



**ASSESSMENT OF MINE
REHABILITATION AGAINST
CENTRAL HUNTER VALLEY
EUCALYPT FOREST AND
WOODLAND CEEC**

FINAL

August 2017



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FINAL

Prepared by
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on behalf of
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1.0 Introduction

Umwelt (Australia) Pty Limited (Umwelt) was engaged by the NSW Minerals Council (NSWMC) to assess the composition and condition of mine rehabilitation against the *Central Hunter Valley Eucalypt Forest and Woodland* Critically Endangered Ecological Community (CEEC) (hereafter referred to as 'CHVEFW') listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The specific key diagnostic characteristics and condition thresholds were compared to the four Hunter Valley mine sites. These case studies include mine rehabilitation located at four subject mine sites: Mount Owen, Mangoola, Mt Thorley Warkworth/Hunter Valley Operations and United. Mount Owen, Mangoola and United mines are owned by Glencore and the Mt Thorley Warkworth/Hunter Valley Operations mines are owned by Coal and Allied. Existing plot/transect data previously collected from mine rehabilitation on these sites has been used in this assessment.

1.1 Importance of Mine Rehabilitation

Mine rehabilitation plays a vital role in the restoration and regeneration of threatened ecological communities in the highly altered landscapes that are typical of many of Australia's mining regions, including the Hunter Valley. Mining companies are committed to meeting the requirements of relevant offset policies and welcome the inclusion of with mine rehabilitation in that process.

Incentivising the ecological rehabilitation of mines by providing credit under offset policies will likely provide a significant improvement for the post-mine landscape compared to traditional offsetting approaches. Offsetting through mine rehabilitation complements and enhances traditional offsetting by:

- Providing contiguous large-scale, long term protected vegetation in areas where land remaining to be offset is highly fragmented. For instance in the Upper Hunter Valley, large lots of the *Central Hunter Valley Eucalypt Forest and Woodland Critically Endangered Ecological Community* (CHVEFW) have been largely exhausted by offsets for current and past projects, and small lots will not have the same connectivity
- Creating connectivity between existing areas of vegetation. The Upper Hunter Synoptic Plan Update project aims to provide coordination of mine rehabilitation and other land uses in the Upper Hunter including conservation land and
- Reducing land use conflicts in highly contested mining regions such as the Upper Hunter and New England North West. In these areas many in the community see land set aside for offsetting as the 'locking up' of otherwise productive agricultural area.

This report aims to provide evidence that ecological rehabilitation can conform to the listed threatened ecological communities. This is an early piece of work, and it is acknowledged that there will be some residual risks relating to the success of ecological rehabilitation, however these are manageable through a number of mechanisms available to Government, including:

- Discounting the offsetting credit that applies to ecological mine rehabilitation
- Providing clear objectives for offsetting, monitoring and reporting requirements
- Commitment by industry and governments to investing in research and application of improved rehabilitation techniques, such as the proposed ACARP study and
- Requirement for financial assurance in the form of a biodiversity bond.

1.2 Background on Central Hunter Valley Eucalypt Forest and Woodland CEEC

The CHVEFW was listed under the *Environment Protection and Biodiversity Conservation Act 1999* on 7 May 2015.

The CHVEFW is a community that is largely concurrent (overlaps in extent) with three NSW listed threatened ecological communities: *Central Hunter Valley Box – Ironbark Woodland* Endangered Ecological Community (EEC), *Central Hunter Valley Ironbark – Spotted Gum – Grey Box Forest* EEC and parts of the *Hunter Valley Slaty Box Woodland* Vulnerable Ecological Community (VEC). However the concurrence is not entire, as there are elements of the three NSW listed communities that do not comprise the CHVEFW, whilst there are also elements of the CHVEFW that extend beyond the three NSW listed communities, including its extension into areas of derived native grassland (DNG, which is not covered by the NSW listings) and bullock forest (which is also not listed at the state level). To determine the presence and extent of the CHVEFW detailed ground surveys are required in accordance with guidelines in the *Commonwealth Conservation Advice* for the community.

The Commonwealth Conservation Advice (TSSC 2015) for the CHVEFW specifies a range of criteria that must be met to determine whether or not the community is present, particularly the “Key Diagnostic Characteristics”, “Other Diagnostic Considerations” and the “Condition Thresholds”. Some of the steps required to address these factors can be done based on desktop assessments, while others require targeted field survey.

The community is estimated to have once covered approximately 99,000 hectares, whilst its current extent is estimated at 37,000 hectares, constituting a 63% reduction in its area. The Conservation Advice notes that “if the condition of the ecological community is taken into account the decline in extent is higher (i.e. greater than 70%).”

The known and predicted distribution of CHVEFW is shown in **Figure 1.1** (reproduced from Department of the Environment, 2015). In terms of how the CHVEFW is recognised through the Office of Environment and Heritage’s (OEH’s) vegetation classification scheme, it is composed of a number of Plant Community Types (PCTs), up to 10 PCTs which are equivalent in part or full.

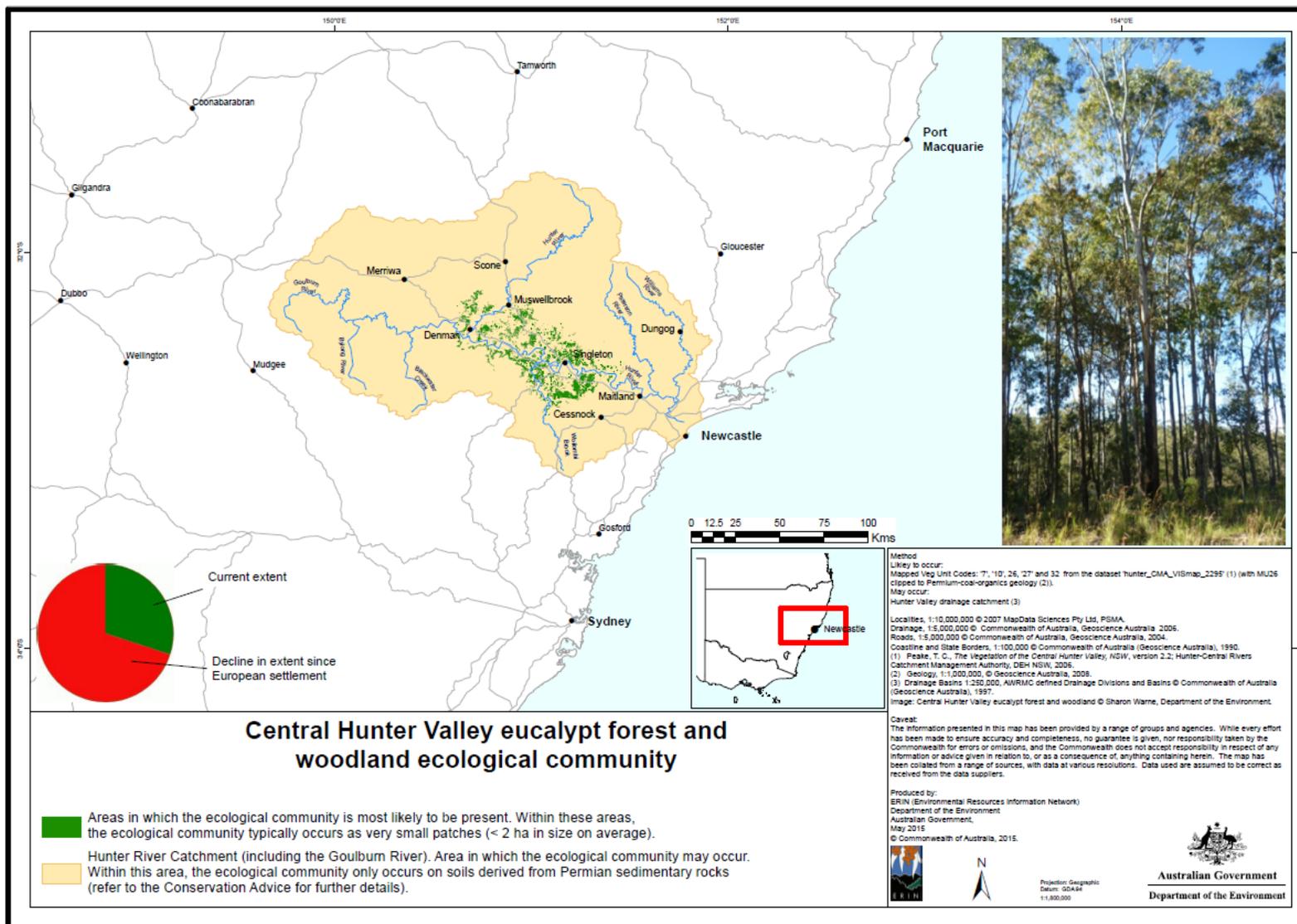


Figure 1.1 Known and Predicted Distribution of Central Hunter Valley Eucalypt Forest and Woodland (CHVEFW) Critically Endangered Ecological Community

Department of the Environment, 2015

One of the most important and limiting Key Diagnostic Characteristics is that the CHVEFW occurs only on “soils derived from Permian sedimentary rocks.” In the Hunter Valley these soils, combined with the other relevant Key Diagnostic Characteristics, mean that the community’s distribution is essentially the same as that of the coal mining district in the central Hunter. Given this and the fact that a large proportion has been previously cleared, locating suitable offset areas is becoming more difficult for new mining projects. The value of mine rehabilitation is beginning to be recognised and if done well could contribute to offsetting a proportion of direct mining impacts. It is thought that, if over time the establishment of this community of mined land becomes well proven, the use of ecological rehabilitation might be able to provide a higher proportion of biodiversity offsetting than is currently the case. This is important also because in the Hunter Valley the development of successful biodiversity conservation outcomes for the coal mining district will depend on good ecological mine rehabilitation.

