APPENDIX K
REHABILITATION STRATEGY

REHABILITATION STRATEGY

Moolarben Coal Stage 2

Preferred Project Report

June 2011

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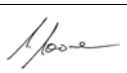
CR 6015_10_v2	First submission to DoP Coffey Natural Systems		28 October 2009
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1 INTRODUCTION

The Department of Planning (DoP) engaged Global Soil Systems (GSS) to undertake an independent technical review of the rehabilitation aspects of the Stage 2 Environmental Assessment (EA) for the Moolarben Coal Project (MCP).

Moolarben Coal Mine (MCM) prepared a response to the issues raised by GSS in its review of the Stage 2 EA. This revision has been made to support the Preferred Project Report.

This report sets out the rehabilitation objectives and principles to be applied for Stage 2 of the Moolarben Coal Project. This report also provides additional information on the approach that will be adopted in rehabilitating the post-mining landscape to achieve a stable, natural looking, vegetated and ecologically diverse post-mining landscape. This report does not discuss vegetation or habitat offsets, which will be addressed in the Rehabilitation and Offset Management Plan (ROMP).

This report is not a detailed rehabilitation plan. MCM will prepare a detailed ROMP upon approval of the Stage 2 Project. The ROMP will be prepared in consultation with rehabilitation and ecological experts and with government authorities and will draw on mine site rehabilitation experience from other coal mines in the Hunter Valley, including the adjacent Ulan and Wilpinjong coal mines and Yancoal's (MCM's parent company) Ashton coal mine. It will be integrated with the land management and rehabilitation strategy for Stage 1.

The information provided in this report is based on:

- Specialist study outcomes presented in the Stage 2 EA and Preferred Project Report (PPR);
- Published research, including:
  - Rehabilitation of open-cut coal mines using native grasses: management guidelines (Huxtable 1999); and
  - Development of Rehabilitation Completion Criteria for Native Ecosystem Establishment on Coal Mines in the Hunter Valley (Nichols 2005).
- Industry and government guidelines, including:
  - Draft Guidelines for Designing Stable Drainage Lines on Rehabilitated Mine Sites (Department of Land and Water Conservation 1990);
  - Mine Rehabilitation: a Handbook for the Coal Mining Industry (Hannan 1995);
  - Best Practice in Environmental Management in Mining (Department of the Environment 1998, and Environment Protection Agency 1998);
  - Synoptic Plan for Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley of NSW (Department of Mineral Resources 1999);
  - A Rehabilitation Manual for Australian Streams (Rutherford 2000);
  - Managing Urban Stormwater (Landcom 2004);

  - Report of the independent hearing and assessment panel for the Wilpinjong Coal Project (Kearns et al. 2005);
  - Leading Practice Sustainable Development Program for the Mining Industry (Mine Rehabilitation Working Group 2006); and
  - Saving Soil – A Landholder's Guide to Preventing and Repairing Soil Erosion (Department of Primary Industries 2009).
- Stage 1 Landscape Management Plan; and
- Experience at other mine sites in the Hunter Valley.

2 REHABILITATION PLANNING

2.1 Mine Closure and Rehabilitation Objectives

MCM acknowledges that rehabilitation of mined land is an integral part of the mining process. It is also acknowledged that the best environmental, social and economic outcomes for the MCC, post-mining, will be achieved through integrating rehabilitation objectives into mine planning. Further, that on-ground rehabilitation works must commence as soon as practicable following mine disturbance and be progressively carried out throughout the life of the mine. This will enable MCM to meet its rehabilitation and mine closure objectives, following the cessation of mining.

Closure of mining operations will need to be undertaken in consultation with government authorities and key stakeholders and be consistent with MCM's rehabilitation objectives and commitments. As discussed in Stage 2 EA Section 4.7, a mine closure plan will be prepared to address the issues of safety, future land uses, post-mining land management, mine relinquishment, financial commitments and social and environmental outcomes.

The overall rehabilitation objective for Stage 2 is to restore mine-disturbed land to a naturally vegetated state using appropriate endemic species to improve biodiversity and general environmental outcomes in the area, post-mining. In addition to rehabilitating mine impacted areas, MCM will also improve existing degraded and cleared land within its ownership, outside the mine disturbance footprint.

MCM does not propose rehabilitating any of the Stage 2 lands to a state that supports grazing or other agricultural activities.

Stage 2 will potentially disturb an area of up to 1,546ha, comprising OC4, the Northern out-of-pit (OOP) emplacement area and infrastructure and facilities areas. This disturbance will require clearing of 902 ha of existing intact native vegetation and additional disturbance to 643 ha of existing cleared and degraded land. Surface subsidence associated with the two underground mines (UG1 and UG2) will potentially result in more subtle indirect disturbance to a further 987 ha of predominantly intact native vegetation.

Rehabilitation will be undertaken in a progressive manner as soon as practicable after open cut and underground (surface subsidence) mine disturbance to mitigate impacts on flora, fauna, landform, soil and surface water. At mine closure, it is envisaged that the rehabilitated Stage 2 area will be used for ecological values; providing connectivity with the Goulburn River National park, Munghorn Gap Nature Reserve and Cope State Forest, and potentially for the purposes of passive recreation.

The specific rehabilitation objectives for Stage 2 are:

- Creating a natural looking, stable and well drained post-mining landform that is visually consistent with surrounding areas;
- Creating a self sustaining and ecologically diverse post-mining landscape that is compatible with the conservation values of the adjacent Munghorn Gap Nature Reserve and Goulburn River National Park;

- Revegetating and enhancing remnant vegetation on non-mined land under MCM's control with endemic native species so as to increase the amount of native woodlands;
- Creating wildlife corridors and habitat links between existing remnant vegetation in the Munghorn Gap Nature Reserve, Goulburn River National Park and other surrounding areas by increasing the continuity of woodland vegetation;
- Maintaining the diversity and genetic resource of flora currently existing within the locality;
- Maintaining and enhancing habitat for native fauna;
- Realigning and rehabilitating Murragamba and Eastern creeks to be hydraulically and geomorphologically stable and ecologically diverse;
- Rehabilitating degraded riparian areas along Wilpinjong Creek and along Murragamba and Eastern creeks downstream from mined areas within the Stage 2 Project Boundary;
- Reinstating subsidiary surface drainage;
- Improving soil condition and native seed bank;
- Preventing soil erosion and sedimentation;
- Providing access for monitoring and adaptive management, control of competitive native and exotic flora and fauna species and suppression of fires; and
- Progressing towards meeting closure and post-mining land use objectives (to be developed in consultation with stakeholders and described in a Mine Closure Plan) in a timely and cost effective manner.

These rehabilitation objectives provide an opportunity to enhance and improve the ecological value of the area by re-establishing native vegetation across an area that has previously been cleared for grazing. The re-establishment of native vegetation will encourage connectivity and continuity between the Munghorn Gap Nature Reserve and Goulburn River National Park and other surrounding existing vegetated areas.

Connectivity and habitat restoration will be achieved through establishment of native forest and woodland in the post-mining landscape. The rehabilitation and revegetation of Stage 2 and adjoining MCM controlled land will achieve a long-term net increase in native vegetation, thus improving the biodiversity value of the area.

To achieve these objectives, MCM will:

- Progressively rehabilitate mined areas;
- Temporarily rehabilitate and revegetate degraded areas ahead of mining to improve soil structure, organic content, nutrient levels and native seed bank, where practicable;
- Progressively divert, realign and rehabilitate Murragamba and Eastern creeks to maintain and enhance creek aquatic and riparian ecological function and connectivity;
- Develop and implement a detailed ROMP which aims to improve local biodiversity values and restore key ecological function; and

- Develop a monitoring and maintenance program as part of the ROMP to guide rehabilitation success and provide continual improvement to meet the long-term post-closure land use objectives.

All cleared and disturbed land under MCM's control will be rehabilitated with native open woodland, shrubland and grass species, including Boxgum Woodland Endangered Ecological Community (EEC) in accordance with the Biodiversity Offset Strategy (Cumberland Ecology, 2011) (BOS). This will enhance the biodiversity values of the area in the long-term and provide connectivity between green spaces and wildlife corridors.

The future post-mining land use will be consistent with the planning provisions that prevail at that time and may include the adaptive reuse of infrastructure for tourism, educational, industrial or transport interchange purposes. However, this will be decided and agreed upon with key stakeholders at an appropriate future stage.

2.2 Rehabilitation Principles

2.2.1 Guiding Principles

Mine rehabilitation generally comprises two stages: design and construction of a stable landform; and establishment of a sustainable post-mining land use (MCA 1998), which in this case is the creation of an ecologically diverse naturally vegetated area.

Successful rehabilitation of Stage 2 will be achieved through the application of the following guiding principles:

- Develop mine completion criteria based on landform design, erosion control, drainage, soil processes, flora, fauna and ecosystem function;
- Develop a detailed rehabilitation plan, which is in accordance with the progressive mine sequence;
- Identify limiting factors (such as topsoil availability, soil fertility, local seed stocks, water availability, soil water retention and surface preparation);
- Determine the suitability of soil and overburden materials for enabling successful establishment of native plant species;
- Remove and retain habitat trees such as hollows and large woody debris to be placed back into the rehabilitated landscape;
- Clear and mulch non-habitat vegetation for collection with topsoil, or stockpiling for respreading on disturbed areas, where practicable;
- Strip and retain topsoil for respreading on disturbed areas;
- Seed and manage topsoil stockpiles with appropriate species;
- Re-shape the land to create a stable, adequately drained landscape that complies with rehabilitation and erosion control guidelines and post-mining land use objectives, and which is visually compatible with adjacent landforms and suitable for the long-term land use;

- Reinstate natural drainages in areas where they have been altered or impaired, where practicable;
- Minimise erosion and include functional sediment controls designed to an appropriate critical storm duration;
- Develop and implement a pest and weed control program to prevent the introduction of pests and noxious weeds in rehabilitated areas and their spread into adjoining conservation areas;
- Fence off rehabilitation areas to exclude stock and damage from unauthorised access, where necessary;
- Implement relevant strategic land use planning and rehabilitation guidelines;
- Develop mine completion criteria for landform design, erosion control, drainage, flora, fauna and ecosystem function;
- Use an adaptive management approach with continuous improvement; and
- Provide necessary access for the suppression of fires, control of competitive native and exotic fauna and noxious weeds, and monitoring of rehabilitated areas.

2.2.2 Prevention of Land Degradation

The prevention of land degradation through the adoption of appropriate soil conservation practices will be an integral component of site management and landscape reconstruction. The identification of land degradation issues in combination with correct remedial solutions provides good environmental management.

The following principles along with broader land management activities will be incorporated into the detailed land management and rehabilitation plan, which will assist in preventing land degradation, pre- and post-mining:

- Minimising land disturbance to only those areas essential to mining and infrastructure development;
- Monitoring to detect occurrences of soil erosion and landform irregularities to ensure prevention and minimisation;
- Identifying lands prone to dryland salinity (e.g. Class IV and V) to enable soil condition to be improved and to reduce the occurrence of saline outbreaks in non-disturbed and reconstructed post-mine areas;
- Preparing and implementing an erosion and sediment control plan in accordance with relevant industry and government guidelines (e.g. Landcom 2004) for all mining and infrastructure disturbance areas;
- Rapidly revegetating all disturbed areas with appropriate vegetation species; and
- Constructing and maintaining all access and haul roads and storm water drainage systems to appropriate standards.

2.3 Mine Planning and Rehabilitation

Planning for and implementing rehabilitation is an integral part of the mine planning process and ensures that the amount of disturbed area exposed through mining at any one time is minimised. It also enables overall rehabilitation objectives (**Section 2.1**) to be met within a realistic time frame. The Stage 2 open cut mine and mine sequence has been designed to maximise coal resource recovery, minimise environmental impacts; particularly to Boxgum Woodland EEC where practicable, and achieve MCM's rehabilitation objectives.

