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Soils, Agricultural and Rehabilitation Matters Report

BYLONG COAL PROJECT
Response to PAC Review Report

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ENVIRONMENTAL CONSULTANTS

global environmental solutions

Bylong Coal Project

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1 INTRODUCTION

SLR Consulting Australia (SLR) has been involved in Bylong Coal Project environmental assessment process as technical specialists in the areas of soils, land capability and mine rehabilitation. SLR undertook the Environmental Impact Statement (EIS) technical studies for soils and land capability and the rehabilitation strategy. SLR prepared technical material, which was submitted as part of the Bylong Coal Project Response to Submissions (RTS). SLR also attended the Planning Assessment Commission (PAC) site visit and was on hand to answer questions on soils, land capability or mine rehabilitation, and presented at the PAC public hearing on the technical aspects of mine rehabilitation.

This report has been prepared in order to provide further clarification and certainty in relation to a number of matters raised by the PAC in its Review Report for the Bylong Coal Project (the Project) in which SLR has been integrally involved. These matters generally include:

- the pre-mining Land and Soil Capability (LSC) assessment;
- the Biophysical Strategic Agricultural Land (BSAL) assessment;
- the proposed rehabilitation strategy for the open cut, including the proposed criteria to be used to assess post mining reinstatement of the various classes of land; and
- general rehabilitation assessment requirements.

Furthermore, the technical soil and rehabilitation terms which have been used by the PAC in its Review Report have been defined in the sections below to ensure a consistent understanding and appreciation of these terms. A summary table is also provided indicating methods of assessments to be used on the rehabilitated landforms.

2 LAND AND SOIL CAPABILITY (LSC) ASSESSMENT

The LSC assessment scheme (OEH, 2012) uses the biophysical features of the land and soil including landform position, slope gradient, drainage, climate, soil type and soil characteristics to derive detailed rating tables for a range of land and soil hazards. The resulting LSC class gives an indication of the land management practices that can be applied to a parcel of land without causing degradation to the land and soil at the site and to the off-site environment. As land capability decreases, the management of hazards requires increased knowledge, expertise and investment to utilise these poorer quality lands for various land uses. In lands with lower capability, the hazards cannot be managed effectively for some land uses. These concepts form the basis of land management according to capability, a theme under the New South Wales (NSW) Natural Resources Monitoring, Evaluation and Reporting Strategy (NSW Department of Environment, Climate Change and Water, 2010).

The LSC assessment scheme (OEH, 2012) is a transparent, scientifically based assessment with clear methodology and protocols. The results of the Project LSC Assessment have been presented within the:

1. Bylong Coal Project Environmental Impact Assessment (EIS);
2. Soils, Land Capability and Strategic Agricultural Land Assessment (Appendix V of the EIS);
3. Bylong Coal Project Response to Submissions (RTS);
4. Bylong Supplementary Response to Submissions (Supplementary RTS); and
5. NSW Department of Planning and Environment Assessment Report.

The results of the LSC assessment were also presented to the PAC during the site visit and at its public hearing for the Project. Section 3.1.2 of the PAC Review Report suggests that KEPCO presenting the results of the LSC assessment, was in some way *"downplaying the value of"* or *"reducing the importance of*" the agricultural land mapped as BSAL within the Bylong project area. The results were presented to provide a clear understanding to the PAC of the LSC class of the land (some of which is also verified as BSAL) which will be impacted by the Project as required by the Secretary's Environmental Assessment Requirements (SEARs) for the Project.

The fact that the results of the LSC assessment demonstrated that there is no LSC Class 1 or Class 2 land to be disturbed by the Project should not be dismissed as *"downplaying"* the value of agricultural land currently on site. In our expert opinion, the best value land which is proposed to be impacted by the Project is LSC Class 3. The Project will directly disturb approximately 142 ha of LSC Class 3 land, while the remaining areas of the Project Disturbance Boundary comprise LSC Class 4 to LSC Class 7. Whilst LSC Class 3 land is highly capable land, it is noted that this land has limitations that must be managed to prevent soil and land degradation.