1.3 Background on the Subject Mine Sites

The following section include the general ages of the rehabilitation assessed and the requirements for existing rehabilitation as specified in consent condition and/or mining operation plans (MOPs) (or equivalent) for the four case study mines.

1.3.1 Mount Owen

The Mount Owen mine rehabilitation assessed in this report ranges from 8 to 18 years since seeding, having been completed in large blocks. There are no specific approval conditions relating to mine rehabilitation in the 2004 Development Consent (DA 14-1-2004). However, commitments relating to the re-establishment of native ecosystems across the site are outlined in the Environmental Impact Statement (EIS) for Mount Owen Operations (Umwelt 2003), which includes a Biodiversity Offset Strategy. The Biodiversity Offset Strategy commits to establishing woodland on all mine areas at Mount Owen, however this report does not specify the precise vegetation communities required to be established.

The 2016 Development Consent (SSD-5850) includes the following objectives for mine rehabilitation:

- *Restore at least 2037 ha of self-sustaining native woodland ecosystems characteristic of vegetation communities found in the local area, as shown conceptually in Figure 7A in Appendix 7b*
- *Establish areas of self-sustaining:*
 - *riparian habitat, within any diverted and/or re-established creek lines and retained water features;*
 - *potential habitat for threatened flora and fauna species; and*
 - *wildlife corridors, as far as is reasonable and feasible, and as*
 - *shown conceptually in Figure 7B in Appendix 7*

It is noted that the 2016 Development Consent (SSD-5850) does not include reference to restoring any threatened ecological communities, however as part of the conditions for the Biodiversity Offset Strategy 518 hectares of mine rehabilitation woodland are required to meet the Central Hunter Ironbark – Spotted Gum – Grey Box Forest EEC:

- *The Rehabilitation Woodland offset area must be rehabilitated to a level that meets the EEC listing criteria for the Central Hunter Ironbark – Spotted Gum – Grey Box Forest EEC.*

Similarly, the overall objectives of current Mount Owen Complex Mining Operations Plan January 2017 – December 2021 (Mount Owen 2017) of the proposed post-mining land use design are:

- *Establish a vegetation community consistent with the Central Hunter Ironbark – Spotted Gum – Grey Box Forest on the post mining landform;*
- *Contribute to effective regional native corridors that promote fauna movements between the MOC, Ravensworth Surface Operations, Liddell Coal Operations, Lake Liddell and the Liddell and Ravensworth Operations Hillcrest Offset Area;*
- *Maintain and provide additional suitable habitat for a range of threatened fauna species including the spotted-tailed quoll (*Dasyurus maculatus maculatus*);*
- *Provide opportunities for future agricultural activities such as sustainable grazing;*
- *Improve the visual amenity of the area; and*
- *Not preclude other potential post mining land use should they be determined to be viable and preferable as part of the detailed mine closure planning process that will commence at least five years prior to the planned cessation of mining.*

There is no specific approval requirement relating to Mount Owen Mine which requires the re-instatement of the CHVEFW.

1.3.2 Mangoola

The Mangoola mine rehabilitation assessed in this report is approximately 3 to 6 years old (Forest Fauna Surveys Pty Ltd/Eastcoast Flora Survey, 2015, Umwelt 2017a). Target vegetation communities of the mine rehabilitation include Grey Box Woodland, Spotted Gum Woodland, Narrow-leaved Ironbark Woodland, Slaty Gum Woodland and Blakelys Red Gum/Rough-barked Apple Woodland.

The Project Application (PA 06_0014) specifies in condition 35 the vegetation communities that should be re-established on mine rehabilitation:

35. The Proponent must ensure that the Biodiversity Offset Strategy (and the rehabilitation of the site) is focused on the re-establishment of

(a) significant and/or threatened plant communities, including:

- *Ironbark Woodland Complex;*
- *Bullock Woodland;*
- *Paperbark Woodland;*
- *Slaty Box Woodland;*
- *Forest Red Gum Riparian Woodland;*
- *Rough Barked Apple Woodland;*
- *Swamp Oak Riparian Forest; and*
- *Weeping Myall Woodland;*

The primary objective of post-mining rehabilitation works according to the current Mangoola Coal Mining Operations Plan January 2016 – December 2020 (Mangoola Coal 2016), as specified in the Ecological Assessment (Umwelt 2006), *'is to create a stable final landform that is consistent with the surrounding natural landscape with acceptable post-mining land use capability'*.

Although Mangoola has requirements to re-establish specific vegetation communities, there are no specific approval requirements for the re-instatement of the any threatened ecological communities, including CHVEFW, under the NSW *Threatened Species Conservation Act 1995* (TSC Act) or the EPBC Act.

1.3.3 Mt Thorley Warkworth/Hunter Valley Operations

The Mt Thorley Warkworth/Hunter Valley Operations mine rehabilitation assessed in this report ranges from 6 to 17 years since seeding (pers. com. Bill Baxter).

The Mt Thorley Warkworth/Hunter Valley Operations operate under a range of project approvals and the relevant requirements with regard to mine rehabilitation include:

Project Application (06 0261) Hunter Valley Operations South Coal Project

34. The Proponent shall progressively rehabilitate the site in a manner that is generally consistent with the final landform set out in the EA (shown conceptually in Appendix 6) to the satisfaction of the Executive Director, Mineral Resources in DRE and the Director-General.

Project Application (SSD-6464) Warkworth Continuation Project

56. The Applicant shall rehabilitate the site to the satisfaction of the DRE. This rehabilitation must be generally consistent with the proposed rehabilitation strategy described in the EIS (and depicted conceptually in the figure in Appendix 6), and comply with the objectives in Table 13.

Applicable biodiversity objectives in Table 13 include:

- *Restore ecosystem function, including maintaining or establishing self-sustaining ecosystems comprising local plant species*
- *Vegetation to be established, with the restoration of at least 1,617 hectares of Central Hunter Grey Box – Ironbark Woodland EEC*
- *Size, location and species of native trees lots and corridors are established to sustain biodiversity habitats*
- *Species are selected that re-establishes and complements regional and local biodiversity*

Project Application (SSD-6465) Mt Thorley Continuation Project

34. The Applicant shall rehabilitate the site to the satisfaction of the DRE. This rehabilitation must be generally consistent with the proposed rehabilitation strategy described in the EIS (and depicted conceptually in the figure in Appendix 5), and comply with the objectives in Table 9.

Applicable biodiversity objectives in Table 9 include:

- *Restore ecosystem function, including maintaining or establishing self-sustaining ecosystems comprising local plant species*

- *Vegetation to be established with at least 483 hectares of Central Hunter Grey Box – Ironbark Woodland EEC*
- *Size, location and species of native trees lots and corridors are established to sustain biodiversity habitats*
- *Species are selected that re-establishes and complements regional and local biodiversity*

Project Application (DA 450-10-2003) Extension of Open Cut Coal Mine Operations at the West Pit of Hunter Valley Operations

The Applicant must rehabilitate the site to the satisfaction of DRE. The rehabilitation must be generally in accordance with the proposed rehabilitation strategy described by the documents listed in Condition 2 of Schedule 3 (and depicted conceptually in the final landform plans in Appendices 6 and 7) and the objectives in Table 17.

The Mt Thorley Warkworth/Hunter Valley Operations mine rehabilitation is covered by several Mining Operation Plans. Relevant objectives of these Mining Operation Plans are summarised below.