2.3.1 Open Cut Pit

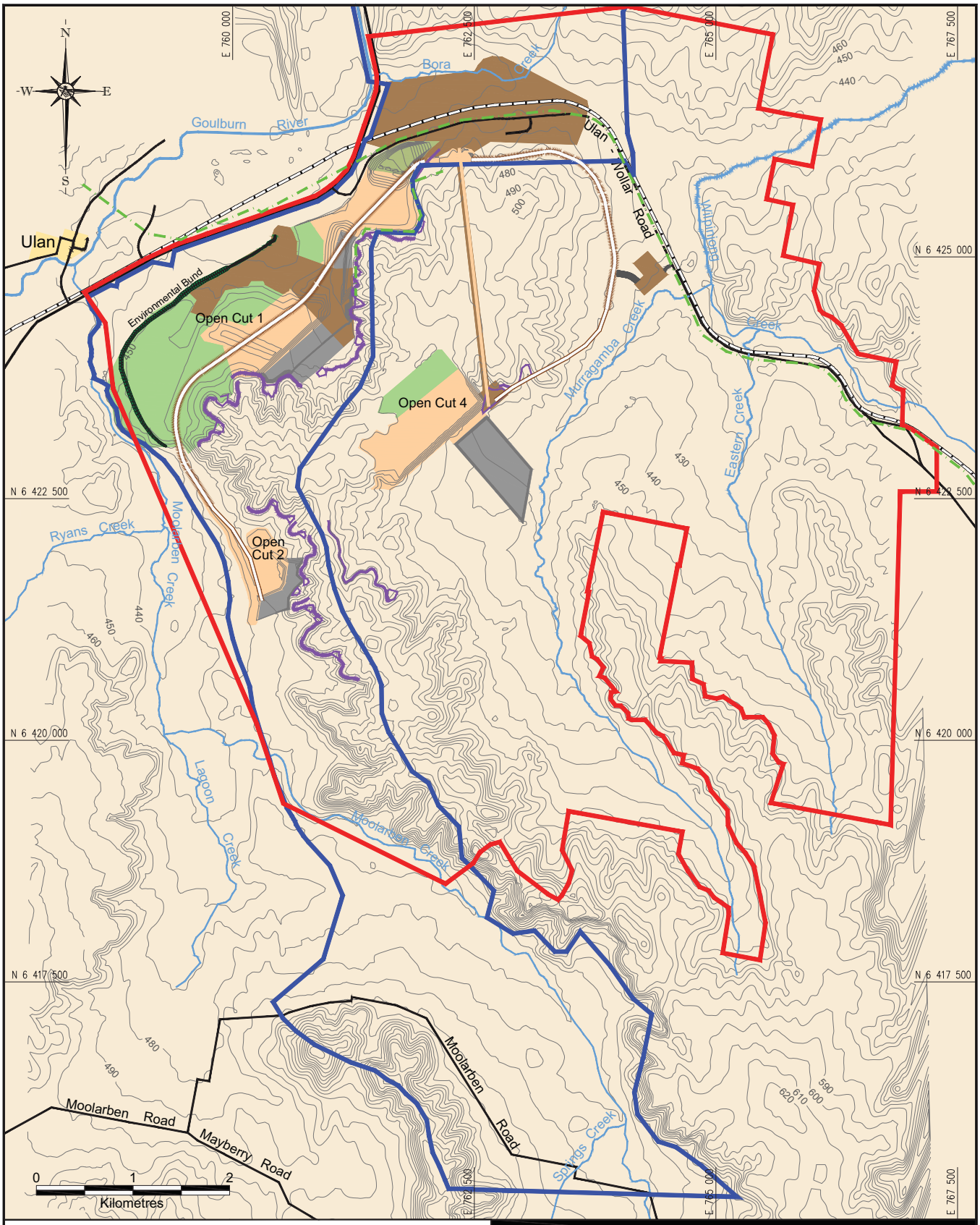
Development of the open cut pit will disturb about 1,278 ha of land in total and will be mined to a maximum depth of about 90 m. However, only a small active pit void will be mined at any one time. Operations are proposed to commence in the north-western extent of OC4 and progress towards the south-west to the most western limit of the pit at approximately Year 6. After this time, operations are proposed to relocate and remobilise in the north-west progressing to the most northern boundary. Operations are then anticipated to turn towards the south-eastern extent of the pit and progress up the valleys to year 24. A final void will remain in the eastern most extent of OC4. The mining and rehabilitation sequence is illustrated conceptually in **Figure 1** to **Figure 6**.

The mine plan provides for direct backfilling of excavated overburden into the mined pit void behind the active mine area. The rate of rehabilitation will be similar to the rate of mining, which will enable the progressive shaping of backfilled areas toward the final landform design. This minimises the need for double handling of overburden and large scale and expensive reshaping of backfilled areas in later years. It also enables the progressive establishment of groundcover and revegetation of exposed post-mined areas, reducing the risk of erosion and increased dust emissions.

Progressive rehabilitation will provide opportunities for rehabilitation trials in the early years of mining. Lessons learnt from these trials will be used in subsequent years as mining, reshaping and rehabilitation of backfilled overburden areas progress together through the valleys.

2.3.2 Creek Diversions

The mine plan includes mining through both Murragamba and Eastern creeks. This will be undertaken in a progressive manner that enables the diversion and realignment of the creeks behind the active mining area (see **Figure 1** to **Figure 6**). This includes the allowance of approximately a five year period for each stage of the realigned and rehabilitated creeks to become hydraulically and geomorphologically stable, prior to reintroducing surface flows. The detailed strategy for the creek realignments is described in detail in Appendix G of the PPR.



Stage 2 Project Boundary
Stage 1 Project Boundary
Roads
Road Realignment
Haul Roads
Sandy Hollow-Gulgong Railway
Creek
Powerline
Conveyor / Access
Water Infrastructure
Overburden Emplacement
Active Mining
Rehabilitation
Infrastructure
Final Void

Source: Worley Parsons (2011), MCO (2011), Wells (2006 & 2009)

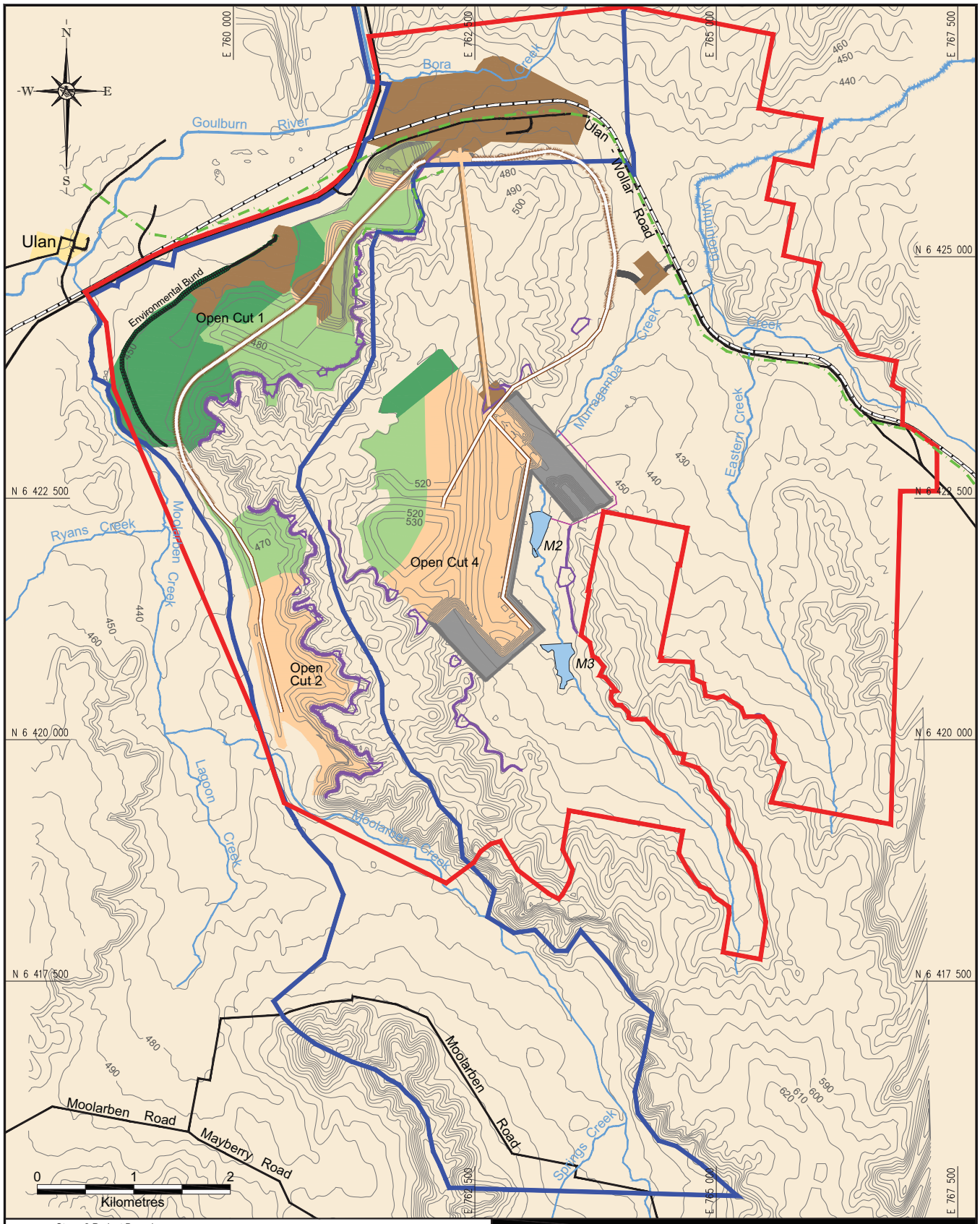
Hansen Bailey

MOOLARBENCOAL

MOOLARBEN STAGE 2 PPR

Conceptual Year 2 Mine Plan

Cad File: 07202J.dwg	Date: 18.07.11	Drawn: CP	Figure 1



MOOLARBEN STAGE 2 PPR

Conceptual Year 7 Mine Plan

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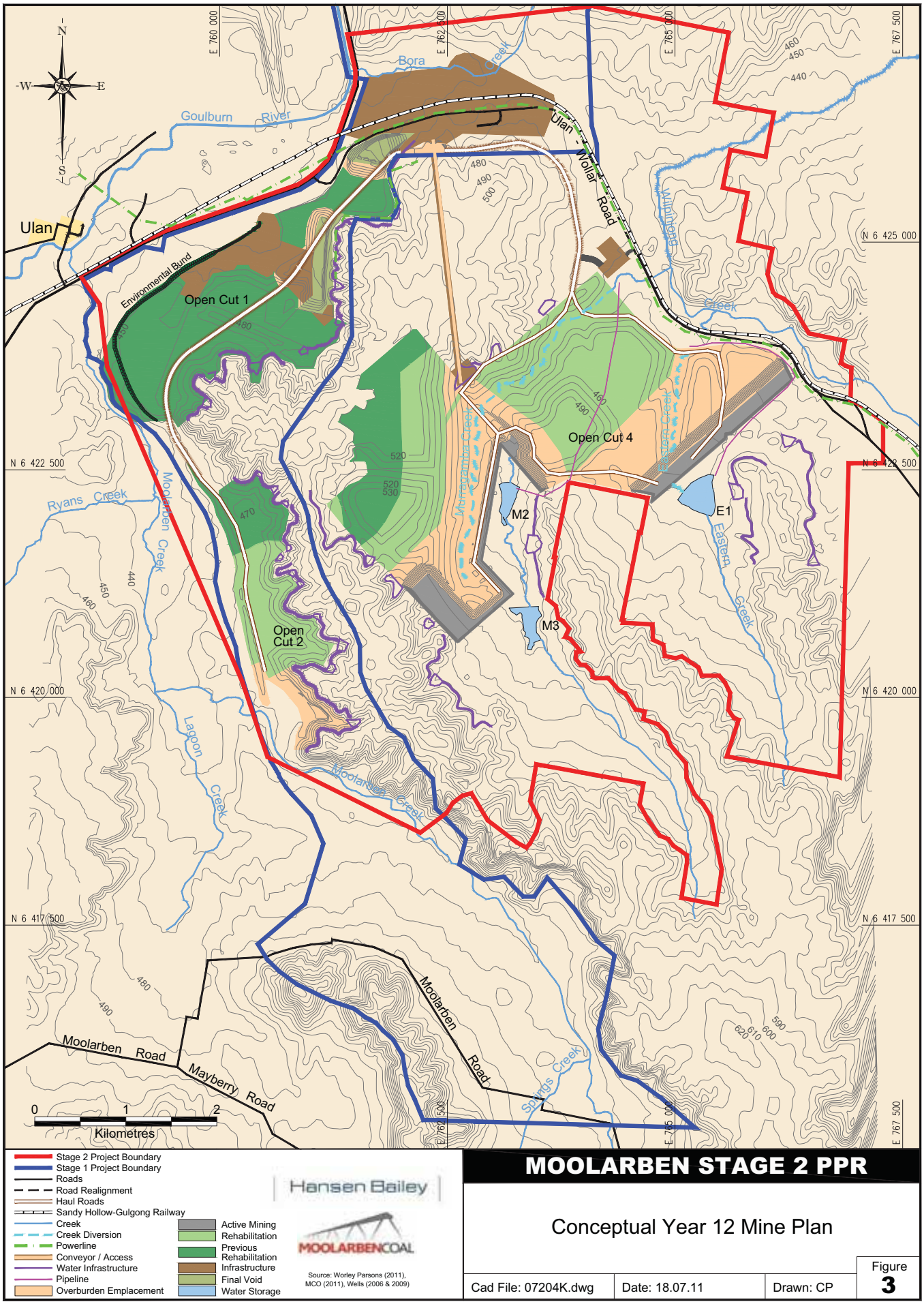

