complex UG4 Ancillary Works Modification Biodiversity Development Assessment Report* (ELA 2019).

Mapping from the Groundwater Dependent Ecosystems (GDE) Atlas (BoM, 2021) identifies the Goulburn River as a low to moderate potential aquatic GDE as well as vegetation identified as low to high potential terrestrial GDEs in the vicinity of UG4 (AGE 2021). The significant depth to water (i.e., approximately 25 – 65 metres) indicates that GDEs are not present within the UG4 area (AGE 2021).

Springs and groundwater seeps in nearby creek valleys and localised pools and soaks along the creeks support riparian vegetation (AGE 2021). None of these features constitute high priority GDEs listed under the Water Sharing Plans relevant to the Moolarben Coal Complex (AGE 2021).

2.4 Threatened flora

No threatened flora species were detected within the study area during the Stage 1 EIS (Moolarben Biota 2006) or *Moolarben Coal Complex UG4 Ancillary Works Modification Biodiversity Development Assessment Report* (ELA 2019) (Figure 4). A population of *Androcalva procumbens* (Vulnerable, BC Act and EPBC Act) were identified during the previous surveys undertaken by ELA and were confirmed by Niche during the baseline assessment and vegetation validation survey.

No other threatened flora species were detected during the baseline assessment and vegetation validation survey.

2.5 Fauna habitat

The Stage 1 EIS (Moolarben Biota 2006) determined that the following two broad fauna habitat types were present within the study area:

- Disturbed vegetation
- Sedimentary Scribbly Gum Woodlands.

The baseline assessment and vegetation validation survey undertaken by Niche aimed to identify specific functional fauna habitat types, such as roosting and foraging habitat, within the study area. The use of functional fauna habitat types allows for identification and assessment of the likelihood of occurrence of fauna species most likely to utilise available resources. The baseline assessment determined that the following fauna habitat features were present in the study area:

- Hollow-bearing trees
- Low cliff lines containing small caves, overhangs and fissures
- Rock outcrops
- Coarse woody debris
- Abundant Mistletoe
- Moderately steep gullies
- Riparian woodland
- Open woodland
- Low woodland with heath understorey

- Disturbed grassland
- Ephemeral waterways and drainage lines.

Based on the diversity of fauna habitat types present within the study area (combined with results of opportunistic survey undertaken during the baseline assessment), the native fauna assemblage present within the study area is also likely relatively diverse, consisting of the following:

- Terrestrial and arboreal mammals
- Hollow and cave-dependent microbats
- Birds including large flightless birds (Emu), woodland birds, small and large parrots, nectivorous birds, large forest owls and diurnal raptors
- Small reptiles
- Amphibians.

2.6 Threatened fauna

Ecological surveys undertaken for the Stage 1 EIS (Moolarben Biota 2006) and subsequent surveys identified the following threatened fauna species on or adjacent to the study area:

- Mammals
 - Corben's Long-eared Bat *Nyctophilus corbeni* (Vulnerable, EPBC Act and BC Act) formerly Greater Long-eared Bat *Nyctophilus timoriensis*
 - Eastern Cave Bat *Vespadelus troughtoni* (Vulnerable, BC Act)
 - Large Bent-winged Bat *Miniopterus orianae oceanensis* (Vulnerable, BC Act) formerly Eastern Bentwing-bat
 - Large-eared Pied Bat *Chalinolobus dwyeri* (Vulnerable, EPBC Act and BC Act)
 - Squirrel Glider *Petaurus norfolcensis* (Vulnerable, BC Act)
 - Yellow-bellied Sheathtail Bat *Saccolaimus flaviventris* (Vulnerable, BC Act)
- Birds
 - Black-chinned Honeyeater – eastern subspecies *Meliphreptus gularis gularis* (Vulnerable, BC Act)
 - Brown Treecreeper – eastern subspecies *Climacteris picumnus victoriae* (Vulnerable, BC Act)
 - Diamond Firetail *Stagonopleura guttata* (Vulnerable, BC Act)
 - Dusky Woodswallow *Artamus cyanopterus cyanopterus* (Vulnerable, BC Act)
 - Gilbert's Whistler *Pachycephala inornata* (Vulnerable, BC Act)
 - Glossy Black Cockatoo *Calyptorhynchus lathami* (Vulnerable, BC Act)
 - Hooded Robin – south-eastern form *Melanodryas cucullata cucullata* (Vulnerable, BC Act)
 - Painted Honeyeater *Grantiella picta* (Vulnerable, BC Act and EPBC Act)
 - Powerful Owl *Ninox strenua* (Vulnerable, BC Act)
 - Speckled Warbler *Cthonicola sagittata* (Vulnerable, BC Act)
 - Square-tailed Kite *Lophoictinia isura* (Vulnerable, BC Act)
 - Varied Sittella *Daphoenositta chrysoptera* (Vulnerable, BC Act).

Opportunistic fauna survey undertaken during the baseline assessment confirmed the presence of habitat for the above species in addition to detecting the presence of the following threatened fauna species (Figure 4):

- Spotted Harrier *Circus assimilis* (Vulnerable, BC Act) foraging for prey in patches of PCT 281 in the western extent of the study area

- Traces of Squirrel Glider consisting of sap scars in PCT 477 on Inland Scribbly Gum *Eucalyptus rossii* in the central and northern extent of the study area and in the northern extent of the Biodiversity Offset Area 2 reference site
- Four threatened microbat species, Large-eared Pied Bat, Large Bentwing-bat, Little Bentwing-bat *Miniopterus australis* (Vulnerable, BC Act) and Yellow-bellied Sheath-tailed Bat near a minor cliffline above proposed Longwall 406.

2.7 Existing Vegetation Condition

The baseline assessment reviewed the existing condition of the vegetation within the study area, identifying the following influences currently affecting the study area:

- Dieback and death of trees and shrubs resulting from the recent prolonged drought
- Poor structural integrity of PCTs resulting from drought related impacts
- Poor ecosystem function and low productivity in drought affected PCTs
- Low levels of disturbance and signs of weeds and feral animals
- Poor health/vigour of canopy trees on plateaus resulting from insect activity (borer)
- Limited extent and abundance of threatened fauna habitat resulting from drought related impacts
- Herbivory impacts resulting from native fauna species resident within the study area.

Most notable impacts affecting the majority of vegetation within the study area result from the prolonged drought which has recently ended with the rains over the Spring 2020 – Summer 2021 season. Native vegetation throughout the study area exhibited signs of water stress of varying severity from foliar discolouration, mild to deep cracking of the cambium layer, through to death of individuals or entire populations of flora species vulnerable to water stress (i.e large patches of dead Tooton *Leptospermum polygalifolium*, Narrow-leaved Stringybark *Eucalyptus sparsifolia* and Scrub She-oak *Allocasuarina distyla* individuals were observed). Vegetation occurring on plateaus and slopes at higher elevations of the study area, particularly PCT 479, were observed to be the most severely affected by the drought to the extent that local loss of whole species has radically altered structural integrity and species assemblage. Canopy species most affected by drought impacts include the Stringybarks *Eucalyptus laevopinia* and *Eucalyptus sparsifolia* in addition to Parramatta Red Gum *Eucalyptus parramattensis* subsp. *parramattensis* and Inland Scribbly Gum *Eucalyptus rossii*. In the most severely impacted areas of the study area, Narrow-leaved Ironbark *Eucalyptus crebra* and Red Ironbark *Eucalyptus fibrosa* also exhibited significant dieback and death of individuals. Mid-storey and understorey shrubs most affected by drought impact include Sheoaks, *Allocasuarina distyla*, *Allocasuarina diminuta* and *Allocasuarina gymnanthera* and Teatree species Tooton *Leptospermum polygalifolium*, *Leptospermum parvifolium* and *Leptospermum* sp. which exhibited foliar discolouration, dieback and death of individuals. Groundcover species were observed to be slightly more resilient to drought impacts; however, groundcover species require prolonged survey data to accurately gauge the presence of drought impacts as perennial species can withstand drought whereas annual species are more likely to be absent during extended dry periods.