Mining Operations Plan HVO North (Coal & Allied Operations Pty Ltd 2017a)

Relevant rehabilitation objectives:

- *Approximately 30% of mined land re-established as woodland areas.*
- *Rehabilitated woodlands are reproducing and sustainable, of dimensions able to support ecosystem biodiversity (habitat), provide transport corridor for fauna, and function consistently with neighbouring remnant ecosystems.*
- *Mined lands are rehabilitated to their original land capability class or better.*
- *Restoration of 4ha of Central Hunter Grey Box Ironbark Woodland to a standard comparable to similar reference EEC woodland communities.*

Mining Operations Plan HVO South (Coal & Allied Operations Pty Ltd 2017b)

Relevant rehabilitation objectives:

- *Return 30-40% of disturbed mining areas to native woodland areas, but not necessarily conforming to any particular vegetation community.*
- *Establish native vegetation areas creating corridors to link surrounding native vegetation.*

Mining Operations Plan Mount Thorley Warkworth (Coal & Allied Operations Pty Ltd 2016)

Relevant rehabilitation objectives:

- *Establish at least 2,100 hectares of Central Hunter Grey Box – Ironbark Woodland EEC.*
- *Establish approximately 319 ha of trees over grass not conforming to any particular community, creating treed corridors to ensure connectivity of woodland community areas.*
- *Establish 1,423 ha of grassland.*

- *Size, location and species of native tree lots and corridors are established to sustain biodiversity habitats.*
- *Species are selected that re-establishes and complements regional and local biodiversity.*
- *Create an additional north/south wildlife corridor providing connectivity to other habitat.*

Overall the Mt Thorley Warkworth/Hunter Valley Operations have requirements to establish grassland, trees over grass not conforming to any particular community and the Central Hunter Grey Box – Ironbark Woodland EEC under the NSW TSC Act. There is no requirement to establish the CHVEFW, however any mine rehabilitation that successfully achieves the establishment of Central Hunter Grey Box – Ironbark Woodland EEC under the NSW TSC Act is also likely to conform to the CHVEFW if the key diagnostic and condition thresholds are met.

1.3.4 United

The United mine rehabilitation assessed in this report is greater than approximately 25 years old.

The existing Development Application (DA-410-11-2002-i) specifies in condition 45:

The Applicant shall establish at least 18.5 hectares of compensatory habitat on the surface colliery holding to the satisfaction of the Director-General, to replace the woodland vegetation removed by the development.

The preliminary closure goal according to the current United Collieries Mining Operations Plan January 2017 – June 2019 (United Collieries 2016) 'is to return mine disturbed areas predominantly to native woodland with the aim of providing enhanced ecological linkages to adjacent operations and remnant woodland areas'. Specific objectives for vegetation community establishment on mine rehabilitation include:

Woodland rehabilitated areas provide a range of vegetation structural habitats (e.g. eucalypts, shrubs, ground cover, developing litter layer etc.).

More than 75% of trees are healthy and growing as indicated by long term rehabilitation monitoring.

Retained vegetation is managed to improve condition and existing flora and fauna habitat values.

Woodland rehabilitation areas contain an appropriate diversity of flora species that are comparable to native vegetation community.

Second generation tree seedlings are present or likely to be, based on monitoring in comparable older rehabilitation sites.

There are no significant weed infestations and weeds do not comprise a significant proportion of the species in any stratum.

There is no specific approval requirement relating to United Collieries which requires the re-instatement of the CHVEFW, or any specific vegetation community type.

1.3.5 Overall Rehabilitation Requirements

Generally the older mine rehabilitation requirements (Mount Owen and United) did not require the establishment of specific vegetation communities. In more recent years the mine rehabilitation consent conditions stipulate the vegetation communities to be re-instated. Mangoola requires the establishment of specific vegetation communities, however there is no requirement for these communities to conform to any listed threatened ecological community under the TSC Act or EPBC Act. The Mt Thorley Warkworth/Hunter Valley Operations and Mount Owen case studies (since the 2016 development consent) require the establishment of *Central Hunter Grey Box – Ironbark Woodland* EEC under the TSC Act, which is also likely to conform to the CHVEFW if the key diagnostic and condition thresholds are met. None of the case study sites require the establishment of CHVEFW, given that this CEEC was only listed in May 2015 and any areas of rehabilitation found to conform as part of this assessment are unplanned.

2.0 Methods

In order to undertake this assessment existing mine rehabilitation data collected from each of the mine sites was interrogated against the specific key diagnostic characteristics and condition thresholds for the CHVEFW (TSSC 2015). Key diagnostic characteristics and condition thresholds are used to determine the presence of a threatened ecological community under the EPBC Act. Key diagnostic characteristics generally specify where a threatened ecological community can occur and other environmental and ecological features that must be present. The condition thresholds set the minimum condition a patch of vegetation needs to be in order meet the listing under the EPBC Act. Resources used include:

- Approved Conservation Advice (including listing advice) for the Central Hunter Valley Eucalypt Forest and Woodland ecological community (TSSC 2015)
- Vegetation surveys at Mt Owen Mine for OEH (Umwelt 2015a)
- Mangoola Open Cut – 2016 Ecological Monitoring Report (Umwelt 2017a)
- Native Vegetation Rehabilitation Monitoring 2016 – Mount Thorley Warkworth and Hunter Valley Operations (Niche Environment and Heritage 2016)
- 2016 Ecological Monitoring Report – United Colliery (Umwelt 2017b)
- Upper Hunter Strategic Assessment – United Collieries Biodiversity Certification Assessment Report (Umwelt 2015b).

The data used for each of the case studies is discussed in further detail below.

2.1 Mount Owen

A total of 32 plots/transects were interrogated for consistency with the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC Conservation Advice (TSSC 2015) (refer to **Figure 2.1**). This comprised floristic data that was collected by Umwelt (2015) and biometric site attribute data collected by OEH on the Mt Owen rehabilitation. Data was collected according to a modified BBAM 2014 (OEH 2014) methodology which provided the collection of more detailed data than is standard. Canopy foliage cover from the biometric site attribute data was converted to crown cover (solid canopies) as per the requirements of the Conservation Advice. The formula for this conversion was sourced from the Australian Soil and Land Survey Field Handbook (Hnatiuk et al. 2009).

2.2 Mangoola

A total of 5 plots/transects were compared against the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC Conservation Advice (TSSC 2015) (refer to **Figure 2.1**). Plot/transect data was collected according to BBAM 2014 (OEH 2014) as part of the Mangoola ecological monitoring program. Target communities of the rehabilitation include Grey Box Woodland, Spotted Gum Woodland, Narrow-leaved Ironbark Woodland, Slaty Gum Woodland and Blakelys Red Gum/Rough-barked Apple Woodland. Since a defined canopy had not matured, this criterion was assessed by adding the foliage cover of all the young canopy species (i.e. eucalypts) and then converting to crown cover.

Data from 2016 walkover inspections of the rehabilitation were also considered in this assessment.