MOOLARBEN STAGE 2 PPR

Conceptual Year 12 Mine Plan

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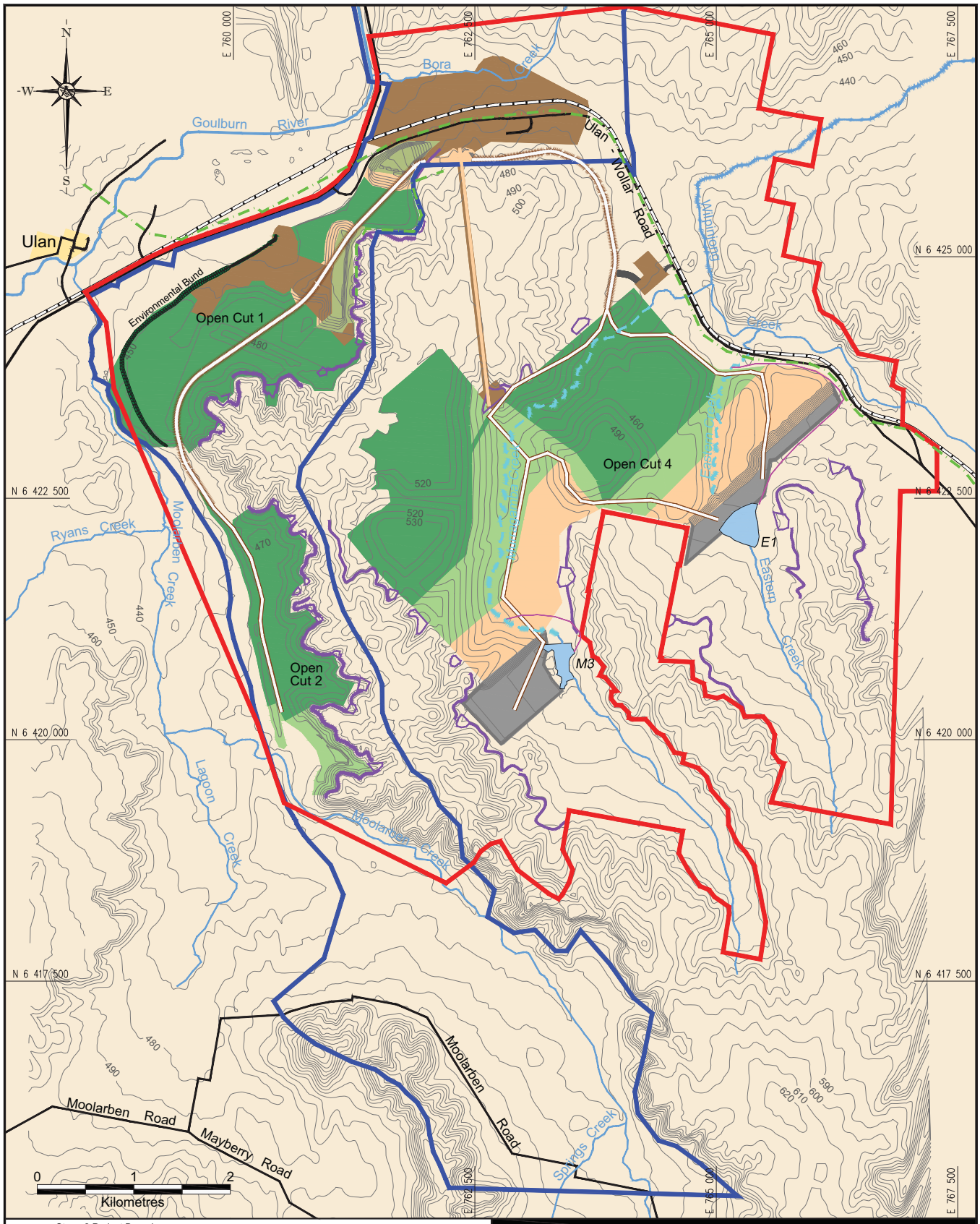

MOOLARBEN STAGE 2 PPR

Conceptual Year 16 Mine Plan

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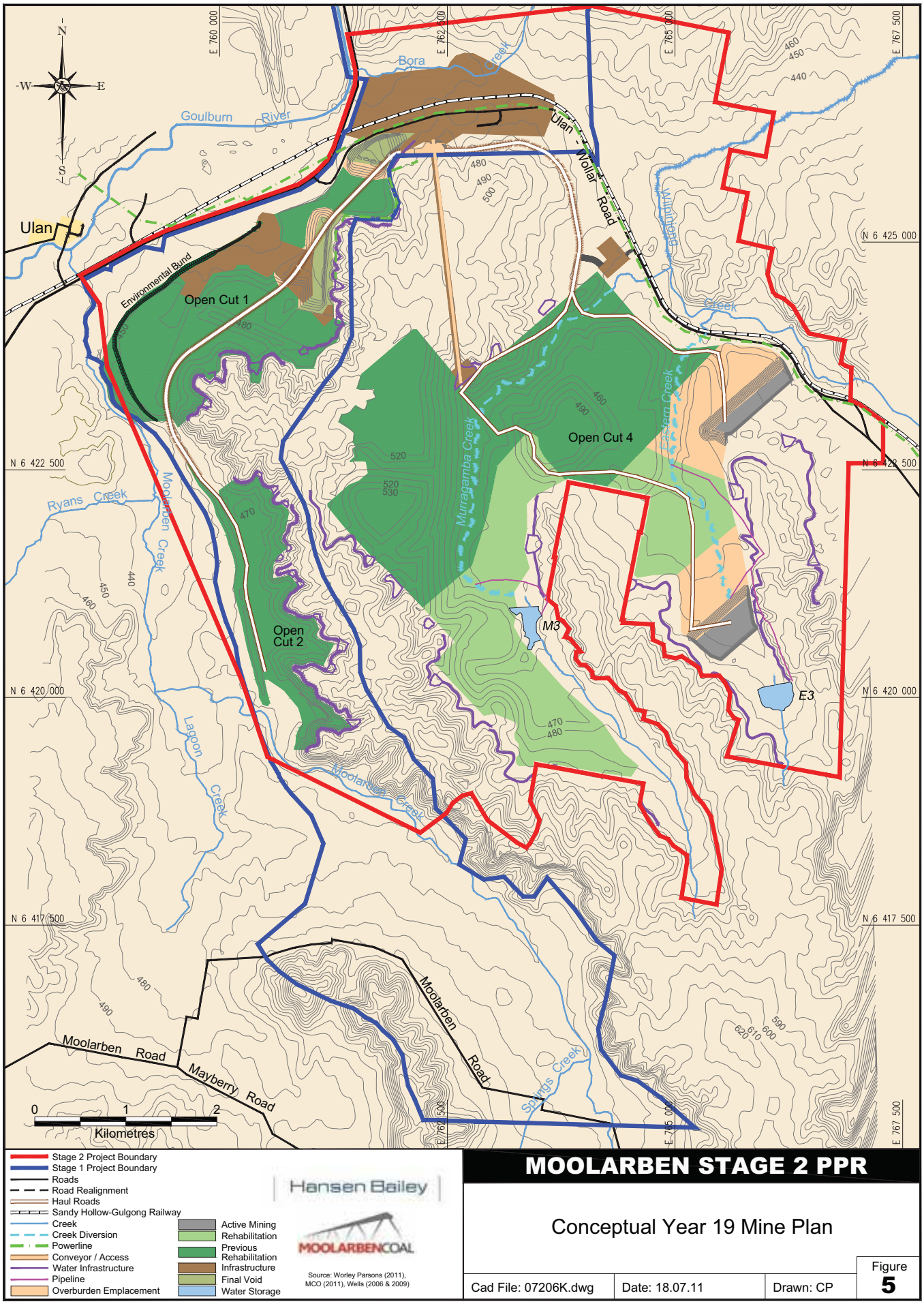

MOOLARBEN STAGE 2 PPR

Conceptual Year 19 Mine Plan

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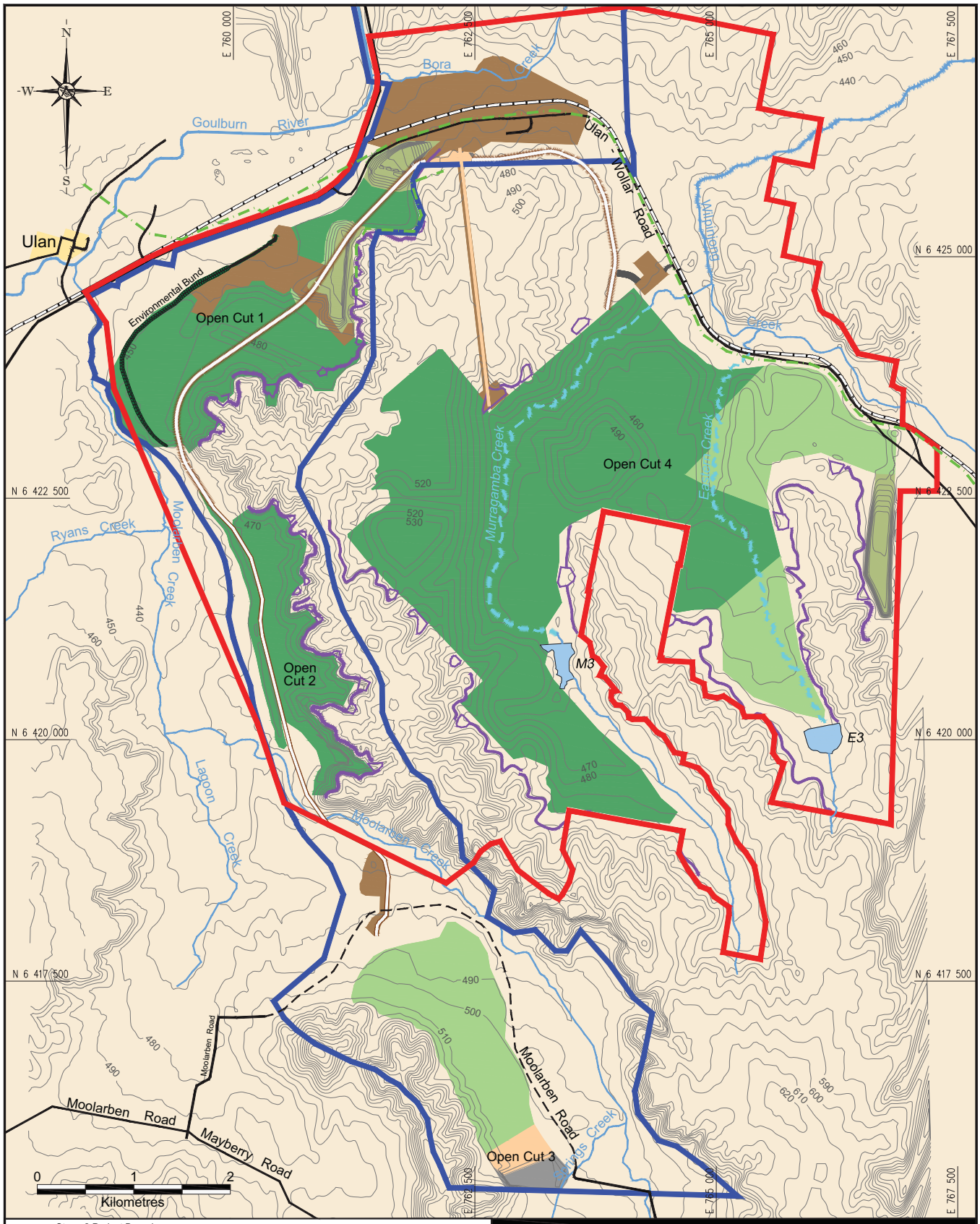


MOOLARBEN STAGE 2 PPR

Conceptual Year 24 Mine Plan

Cad File: 07207K.dwg	Date: 18.07.11	Drawn: CP	Figure 6

2.3.3 Pre-mining Temporary Land Improvement

As part of its rehabilitation objectives, MCM will also assess the viability of temporarily improving degraded areas within the OC4 footprint ahead of mining. A pre-mining land improvement program would consider the viability and effectiveness of the following components:

- Removal of remaining stock;
- Weed control;
- Rehabilitation of salt scalds, where practicable; and
- Seeding and fertilizing of cleared areas with native grass and shrub species.