Other major impacts of note include groundcover disturbance by Feral Pigs which was predominantly recorded in PCT 1711. Disturbance related to Feral Pigs has resulted in localised reduction of flora species diversity and abundance in affected areas in addition to increased soil compaction and disturbance.

3. Subsidence impact review

3.1 Predicted subsidence impacts

An examination of the extent of predicted subsidence associated with secondary extraction at LW401-408 has been undertaken by Mine Subsidence Engineering Consultants (MSEC 2021). Based on the approved maximum cut height of three (3) metres (m), the maximum predicted subsidence is 1.9 m, predicted tilt is 60 millimetres per metre and predicted systematic curvature is greater than three kilometres (MSEC 2021). The proposed panel and pillar widths in the Extraction Plan Layout are the same as the Approved Layout however, there are minor changes to the proposed commencement and finishing ends of the longwalls. This is expected to slightly increase / reduce levels of subsidence, tilt, curvature and strain at longwall ends but is not expected to alter the maximum predicted subsidence parameters to a degree that is greater than defined in the Approved Layout (MSEC 2021). Based on the above, the predicted subsidence conforms with the approved Stage 1 Extraction Plan Layout.

Predicted subsidence impacts relevant to the natural features of the study area include (MSEC 2021):

- Ephemeral waterways and drainage lines - potential for minor changes to stream alignments, cracking in stream beds and fracturing of bedrock and increased levels of ponding and scouring.
- Minor cliffs – potential for cracking and rock fall.
- Slopes – potential for surface tension cracking.

The predicted subsidence impacts are expected to effect natural features directly above the proposed LW401-408 extraction plan layout and are unlikely to extend beyond the end point of the longwalls (MSEC 2021).

3.2 Predicted subsidence impacts on biodiversity values

Predicted subsidence impacts (MSEC 2021) on biodiversity values of the study area are expected to be limited to the extent of longwall panels, being localised in nature. An analysis of the predicted subsidence impacts on biodiversity values listed above has been undertaken (Table 1) and has determined that the majority of impacts in relation to fauna are predominantly indirect impacts to fauna habitat values with direct impacts (DPIE 2020) limited to potential injury or death of individuals due to rock fall.

It has been determined that secondary extraction at LW401-408 will not significantly impact the biodiversity values within the study area.

Table 1: Predicted subsidence impacts on Threatened biodiversity values of UG4 LW401-408

Aspect	Description	Predicted subsidence impact	Impact assessment
Threatened Species, populations and habitats - Mammals	Threatened Cave-dwelling bat species	Predicted subsidence impacts relevant to threatened cave-dwelling microbats utilising the study area include localised surface tension cracking, cliff line instability and rock fall which may impact on potential roosting/breeding habitat	<p>Habitat features utilised by cave-dwelling bats were recorded in a minor cliff line C6 above LW 406 within the north-west section of the study area. The baseline assessment detected a number of bat species that may be using the cliff line as roosting habitat; however, species abundance was quite low and the habitat is unlikely to be used for breeding.</p> <p>Predicted subsidence impacts to the minor cliff line may result in impacts to cave-dwelling microbats. Impacts may include reductions in habitat suitability and extent in addition to potential injury or mortality to individuals as a result of subsidence induced rock fall. The subsidence impacts are not expected to significantly reduce the suitability or extent of existing habitat for cave-dwelling microbats such that it would adversely affect the lifecycle of these species or cause these species to become extinct within the locality.</p> <p>Habitats suitable for cave-dwelling microbats were identified in MCO biodiversity offset sites within the locality including the Biodiversity Offset Area 1 (BOA1) site with additional habitat available in the adjacent Goulburn River National Park (GRNP) to the east. Baseline assessment data indicates that cave-dwelling microbat species are currently utilising suitable habitat in the BOA1 site, demonstrating its suitability as potential refuge for microbat species affected by predicted subsidence impacts.</p>
Threatened Species, populations and habitats - Birds	Threatened Bird species	Predicted subsidence impacts relevant to threatened bird species utilising the study area include localised surface tension cracking and altered overland flow which may impact health, abundance and diversity of foraging resources and sheltering resources.	<p>The baseline assessment identified foraging and nesting habitat for threatened bird species within the study area.</p> <p>Foraging habitat for threatened bird species throughout the study area currently display drought impacts which include foliar dieback and death of individual plants, reduction in extent and reduction in flowering and fruiting abundance. This is particularly evident with She-oak species which are the preferred foraging resource for Glossy Black Cockatoo. Some regeneration of flora comprising foraging resources was observed during the baseline assessment; however, regenerating individuals are not expected to provide foraging resources for large parrots for at least five to ten years from current.</p> <p>Alterations to hydrology resulting from surface tension cracking or surface ponding may result in localised short-term reduction in the extent and quality of foraging habitat. Impacts to foraging habitat are not expected to significantly impact species within the locality as bird species are highly mobile and are likely to seek alternative foraging habitat elsewhere within the surrounding landscape. Baseline assessment data indicates that bird species are currently utilising foraging habitat in Biodiversity Offset Area 1, demonstrating its suitability as an alternative foraging resource. Additional high quality foraging resources are available in the adjacent GRNP and vegetated surrounds. Based on the above, it is unlikely that subsidence impacts will result in the long-term reduction of foraging habitat such that it would adversely affect the lifecycle of these species or cause these species to become extinct within the locality.</p>

Aspect	Description	Predicted subsidence impact	Impact assessment
			Predicted subsidence impacts are not expected to affect breeding habitats within the study area.
Threatened Species, populations and habitats – Threatened Flora	Threatened flora species	There are no predicted subsidence impacts relevant to threatened flora species within the study area.	<p>The known extent of <i>Androcalva procumbens</i> is located outside of the subsidence zone for UG4 LW 401-408. The population of this species within the study area occurs as two discrete subpopulations in areas adjacent to an existing track which have limited canopy cover as a result of the recent prolonged drought. The subpopulations comprise of mature adults and numerous seedling and juvenile individuals which have recently regenerated in response to rainfall during the summer and autumn of 2021.</p> <p>This species is known to be reliant on disturbance for regeneration and is highly likely to be resilient to predicted subsidence impacts. As such, the predicted subsidence impacts are not likely to adversely affect the subpopulations of <i>Androcalva procumbens</i> within the study area.</p>
Endangered ecological communities	PCT 281: <i>Rough-Barked Apple - Red Gum - Yellow Box woodland on alluvial clay to loam soils on valley flats in the northern NSW South Western Slopes Bioregion and Brigalow Belt South Bioregion</i>	Predicted subsidence impacts relevant to ecological communities of the study area include localised surface tension cracking, altered overland flow and surface ponding which may affect water delivery/availability to this PCT	<p>PCTs 281 is located in close proximity to overland flows and pooling, and as discussed in section 2.7 above currently exhibits signs of stress due to previous prolonged drought consisting of reduction in productivity (i.e., reduced foliage cover and low litter cover). Regeneration response to seasonal rainfall indicates that the PCT 281 is highly resilient and is expected to revert to a pre-drought condition state over the next decade (Niche 2021). As such, post drought conditions are expected to result in increased ecosystem productivity indicated by an increase in canopy and shrub foliage cover, decreased forb cover and increased leaf litter levels.</p> <p>Predicted subsidence impacts are not expected to result in altered species composition or vegetative cover of PCT 281 within the study area.</p> <p>Based on the results of UG1 LW104-105 post mining monitoring, in addition to the nature of predicted subsidence impacts, PCT 281 is not expected to experience significant reductions to species assemblage or cover as a result of predicted subsidence impacts.</p>