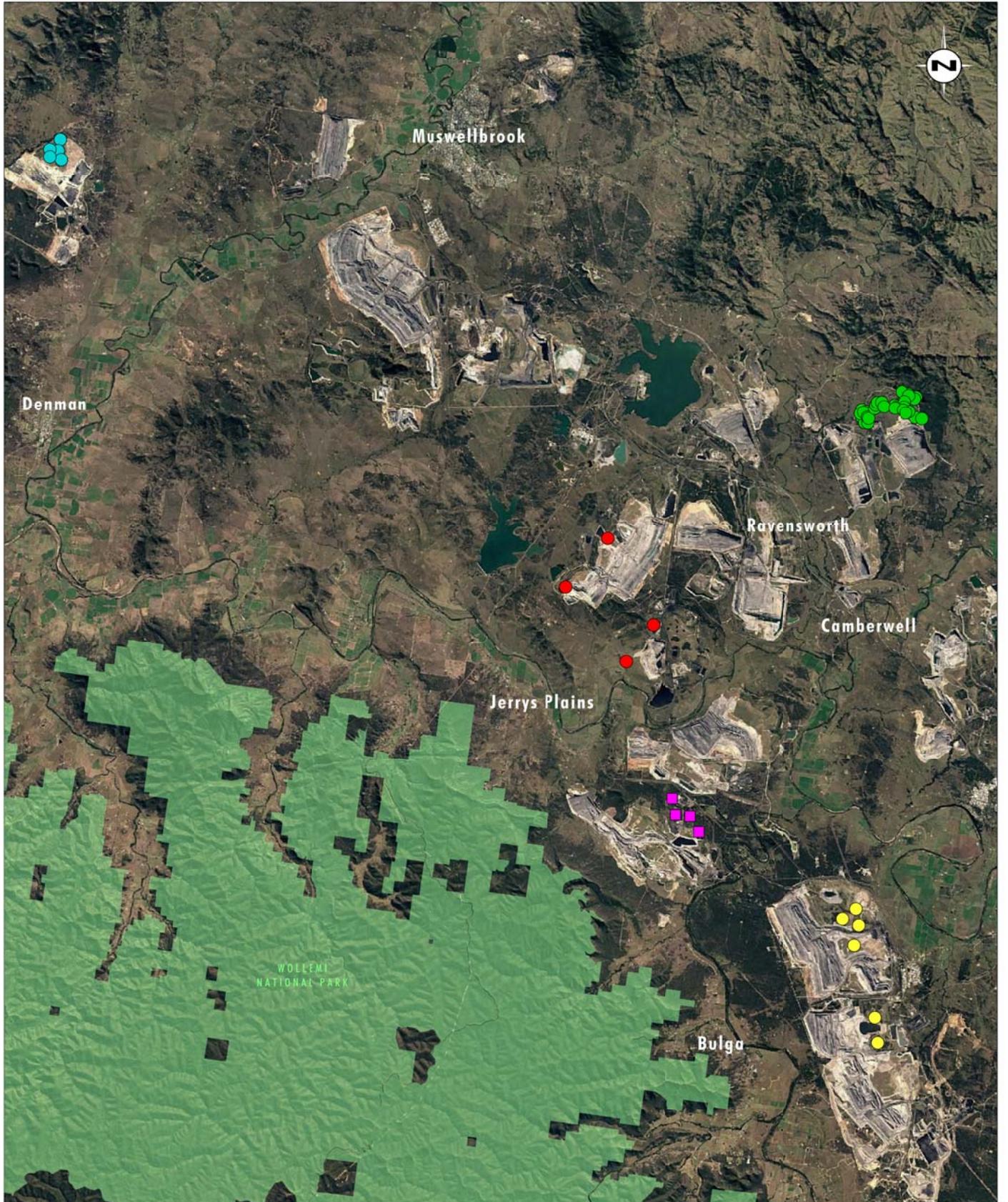


Image Source: Google Maps (Dec 2016)

0 2.5 5.0 10.0km
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Legend

- Hunter Valley Operations Rehabilitation Monitoring Site
- Mangoola Rehabilitation Monitoring Site
- Mount Owen Rehabilitation Monitoring Site
- Mount Thorley Warkworth Rehabilitation Monitoring Site
- United Rehabilitation Monitoring Site

FIGURE 2.1

Location of Mine Rehabilitation Case Studies

2.3 Mount Thorley Warkworth/Hunter Valley Operations

A total of 10 plots/transects were compared against the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC Conservation Advice (TSSC 2015) (refer to **Figure 2.1**). These plots/transects include the collection of biometric site attribute data, however the Braun-Blanquet six point scale was used to record the cover and abundance of each species. This meant that the data need to be modified to a cover per cent to compare to the relevant CHVEFW condition thresholds. The maximum foliage cover for each six point scale was applied, which were assumed to be:

- 1 = 5%
- 2 = 5%
- 3 = 25%
- 4 = 50%
- 5 = 75%
- 6 = 100%

This removes some of the sensitivity of the assessment. Also given that the number of trees present was not counted, every record of a tree species was assumed to represent at least a single tree per 20 x 20 metre area and extrapolated across the rehabilitation.

Canopy foliage cover from the biometric site attribute data was converted to crown cover (solid canopies) as per the requirements of the Conservation Advice. The formula for this conversion was sourced from the Australian Soil and Land Survey Field Handbook (Hnatiuk et al. 2009).

2.4 United

A total of 4 plots were compared against the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC Conservation Advice (TSSC 2015) (refer to **Figure 2.1**). Three of these plots in the United mine rehabilitation are permanently marked and have been monitored over a number of years. The data from the most recent monitoring event in 2016 has been used in this assessment. The flora species in these three plots has been recorded using the Braun-Blanquet six point and as discussed for the Mount Thorley Warkworth/Hunter Valley Operations the maximum foliage cover was applied. The fourth plot is from the surveys undertaken as part of the United Collieries Upper Hunter Strategic Assessment Report (Umwelt 2015b). Biometric site attribute data along a transect was also recorded at this site.

Rapid targeted surveys of the CHVEFW undertaken as part of the Upper Hunter Strategic Assessment were also considered in this assessment. Forty-three (43) rapid assessment points were undertaken across the United Upper Hunter Strategic Assessment area.

3.0 Case Studies

The results of the four case studies are described in detail below.

3.1 Mount Owen Mine Rehabilitation

3.1.1 Key Diagnostic Characteristics

Table 3.1 below details the assessment of each of the key diagnostic characteristics of the Conservation Advice (TSSC 2015) against the Mount Owen mine rehabilitation plot/transect data.

Table 3.1 Key Diagnostic Characteristics for Mt Owen Rehabilitation

Key Diagnostic Characteristics according to Conservation Advice	Meets the Key Diagnostic Characteristic?	Additional Comments
It occurs in the Hunter River catchment (typically called the Hunter Valley region).	Yes – all sites.	The Mt Owen rehabilitation occurs entirely in the Hunter River Catchment.
It typically occurs on lower hillslopes and low ridges, or valley floors in undulating country; on soils derived from Permian sedimentary rocks.	Yes – all sites.	The Mt Owen rehabilitation occurs on a constructed low hill and it is <i>assumed*</i> that the soils are derived from Permian sedimentary rocks. Regional soil mapping of the previously mined area details the soils, Bayswater Soil Landscape, as being Permian derived (Kovac and Lawrie, 1991).
It does not occur on alluvial flats, river terraces, aeolian sands, Triassic sediments, or escarpments.	Yes – all sites.	The Mt Owen rehabilitation does not occur on any of these described landscapes.
<p>i) It is woodland or forest, with a projected canopy cover of trees of 10% or more</p> <p>OR</p> <p>ii) with a native tree density of at least 10 native tree stems per 0.5 ha (at least 20 native tree stems/ha) that are at least one metre in height</p>	<p>i) Yes for 10 sites (out of 32). A total of 10 sites have canopy cover (or crown cover – represented by solid canopies) of 10% or more from a total of 32 sites.</p> <p>ii) Yes for 23 sites (out of 32). A total of 23 sites (from 32 sites sampled) have at least 10 native trees per 0.5 ha. Density of native tree stems range from 12.5 to 1850 per 0.5 ha.</p>	In many cases the sites that do not meet the canopy cover threshold, however the minimum native tree density is achieved.

Key Diagnostic Characteristics according to Conservation Advice	Meets the Key Diagnostic Characteristic?	Additional Comments
<p>i) The canopy of the ecological community is dominated by one or more of the following four eucalypt species: <i>Eucalyptus crebra</i> (narrow-leaved ironbark), <i>Corymbia maculata</i> (syn. <i>E. maculata</i>) (spotted gum), <i>Eucalyptus dawsonii</i> (slaty gum) and <i>Eucalyptus moluccana</i> (grey box)</p> <p>OR</p> <p>ii) a fifth species, <i>Allocasuarina luehmannii</i> (bulloak, buloke) dominates in combination with one or more of the above four eucalypt species, in sites previously dominated by one or more of the above four eucalypt species</p>	<p>i) Yes for 18 sites (out of 32). A total of 18 sites (from 32 sites sampled) are dominated by one or more of the four characteristic eucalypt species. Dominance ranges from 0 to 100 per cent.</p> <p>ii) Not applicable</p>	<p>Note that four sites do not contain any native canopy species. The remaining sites that are not dominated by one of the four characteristic canopy species are dominated by the canopy species red ironbark (<i>Eucalyptus fibrosa</i>), grey gum (<i>Eucalyptus punctata</i>), forest red gum (<i>Eucalyptus tereticornis</i>) and the non-locally native species Western Australian golden wattle (<i>Acacia saligna</i>).</p>
<p><i>Allocasuarina torulosa</i> (forest oak), <i>Eucalyptus acmenoides</i> (white mahogany) and <i>Eucalyptus fibrosa</i> (red/broad-leaved ironbark) are largely absent from the canopy of a patch</p>	<p>Yes for 2 sites (out of 4).</p>	<p>Two sites contain greater than two red ironbark (<i>Eucalyptus fibrosa</i>) per hectare. These sites are extrapolated to contain 25 red ironbark (<i>Eucalyptus fibrosa</i>) trees per hectare.</p>
<p>A ground layer is present (although it may vary in development and composition), as a sparse to thick layer of native grasses and other native herbs and/or native shrubs</p>	<p>Yes – all sites.</p>	<p>All sites contain a ground layer of varying development and composition.</p>

Note: *This is a reasonable assumption because the coal that is mined occurs in Permian aged strata.

3.1.2 Condition Categories (classes) and Thresholds

Table 3.2 details of each of the condition categories and thresholds of the Conservation Advice (TSSC 2015) against the Mount Owen mine rehabilitation plot/transect data.