It is expected that a pre-mining land improvement program would:

- Improve soil structure;
- Increase soil organic content;
- Reduce soil salinity;
- Reduce erosion and loss of topsoil;
- Improve surface water quality;
- Increase native seed bank in the topsoil resource;
- Provide a source of native and endemic seed for revegetation;
- Establish interim habitat and wildlife linkages across the valley floor; and
- Reduce weed invasion in rehabilitated and revegetated areas.

2.3.4 Rehabilitation of Non-mined Areas

In addition to the rehabilitation of mined areas, MCM will also remediate land under its control outside the mine disturbance footprint consistent with the PPR BOS (Cumberland Ecology, 2011). This will include allowing vegetated areas to naturally revegetate, enhancing areas of degraded remnant native vegetation and revegetating cleared areas with native species.

This program will be implemented over the course of the mine life and will increase the quantity of naturally vegetated land leading to improvement in biodiversity outcomes.

3 LANDFORM DESIGN

The proposed final landform has been designed to accommodate the mining sequence; quantity of excavated overburden to be emplaced in the OOP emplacement area and backfilled into the pit; low gradient slopes; drainage channels, swales and sediment ponds; reconstructed creek lines and associated floodplains; and to provide a natural looking landform compatible to that of surrounding areas.

3.1 Open Cut Pit

The backfilled waste rock material will be shaped to its final form as mining progresses through the valleys, including realignment of creeks, floodplains and slopes to key into elevated areas outside the mine disturbance footprint. The final landform will be constructed so that the post mining rehabilitated landscape is self-sustaining. The proposed final landform is shown in **Figure 6**.

The recovery of coal via open cut mining will require the removal and emplacement of almost 800 Million bank cubic metres (Mbcm) of overburden. Approximately 47 Mbcm will be emplaced the Northern out-of-pit emplacement area at the north-western boundary of OC4, where mining will commence (see PPR Section 3.1.1). Overburden will be directly placed in the pit behind the active mining area when sufficient pit void becomes available.

Backfilled pit areas will generally be built up above the pre-mined land surface. This is required to account for bulking and expansion of the excavated overburden material. These areas will be shaped to provide a natural looking landform and will grade down to the re-established constructed creek realignments (**Figure 7**).

The implementation of the conceptual final landform design will focus on minimising the risk of erosion and preventing sediment release into downstream off-site areas. However, it is recognised that erosion will be difficult to manage during the landform reconstruction, top soil spreading and early revegetation stages of rehabilitation works due to the exposed slopes and areas covered in soils that are potentially prone to erosion (see **Section 5**), and seeded areas will require time for effective groundcover to establish. To mitigate this risk, erosion and sediment control measures will be built into the design of the landform and will form an integral component of site rehabilitation. In addition, fast growing, sterile or low competitive cover crops (such as millet or oats) will be used to initially stabilise the reshaped exposed landform, prior to establishing native vegetation cover.

The gradient, shape and length of slopes in the constructed landform will play an important part in controlling water and erosion. The longer and steeper the slope the more prone the landform will be to erosion (Department of Primary Industries 2009). To overcome these potential issues, the final post-mining landform has been designed to comprise slopes with gradients of no more than 10º - 14°.

Slopes will be designed in accordance with contemporary relevant regulators guidelines so as to reduce the velocity of runoff. Where practical, reconstructed landform slopes will be shaped to have non-linear profiles and a high degree of surface roughness. S-shaped slopes and straight slopes offer greater stability than concave or convex slopes (Department of Primary Industries 2009) (Figure 7a and 7b). In addition, the use of graded banks and contour channels may be necessary to break up long slopes and slow down and redirect runoff. These measures will assist to reduce the risk of soil loss and erosion on exposed slopes while effective groundcover is established. Where required, the design, spacing and construction of benches to reduce soil loss and erosion on long slopes will generally follow the design guidelines provided in Figure 7c and **Table 1**.

Table 1
Spacing Guidelines on Slopes (MCA 1998)

Slope (degrees)	Slope (%)	Spacing Between Benches (m)
3	5.2	520
6	10.5	220
7 to 9	12.3 to 15.8	100
9 to 11	15.8 to 19.4	80
11 to 13	19.4 to 23	50
13 to 17	23 to 30.6	30

Engineering controls such as sediment dams, spillways, drainage and diversion channels, rock armouring and drop structures will be incorporated into the final landform to manage the flow of surface water in the post-mining landscape (see Section 4).

3.2 Out-of-pit Emplacement

Where practicable, the external faces of the Northern out-of-pit emplacement will be reshaped to have slopes with gradients of between 10º and 14º. However, where spatial constraints do not allow this, the gradient of out-of-pit emplacement slopes will be constructed to be 20º or less with the approval of relevant regulators. Where practical, steeper slopes will be rock armoured to prevent erosion.

3.3 Creek Diversions

The final landform design includes the realignment of Murragamba and Eastern creeks. Approximately 7 km of Murragamba Creek and 5 km of Eastern Creek will be relocated to maximise open cut coal recovery.

This will require the temporary diversion of surface flows around the mine area and the reinstatement of the creeks in the post-mining landform (generally as shown in **Figure 1** to **Figure 6**).

The design and timing of temporary and permanent creek diversions has been accommodated into the mining sequence. At mine closure both creeks will comprise a mix of natural and reconstructed rehabilitated alignments, consistent with the Concept Design for Proposed Diversions of Murragamba and Eastern Creeks in Appendix G of the PPR (Worley Parsons, 2011).

The concept design for reinstating these creeks exploits the inclusion of natural creek characteristics, such as meanders, pool and rifle structures (to reduce overall bed gradient and flow velocity) and overbank floodplain areas.

The reconstructed creek beds will have a trapezoidal shape which will grade up to an intermediate terrace and then to an over bank floodplain (Worley Parsons 2011). These landform designs follow industry guidelines (Rutherford 2000).

The majority of material excavated through the mining operations will be used as backfill material. However, certain materials have been identified as being of particular benefit to the rehabilitation of the permanent creek diversion (Worley Parsons, 2011). Where practicable, these materials will be stockpiled for reuse in creek rehabilitation works. Materials to be stockpiled include:

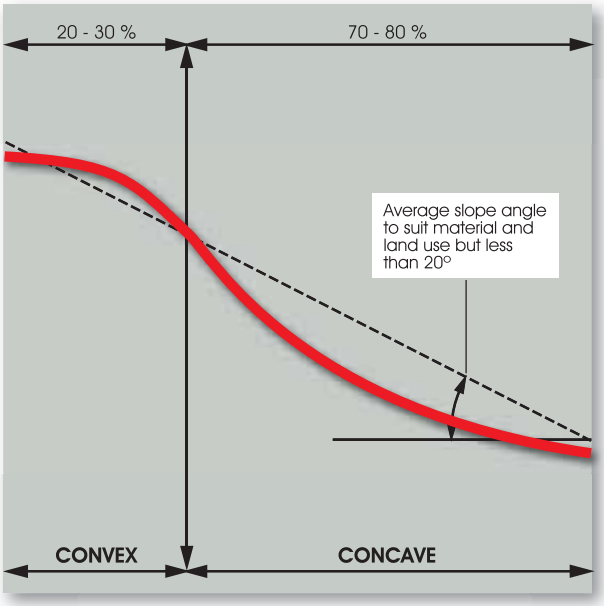
- Topsoils, to be used in rehabilitating creek bed, banks and floodplains;
- Clay soils, to be used in forming a low permeable creek bed;
- Rocks and stones, to be used in constructing rock ramps and drop structures;
- Large wooded material, to be used to create in-stream habitat conditions; and

In the event of a shortfall in these materials, use of off-site sources may be required.

3.4 Final Void

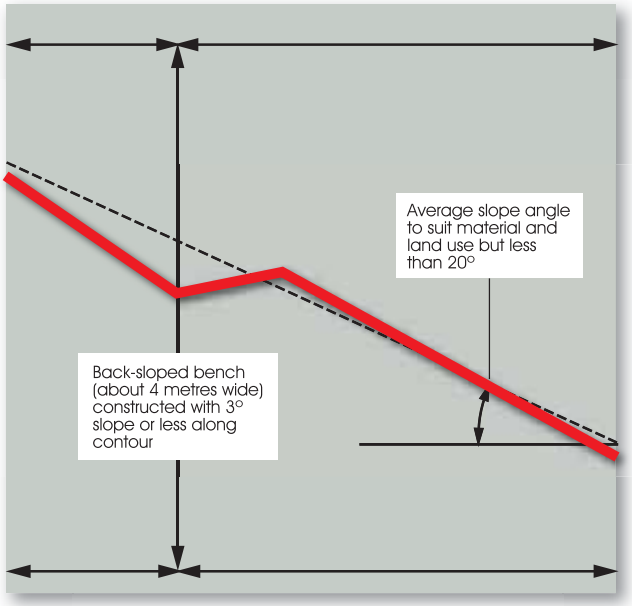
As described in **Section 2.3.1**, the mine plan includes a small void to be left at the completion of mining (**Figure 6**). The final void will provide potential access to adjoining underground and open cut coal resources. The final void will not adjoin Wilpinjong Coal Mine's operations.

a) Ideal slope profile



Sources: Hannan, 1994.

b) Profile design when space limited



Sources: Hannan, 1994.

c) Bank batter profiles

BANK SHAPE	LAND SLOPE	SLOPE OF BANK BATTER TO CHANNEL	EXAMPLE
Broad	0 - 3 %	1 : 6 or flatter	
Semi-broad	3 - 8 %	1 : 4	
Peaked	8 - 20 %	1 : 1.5	

Source: Department of Primary Industries, 2009.

coffey natural systems	Job No: 6015 File Name: 6015_10_F007_HB	Felix Resources Ltd Moolarben Coal Project – Stage 2	FELIX RESOURCES	Recommended design of slope and bank batter profiles	Figure No: 7

4 SURFACE WATER MANAGEMENT AND EROSION CONTROL

Installation of effective drainage and surface water control will be an important aspect of site rehabilitation. Effective surface water management is essential for reducing erosion and creating a stable self draining landform. The design of surface water management structures and controls in the final landform will be influenced by the progressive nature of mining and rehabilitation (see EA Appendix 6A and Worley Parsons 2009). A Water Management Plan (WMP), including erosion and sediment control, will be developed in consultation with technical specialists and government authorities prior to open cut mining.

4.1 Surface Water Management

Surface water will be managed with the aim of minimising erosion, preventing off-site sediment release and increasing water availability for uptake by vegetation in rehabilitated areas. Drainage of rehabilitation areas will be developed in accordance with industry and government guidelines, (Department of Land and Water Conservation 1990 and Landcom 2004).

Runoff from rehabilitation areas will be managed via the inclusion of drainage and diversion channels and sediment dams and retention basins in the post-mining landform. This will control the velocity of surface drainage across rehabilitation areas and assist minimise erosion. Sediment dams and ponded areas will also act to provide habitat features in the final landscape.

Drainage and diversion channels and swales will be installed to divert runoff and carry surface water away from erodible surfaces, particularly during construction and seed emergence stages of rehabilitation. Drainage channels will be designed and built to ensure they reduce flow velocity. This may include use of temporary check structures (such as hay bales), rock armouring or lining to prevent scouring. Ultimately, channels will be vegetated with stoloniferous grasses or other suitable groundcover for long term protection.

Sediment dams and ponds will be incorporated into the mining and rehabilitation sequence and will be designed and constructed to accommodate critical storm events. Sediment dams and ponds will generally be located downhill of disturbance and rehabilitation activities, although some ponds will be incorporated into reconstructed drainage lines in the final landform. This will provide control of sediment laden water and prevent off-site contamination. It will also provide potential ponded water for irrigating rehabilitation areas. The inclusion of sediment dams and ponds into the final landform will increase potential water availability in the post-mining landscape, which will act to provide aquatic and water sensitive terrestrial habitat.

Drainage from rehabilitation areas will be directed to the reconstructed and rehabilitated Murragamba and Eastern creeks and away from the final void. However, during the creek rehabilitation and the subsequent stabilisation period, flows from upslope rehabilitation areas will be diverted around the creek realignments.

The quality of water discharging from the site, either under natural conditions or through controlled release, will be managed to avoid the potential for off-site sediment deposition and pollution of downstream receiving waters.