3.3 Review of biodiversity performance measures

The EIS (Moolarben Biota 2006) prepared for the Stage 1 Project Approval (05_0117) and subsequent environmental assessments prepared for approved modifications have assessed impacts to biodiversity (including those pertaining to the UG4 LW401-408 secondary extraction). The Biodiversity Management Plan prepared for Stages 1 and 2 of the Moolarben Coal Mine operation (MCO 2020) contains relevant performance measures and indicators to evaluate the outcomes of management measures. The Stage 1 Project Approval (05_0117) does not include specific subsidence impact performance measures for biodiversity; however, Project Approval condition 77 (i) requires the management of potential and/or environmental consequences of the proposed second workings on aquatic and terrestrial flora and fauna, with a specific focus on threatened species, populations and their habitats; endangered ecological communities and water dependent ecosystems. As a new Biodiversity Management Plan is to be prepared for the UG4 LW401-408 Secondary Extraction Plan, Niche recommend the following evaluation criteria listed in Table 2 for inclusion. All evaluation criteria in Table 2 have been prepared with due consideration of the existing biodiversity values on site identified as being vulnerable to subsidence impacts, and the recommended monitoring methods outlined in Section 4 of this report.

Table 2: Recommended evaluation criteria

Biodiversity value	Monitoring method	Performance Indicator
Threatened ecological communities	BAM Plot survey	No significant reduction in vegetation integrity score greater than observed at reference sites (vegetation integrity score is not to decrease by more than 20% for two consecutive survey periods post mining) combined with observed subsidence impacts; or No significant reduction in species diversity greater than observed at reference sites (a significant reduction being greater than 5 species consistently absent from established BAM plots for 4 consecutive years) combined with observed subsidence impacts.
Threatened fauna	Monitoring for microbat presence and diversity	No significant reduction in threatened species presence greater than observed at reference sites (at least 1 species absent from acoustic data analysis results for 4 consecutive years) combined with observed impacts to habitat directly related to subsidence.
Threatened flora	Visual assessment of species presence.	Threatened flora remains present within the study area.

4. Monitoring methodology

4.1 Monitoring aims

The UG4 LW401-408 secondary works Extraction Plan, Biodiversity Management Plan (BMP) and subsidence monitoring program are currently in preparation; therefore, the following monitoring program outline is based on the overarching BMP prepared in accordance with the Stage 1 approval. The Stage 1 BMP focuses on managing the potential environmental impacts associated with subsidence on aquatic and terrestrial biota with a specific focus on threatened species, populations and their habitats; endangered ecological communities; and water dependent ecosystems.

4.2 Monitoring program

The monitoring program outlined below focuses on early detection of potential subsidence impacts. A review of previous monitoring methodologies for the UG1 sections of Moolarben Mine has been undertaken to determine the nature and type of data collected and allow for recommendation of alternate monitoring methods whilst still allowing conversion for comparative analysis with prior monitoring data collected on site.

Fauna species selected for monitoring are those which are considered to occur in habitats sensitive to direct impacts (DPIE 2020) which in the case of UG4, consists of geological features such as caves, crevices and fissures in minor cliff lines.

It is recommended that the baseline monitoring be conducted prior to mining and further monitoring be conducted annually upon commencement of mining through to an additional two years past the point that mining has been completed, or as determined by monitoring results (i.e., monitoring may continue beyond two years post mining). Ideally, the recommended monitoring timing would be during the Spring months when the majority of flora and fauna are actively reproducing and active. The program below allows for one round of monitoring in Spring of each year over the duration of the monitoring period upon approval of the UG4 extraction plan.

A summary of the proposed monitoring program is provided below in Table 3 and a detailed description of the methods are provided in Section 4.3. Proposed monitoring locations are shown in Figure 3.

Table 3: Recommended UG4 LW401-408 monitoring program

Survey type	Methods	Timing
Floristic plots (modified BAM plots)	Floristic survey at specific locations in the study area and reference sites consisting of a modified 50 x 20 m plot containing a nested 20 x 20 m plot along a fixed transect, recording the composition, structure and functional attributes of extant PCTs.	Annually in Spring
Photo point monitoring	Two photographs (portrait and landscape) to be taken at the established pickets at the start and end of each 50 metre transect of all floristic plots.	Annually in Spring
Acoustic monitoring	Four acoustic devices targeting bats (three in the study area and one in the reference site) to be deployed for four nights	Annually in Spring

Survey type	Methods	Timing
Visual assessment	Visual inspection of threatened flora populations	Annually in Spring

4.3 Monitoring program methodology

4.3.1 Floristic plots

Nine permanent floristic plots in accordance with the NSW Biodiversity Assessment Method (BAM) (DPIE 2020) have been established at various locations of the study area, targeting PCTs potentially impacted by LW401-408 prior to commencement of works (Figure 3). An additional five permanent floristic plots have been established in corresponding PCTs at nearby reference sites to provide control data for the purpose of comparative analysis and to allow the identification of confounding bias in monitoring results (Figure 3). One additional plot will be established during the upcoming Spring 2021 surveys in PCT 479 in the Red Hills Biodiversity Offset Site.

An initial round of monitoring is to be undertaken in Spring prior to commencement of secondary works, to record the baseline condition of PCTs present at impact and reference sites for future comparative analysis of post impact data. Baseline data collection is to focus on flora species diversity and abundance in addition to the structural and functional attributes of native vegetation present at each monitoring location (as recorded through BAM).

Baseline data has been entered into the NSW Biodiversity Assessment Method Calculator (BAM-C) to generate an overall vegetation integrity score (VIS). An analysis of the ecological trajectory of each floristic plot within the study area and reference sites has been undertaken in accordance with the Ecological Monitoring Module (BCT 2021) to determine the rate of the expected rate of change over a 20 year period under three scenarios; no change, natural attrition (based on the BAM-C future value without offset) and a 20% degradation rate based on a 20% reduction of current VIS, which indicates a less than significant impact (Chart 1). It is expected that a fourth scenario will be added in future rounds of monitoring to track the updated ecological trajectory against a 20% degradation rate between consecutive years, which forms the trigger for an action response as per Table 2. The three ecological trajectories for each floristic plot have been charted for future reference to track the ecological trajectory of PCTs at the UG4 LW401-408 impact site during future monitoring rounds.