Table 3.2 Condition Categories (classes) and Thresholds for Mt Owen Rehabilitation

Condition Category	Condition Thresholds	Meets the Key Condition Threshold?	Additional Comments
<p>Class A. High Quality</p>	<p>i) Patch size is ≥ 5 ha AND ii) $\geq 50\%$ of perennial understorey vegetative cover is native AND iii) the patch contains at least 12 native understorey species.</p>	<p>i) For the purposes of this assessment it is assumed that each site meets the minimum 5 ha size ii) Yes in part. 18 of the 32 sites meet this condition threshold iii) Yes – all sites. All 32 sites meet this condition threshold. Between 19 and 54 native understorey species have been recorded from each site.</p>	<p>iii) Additionally 30 of the 32 sites contain at least 12 native understorey species that are identified in the Conservation Advice as being characteristic flora species. The two sites that do not meet this condition threshold have 10 characteristic native understorey species.</p>
<p>Class B. High Quality Condition</p>	<p>i) Patch size is ≥ 0.5 ha; AND ii) $\geq 70\%$ of perennial vegetative cover in each layer present is native; AND iii) the patch contains at least 12 native understorey species.</p>	<p>i) For the purposes of this assessment it is assumed that each site meets the minimum 0.5 ha size. ii) Yes in part. 11 of the 32 sites meet this condition threshold. iii) Yes – all sites. As discussed above for Class A category, all 32 sites meet this condition threshold.</p>	<p>Typically those sites that do not meet condition ii) have a large proportion of perennial weeds in the ground layer. Sites are also ruled out based on the dominance of the non-locally native Western Australian golden wattle (<i>Acacia saligna</i>). This species was deliberately planted and is not highly invasive and in the future it could be prevented from becoming established in mine rehabilitation.</p>

Condition Category	Condition Thresholds	Meets the Key Condition Threshold?	Additional Comments
<p>Class C. Moderate Quality Condition</p>	<p>i) Patch size is ≥ 0.5 ha AND ii) $\geq 50\%$ of perennial understorey vegetative cover is native AND iii) the patch contains at least 12 native understorey species.</p>	<p>i) For the purposes of this assessment it is assumed that each site meets the minimum 0.5 ha size. ii) Yes in part. As discussed above for Class A category, 18 of the 32 sites meet this condition threshold. iii) Yes – all sites. As discussed above for Class A category, all 32 sites meet this condition threshold.</p>	<p>-</p>
<p>Class D. Moderate Quality Condition</p>	<p>i) Patch size is ≥ 2 ha AND ii) $\geq 50\%$ of perennial understorey vegetative cover is native AND iii) The patch is contiguous with another patch of native woody vegetation ≥ 1 ha in area OR iv) The patch has at least one large locally indigenous tree (≥ 60 cm dbh), or at least one tree with hollows.</p>	<p>i) For the purposes of this assessment it is assumed that each site meets the minimum 2 ha size. ii) Yes in part. As discussed above for Class A category, 18 of the 32 sites meet this condition threshold. iii) For the purposes of this assessment it is assumed that each site is contiguous with another patch of native woody vegetation ≥ 1 ha in area; iv) No – all sites. No trees have a dbh ≥ 60 cm and no natural hollows were recorded.</p>	<p>The trees across the rehabilitation are still young and typically range from <5 cm to 20-30 cm. The largest tree recorded was a spotted gum (<i>Corymbia maculata</i>) between 40 to 50 cm diameter at breast height (DBH).</p>

3.1.3 Overall Results of Key Diagnostic Characteristics and Condition Thresholds

Overall 12 of the 32 sites sampled on the Mount Owen rehabilitation are considered likely to conform to the CHVEFW. The main reasons for sites not conforming to the CHVEFW include:

- a high proportion of exotic perennial species in the ground layer
- canopy layer dominated by species other than the four characteristic eucalypt species
- canopy cover less than 10 per cent and the density of native trees less than 10 per 0.5 ha.

3.1.4 Photographs of Mount Owen Mine Rehabilitation

Plate 3.1 below is a representative photograph of the Mount Owen mine rehabilitation at one of the 32 monitoring sites used in this assessment and is considered likely to conform to the CHVEFW. Dominant tree species recorded include spotted gum (*Corymbia maculata*), narrow-leaved ironbark (*Eucalyptus crebra*), grey box (*Eucalyptus moluccana*) and grey gum (*Eucalyptus punctata*).



Plate 3.1 Representative Mount Owen mine rehabilitation considered likely to conform to the CHVEFW

Source: OEH

3.2 Mangoola Mine Rehabilitation

3.2.1 Key Diagnostic Characteristics

Table 3.3 below details the assessment of each of the key diagnostic characteristics of the Conservation Advice (TSSC 2015) against the Mangoola mine rehabilitation plot/transect data.

Table 3.3 Key Diagnostic Characteristics for Mangoola Rehabilitation

Key Diagnostic Characteristics according to Conservation Advice	Meets the Key Diagnostic Characteristic?	Additional Comments
It occurs in the Hunter River catchment (typically called the Hunter Valley region)	Yes – all sites.	The Mangoola rehabilitation occurs entirely in the Hunter River Catchment.
It typically occurs on lower hillslopes and low ridges, or valley floors in undulating country; on soils derived from Permian sedimentary rocks	Yes – all sites.	The Mangoola rehabilitation occurs on a constructed low hill. Regional soil mapping of the previously mined area classifies it as part of the Sandy Hollow soil landscape which comprises Quaternary colluvium and not Permian derived sediments (Kovac and Lawrie, 1991). However the adjacent Castle Rock soil landscape comprises Permian sediments. For the purposes of this assessment the Mangoola rehabilitation is not excluded from meeting this key diagnostic characteristic as the source of the material is not known, however it is likely to contain or be dominated by Permian sediments*.
It does not occur on alluvial flats, river terraces, aeolian sands, Triassic sediments, or escarpments	Yes – all sites.	The Mangoola rehabilitation does not occur on any of these described landscapes.

Key Diagnostic Characteristics according to Conservation Advice	Meets the Key Diagnostic Characteristic?	Additional Comments
<p>i) It is woodland or forest, with a projected canopy cover of trees of 10% or more</p> <p>OR</p> <p>ii) with a native tree density of at least 10 native tree stems per 0.5 ha (at least 20 native tree stems/ha) that are at least one metre in height</p>	<p>i) Yes for 4 sites (out of 5).</p> <p>A total of 4 sites have canopy cover (or crown cover – represented by solid canopies) of 10% or more from a total of 5 sites.</p> <p>ii) Yes – all sites.</p> <p>All 5 sites have at least 10 native trees per 0.5 ha. Density of native tree stems range from 100 to 337.5 per 0.5 ha.</p>	-
<p>i) The canopy of the ecological community is dominated by one or more of the following four eucalypt species: <i>Eucalyptus crebra</i> (narrow-leaved ironbark), <i>Corymbia maculata</i> (syn. <i>E. maculata</i>) (spotted gum), <i>Eucalyptus dawsonii</i> (slaty gum) and <i>Eucalyptus moluccana</i> (grey box)</p> <p>OR</p> <p>ii) a fifth species, <i>Allocasuarina luehmannii</i> (bulloak, buloke) dominates in combination with one or more of the above four eucalypt species, in sites previously dominated by one or more of the above four eucalypt species.</p>	<p>i) Yes – all sites.</p> <p>All 5 sites area dominated by a combination of the 4 characteristic canopy species.</p> <p>ii) Not applicable</p>	Bulloak (<i>Allocasuarina luehmannii</i>) is only a minor component of the canopy.
<p><i>Allocasuarina torulosa</i> (forest oak), <i>Eucalyptus acmenoides</i> (white mahogany) and <i>Eucalyptus fibrosa</i> (red/broad-leaved ironbark) are largely absent from the canopy of a patch.</p>	Yes – all sites.	These three species have not been recorded on the Mangoola rehabilitation at the five sites.
<p>A ground layer is present (although it may vary in development and composition), as a sparse to thick layer of native grasses and other native herbs and/or native shrubs</p>	Yes – all sites.	All sites contain a ground layer of varying development and composition.

Note: *This is a reasonable assumption because the coal that is mined occurs in Permian aged strata.

3.2.2 Condition Categories (classes) and Thresholds

Table 3.4 details of each of the condition categories and thresholds of the Conservation Advice (TSSC 2015) against the Mangoola mine rehabilitation plot/transect data.