4.2 Erosion and Sediment Control

Erosion and sediment control measures will be implemented to protect the quality of surface water and reduce the potential for soil loss through erosion. These will be consistent with government and industry guidelines (Department of Land and Water Conservation 1990 and Landcom 2004) and include practices currently implemented in Stage 1. The MCC WMP will include an erosion and sediment control plan which will include measures to control erosion from rehabilitation areas.

Where practicable, the soil surface will be contoured and ripped to further reduce the amount of runoff and to increase infiltration into the reconstructed surface. The use of contour banks on long slopes (**Section 3**) and sediment fencing will also encourage localised water ponding and infiltration. This will potentially increase overall water availability for plants during revegetation.

In addition to the drainage control structures described in **Section 4**, sediment fencing will be installed across and downslope of rehabilitation areas. This will minimise the transfer of sediment from exposed reconstructed land surfaces prior to and during groundcover establishment. Sediment fencing will be constructed to maintain stability during high intensity runoff events and to withstand scouring at the base of the fencing. The sediment fences will also accumulate sediment and organic matter in rows upslope of the fencing, which will potentially provide areas of greater fertility and assist in the general uptake of vegetation.

It is expected that a high percentage of groundcover will be needed to reduce the risk of soil loss from rehabilitation areas. This will be achieved through use of fast growing high density cover crops and supplemented with perennial and stoloniferous grasses. Deep-rooted perennial grasses are better suited to survival during dry periods and recover quickly after rain. Stoloniferous grasses are better suited to sloping land and erosion-prone areas and are also better at maintaining groundcover during dry periods (Department of Primary Industries 2009). Where practicable, drainage channels will be seeded with stoloniferous grasses to maintain soil stability. This will be supplemented with deep-rooted native perennial grasses which will assist in preventing gully erosion.

The choice of appropriate rapid growing grasses will be based on sterile and low competitive species that will allow native endemic vegetation to re-establish in the long-term (see **Section 7**). No species known to be noxious weeds will be knowingly used in the seed mix applied to stabilise rehabilitation areas.

Additional erosion control methods such as the application of Jute or cotton mesh, hay or hydro mulch may be required to provide additional protection to areas that present as being particularly prone to erosion.

5 SOIL AND OVERBURDEN

All soils for rehabilitation purposes will be derived from Stage 2 open cut mine and infrastructure development areas. Topsoil stripping and stockpiling or direct re-spreading of the soil resource will be undertaken in a progressive manner following the mine sequence. The general management practices to be applied prior to and during mining and rehabilitation are summarised in **Table 2**.

Table 2
Soil Resource Management

Prior to Stripping	During Stripping / Stockpiling	Prior to / During Rehabilitation
Quantification of soil resources. Characterisation of the suitability of material for rehabilitation purposes. Formulation of stripping and stockpiling guidelines including the nomination of appropriate depths, scheduling, and location of areas to be stripped and stockpile locations.	Minimise over-clearing, compaction and erosion. Stockpiling based on soil type and physiochemical properties. Stockpiling to preserve soil viability (e.g. low, large surface area stockpiles; located away from disturbance areas; revegetated to prevent erosion; and weed control).	Implementation of amelioration measures to ensure the long term viability of soil resources and to manage salinity. Management of soil suitability for rehabilitation. Progressive reuse and spreading on final landforms as soon as practicable. Weed control.

5.1 Available Resources

5.1.1 Soil Resources

Up to eight distinct soil types occur within the Stage 2 disturbance areas (see Stage 2 EA Section 5.11 and Stage 2 EA Appendix 11). The recommended stripping depth, areal extent and approximate volume available for rehabilitation purposes for each soil type are summarised in **Table 3**. The available soil resource includes the A1 horizon and top 0.1 to 0.2 m of the A2 soil horizon. The total amount of soil available for Stage 2 rehabilitation purposes is estimated to be about 8,042,300 m^3.

Table 3
Topsoil resource availability – Stage 2

Type	Stripping Depth (cm)	Stripping Area (ha)	Volume (m^3)
Yellow Solodic	30*	544	1,631,400
Yellow Podzolic	30*	188	562,800
Earthy Sand	100	526	5,261,000
Red Podzolic	25*	44	109,250
Red Earth	100	36	355,000
Alluvial	45	9.3	41,850
Euchrozems	100#	8	81,000
Lithosol	0	265	-
Total	N/A	1619	8,042,300

* Stripping depth has incorporated the blending of the top 10 to 20 cm of the A2 horizon to increase topsoil volume.

Subject to investigation prior to disturbance.

5.1.2 Overburden Resources

Mining of OC4 will require the removal and storage of about 800 Mbcm of overburden. In addition, about 4 Million tonnes per annum (Mtpa) of coarse rejects and tailings will be generated from the washing of coal when the MCC is operating at full capacity. Following initial out-of-pit emplacement of up to 47 Mbcm of overburden, all other waste rock (i.e. overburden, coarse rejects and tailings) will be used to backfill the mine void.

Selected overburden materials (e.g. clay subsoils and large rocks) will be stockpiled for later use, or used directly, in the reconstruction of Murragamba and Eastern creeks.

5.2 Physical and Geochemical Characteristics

5.2.1 Soil Characteristics

Field and laboratory tests indicate that the soils are mainly acid in nature, have low organic matter content, are deficient in all major nutrients (such as phosphorus, sulphur and nitrogen) and are highly erodible (Stage 2 EA Appendix 11). They are generally non-saline (EC_{se} < 2 dS/m) but may be prone to dryland salinity outbreak (there is some occurrence of saline discharge from soils within OC4).

The suitability of the Stage 2 soil types for rehabilitation is summarised in **Table 4**. This table also includes a brief description of chemical and physical characteristics for each soil type, as determined from testing (EA Appendix 11).

Table 4
Topsoil suitability for rehabilitation purposes

Soil Type	Soil Horizon	Rehabilitation Suitability	Physical and Chemical Characteristics
Yellow Solodic	A1	Suitable if ameliorated	Acid pH with severe dispersive qualities, excessive Mg levels (low Ca:Mg ratio), poor fertility, low Ca
	A2	Suitable if ameliorated	Acid pH with severe dispersive qualities, excessive Mg levels (low Ca:Mg ratio), poor fertility, low Ca
	B	Not suitable	Dispersive clay, excessive Mg and Na levels
Yellow Podzolic	A1	Suitable if ameliorated	Acid pH with severe dispersive qualities, excessive Mg levels (low Ca:Mg ratio), poor fertility
	A2	Suitable if ameliorated	Acid pH with severe dispersive qualities, excessive Mg levels (low Ca:Mg ratio), poor fertility
	B	Not suitable	Dispersive clay
Earthy Sands	A1	Suitable for blending only.	Acid pH, elevated Al levels, high sand content.
	A2	Suitable for blending only	Acid pH, elevated Al levels, high sand content with moderate dispersive qualities
	A3	Suitable for blending only	Acid pH, elevated Al levels, high sand content with severe dispersive qualities
	A3	Not suitable	Dispersive clay, high Na and Mg levels
Red Podzolic	A1	Suitable if ameliorated	Acid pH with severe dispersive qualities, elevated Al levels, poor fertility
	A2	Suitable if ameliorated and blended	Acid pH with severe dispersive qualities, excessive Mg levels (low Ca:Mg ratio), poor fertility, sand gravel content exceeds 60%

Soil Type	Soil Horizon	Rehabilitation Suitability	Physical and Chemical Characteristics
	B	Not suitable	Dispersive clay, high Na and Mg levels.
Red Earth	A1	Suitable for blending only	Acid pH, elevated Al levels, high sand gravel content
	A2	Suitable for blending only	Acid pH, elevated Al levels, high sand gravel content
	B	Suitable for blending only	Acid pH, elevated Al levels, high sand gravel content
Alluvial	A1	Suitable if blended and ameliorated	Acid pH with moderate dispersive qualities, elevated Mg levels, poor fertility
	A2	Suitable if blended and ameliorated	Acid pH with moderate dispersive qualities, excessive Mg levels (low Ca:Mg ratio), poor fertility, sand gravel content levels are high
Euchrozem	A1-B	Highly suitable	Neutral to alkaline pH, low erosion hazard, moderate to high fertility, potentially elevated Mn at depth

5.2.2 Overburden and Waste Rock Characteristics

Geochemical tests on overburden materials indicate that only a small proportion of overburden is potentially acid forming (PAF) and operational mixing may be sufficient to control any acid rock drainage (ARD) from these materials in the final landscape. However, this will depend on the overall distribution of PAF materials and the acid potential. Alternatively, the PAF overburden materials may need to be selectively handled (EA Section 5.16). This will be investigated through further testing of overburden materials over the course of the mine life.

In addition, geochemical testing of coal rejects has indicated that these materials present a higher ARD risk than overburden materials, and may require specific management to control ARD (**Section 5.2.2**).

5.3 Limitations

5.3.1 Soil Limitations

Acidic soils with low organic and nutrient content provide unfavourable conditions for seed germination and maintaining plant vigour. Highly dispersive soils also pose problems for erosion and sediment control in the post-mining landscape.

These factors will require the application of special soil management practices to improve fertility and to reduce soil loss in the post-mining landscape. Suitable management techniques and use of soil amendments will be developed in consultation with a rehabilitation expert or agronomist.

5.3.2 Overburden and Waste Rock Limitations

Bulk swelling of excavated overburden by 25% will require landform construction above the existing valley floor surface, even though additional void space will be created by the extraction of up to 13 m of coal from the bottom of the pit.

Materials identified as PAF and capable of ARD will be managed and placed deep within the backfilled pit so as to prevent any long-term degradation of rehabilitated surface areas and water courses.

Compaction of the surface of the overburden in backfilled pit areas will potentially prevent plant root penetration and lower plant water availability. This will be managed by deep ripping compacted surfaces prior to topsoil spreading or direct seeding or planting of overburden areas, where required (Nichols 2005).

5.4 Soil Management

Where practicable, the following management practices will be implemented to improve the available soil resource for use in rehabilitation:

- Soil types will be blended to improve the overall quality and quantity of the existing soil resource;
- Vehicular traffic on soils to be stripped and on soils sensitive to structural degradation will be minimised;
- Loaders and trucks will be used during stripping rather than scrapers to minimise structural degradation of the soil;
- Soil stockpiles will be kept as low as possible with large surface area;
- Soil stockpiles will be managed to reduce weed growth;
- Long-term soil stockpiles will be located outside of mine disturbance areas;
- Long-term soil stockpiles will be revegetated with native species;
- Soil stockpiles will be deep ripped prior to reinstatement;

- Application of appropriate (type and quantity) soil amendments and fertilisers (e.g. sodic and dispersive soils will be treated with gypsum or lime, as required, where they are to be used on exposed surface areas); and
- Planting of appropriate groundcover species on soils identified for future stripping and rehabilitation use, to improve soil structure, organic content and native seed bank.

The application of these measures will assist preserve and improve overall soil health; reduce soil loss and weed growth; and ultimately assist in re-establishing native vegetation on rehabilitation areas. This is discussed further in **Section 6.3**.

6 SITE PREPARATION

6.1 Vegetation Management

Stage 2 will require the staged clearing of approximately 902 ha of intact native vegetation. This vegetation contains valuable habitat (e.g. tree hollows and large trees) and timber (e.g. fence posts) resources. Where practicable, these will be salvaged, stockpiled and re-used in the rehabilitated landscape. Re-use of timber resources will include:

- Reinstatement of nesting hollows;
- Reinstatement of arboreal fauna and avian roosting sites;
- Establishment of habitat for reptiles and small ground dwelling fauna;
- Establishment of large woody debris in reconstructed creeks and drainages as habitat;
- Use as erosion control structures; and
- Use as fence posts.

Habitat salvage will be undertaken prior to and during land clearing. In addition to timber, large rocks may be salvaged as habitat or for use in the reconstructed creeks.

Vegetation clearing will generally be carried out three to six months in advance of mining and only the area identified to be mined in the short-term, in the progressive mine sequence, will be cleared. This will minimise the potential for land degradation and reduce the overall extent of exposed and disturbed areas. Any flora identified as requiring retention or relocation (e.g. specimens of endangered species) will be identified and salvaged prior to land clearing.

The clearing of vegetation will typically involve:

- Selection and marking of significant hollowed and potential habitat trees for use as whole or in part timber habitat in the rehabilitation process;
- Cropping of revegetated areas for collection of native seed;
- Collection of seed from a variety of species prior to and during the clearing operations; and
- Removal of remaining tree limbs, stumps, shrubs and other woody vegetation that may be mulched or used in whole or in part for post-mining rehabilitation.