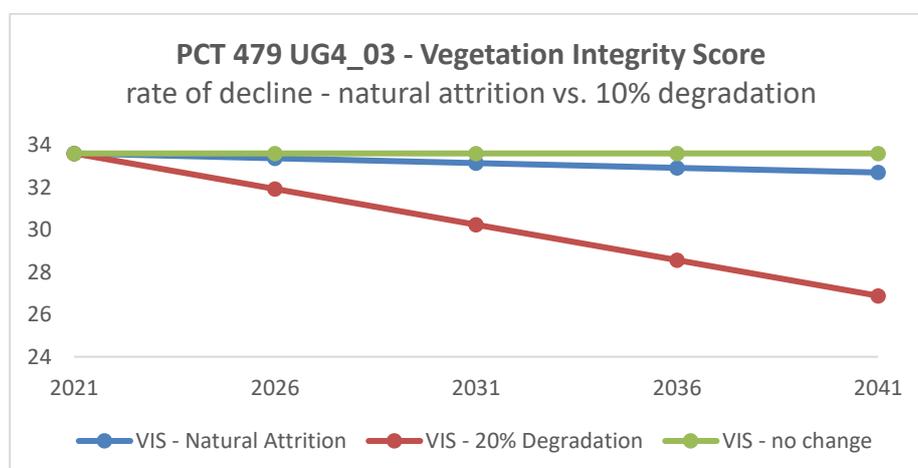


Chart 1: Example of baseline assessment ecological trajectory chart using the VIS

The VIS of each PCT within the impact area derived from baseline data has been compared to VIS of corresponding PCTs within the reference sites to establish a baseline for the average degree of variance between sites. Further analysis will be undertaken by comparing the benchmark scores within the BioNET vegetation classification system for each PCT to determine the presence and extent of any current variance from the scores at impact and reference sites. Identification of the factors influencing variance from the benchmark scores will be undertaken to determine a cause for alteration in the ecological trajectory of an affected PCT. If a cause for variation from benchmark scores is identified at a particular site/s, the causative factor/s will be considered when completing any future analysis of monitoring data.

Monitoring via floristic plots is to take place every Spring from commencement of works, over the duration of secondary extraction, extending for at least two years once mining has been completed. Annual data analysis will focus on tracking the updated VIS against the four ecological trajectory scenarios described above in addition to comparative analysis of PCT composition, structure and function data; and indicators of vegetation stress between the study area and reference sites using descriptive statistics.

Each floristic plot is to consist of a 20 x 50 metre plot (centred around a central 50 metre transect) for recording of functional attributes and a nested 20 x 20 metre quadrat for recording floristic and structural attributes (refer to Plate 1 below). Each plot will be permanently marked with a capped star picket (or similar) to ensure the site is easily located for future monitoring rounds.

Data recorded within each 20 x 20 metre nested quadrat is to consist of:

- A full count of native and exotic species diversity.
- Projected foliage cover (PFC) of all species in increments of 0.1-1, 1-10 then 5% increments capped at 100%.
- Abundance of all species recorded within the quadrat measured at 1-10 then in increments of 10 up to 100. Upon reaching 100 individuals, further measurements will be recorded in increments of 500.
- A record of the structural layer/s occupied by each species including the dominant species occupying the canopy, mid-storey and ground layers.

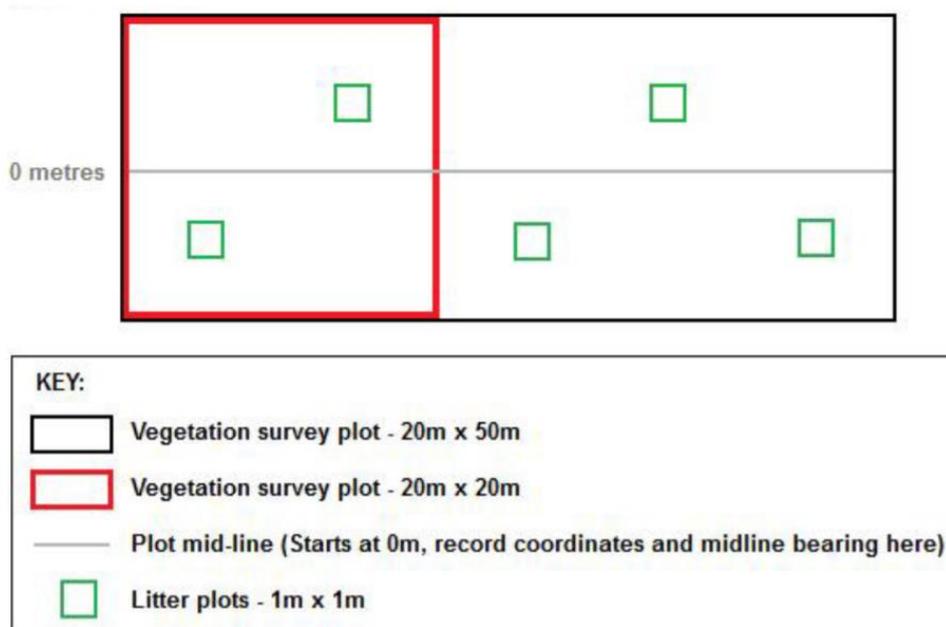


Plate 1: Floristic plot layout as per the NSW Biodiversity Assessment Method 2020 Operational Manual - Stage 1 (DPIE 2020)

Data recorded within the 20 x 50 metre plot is to consist of the following:

- Diameter at breast height (DBH), measured 1.3 metres from the ground, of all canopy trees present within the plot
- Presence and number of canopy trees within specific DBH size increments (<5 cm, 5-10 cm, 11-20 cm, 21-30 cm, 31-40 cm, 41-50 cm etc)
- Number of large trees (>50 cm DBH) and presence of regenerating trees (<5 cm DBH)
- Number of hollow-bearing trees
- Length of coarse woody debris measured in metres
- Cover (%) of epicormic foliage relative to total cover of foliage within the plot
- Cover (%) of discoloured canopy foliage relative to total cover of healthy foliage within the plot
- Cover (%) of dieback relative to live vegetation within the plot and the PCT patch
- Cover value (%) of bare branches
- Count of any stags encountered within the plot
- Evidence of subsidence impacts (cracking or ponding)
- Extent of subsidence impacts (cracking or ponding) as a percent of the plot area.

Landscape characteristics recorded at each plot include aspect, slope (expressed as a percentage), type and percentage cover of surface rock, cryptograms, bare soil, presence/absence of rock outcrop, cliffs or caves, proximity to nearest waterway or waterbody in addition to soil colour and texture.

4.3.2 Photo-point monitoring

A photo point is to be established at each end of the central 50 metre transect of floristic plots. During the baseline monitoring and each subsequent monitoring round, two photographs (portrait and landscape) are to be taken at each end along the central transect, to retain a visual record.

Photographs taken at each point are to undergo comparative analysis to the baseline and previous years imagery to quantify any changes in observable dieback or stress (foliage discolouration) visible on terrestrial vegetation.

4.3.3 Monitoring for threatened fauna populations – Microbat activity

Passive monitoring using acoustic devices is to be undertaken to assess potential impacts to threatened microbats previously recorded in the study area. Passive monitoring via acoustic device is easily replicated and analysed and can be used to determine changes over time to abundance, diversity, habitat preference, foraging guild and activity of target microbat species.