Table 3.4 Condition Categories (classes) and Thresholds for Mangoola Rehabilitation

Condition Category	Condition Thresholds	Meets the Key Condition Threshold?	Additional Comments
<p>Class A. High Quality</p>	<p>i) Patch size is ≥ 5 ha</p> <p>AND</p> <p>ii) $\geq 50\%$ of perennial understorey vegetative cover is native</p> <p>AND</p> <p>iii) the patch contains at least 12 native understorey species.</p>	<p>i) For the purposes of this assessment it is assumed that each site meets the minimum 5 ha size.</p> <p>ii) Yes –all five sites meet this condition threshold.</p> <p>iii) Yes – all five sites meet this condition threshold. Between 19 and 25 native understorey species have been recorded from each site.</p>	<p>-</p>
<p>Class B. High Quality Condition</p>	<p>i) Patch size is ≥ 0.5 ha</p> <p>AND</p> <p>ii) $\geq 70\%$ of perennial vegetative cover in each layer present is native</p> <p>AND</p> <p>iii) the patch contains at least 12 native understorey species.</p>	<p>i) For the purposes of this assessment it is assumed that each site meets the minimum 0.5 ha size.</p> <p>ii) Yes in part.</p> <p>3 of the 5 sites meet this condition threshold.</p> <p>iii) Yes – all sites.</p> <p>As discussed above for Class A category, all 5 sites meet this condition threshold.</p>	<p>The two sites that do not meet condition ii) have a large proportion of perennial weeds in the ground layer. The proportion of ground layer perennial native vegetative cover for these two sites is 55% and 60%.</p>

Condition Category	Condition Thresholds	Meets the Key Condition Threshold?	Additional Comments
<p>Class C. Moderate Quality Condition</p>	<p>i) Patch size is ≥ 0.5 ha AND ii) $\geq 50\%$ of perennial understorey vegetative cover is native; AND iii) the patch contains at least 12 native understorey species.</p>	<p>i) For the purposes of this assessment it is assumed that each site meets the minimum 0.5 ha size. ii) Yes – all sites. As discussed above for Class A category, all 5 sites meet this condition threshold. iii) Yes – all sites. As discussed above for Class A category, all 5 sites meet this condition threshold.</p>	<p>-</p>
<p>Class D. Moderate Quality Condition</p>	<p>i) Patch size is ≥ 2 ha AND ii) $\geq 50\%$ of perennial understorey vegetative cover is native AND iii) The patch is contiguous with another patch of native woody vegetation ≥ 1 ha in area OR iv) The patch has at least one large locally indigenous tree (≥ 60 cm dbh), or at least one tree with hollows.</p>	<p>i) For the purposes of this assessment it is assumed that each site meets the minimum 2 ha size. ii) Yes – all sites. As discussed above for Class A category, all 5 sites meet this condition threshold. iii) For the purposes of this assessment it is assumed that each site is contiguous with another patch of native woody vegetation ≥ 1 ha in area. iv) No – all sites. No trees have a dbh ≥ 60 cm and no natural hollows are considered likely to occur given the young age of the rehabilitation.</p>	<p>-</p>

3.2.3 Overall Results of Key Diagnostic Characteristics and Condition Thresholds

All 5 sites sampled on the Mangoola rehabilitation are considered likely to conform to the CHVEFW. All key diagnostic characteristics and conditions thresholds are achieved (exceeded in many cases). As previously discussed the soils cannot be definitively classified as Permian sediments as the source material is unknown, however they are likely to contain or be dominated by Permian sediments.

3.2.4 Photograph of Mangoola Mine Rehabilitation

Plate 3.2 below is a representative photograph of the Mangoola mine rehabilitation at one of the five monitoring sites considered in this assessment. This is regarded to be likely to conform to the CHVEFW. Dominant tree species recorded slaty gum (*Eucalyptus dawsonii*), narrow-leaved ironbark (*Eucalyptus crebra*), grey box (*Eucalyptus moluccana*) and hickory wattle (*Acacia implexa*).



Plate 3.2 Representative Mangoola Mine rehabilitation considered likely to conform to the CHVEFW

Source: Umwelt

3.3 Mt Thorley Warkworth/Hunter Valley Operations Mine Rehabilitation

3.3.1 Key Diagnostic Characteristics

Table 3.5 below details the assessment of each of the key diagnostic characteristics of the Conservation Advice (TSSC 2015) against Mt Thorley Warkworth/Hunter Valley Operations mine rehabilitation plot/transect data.

Table 3.5 Key Diagnostic Characteristics for Mt Thorley Warkworth/Hunter Valley Operations Rehabilitation

Key Diagnostic Characteristics according to Conservation Advice	Meets the Key Diagnostic Characteristic?	Additional Comments
It occurs in the Hunter River catchment (typically called the Hunter Valley region)	Yes – all sites.	The Mt Thorley Warkworth/Hunter Valley Operations rehabilitation occurs entirely in the Hunter River Catchment
It typically occurs on lower hillslopes and low ridges, or valley floors in undulating country; on soils derived from Permian sedimentary rocks	Yes – all sites.	The Mt Thorley Warkworth/Hunter Valley Operations rehabilitation occurs on constructed low hills. Regional soil mapping of the previously mined area classifies Hunter Valley Operations rehabilitation as part of the Liddell soil landscape and the Mt Thorley Warkworth as part of the Branxton soil landscape, both of which comprise Permian derived sediments (Kovac and Lawrie, 1991).
It does not occur on alluvial flats, river terraces, aeolian sands, Triassic sediments, or escarpments	Yes – all sites.	The Mt Thorley Warkworth/Hunter Valley Operations rehabilitation does not occur on any of these described landscapes.
<p>i) It is woodland or forest, with a projected canopy cover of trees of 10% or more</p> <p>OR</p> <p>ii) with a native tree density of at least 10 native tree stems per 0.5 ha (at least 20 native tree stems/ha) that are at least one metre in height.</p>	<p>i) Yes for 6 sites (out of 10). A total of 6 sites have canopy cover (or crown cover – represented by solid canopies) of 10% or more from a total of 10 sites.</p> <p>ii) Yes – all sites.</p> <p>All 10 sites have at least 10 native trees per 0.5 ha.</p>	Native tree density is based on at least one tree for each canopy species recorded being present within the 20 x 20 m plot.

Key Diagnostic Characteristics according to Conservation Advice	Meets the Key Diagnostic Characteristic?	Additional Comments
<p>i) The canopy of the ecological community is dominated by one or more of the following four eucalypt species: <i>Eucalyptus crebra</i> (narrow-leaved ironbark), <i>Corymbia maculata</i> (syn. <i>E. maculata</i>) (spotted gum), <i>Eucalyptus dawsonii</i> (slaty gum) and <i>Eucalyptus moluccana</i> (grey box)</p> <p>OR</p> <p>ii) a fifth species, <i>Allocasuarina luehmannii</i> (bulloak, buloke) dominates in combination with one or more of the above four eucalypt species, in sites previously dominated by one or more of the above four eucalypt species.</p>	<p>i) Yes for 6 sites (out of 10). A total 6 of the 10 sites are dominated by a combination of the four characteristic canopy species.</p> <p>ii) Not applicable</p>	<p>Those sites not dominated by one or more of the four characteristic canopy species are dominated by grey gum (<i>Eucalyptus punctata</i>) and/or Western Australian golden wattle (<i>Acacia saligna</i>).</p> <p>Bulloak (<i>Allocasuarina luehmannii</i>) has not been recorded in the Mt Thorley Warkworth/Hunter Valley Operations rehabilitation.</p>
<p><i>Allocasuarina torulosa</i> (forest oak), <i>Eucalyptus acmenoides</i> (white mahogany) and <i>Eucalyptus fibrosa</i> (red/broad-leaved ironbark) are largely absent from the canopy of a patch</p>	<p>Yes – all sites.</p>	<p>These three species have not been recorded on the Mt Thorley Warkworth/Hunter Valley Operations rehabilitation at the 10 sites.</p>
<p>A ground layer is present (although it may vary in development and composition), as a sparse to thick layer of native grasses and other native herbs and/or native shrubs</p>	<p>Yes – all sites.</p>	<p>All sites contain a ground layer of varying development and composition.</p>

3.3.2 Condition Categories (classes) and Thresholds

Table 3.6 details of each of the condition categories and thresholds of the Conservation Advice (TSSC 2015) against the Mt Thorley Warkworth/Hunter Valley Operations mine rehabilitation plot/transect data.

Table 3.6 Condition Categories (classes) and Thresholds for Mt Thorley Warkworth/Hunter Valley Operations Rehabilitation

Condition Category	Condition Thresholds	Meets the Key Condition Threshold?	Additional Comments
Class A. High Quality	i) Patch size is ≥ 5 ha AND ii) $\geq 50\%$ of perennial understorey vegetative cover is native AND iii) the patch contains at least 12 native understorey species.	i) For the purposes of this assessment it is assumed that each site meets the minimum 5 ha size. ii) Yes in part. 7 of 10 sites meet this condition threshold. iii) Yes in part. 9 of 10 sites meet this condition threshold. Between 8 and 20 native understorey species have been recorded from each site.	-
Class B. High Quality Condition	i) Patch size is ≥ 0.5 ha AND ii) $\geq 70\%$ of perennial vegetative cover in each layer present is native AND iii) the patch contains at least 12 native understorey species.	i) For the purposes of this assessment it is assumed that each site meets the minimum 0.5 ha size. ii) No – all sites. None of the 10 sites meet this condition threshold. iii) Yes – in part. As discussed above for Class A category, 9 of 10 sites meet this condition threshold.	The sites that do not meet condition ii) have a large proportion of perennial weeds in the midstorey and ground layer.