During vegetation clearing, non-habitat vegetation will either be mulched in-situ, stockpiled for later mulching or re-use as large woody debris, or disposed of in some other manner. Timber not salvaged for habitat and considered too large for mulching (such as large tree trunks and branches) will be stockpiled for future use in the rehabilitated landscape, including use in creeks, where practicable.

While mulching is the preferred option, some areas of vegetation or vegetation species may not engender themselves to re-use. In this case, alternative uses or alternative means of disposal may need to be investigated and implemented. However, this will be done in consultation with a rehabilitation expert.

Where mulching is performed in-situ, the mulched material will be placed back onto the soil area and collected with the topsoil during the stripping process. This practice will result in the mixing of mulch into the soil which when composted will enhance soil nutrient levels and water holding capacity. This process has performed successfully in the initial stages of mining and rehabilitation associated with the Stage 1 Project. Where mulching is performed ex-situ, mulched material will be stockpiled and allowed to compost for later use on areas undergoing rehabilitation.

6.2 Topsoil Stripping

Viable topsoil is recognised as one of the most important factors in successful rehabilitation. Throughout the life of Stage 2, topsoil will be managed so as to improve soil health and fertility, and to improve its long-term viability for use in rehabilitation. Topsoil stripping, stockpiling and re-spreading will be planned to make optimal use of the available resource.

Erosion and sediment control structures will be installed around the perimeter of the area prior to stripping to reduce the loss of soil.

Topsoil will be stripped progressively, which will reduce the period over which topsoil will be stockpiled. Soil and the mulched vegetation material will be collected together and mixed. This will lead to increased soil organic content. The timing of stripping will be considered and efforts made not to strip soils when they are too dry or too wet, as this can lead to compaction, loss of structure and loss of seed viability and mycorrhizal inoculums. Stripping will be conducted using loaders and trucks rather than scrapers to minimize the damage to soil structure (i.e. soil peds).

Topsoil stripping will be undertaken no more than one month prior to mining. Areas of weed infestation (such as areas previously used for grazing) will be delineated and the topsoil in these areas will be stockpiled and treated separately, in order to minimise the spread of weeds.

6.3 Long-term Soil Stockpiles

Soils will be selectively stockpiled according to their physical and chemical characteristics where they cannot be used directly for re-spreading on rehabilitation areas. This will aid in the management of soils between stripping and reinstatement. Where practicable, the application of the following soil management practices will improve the long-term viability of the soil resource where stockpiling is required:

- Stockpiles will be located in areas free of slopes, natural drainage and traffic routes;
- Stockpiles will be located outside of the proposed mining areas, however efforts will be made to locate stockpiles as close to the target area for rehabilitation as possible;
- Soil types identified as saline will be stripped and stockpiled separately over an aggregate substrate to allow leaching of salt concentrations over time;
- Silt fencing will be installed around stockpiles to minimise erosion and loss of soil;

- Stockpiles will be small – maximum 60 cm in height to maintain soil micro- and macroflora biology; or, if this is not possible, maximum 3 m in height to minimise problems associated with anaerobic conditions;
- Stockpiles will be formed with regular surfaces (i.e. without peaks and troughs) to enable easier weed scalping;
- Inactive stockpiles will be fertilised to maintain soil fertility and seeded with native species as soon as possible to increase the native seed bank, aid in erosion control, and help prevent weeds;
- Soil amendments (i.e. gypsum and lime) and imported organic materials (in addition to the mulch incorporated during stripping) such as biosolids, may be applied to stockpiles, pending appropriate approval;
- Long-term stockpiling (i.e. stockpiling for more than 6 months) will be stabilised with permanent native vegetation and possible barrier systems to control erosion and weeds;
- Stockpiles will be inspected regularly, particularly after storm events, with eroded areas stabilised as required;
- Weed growth on stockpiles will be monitored and subsequently controlled if necessary. Herbicides will be applied to control weeds and reduce the weed seed bank;
- Prior to the reapplication of stockpiled soil for rehabilitation, stockpiles will be deep-ripped to establish aerobic conditions; and
- Stockpiles will also be appropriately labelled and their position recorded. This will ensure the material is not misused for other construction purposes at the site or disturbed.

6.4 Soil Improvement

Soil tests will be conducted to determine the chemical properties and nutrient levels of soils, and to determine if amendments are required. Application of soil amendments will ensure the best conditions for plant growth are achieved. Amendments may include gypsum or lime to improve soil pH and soil structure and fertilisers to increase nutrient levels. However, use of fertilisers may favour competitive species and prejudice establishment of local native species. While inorganic fertilisers are commonly used, recent research has identified the value of biosolids in mine site rehabilitation (Department of Industry Tourism and Resources 2006).

The use of biosolids at the MCC will be investigated in consultation with the Office of Environment and Heritage (OEH) and Mid-Western Regional Council. Potential use of biosolids in rehabilitation will also depend on the availability of a suitable source.

A rehabilitation expert or agronomist will be engaged to determine the amount and application rate of amendments (including fertilisers) to be added to the soils. This may also require the use of field trials in the early years of rehabilitation.

6.5 Weed Control

Weed control will be undertaken through seeding of rehabilitation areas and stockpiles with native species, through targeted use of herbicides and through selective handling of soils. Herbicides that target locally found weeds and avoid impacting native species will be selected. For example, Atrazine has been found to control a number of broad leaf and annual grass species, yet does not affect native grasses (Cole & Lunt 2005).

6.6 Soil Reinstatement

Where practicable, topsoil will be spread onto rehabilitation areas to ensure that:

- Topsoil is distributed in a uniform manner to a thickness of at least 50 mm, or consistent with its pre-mining thickness; and
- Gradients are maintained in accordance with the rehabilitation plan.

This will provide the best conditions possible for plant establishment and growth and will minimise erosion and land instability.

Where possible, topsoil will be immediately replaced in areas where landform reconstruction is complete. This avoids the need for double handling and long-term stockpiling of soils which can degrade the quality of the soil resource (Department of Industry, Tourism and Resources 2006).

Once reinstated the soil and underlying emplaced overburden will be deep ripped. This will key the soil into the emplaced overburden and will reduce soil loss potential.

Following reinstatement, surfaces will be vulnerable to large scale sheet erosion and wind erosion. This will be avoided by planting a fast growing cover crop to bind the soil and reduce erosion potential (see **Section 4.2**).

7 REVEGETATION TECHNIQUES

Global Soil Systems review of the EA raised concerns that part of the revegetation strategy for Stage 2 placed a strong reliance on the establishment of large tracts of native grasslands, with clumped tree and shrub plantings to enhance landscape and ecological values. Establishing vast grasslands is not the goal, although some grassland areas will be incorporated into the final landscape to provide foraging habitat for woodland birds. Areas of re-established native grasslands will form a subsidiary component of the rehabilitated and revegetated landscape and will generally be restricted to flat or gently sloping areas where the risk of erosion is low.

It is envisaged that at mine closure the landscape will be dominated (at least 80% coverage) by forest and woodlands at various stages of progressive establishment. The remaining areas will comprise native grasses and riparian habitat.

7.1 Temporary Revegetation Measures

7.1.1 Temporary Revegetation of Pre-mining Areas

As described in **Section 2.3.3**, existing cleared, disturbed and degraded areas proposed for mining in future years will be temporarily revegetated and improved, where practicable. These temporary rehabilitation measures will improve soil condition and increase the native vegetation seed bank, which will improve the overall quality of the soil resource for use on mine-rehabilitation areas. Temporary rehabilitation will occur on land planned for mining approximately seven years in advance of the active pit area. Temporary revegetation and land improvement activities will include the removal of weeds, ripping of soil and seeding with native grasses. Temporary erosion control and addition of soil amendments may also be applied to these lands.

7.1.2 Temporary Revegetation of Post-mining Areas

Once earth works (i.e. landform shaping) are complete, the surface will need to be revegetated as quickly as possible. Good surface preparation will be an essential part of attaining successful revegetation.

The reshaped post-mining landform will be sown with a fast growing high density sterile cover crop to reduce the risk of soil loss and erosion. The use of temporary cover crops will assist stabilise the reconstructed surface, slow water flow, bind the soil and increase soil organic content. Examples of cover crops that will be considered for use include Japanese millet, oats and cereal rye.

The most suitable cover crop will be tailored to the time of year when seeding and groundcover establishment is required. Consideration will also be given to using a mix of crop varieties.

The objective will be to produce a thick groundcover to immediately stabilise the surface. This will require a heavy rate of seeding and most likely the application of fertiliser to stimulate germination and growth of the cover crop.

The type, amount and rate of seed and fertiliser mix to be applied to exposed areas will be determined in consultation with a rehabilitation expert or agronomist.

7.2 Permanent Revegetation Measures

7.2.1 Permanent Revegetation of Post-mining Areas

Following the establishment of a temporary cover crop and during its senescence, rehabilitation areas will be seeded with a mix of native perennial grasses (such as wallaby and kangaroo grass, depending on season) and endemic shrub and tree species. Native grass species have varying responses to fertiliser use and this will need to be considered when introducing these species into the seed mix.

The shrub and tree seed mix will be adjusted to ensure that sown species are compatible with the landform (i.e. slope). Sowing rates will also be adjusted to achieve a balance of forest and woodland stands. Areas sown by direct seeding will be supplemented with tube stock of targeted endemic species.

As described previously, small non-treed areas will be established to enhance woodland bird habitat (e.g. Hooded Robbins, Diamond Firetails and Grey-crowned Babblers). These areas will be seeded with select native grasses and will generally be limited to low angled or flat lying areas (i.e. low erosion risk areas). The total area of grasslands will be limited to between 10 and 20% of the total rehabilitation area

Stoloniferous grass may need to be included in the native seed mix to ensure groundcover is maintained during establishment of endemic shrub and tree communities. A suitable variety (such as couch) could be sown at a light application rate (e.g. 5 kg/ha). As described in **Section 4.2**, stoloniferous grass will also be used to stabilise drainage channels.

It is also expected that cover crops, perennial and stoloniferous grasses and endemic native species will respond differently to the use, type and application rate of fertilisers. Further, that these species will be competing with each other for the potentially limited resources (i.e. soil water and nutrients) within the rehabilitation areas. Hence, it will be necessary to conduct revegetation trials so that optimum species mix, sowing rates, tube stock planting density and fertiliser use can be determined.

A range of native and stoloniferous grasses and trees are proposed for revegetating the in-channel bench and channel side slopes of the reconstructed creek alignments. The potential for erosion along the in-channel terrace will be mitigated through the use of dense copse of deep-rooted tree species with soil binding characteristics.

Dense tree coverage will increase the thickness of the boundary layer over the bank, thereby reducing shear stresses acting on the surface of the bank during high flows. The dense copse will be aligned so as to centralise low and mid-bank flows, and thereby minimise erosion potential. Native species selection (**Section 7.4.1**) and planting density will enhance habitat, and provide shade protection to the banks and in-stream habitat.

Regular monitoring and adoption of adaptive management practices will be important during the initial establishment stages of revegetation. Species selection and monitoring will also be important to discourage dominance of competitive native fauna (e.g. Pied Currawong and Noisy Minor) and exotic fauna species (e.g. Black Birds and Starlings).

Competitive native and exotic fauna species are known to out-compete and displace more sensitive native species (e.g. Hooded Robbins, Diamond Firetails and Grey-crowned Babblers) which are preferentially desired to inhabit the post-mining landscape.

Shrub density can improve habitat for the more sensitive native fauna, and this will be considered in the selection, seeding and planting of rehabilitation species.

Species selection, seeding and supplemental tube stock planting will be designed to promote the development of understorey, mid-storey and canopy coverage on rehabilitation areas that is similar to existing forest and woodland areas in surrounding areas.

7.2.2 Permanent Revegetation of Non-mining Areas

MCM will improve cleared and degraded areas outside the mine disturbance footprint on land within its control in accordance with the BOS (Cumberland Ecology, 2011). On these lands, natural regeneration of native species will be supported. This will require the application of land improvement methods to arrest degraded and eroding areas. This may include earthworks to restore effective drainage, ripping of compacted areas and application of soil amendments to improve soil condition and plant regeneration potential. It will also include the implementation of weed and pest control programs. Fencing may also be required to prevent stock access from neighbouring land users, where this is deemed to be a problem.

Following surface preparation, restored land surfaces will be seeded and supplemented with tube stock, as described in **Section 7.2.1**.