The diversity, abundance, habitat preference, foraging guild or residency of microbat species within the study area may be a useful surrogate for detecting subsidence related impacts in correlation with visible signs of cracking or ponding.

A total of four Anabat acoustic devices (or equivalent) are recommended for installation in the vicinity of microbat habitat identified in the study area (three devices) and reference site (one device) for four nights to determine the identity of microbat species present on site, the approximate abundance (based on activity and number of passes) of each species on site and the average residency time on site (time and duration of activity). The results of subsequent monitoring rounds will be compared against the baseline to determine any changes to microbat presence, activity or residency time between the impact and reference sites.

4.3.4 Monitoring for threatened flora populations – *Androcalva procumbens*

Monitoring, including an estimated population count at each of the known locations of *Androcalva procumbens* will be undertaken annually in spring.

The estimated population counts will undergo comparative analysis to the baseline and previous years monitoring to quantify any changes.

If additional populations of *Androcalva procumbens* are detected during subsequent monitoring rounds, their locations and extents will be recorded in the annual monitoring report.

5. Management of impacts

5.1.1 Recommendations for management of impacts

The following recommendations are to be enacted in the event that performance indicator criteria outlined in Table 2 of Section 3.3 are greater than predicted. In the event that performance indicator criteria are close to being exceeded, additional investigation (i.e., more floristic plots, additional survey periods, additional acoustic monitoring sites and more intensive data analysis) may be required to understand the nature of the impact and identify the most appropriate management measures that should be applied to avoid exceedance. If monitoring indicates that impacts are occurring which exceed the performance indicator criteria outlined in Table 2 of Section 3.3 and can be directly attributed to physical observations of subsidence, the management measures outlined below will be required.

In the event that subsidence repairs are planned in vegetated areas, a site assessment should be undertaken prior to the commencement of works. The site assessment is to focus on determining the risk of potential impacts of remediation on biodiversity values and provision of recommendations to avoid, minimise or mitigate identified impacts. Recommendations should be enacted prior to commencement of works to ensure that remediation does not create greater impacts than the surface cracking or ponding itself.

Based on the predicted subsidence impacts and vulnerable threatened biodiversity values identified in Sections 3.1 to 3.3 of this report, management measures have been prescribed for:

- Threatened ecological communities
- Threatened fauna
- Threatened flora.

Additional management measures have been prescribed for non-threatened biodiversity values identified within the study area which, if impacted, may have the potential to indirectly affect threatened fauna habitat:

- Vegetation management
- Fauna habitat management
- Weed management
- Additional monitoring.

5.1.2 Threatened ecological communities

Vegetation management measures are to be triggered by changes in the VIS of monitored floristic plots in PCT 281 when they exceed the performance indicator (20% between consecutive years outlined in Table 2 and displayed in Chart 2 below). The type of vegetation management measures required to remediate potential subsidence impacts will depend on the identity and functional role of affected flora species and the nature of the impact.

Potential management measures for impacts greater than the performance indicator to PCT 281 may include, but are not limited to the following:

- Supplementary planting focused on restoring the structural layer undertaken using species representative of the PCT mapped in the area (Figure 2)
- Implementation of subsidence repairs if required
- Extension of the monitoring program duration and additional floristic plots

- Tracking of the ecological response to management measures via analysis of monitoring data.

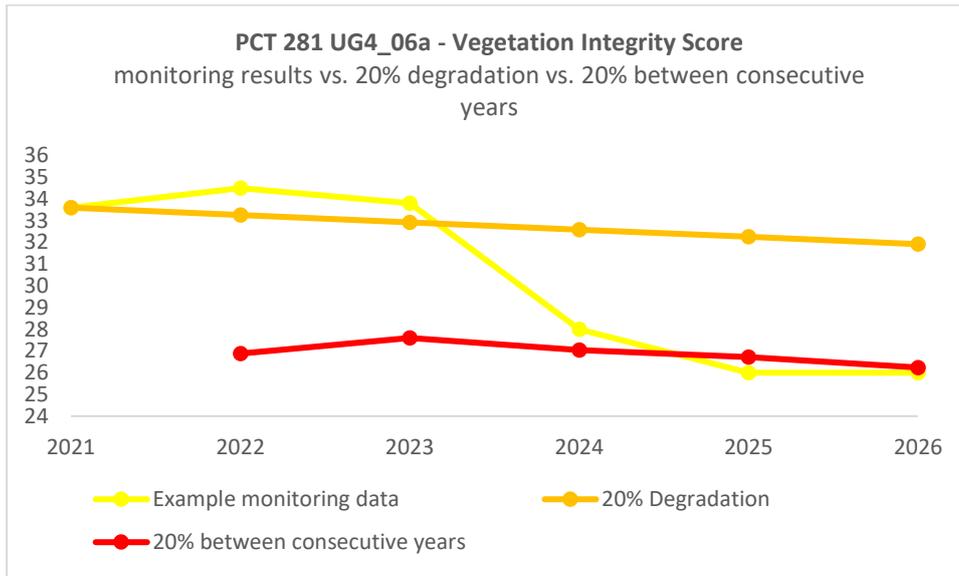


Chart 2: Example of exceedance of the threatened ecological communities performance indicator

An early warning system has been built into the monitoring program (consisting of the 20% degradation rate scenario described in Section 4.3.1 and displayed in Chart 3, which if exceeded, will allow for early identification of potential impacts and management responses where required. The early warning system has been designed to minimise any detected subsidence impacts within the study area prior to exceedance of the performance indicator.

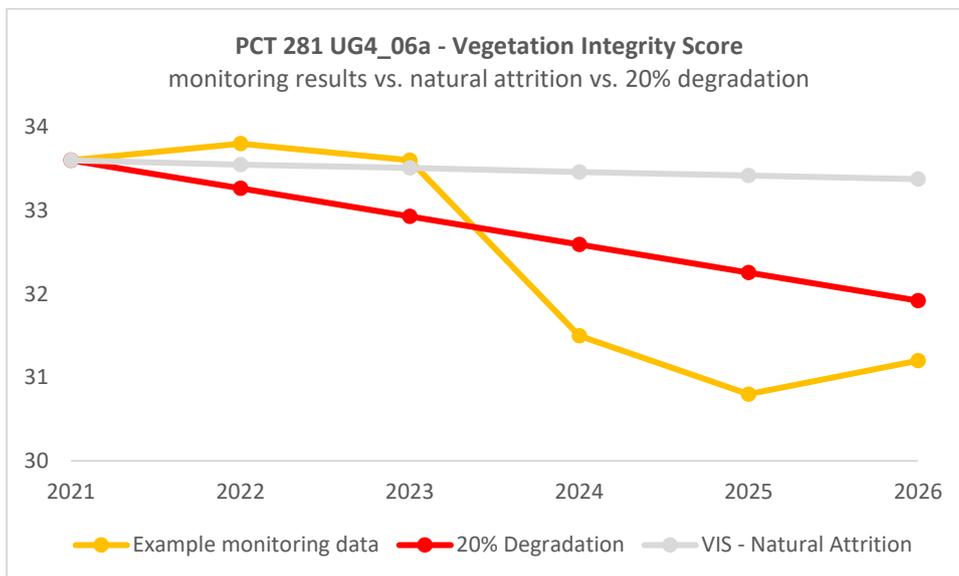


Chart 3: Example of early warning system inbuilt into the monitoring program

Internal actions which may be undertaken if the VIS of PCT 281 exceeds the 20% degradation rate include, but are not limited to:

- Site assessment to determine the level of impact to biodiversity values
- Changes to the monitoring program and/or more intensive statistical analysis to determine the causative factors and most appropriate minimisation, mitigation and / or remediation measure
- Installation of recommended minimisation or mitigation measures to reduce the risk of further impacts

- Tracking of ecological response to minimisation and mitigation measures.