Condition Category	Condition Thresholds	Meets the Key Condition Threshold?	Additional Comments
<p>Class C. Moderate Quality Condition</p>	<p>i) Patch size is ≥ 0.5 ha</p> <p>AND</p> <p>ii) $\geq 50\%$ of perennial understorey vegetative cover is native</p> <p>AND</p> <p>iii) the patch contains at least 12 native understorey species.</p>	<p>i) For the purposes of this assessment it is assumed that each site meets the minimum 0.5 ha size.</p> <p>ii) Yes – in part.</p> <p>As discussed above for Class A category, 7 of 10 sites meet this condition threshold.</p> <p>iii) Yes – in part.</p> <p>As discussed above for Class A category, 9 of 10 sites meet this condition threshold.</p>	<p>-</p>
<p>Class D. Moderate Quality Condition</p>	<p>i) Patch size is ≥ 2 ha</p> <p>AND</p> <p>ii) $\geq 50\%$ of perennial understorey vegetative cover is native</p> <p>AND</p> <p>iii) The patch is contiguous with another patch of native woody vegetation ≥ 1 ha in area</p> <p>OR</p> <p>iv) The patch has at least one large locally indigenous tree (≥ 60 cm dbh), or at least one tree with hollows.</p>	<p>i) For the purposes of this assessment it is assumed that each site meets the minimum 2 ha size.</p> <p>ii) Yes – in part.</p> <p>As discussed above for Class A category, 7 of 10 sites meet this condition threshold.</p> <p>iii) For the purposes of this assessment it is assumed that each site is contiguous with another patch of native woody vegetation ≥ 1 ha in area.</p> <p>iv) No – all sites.</p> <p>No trees have a dbh ≥ 60 cm and no natural hollows are considered likely to occur given the young age of the rehabilitation.</p>	<p>-</p>

3.3.3 Overall Results of Key Diagnostic Characteristics and Condition Thresholds

Of the ten sites sampled on the Mt Thorley Warkworth/Hunter Valley Operations rehabilitation, four sites are considered likely to conform to the CHVEFW. The main reasons for six sites not conforming to the CHVEFW include:

- a high proportion of exotic perennial species in the midstorey and ground layer
- canopy layer dominated by species other than the four characteristic eucalypt species, comprising grey gum (*Eucalyptus punctata*) and Western Australian golden wattle (*Acacia saligna*).

3.3.4 Photograph of Mt Thorley Warkworth/Hunter Valley Operations Mine Rehabilitation

Plate 3.3 below is a representative photograph of the Mt Thorley Warkworth/Hunter Valley Operations mine rehabilitation at one of the four monitoring sites considered in this assessment. It is regarded as being likely to conform to the CHVEFW. Dominant tree/shrub species include spotted gum (*Corymbia maculata*), narrow-leaved ironbark (*Eucalyptus crebra*), Sydney golden wattle (*Acacia longifolia*) and hickory wattle (*Acacia falcata*).



Plate 3.3 Representative Mt Thorley Mine rehabilitation considered likely to conform to the CHVEFW

Source: Rio Tinto Coal Australia | Coal & Allied

3.4 United Mine Rehabilitation

3.4.1 Key Diagnostic Characteristics

Table 3.7 below details the assessment of each of the key diagnostic characteristics of the Conservation Advice (TSSC 2015) against the United mine rehabilitation plot/transect data.

Table 3.7 Key Diagnostic Characteristics for United Rehabilitation

Key Diagnostic Characteristics according to Conservation Advice	Meets the Key Diagnostic Characteristic?	Additional Comments
It occurs in the Hunter River catchment (typically called the Hunter Valley region)	Yes – all sites.	The United rehabilitation occurs entirely in the Hunter River Catchment
It typically occurs on lower hillslopes and low ridges, or valley floors in undulating country; on soils derived from Permian sedimentary rocks	Yes – all sites.	The United rehabilitation occurs on constructed low hills. Regional soil mapping of the previously mined area classifies the soils, Jerrys Plains soil landscape, as being derived from Permian sediments (Kovac and Lawrie, 1991).
It does not occur on alluvial flats, river terraces, aeolian sands, Triassic sediments, or escarpments	Yes – all sites.	The United rehabilitation does not occur on any of these described landscapes.
i) It is woodland or forest, with a projected canopy cover of trees of 10% or more OR ii) with a native tree density of at least 10 native tree stems per 0.5 ha (at least 20 native tree stems/ha) that are at least one metre in height	i) Yes for 1 site (out of 4). 1 of the 4 sites has a canopy cover (or crown cover – represented by solid canopies) of 10% or more. ii) Yes for 2 sites (out of 4). 2 of the 4 sites have at least 10 native trees per 0.5 ha.	Native tree density is based on at least one tree for each canopy species recorded being present within the 20 x 20 m plot. The non-locally native species Western Australian golden wattle (<i>Acacia saligna</i>) dominates the canopy. This species was deliberately planted and is not highly invasive and in the future it could be prevented from becoming established in mine rehabilitation.

Key Diagnostic Characteristics according to Conservation Advice	Meets the Key Diagnostic Characteristic?	Additional Comments
<p>i) The canopy of the ecological community is dominated by one or more of the following four eucalypt species: <i>Eucalyptus crebra</i> (narrow-leaved ironbark), <i>Corymbia maculata</i> (syn. <i>E. maculata</i>) (spotted gum), <i>Eucalyptus dawsonii</i> (slaty gum) and <i>Eucalyptus moluccana</i> (grey box)</p> <p>OR</p> <p>ii) a fifth species, <i>Allocasuarina luehmannii</i> (bulloak, buloke) dominates in combination with one or more of the above four eucalypt species, in sites previously dominated by one or more of the above four eucalypt species</p>	<p>i) Yes for 1 site (out of 4). 1 of the 4 sites is dominated by a combination of the four characteristic canopy species.</p> <p>ii) Not applicable</p>	<p>Those sites not dominated by one or more of the four characteristic canopy species are dominated by Western Australian golden wattle (<i>Acacia saligna</i>).</p> <p>Bulloak (<i>Allocasuarina luehmannii</i>) was recorded as a minor component of one of the sites.</p>
<p><i>Allocasuarina torulosa</i> (forest oak), <i>Eucalyptus acmenoides</i> (white mahogany) and <i>Eucalyptus fibrosa</i> (red/broad-leaved ironbark) are largely absent from the canopy of a patch</p>	<p>Yes – all sites.</p>	<p>These three species have not been recorded on the United rehabilitation at the four sites.</p>
<p>A ground layer is present (although it may vary in development and composition), as a sparse to thick layer of native grasses and other native herbs and/or native shrubs</p>	<p>Yes – all sites.</p>	<p>All sites contain a ground layer of varying development and composition.</p>

3.4.2 Condition Categories (classes) and Thresholds

Table 3.8 details of each of the condition categories and thresholds of the Conservation Advice (TSSC 2015) against the United mine rehabilitation plot/transect data.