7.3 Seed Collection and Management

Seed collection on naturally vegetated areas will be carried out across the MCC and surrounding areas on a seasonal basis for the life of the mine. Native seed collection has already commenced in Stage 1 areas and this will be extended to Stage 2 areas. Only seeds of native species will be collected so as to avoid the spread of weeds and exotic species.

Priority will be given to seed collection from areas and species cleared for mining. Locally harvested native seeds will be supplemented with commercially sourced seeds.

Harvested seeds not used in direct sowing or production of tube stock will be stored for future use on rehabilitation areas. Storage and management of seed stocks will be done according to best practice so as to maintain seed viability. This will include:

- Storage of seed in paper or calico bags;
- Labelling of seed collection and storage bags with relevant details (e.g. species and collection and storage dates); and
- Maintenance of a seed inventory which will record the amount of seed collected, species type and treatment and propagation specifications.

Collected seeds will be used to seed long-term soil stockpiles, topsoil respread on rehabilitation areas and ripped off-site regeneration areas. Collected seeds will also be used to produce tube stock for planting on rehabilitation areas.

This may require the establishment of an on-site nursery so that locally harvested seed not used in direct sowing can be germinated and developed into tube stock for later planting on rehabilitation areas. Alternatively, local nursery facilities will be supported.

Use of nursery facilities will provide a controlled environment for germination and production of native seedlings. This will enable moisture availability, temperature, pests and native animal grazing to be managed during germination and emergence when seedlings are most vulnerable.

Collection of native grass seed will be enhanced through the temporary revegetation measures to be implemented on areas ahead of mine development, as described in **Section 7.1.1**.

7.4 Species Selection

The final landform and post-mining land use objectives will dictate the composition and structure of species to be established for rehabilitation. The re-establishment of ecological function conducive to the development of Box Woodland EEC will be a key feature of the rehabilitation of OC4. Species will be chosen to improve faunal biodiversity and habitat. As described in **Section 7.2.1**, shrubs and small patches of native grasslands will be used to improve habitat for declining woodland bird species (e.g. Hooded Robins and Grey Crowned Babblers) and control dominance of competitive native and exotic species.

Rehabilitation areas will be seeded with a combination of native perennial grasses, shrubs and woodland species consistent with those species found in the local area (**Section 7.2.1**). Species selection will be designed to promote the development of forest and woodland with structured understorey, mid-storey and tree canopy coverage. This will increase overall biodiversity values and promote survival of these vegetation types in the post-mining landscape.

The Hunter Central Rivers Catchment Management Authority has developed a resource kit to guide effective management of native vegetation (Bushland Resource Kit, undated).

This includes a comprehensive list of native plant species found in the Hunter Catchment. This species list will be used in combination with the species identified in the Ecological Impact Assessment (Stage 2 EA Appendix 7) to guide selection of appropriate native species for rehabilitation of disturbed Stage 2 areas in accordance with the BOS (Cumberland Ecology, 2011).

Species selection will take into consideration climate (e.g. water availability and frosts), landform (e.g. slopes, floodplains and creeks), soil availability and nutrition.

Terrestrial Species

Priority will be given to revegetating mined areas with EEC species found within and surrounding the mine disturbance footprint. This includes:

- Blakely's Redgum – Rough Barked Apple Woodland;
- Blakely's Redgum – Yellow Box – Apple Woodland;
- Grassy White Box Woodland; and
- Lowland Box – Redgum Woodland.

Threatened local flora (e.g. Ausfield's Wattle, Painted Diuris, Cannons Stringybark, Hoary Sunray and Scant Pomaderris) will also be targeted for planting in areas conducive to their establishment and survival. This will be guided by input from an ecological expert and consistent with the BOS (Cumberland Ecology, 2011).

Other terrestrial vegetation communities targeted for seeding and planting in rehabilitation areas will include:

- Ridgetop Broad-leaved Ironbark - Black Cypress Pine;
- Hardcap Scribbly Gum – Ironbark Woodland;
- Broad-leaved Ironbark – Grey Gum Forest;
- Footslope Box – Gum – Ironbark;
- Grey Box - Narrow-leaved Ironbark Forest;
- Lowland Ironbark Forest;
- Shrubby White Box Forest;
- Scribbly Gum Narrow-leaved Ironbark Woodland; and
- Rough-barked Apple – Banksia Woodland.

Where practicable, vegetation species comprising these communities will be seeded and planted in rehabilitation areas adjacent to or in close proximity to undisturbed natural occurrences of these vegetation types. This will enhance connectivity of similar communities and habitat types between rehabilitated areas and surrounding naturally vegetated areas.

Endangered plant species or communities will be replaced close to their area of origin in the pre-mining landscape. Where possible, threatened species and endangered community vegetation types will also be enhanced or planted in restoration areas outside the mine disturbance footprint.

It is recognised that transitional habitats between valley floor (i.e. Western Slopes Grassy Woodlands) and adjoining ridge tops (i.e. Western Slopes Dry Sclerophyll Forests) are locally important and contain substantial biodiversity values. Hence, where practicable, targeted seeding and planting within rehabilitation areas will attempt to also re-establish areas of transitional habitat.

Examples of existing native vegetation in and surrounding OC4 are shown in **Plate 1** to **Plate 5**.

7.4.1 Riparian Species

Rehabilitation measures will be incorporated into the post-mining creek design to increase habitat and diversity, minimise erosion, sedimentation and instability. This will include planting of native perennial grasses and deep-rooted woodland species (such as Box and Redgum) on upper and mid banks. The use of native endemic riparian species will increase groundcover and provide cohesion of the banks.

Table 5 lists a selection of species that are proposed for use in revegetating the reconstructed creeks. Where necessary, these will be supplemented with other groundcover (such as stoloniferous grasses) to ensure the creek beds are appropriately protected against erosion.

Examples of existing good quality riparian vegetation along creek lines in OC4 are shown in **Plate 6** and **Plate 7**.

Table 5
Riparian species proposed for Creeks Revegetation

Location	Species
Upper banks	Blakely's Redgum – clayey soils Yellow Box Grey Box Mudgee Wattle, Western Silver Wattle – sandy soils Broom Bitter Pea – clayey soils Kangaroo grass Rough-barked apple (Angophora floribunda) – sandier soils
Mid banks	Thyme Honey-myrtle – clayey soils Tantoon – sandy soils Shorthair Plumegrass Mat-rush Kangaroo grass Blakely's Redgum Rough-barked apple
Lower banks	Reedgrass Thyme Honey-myrtle

7.5 Seeding and Planting Techniques

Various techniques exist for seeding and planting of rehabilitation areas and these will be investigated during the early years of rehabilitation with the best techniques being carried through for use in later years. Consideration will be given to site conditions, including soil type and condition, landform, time of year, climate, water availability and vegetation community establishment outcomes.

A seeding and planting specification will be provided to any subcontractors engaged to carry out the rehabilitation works. Surface preparation techniques, planting techniques, fertiliser and water application rates will be developed in consultation with a rehabilitation expert or agronomist. The specification will be regularly updated to include the findings from rehabilitation trials and monitoring. This will ensure successful methods with good strike rates will be developed and applied in a progressive manner.

Plate 1 Example of remnant native forest within the footprint of OC4

Plate 2 Example 1 of remnant native forest on ridge line areas above OC4

Plate 3 Example 2 of remnant native forest on ridge line areas above OC4

Plate 4 Example of remnant native forest upslope from OC4

Plate 5 Example of remnant native forest along footslope drainage channel

Plate 6 Example of riparian vegetation along Eastern Creek

Plate 7 Example of riparian vegetation along Eastern Creek

8 REHABILITATION PERFORMANCE

Performance indicators for successful vegetation coverage; ecological development and function; and rehabilitation completion will be developed in consultation with rehabilitation and ecological experts and with government authorities and will be described in the ROMP. It is expected that this will include references to the ROMP land and water management outcomes and appropriate timelines for achieving rehabilitation objectives.

Rehabilitation performance criteria will be defined during early rehabilitation and agreed upon in consultation with the government authorities. This may include:

- Surface and slope stability;
- Runoff water quality;
- Soil and root zone properties (including soil biota);
- Minimum canopy cover;
- Minimum tree height and girth standards for a selected indicator species at different years;
- Structural attributes of plant communities;
- Composition of plant communities;
- Key fauna species (type and quantity) in revegetated areas;
- Abundance of fauna;
- Presence of weeds and pest species;
- Indicators of ecosystem functioning; and
- Adequacy of fire breaks.

Where feasible, rehabilitation performance will be evaluated against undisturbed reference sites for key indicators (see **Section 10**). There will also be a strong focus on ecosystem function (i.e. landscape development, vegetation dynamics and habitat complexity), rather than simply evaluating vegetation performance. Rehabilitation performance criteria will be included in the ROMP and may include:

- Vegetation:
    - Species diversity: e.g. at least four over-story and four understory species in each 20 m x 10 m plot at all ages;
    - Stem densities: e.g. minimum total tree and shrub densities at nominated development ages:

1 year	3,000 stems/ha
5 years	1,000 stems/ha
15 years	500 stems/ha

    - Evidence of regeneration: e.g. evidence of natural regeneration of at least four indicator species at Year 10;

  - Canopy density: e.g. 50 trees per hectare with a 10 m wide canopy, providing 3,000 m^2 of canopy cover at Year 15; and
  - Understorey density.

- Fauna:
  - Species diversity: e.g. evidence of invertebrates, reptiles, birds, mammals and aquatic species; and
  - Species type: e.g. evidence of foraging or nesting of key indicator species.

- Soil and Water:
  - Soil pH: e.g. pH of replaced soil to be in the range of 6.0 to 8.0 after 5 years (or within the pH limits of the off-site reference sites);
  - Soil conductivity: e.g. replaced topsoil to be below 900 µS/cm after 5 years (or within the EC of the off-site reference sites);
  - Soil fertility: e.g. nitrogen and phosphorous levels to be within 20% of levels in the off-site reference sites after 10 years;
  - Soil biota;
  - Soil loss: e.g. less than 40 t/ha/year;
  - Runoff water quality: e.g. to be less than 100 µS/cm after 5 years; and
  - Surface water quality: e.g. meet ANZECC guideline water quality criteria for upland rivers during all time periods.

9 MAINTENANCE STRATEGY

Maintenance of rehabilitation areas is recognised as being essential in creating a sustainable post-mining ecosystem. Rehabilitation areas at the juvenile stage are prone to invasion of weeds and pests and self-sustaining conditions may take many years to reach.

Maintenance of Stage 2 rehabilitation areas will focus on re-establishing natural processes including surface stability, cycling of nutrients and plant lifecycles. This may require:

- Maintenance to eroded areas and creek beds;
- Application of fertiliser or other soil amendments;
- Control of seed predation;
- Watering of plants, especially in the establishment phase;
- Control of pests and weeds;
- Control of feral and native animals;
- Replanting failed or unsatisfactorily revegetated areas; and
- Fire management (restriction of fire through juvenile communities).

Intensive maintenance will be required during the establishment phase with input efforts tapering as plant and ecological communities become established. Some maintenance actions will need to be continued for the duration of the rehabilitation phase, such as controlling weeds, pests and native grazers (e.g. kangaroos), as well as fire management (Nichols 2005).

Climate and rainfall will also play an important role in the amount of maintenance required. For example, watering may be required during drought and in summer months when rainfall is low. Drought can significantly impact both the success of initial establishment and successional trends within rehabilitated areas (Nichols 2005), while intense storm events can lead to erosion and soil loss.

Monitoring of rehabilitation (**Section 10**) areas will identify locations where targeted maintenance and management actions are required.

10 MONITORING STRATEGY

A monitoring program will be developed for inclusion in the ROMP as relevant and will be implemented to enable:

- Performance of Stage 2 rehabilitation to be assessed;
- Areas that require maintenance or targeted management to be identified;
- Compliance with regulatory requirements to be demonstrated; and
- Progress against rehabilitation objectives and performance measures to be reported.

The monitoring program will be developed in consultation with rehabilitation and ecological experts and government authorities.

Rehabilitation is an iterative process which allows activities to be defined and improved on throughout the lifetime of the mine. Monitoring of rehabilitation successes and failures will enable lessons learnt in early years of rehabilitation to be applied in subsequent and later years. It will also ensure that continuous improvement in rehabilitation performance is achieved.

An example of an iterative, continual improvement approach to mine site rehabilitation which may be implemented is shown in Figure 8 (Nichols 2005).