5.1.3 Threatened fauna

Specific threatened fauna habitat management measures will depend on the type and identity of threatened species and the nature of the impacted habitat features. Of the threatened species identified during the baseline assessment, only cave-dwelling microbat species have breeding habitat within the study area which occurs in features sensitive to direct impacts (DPIE 2020). As such, the trigger for threatened fauna habitat management measures, is a measured reduction in threatened microbat species richness (only cave-dwelling threatened microbats occur in the study area) over four consecutive years combined with visible observations of subsidence impact as defined in Table 2 of Section 3.3.

Recommended management measures for subsidence impacts to cave-dwelling microbat species include:

- Site assessment to determine the level of impacts to cave-dwelling microbats
- Changes to the monitoring program and / or more intensive statistical analysis to determine the causative factors and most appropriate minimisation, mitigation and / or remediation measures
- Installation of alternative roosting habitat for cave-dwelling microbats near the minor cliffline of LW 406
- Targeted survey of affected microbat species to gauge the outcomes of enacted measures.

5.1.4 Threatened flora

A population of threatened flora species, *Androcalva procumbens* (Vulnerable, BC Act and EPBC Act), has been previously recorded in the study area occurring as two separate subpopulations on the eastern extent of UG4. If annual visual inspections determine that the threatened flora subpopulations have significantly declined in excess of the performance indicators outlined in Table 2 of Section 3.3 as a direct result of subsidence impacts, then the following recommended measures should be considered:

- A suitably qualified bush regeneration contractor to collect seed from affected individuals for use in propagation and planting of seedlings in nearby undisturbed areas of associated habitat.
- Increased monitoring of threatened flora populations and habitat to measure the outcomes of enacted measures.

5.1.5 Vegetation management

Vegetation management measures are to be triggered by changes in the VIS of monitored floristic plots when they exceed less than significant impact (20% between consecutive years) as described in Section 5.1.2. As with the management measures outlined for PCT 281, the type of measures required to address potential subsidence impacts will depend on the identity and functional role of affected flora species and the nature of the impact.

Potential management measures may include supplementary planting focused on restoring vegetation structure and subsidence repairs. Stags and dead shrubs should be retained on site for the fauna habitat features they provide in addition to their role in supporting a functional mycorrhizal system which some flora species, particularly orchids, are dependent upon.

Tracking of the ecological outcomes of any implemented management measures should be undertaken in conjunction with future rounds of monitoring.

5.1.6 Fauna habitat management

Specific fauna habitat management measures will depend on the species/fauna habitat features potentially impacted. The majority of fauna recorded in the study area (Moolarben Biota 2006; ELA 2019; Niche 2021) are reliant on breeding and foraging habitat that is not considered sensitive to subsidence impact. Therefore, the measures recommended below should be implemented only in the unlikely event of significant reduction in foraging habitat or significant loss of hollow-bearing trees directly related to subsidence (as determined by the function component of the VIS of monitored floristic plots).

General fauna habitat management measures recommended include the following:

- In the event that significant reductions in fauna foraging habitat for fauna species known to occur on site are observed, it is recommended that supplementary planting of preferred foraging species be undertaken.

5.1.7 Weed management

Currently, priority weed incursions in the study area are restricted to the north-west section of the site in the vicinity of the entrance gate and historically cleared land along the western perimeter (Figure 2). Priority weed populations are in relatively low abundance in these areas and are unlikely to require additional management actions at this stage. The remainder of the study area contained extremely low cover of herbaceous annual weed species. Weed management measures should continue to be undertaken in accordance with the BMP (MCO 2020).

5.1.8 Additional monitoring

In the event that any of the recommended evaluation criteria outlined in Section 3.3 of this report is exceeded, additional monitoring may be required. Additional monitoring methods to be employed will depend on the exact nature of the exceedance, the impacted biodiversity value and the management measure utilised. Additional monitoring may include targeted survey if specific species are impacted or decreased interval between survey periods if fauna habitat or a threatened ecological community is impacted.

6. Conclusion

This biodiversity technical report contains a summary of the extant biodiversity values within the study area based on desktop review of previous ecological surveys and the recent baseline assessment undertaken by Niche ecologists. The baseline assessment has resulted in the preparation of field validated vegetation mapping for the study area in addition to the implementation of the monitoring program, including establishment of monitoring plots. Observations undertaken during the baseline assessment determined that vegetation covering the study area is currently moderately to severely impacted by the recent prolonged drought with worst affected areas occurring on plateaus and upper slopes.

Based on review of predicted subsidence impacts as detailed in MSEC (2021 *in prep.*) secondary extraction of UG4 LW401-408 is considered unlikely to significantly impact threatened and non-threatened biodiversity resident within the study area.

Niche have provided recommendations for more detailed evaluation criteria to align with the Stage 1 Project Approval (05_0117) condition 77(i) and have provided recommended management measures to be enacted if evaluation criteria are exceeded. The monitoring program has been built around these performance measures and designed to allow for early detection and identification of impacts to vulnerable biodiversity values.

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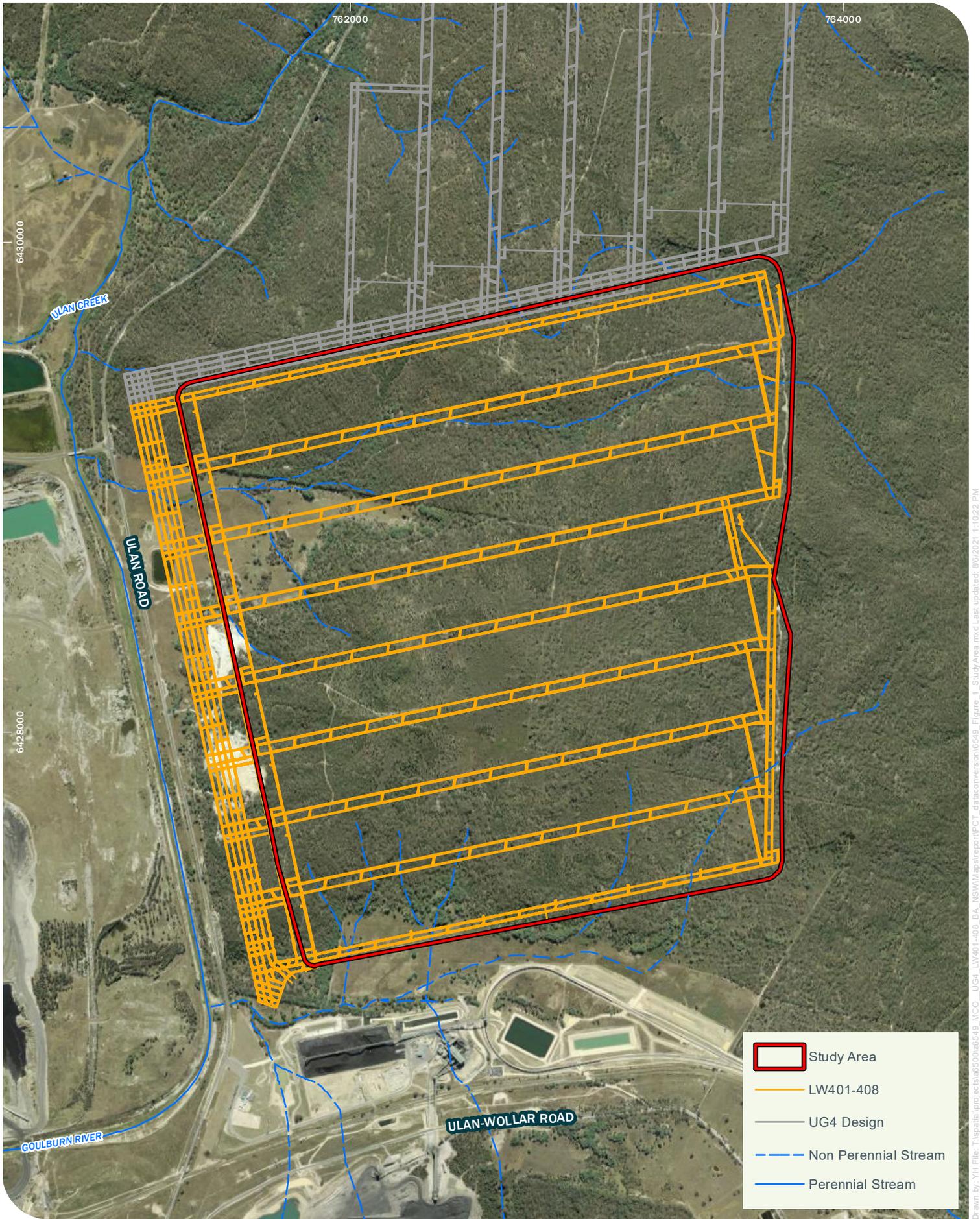
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Figures