Table 3.8 Condition Categories (classes) and Thresholds for United Rehabilitation

Condition Category	Condition Thresholds	Meets the Key Condition Threshold?	Additional Comments
<p>Class A. High Quality</p>	<p>i) Patch size is ≥ 5 ha AND ii) $\geq 50\%$ of perennial understorey vegetative cover is native AND iii) the patch contains at least 12 native understorey species.</p>	<p>i) For the purposes of this assessment it is assumed that each site meets the minimum 5 ha size ii) Yes – in part. 2 of the 4 sites meet this condition threshold iii) Yes – all sites. All 4 sites meet this condition threshold. Between 14 and 33 native understorey species have been recorded from each site.</p>	<p>Those sites that do not meet condition ii) perennial weeds in shrub layer/midstorey.</p>
<p>Class B. High Quality Condition</p>	<p>i) Patch size is ≥ 0.5 ha AND ii) $\geq 70\%$ of perennial vegetative cover in each layer present is native AND iii) the patch contains at least 12 native understorey species.</p>	<p>i) For the purposes of this assessment it is assumed that each site meets the minimum 0.5 ha size. ii) Yes in part. 1 of the 4 sites meet this condition threshold. iii) Yes – all sites. As discussed above for Class A category, all 4 sites meet this condition threshold.</p>	<p>The sites that do not meet condition ii) have a large proportion of perennial weeds in shrub/midstorey and canopy. Common weed species include African olive (<i>Olea europaea</i> subsp. <i>cuspidata</i>) and Western Australian golden wattle (<i>Acacia saligna</i>). Western Australian golden wattle (<i>Acacia saligna</i>) was deliberately planted and is not highly invasive and in the future it could be prevented from becoming established in mine rehabilitation.</p>

Condition Category	Condition Thresholds	Meets the Key Condition Threshold?	Additional Comments
<p>Class C. Moderate Quality Condition</p>	<p>i) Patch size is ≥ 0.5 ha</p> <p>AND</p> <p>ii) $\geq 50\%$ of perennial understorey vegetative cover is native</p> <p>AND</p> <p>iii) the patch contains at least 12 native understorey species.</p>	<p>i) For the purposes of this assessment it is assumed that each site meets the minimum 0.5 ha size.</p> <p>ii) Yes in part.</p> <p>As discussed above for Class A category, 2 of 4 sites meet this condition threshold.</p> <p>iii) Yes – all sites.</p> <p>As discussed above for Class A category, all 4 sites meet this condition threshold.</p>	<p>-</p>
<p>Class D. Moderate Quality Condition</p>	<p>i) Patch size is ≥ 2 ha</p> <p>AND</p> <p>ii) $\geq 50\%$ of perennial understorey vegetative cover is native</p> <p>AND</p> <p>iii) The patch is contiguous with another patch of native woody vegetation ≥ 1 ha in area</p> <p>OR</p> <p>iv) The patch has at least one large locally indigenous tree (≥ 60 cm dbh), or at least one tree with hollows.</p>	<p>i) For the purposes of this assessment it is assumed that each site meets the minimum 2 ha size.</p> <p>ii) Yes in part.</p> <p>As discussed above for Class A category, 2 of 4 sites meet this condition threshold.</p> <p>iii) For the purposes of this assessment it is assumed that each site is contiguous with another patch of native woody vegetation ≥ 1 ha in area.</p> <p>iv) No – all sites.</p> <p>No trees have a dbh ≥ 60 cm and no natural hollows are considered likely to occur given the young age of the rehabilitation.</p>	<p>-</p>

3.4.3 Overall Results of Key Diagnostic Characteristics and Condition Thresholds

Of the four sites sampled on the United rehabilitation, one site is considered to conform to the CHVEFW. This site would meet all the patch size requirements given that it is located directly adjacent to a large patch of native woodland that is consistent with the CHVEFW. This same area was assessed as conforming to the CHVEFW as part of the United Wambo Open Cut Coal Mine Project Environmental Impact Statement (Umwelt 2016) and has been accepted by OEH and DoEE.

The main reasons for the other three sites not conforming to the CHVEFW include:

- the absence of characteristic eucalypt species;
- a high proportion of exotic perennial species in the shrub/midstorey layer; and
- canopy layer dominated by the non-locally native Western Australian golden wattle (*Acacia saligna*).

Rapid targeted surveys of the CHVEFW undertaken as part of the Upper Hunter Strategic Assessment found that the majority of the rehabilitation did not meet the minimum condition thresholds given the presence of non-locally native sugar gum (*Eucalyptus cladocalyx*) dominating the canopy in many areas and the high abundance of perennial weeds in the understorey. Sugar gum (*Eucalyptus cladocalyx*) was deliberately planted in older mine rehabilitation and can be prevented from occurring in the future through the use of desirable seed/planting lists.

3.4.4 Photograph of United Mine Rehabilitation

Plate 3.4 below is a representative photograph of the United mine rehabilitation that is considered to conform to the CHVEFW. Dominant tree species recorded include spotted gum (*Corymbia maculata*), bullock (*Allocasuarina luehmannii*) and black wattle (*Acacia decurrens*).



Plate 3.4 Representative United Mine rehabilitation considered to conform to the CHVEFW

Source: Umwelt

4.0 Summary of Results

The results of this assessment are encouraging given that none of the case study mine sites set out to achieve the CHVEFW on their mine rehabilitation. The consent conditions and mine rehabilitation objectives contained in the relevant Mining Operation Plans to date have not specified the requirement for the establishment of CHVEFW. Based on existing monitoring data, the mine rehabilitation in all four case studies are likely to contain areas of the CHVEFW, noting that patch size (minimum 0.5 hectares) is yet to be assessed for each site. With a targeted effort future mine rehabilitation across the central Hunter Valley could be established which focuses on the CHVEFW. **Section 6** below includes recommendations for improving and further enhancing outcomes of mine rehabilitation with regard to establishing CHVEFW. In addition to this, further areas of mine rehabilitation which do not currently meet the condition thresholds of CHVEFW could be managed to conform in the future. For instance, weed control could be used to meet the per cent perennial native cover thresholds, along with further planting of characteristic canopy species.

5.0 Limitations of the Assessment

A number of limitations of this desktop assessment are recognised and include:

- This report is based on using point based data assessment, as opposed to data collected widely across a patch as per the Conservation Advice. Further assessment and survey are required to look at the extent of CEEC and patch size to better determine condition categories.
- Classification of midstorey and canopy foliage cover has not been undertaken consistently between the mine sites. In most cases this does not affect the identification of the CEEC as the minimum tree density is met.
- The number of individuals of a tree species has been assumed to meet the minimum height criteria of 1 metre, as the height of individual trees has not been recorded at any of the mine sites.
- This desktop assessment does not include an assessment of reproduction capacity or establishment of species, which would demonstrate how sustainable the ecological communities on mine rehabilitation are. Additional data for the Mt Owen rehabilitation could be analysed to assess this.
- The source and age of the soil on the mine rehabilitation is unknown and is assumed to be derived from Permian sediments. In most cases this is a reasonable assessment based on the regional soil mapping and the occurrence of the coal measures within Permian strata. At Mangoola, where the regional soil mapping suggests that the surface strata are of Quaternary age, it is likely that the vast majority of the excavated material is from the Permian-aged coal measures, and therefore it is assumed that the sites at which rehabilitation has been established are overwhelming composed of Permian-derived material.

6.0 Recommendations

The following recommendations are made to better understand the extent of the CHVEFW across each of the mine sites:

- As previously discussed further surveys considering the whole patch as per the Conservation Advice to understand the full extent and spatial distribution of the CHVEFW across the mine rehabilitation areas.
- Further surveys and consideration of native grasslands on mine rehabilitation could form part of the CHVEFW.
- Future rehabilitation monitoring should incorporate measurement of reproduction and establishment of species to demonstrate a sustainable ecological community and address relevant regulatory requirements.
- A further detailed assessment of the Mt Owen data to better understand the proportion of the native species that are producing reproductive structures and are establishing second generation individuals through the presence of seedlings.

The following recommendations are made to assist mines in establishing rehabilitation that conforms to the CHVEFW:

- Seed mixes and planting lists should include the four characteristic eucalypt species as the dominant canopy species being established.
- Contra-indicative species should be removed from seed mixes and planting lists. This mainly relates to the use of red ironbark (*Eucalyptus fibrosa*). The other two species which should be excluded comprise forest oak (*Allocasuarina torulosa*) and white mahogany (*Eucalyptus acmenoides*).
- Weed control, in particular perennial species, is required within mine rehabilitation to ensure condition thresholds are achieved.

7.0 Future Steps

Publication of peer-reviewed scientific research regarding the cases of, or prospects for, the successful establishment of the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC on mine rehabilitation will contribute substantially to the recognition of mine rehabilitation as providing positive environmental outcomes and being considered as a component of offset strategies. A suitable pathway for this would be through research funding from Australian Coal Industry's Research Program (ACARP). With stated support from the coal mining industry, Umwelt has prepared an initial application for this. This study, should it be funded, is likely to comprise three stages, including a Stage 1 – literature review of published and unpublished studies, Stage 2 – detailed review of mine rehabilitation ecological monitoring data across the Hunter region and Stage 3 – collection of new data at several mine site which is specific to the key diagnostic characteristics and condition thresholds of the *Central Hunter Valley Eucalypt Forest and Woodland* CEEC. The collection of new data will also consider the relevant biometric approach (likely to be BAM), along with function data to show the mine rehabilitation is self-sustaining. Although not currently proposed as part of the ACARP study, determining what constitutes suitable 'successional pathway benchmarks' will also be a valuable and likely necessary component of future studies.

Another consideration for maximising the value of mine rehabilitation is to plan the overall site rehabilitation (in concert with adjoining landholders where possible) so that connectivity of native vegetation at the landscape scale is increased. This will maximise potential credits generated through biometric assessments under the FBA or new BAM, as 'landscape value' is an important element of generating credit value for any offset site, including ecological mine rehabilitation.

8.0 References

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