An essential part of monitoring will be the use of representative reference sites to which the performance of rehabilitation areas will be compared. These will be established in consultation with rehabilitation and ecological experts and will comprise a combination of representative sites in the surrounding areas. Reference sites will be selected on their ability to represent the physical, chemical and ecological rehabilitation objectives (i.e. soil, water, landscape and ecology) for Stage 2. A number of reference sites will be selected as it will be difficult for any one site to fully represent the overall rehabilitation objectives for Stage 2. Nichols (2005) recommends the establishment of permanent plot sizes of 10 x 20 m in off-site (reference) and onsite (rehabilitation) areas for long-term monitoring and comparisons.

In the short-term, monitoring will involve ensuring early successful establishment and growth of plants and will be undertaken on a regular basis, with subsequent monitoring as necessary. Following successful establishment, monitoring will be undertaken at less frequent intervals, but at least annually for the duration of the mine and rehabilitation periods.

Monitoring will focus on the indicators and performance measures described in **Section 8**.

Monitoring of rehabilitation areas will be detailed in the ROMP and are likely to include:

- Visual monitoring:
  - To be conducted on a regular basis as part of the maintenance strategy.
- Flora surveys:
  - To be carried out at both rehabilitation areas and off-site control sites, using quadrats. Initially, surveys will be undertaken on an annual basis.

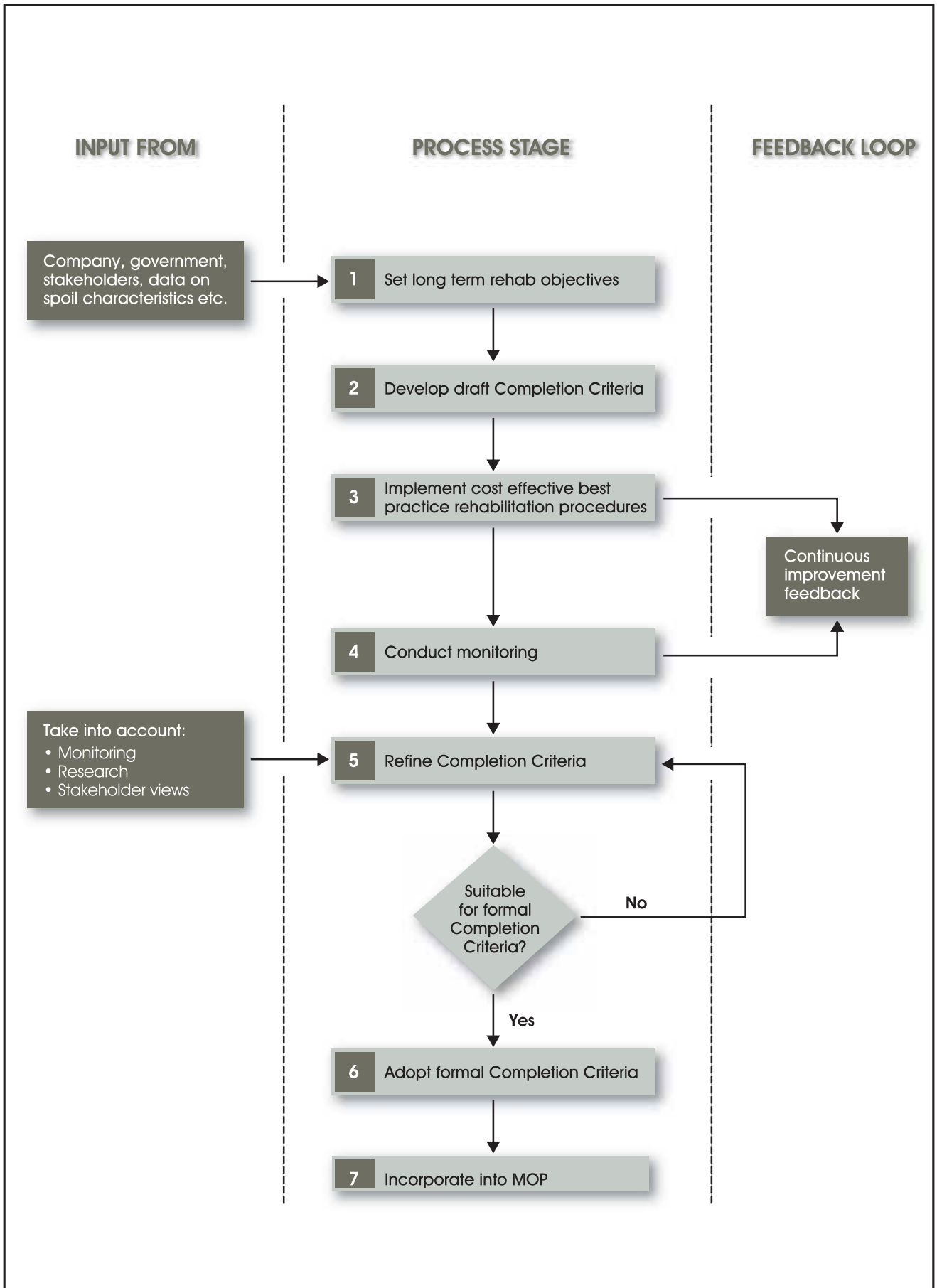
- Terrestrial fauna surveys:
  - To be undertaken to determine fauna species diversity and change in species diversity and abundance over time.
- Geochemical monitoring:
  - pH, electrical conductivity (EC) and major cations of soils and runoff.
- Landscape monitoring:
  - Slope stability, creek and drainage operability, habitat connectivity, ecosystem and habitat functionality.

Nichols (2005) describes a useful procedure for monitoring representative native ecosystem rehabilitation of reference sites in use at other NSW coal mines. This is reproduced in **Table 6** as an example of the type of monitoring that will be developed in the detailed rehabilitation plan for Stage 2.

Table 6
Example of native ecosystem rehabilitation monitoring procedures

Plot size	Measurement
General description	Describe the vegetation in general terms (e.g. mixed eucalypt woodland with grass understorey and scattered shrubs, dense Acacia scrub, etc)
2 m x 2 m quadrats	Count the number of plants of all species, excluding grass Measure live vegetation cover for understorey and grasses (separately) using a line intercept method Record details of ground cover (e.g. litter, logs, rocks, etc)
20 m x 10 m plots	Count, by species, all trees >1.6 m tall (N.B. count in 2, 10 x 10 plots to allow comparison with previous monitoring data) Tag and measure DBH of trees >1.6 m tall, to a maximum of 10 for any one species Record canopy cover over the whole 20 m centreline Subjectively describe tree health, by species if relevant, noting signs of drought stress, nutrient deficiencies, disease and severe insect attack Where health problems are noted, record the percentage of healthy trees Record any new plant species not present in the smaller plots, including any problem and declared noxious weeds Take five surface soil samples (e.g. at approximately 5 m intervals along the centreline) and bulk these for analyses of: pH, EC, chloride and sulphate; exchangeable Ca/Mg/K/Na; cation exchange capacity; particle size analysis and R1 dispersion index; 1.5 bar and field capacity moisture content; organic carbon; total and nitrate nitrogen; total and extractable phosphorus; Cu, Mn and Zn (where applicable)

Plot size	Measurement
50 m	Along the 50 m erosion monitoring transect, record the location, number and dimension of all gullies >30 cm wide and / or 30 cm deep Erosion pins should be established in plots located in newer rehabilitation to record sheet erosion
Rehabilitation in general	When traversing between monitoring plots, note the presence of species of interest not previously recorded (e.g. key functional or structural species, protected species, noxious weeds), as well as obvious problems including any extensive bare areas (i.e. bare areas greater than 0.1 ha) Observations such as this can provide useful, broad scale information on rehabilitation success and problems
Photographic record	For each 20 m x 10 m plot, a photograph should be taken at each end of the plot, along the centreline looking in



Source: Nichols, 2005.

coffey natural systems	Job No: 6015 File Name: 6015_10_F008_HB	Felix Resources Ltd Moolarben Coal Project – Stage 2	FELIX RESOURCES	Continuous improvement applied to mine site rehabilitation	Figure No: 8

10.1 Flora Monitoring

Flora surveys will be conducted in accordance with the approved ROMP within rehabilitation areas and offset areas to monitor species diversity, abundance, growth and health over time. An example of a potentially appropriate flora monitoring method is outlined in **Table 7**. The locations and specifications of flora survey quadrats for Stage 2 rehabilitation areas will be determined in consultation with rehabilitation and ecological experts and will be reviewed on a regular basis.

Table 7
Stage 1 Rehabilitation Flora Sampling Method

Parameter	Survey Method	Units of Measure
Flora species diversity	Each quadrat will be systematically monitored to compile a list of vascular plant species (i.e. trees, shrubs, grasses and herbs) observed	Total number of flora species Number and percent of native flora species Number and percent of introduced flora species
Flora species abundance	A count will be made of the number of individuals of each tree and shrub species in each quadrat All species present in each quadrat will be assigned a rating for their relative cover of the ground surface using a modified Braun-Blanquet scale: Rating Description: 1 – Cover less than 1% 2 – Cover between 1 to 5% 3 – Cover between 6 to 25% 4 – Cover between 26 to 50% 5 – Cover between 51 to 75% 6 – Cover between 76 to 100%	Total number of each tree species Total number of each shrub species Braun-Blanquet cover rating for all flora species present
Vegetation height	The approximate height of each vegetation layer (i.e. overstorey, midstorey and understorey) will be recorded	Height of each vegetation layer

Vegetation progress	Photographs of each quadrat will be taken as part of the overall monitoring program. Photos will be taken from the same position and aspect during each monitoring program to provide a visual record of vegetation performance	2 to 3 photos for each quadrat

10.2 Fauna Monitoring

Terrestrial fauna surveys will be conducted in accordance with the approved ROMP to sample fauna species diversity and abundance in the rehabilitation areas and to monitor any change in species diversity and abundance over time. These surveys will aim to determine whether changes seen are long-term environmental trends, natural variation in time, or due to an outside influence. Systematic survey sites will be established in the reference and rehabilitation areas to monitor amphibians, reptiles, birds and mammals. This will include the establishment of 100 m transects to measure the following fauna and habitat variables:

- Presence and where possible abundance of significant fauna species known to the local area;
- Biodiversity of each site; and
- Specific habitat attributes (such as flat rocks and tree hollows).

Quantitative data will be recorded at each site using techniques generally similar to the following:

- Ground and arboreal trapping using a range of traps for four consecutive nights at all sites for each survey period;
- Point and quadrat diurnal avian surveys for five consecutive days at all sites for each survey period;
- Nocturnal transects and point surveys including spotlighting and call play back; and
- Anabat fixed continuous point surveys and walking transects for four consecutive nights.

It is proposed that terrestrial fauna surveys be undertaken annually.

The locations and specifications of fauna survey transects for Stage 2 rehabilitation areas will be determined in consultation with rehabilitation and ecological experts and will be reviewed on a regular basis.

10.3 Landscape Monitoring

Rehabilitated areas will be monitored for backfilled spoil pH, electrical conductivity (EC) and major cations to determine whether the vegetation substrate is approaching conditions similar to those found in the reference sites. This data will be used to identify potential spoil deficiencies over time and assist with the development of maintenance programs if underperforming areas are identified during visual and other monitoring.

Samples will typically be taken to a minimum depth of 300 mm and comprise samples of the 0 mm to 100 mm, 100 to 200 mm and 200 to 300 mm intervals. It is proposed that samples be taken from the flora sampling quadrats every three years. The locations and specifications of soil samples in rehabilitation areas will be determined in consultation with rehabilitation and ecological experts.

It is also proposed that landscape parameters, including measures of connectivity, isolation, area and dimensions of the remnant in which the site is located will be recorded.

11 MANAGEMENT OF REHABILITATION RISKS

Issues and risks that may affect successful rehabilitation include:

- Not fully meeting government and community guidelines and expectations;
- Inadequate provision to meet the cost of both planned and unexpected rehabilitation;
- Failure of rehabilitation due to weather conditions (e.g. drought and frost);
- Inadequate treatment and improper use of dispersive soils;
- Availability of contractors and equipment;
- Inefficient use of machinery during rehabilitation; and
- Site security.

MCM will manage these risks by:

- Keeping up to date with changes to government and community guidelines and expectations;
- Providing adequate provision to meet the cost of planned and unexpected rehabilitation through the accounting department;
- Undertaking rehabilitation monitoring to identify early any failure of rehabilitation and implement remediation measures to the rehabilitation;
- Engaging rehabilitation, ecological experts and agronomists who are suitably qualified to assist with the rehabilitation works; and
- Fencing off rehabilitation areas to exclude stock and damage from unauthorised access.

All rehabilitation will be completed to the satisfaction of relevant regulators.

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