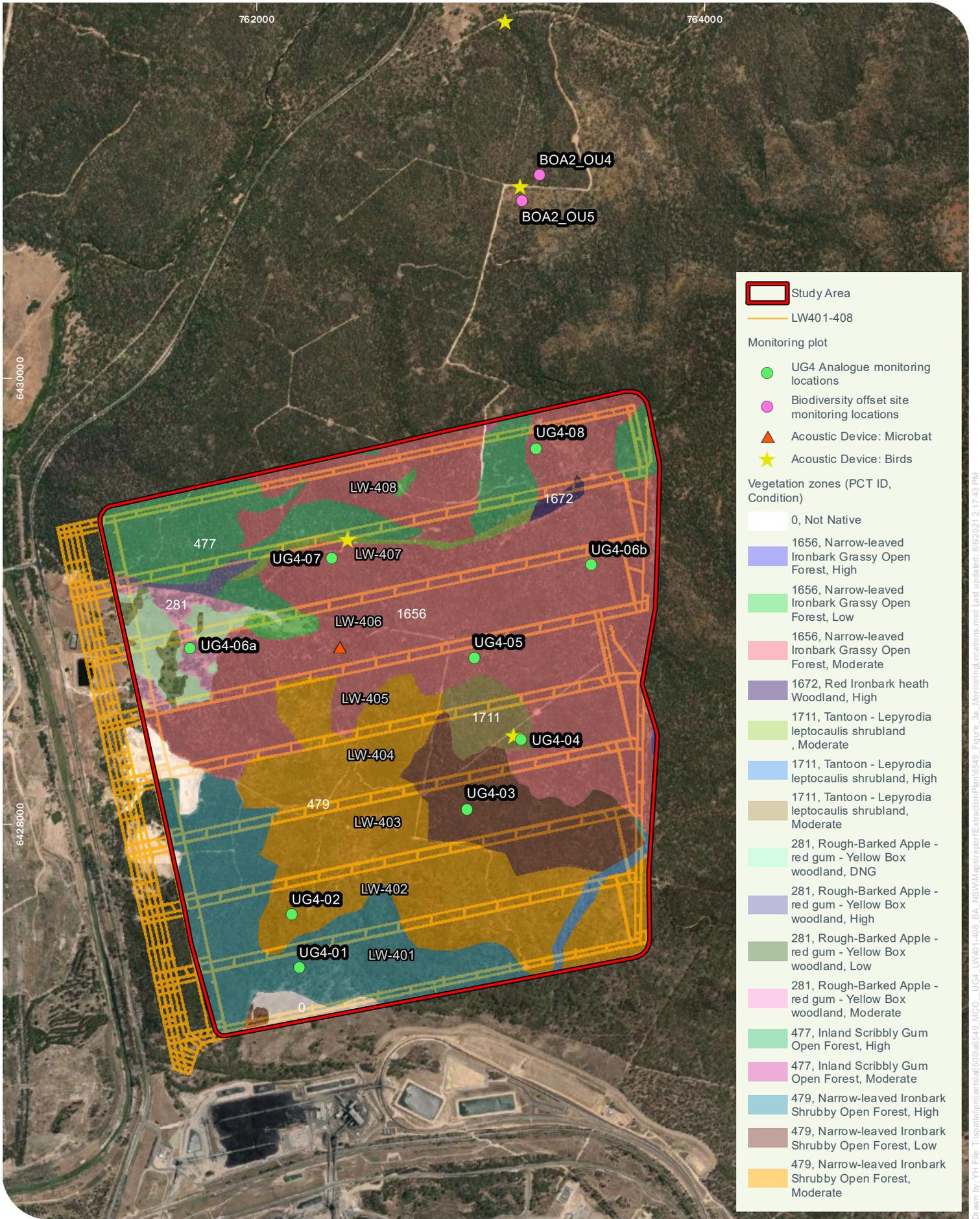
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**Study area within the locality
 Moolarben Coal Mine - UG4 LW401-408**

Figure 1



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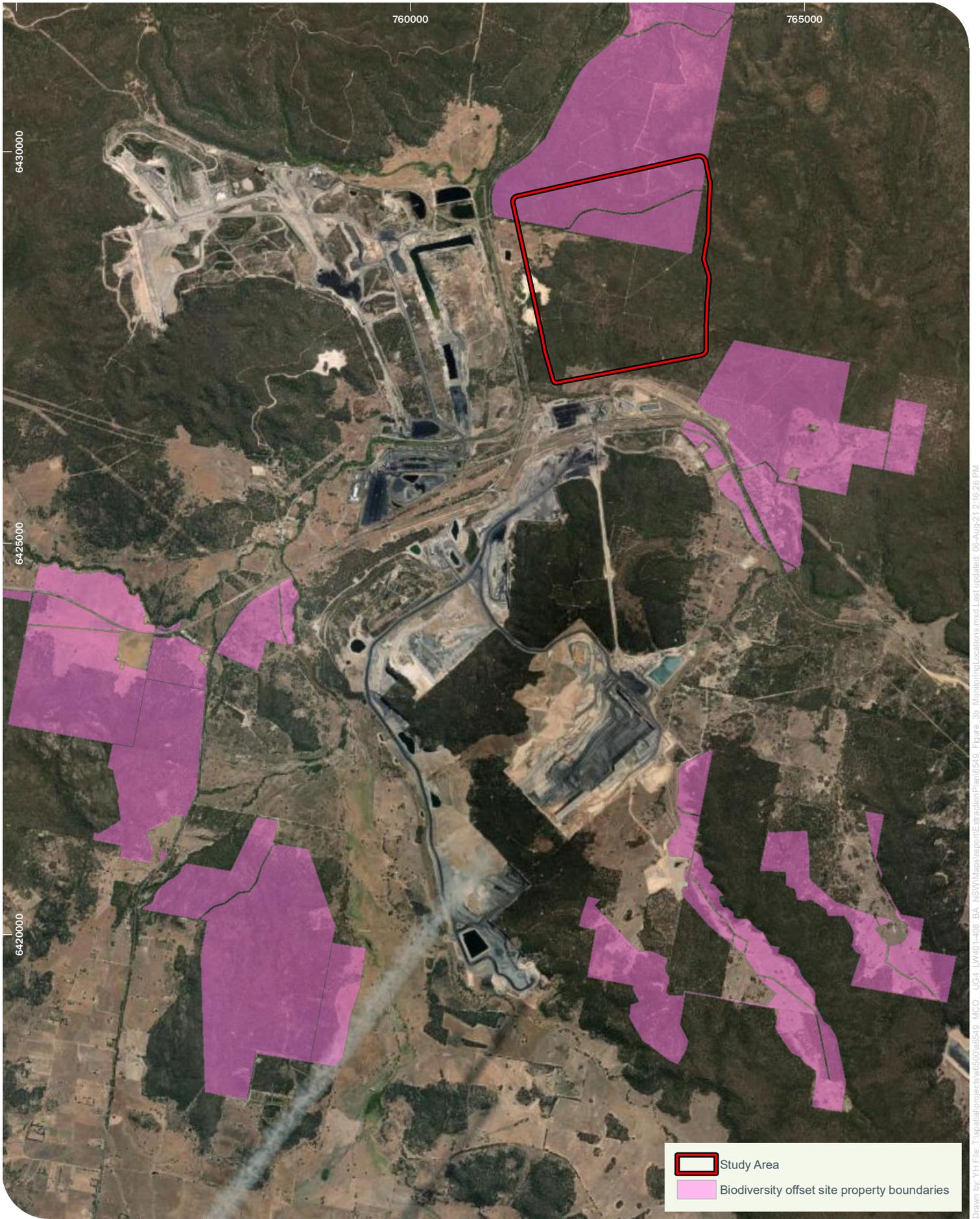


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UG4 Extraction Plan Monitoring Locations
Moolarben Coal Mine - UG4 LW401-408

Figure 3a

World Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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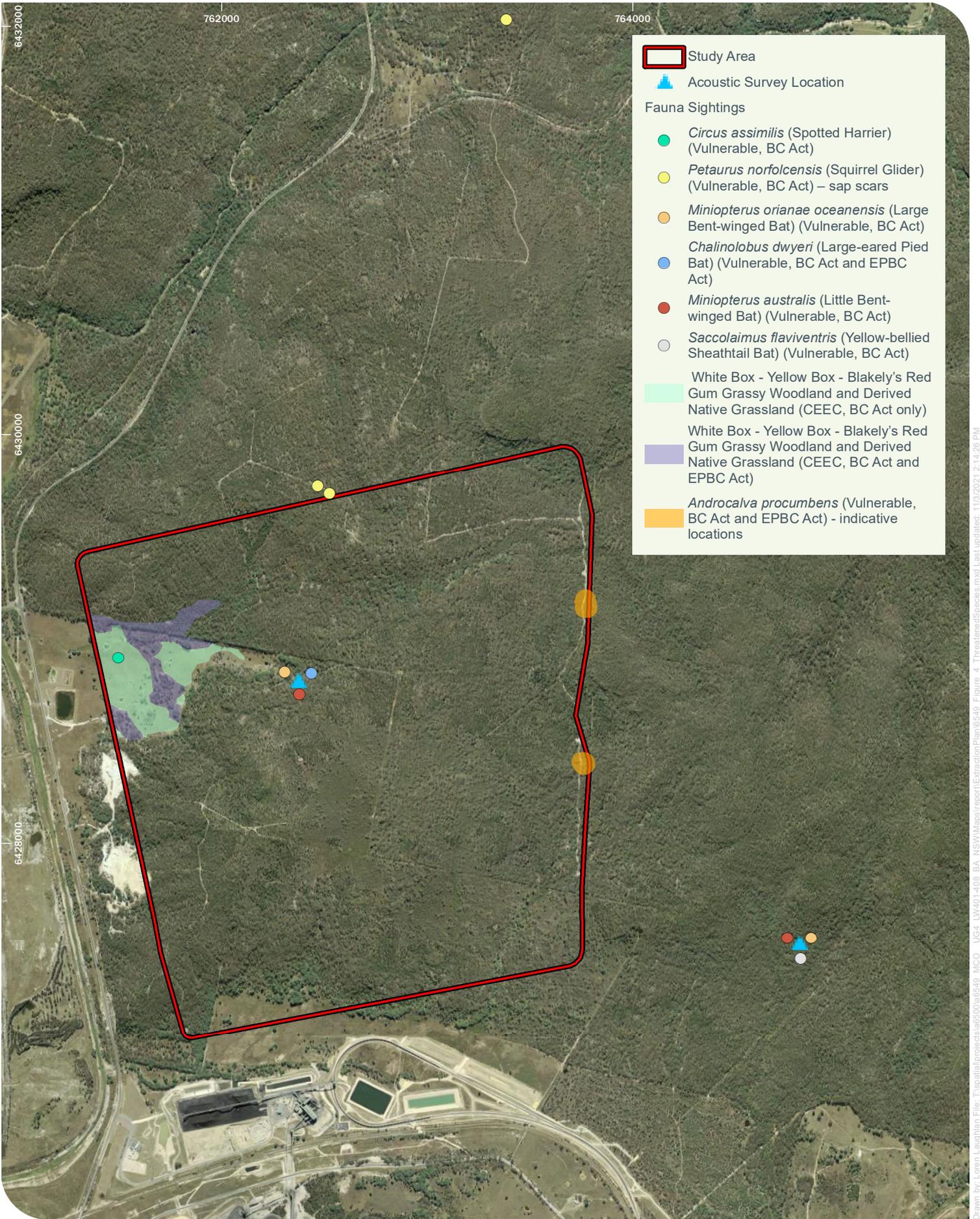


UG4 Extraction Plan Monitoring Locations
Moolarben Coal Mine - UG4 LW401-408

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Figure 3b

World Imagery: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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Threatened biodiversity in the study area
Moolarben Coal Mine - UG4 LW401-408

Figure 4

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Sydney
Brisbane
Cairns
Port Macquarie
Illawarra
Coffs Harbour
Central Coast
Gold Coast
Canberra



Our services

Ecology and biodiversity

Terrestrial
Freshwater
Marine and coastal
Research and monitoring
Wildlife Schools and training

Heritage management

Aboriginal heritage
Historical heritage
Conservation management
Community consultation
Archaeological, built and landscape values

Environmental management and approvals

Impact assessments
Development and activity approvals
Rehabilitation
Stakeholder consultation and facilitation
Project management

Environmental offsetting

Offset strategy and assessment (NSW, QLD, Commonwealth)
Accredited BAM assessors (NSW)
Biodiversity Stewardship Site Agreements (NSW)
Offset site establishment and management
Offset brokerage
Advanced Offset establishment (QLD)