KEPCO has consistently proposed to re-instate areas of LSC Class 3 land post mining. The LSC classes will be measured and assessed in accordance with the scientific based LSC assessment protocol – that is the same protocol used in the pre-mining assessment – to demonstrate the required areas of each LSC class has been achieved on the post mining landform. It is noted that Schedule 4, Condition 63 of the Recommended Development Consent conditions specifies the relevant rehabilitation objectives.

3 BSAL ASSESSMENT AND REINSTATEMENT CRITERIA

The purpose of the Interim Protocol for the Verification of BSAL (DP&E, 2013) (BSAL protocol) is to assist proponents and landholders understand what is required to identify the existence of BSAL and outline the technical requirements for the on-site identification and mapping of BSAL. Essentially the BSAL verification protocol involves a list of 12 criteria, which are applied to a landform and soil profiles. Each of the BSAL criteria is measureable and evidence based, which allows the results to be reviewed and critiqued to ensure accuracy.

KEPCO's proposal to reinstate BSAL on the post mining landform, as was assessed and identified on the pre-mining landform, includes the same measurable evidence based parameters. That is, the BSAL protocol used to identify and map the pre-mining BSAL area will be used to verify the post mining BSAL area. The suggestion by the PAC that additional parameters (function and productivity) should be imposed to verify BSAL on the post mining landform does not align with any scientifically sound concepts of assessment consistency and is not supported by KEPCO or its technical specialists.

The one exception to the criteria from the BSAL protocol will be the fertility criteria. Within the BSAL protocol, this criteria is based on the in situ soil types. Once the soil material is stripped, salvaged and respread onto a new landform, the soil type is referred to as an Anthroposol (or man-made soil). Even though the soil material is the same, the physical arrangement of that material will have changed. Anthroposols are not ranked in the fertility criteria of the BSAL protocol due to the potential for high variability of these soils. Therefore, KEPCO has proposed the following techniques to ensure the 'inherent' fertility is adequately assessed:

1. Identification and tracking of the original in situ 'parent' soil material; and

2. The analytical testing in the laboratory for Cation Exchange Capacity.

These two parameters best reflect the potential match of the soil material to the BSAL fertility criteria. In a meeting in Tamworth on 17th June, the NSW DPI – Agriculture agreed that replacement fertility parameters be implemented to assess BSAL. NSW DPI - Agriculture provided in principle support for these parameters which are to be proposed in the Rehabilitation Management Plan and will be prepared in consultation with the NSW DPI - Agriculture.

The assessment which identifies and maps BSAL on post mining landforms is a stand-alone assessment, which is only targeted at verifying BSAL-equivalent land as per Schedule 4, Condition 65 of the Recommended Development Consent conditions.

4 CONSIDERATION OF BOTH LSC AND BSAL RESULTS

It should be noted that BSAL can be identified and mapped over a wide range of areas of varying agricultural quality and productivity, such is the nature of using limited criteria to assess such variable land in NSW. Across NSW some areas mapped as BSAL are very high quality LSC Class 1 and 2 land, whilst other areas of BSAL are identified in LSC Class 3, 4 and 5 land. Land within LSC Classes 3, 4 and 5 are subject to limitations in agricultural productivity. On the flip side, there are areas which are the most productive soils in NSW including LSC Class 1 and 2 land, which are not considered BSAL due to one or more of the BSAL criteria failing. Therefore to obtain the clearest understanding possible about the agricultural value of the land, both assessment results should be considered in detail, as well as a site inspection to appreciate the differences between BSAL that is also mapped as different LSC classes. An oversimplified view of a parcel of land is or is not BSAL only provides a limited perspective of the agricultural value of the land in question.

5 GENERAL REHABILITATION ASSESSMENT REQUIREMENTS

As identified in the Draft Bylong Rehabilitation Management Plan and in line with general practice in the coal mining industry, additional rehabilitation assessment methods will be applied on the post mining landform to ensure stable, non-polluting and sustainably productive land is achieved. These methods of assessing rehabilitation are based on the use of analogue reference sites to ensure the parameters measured are consistent between non-mined land and mined land rehabilitation. These parameters include soil function, soil resilience, agricultural productivity, species composition and density, and ecological succession.

Table 1 provides a summary the additional rehabilitation assessment methods proposed for the Project.

The PAC has suggested some of these parameters should be imposed on the LSC or BSAL assessments for the post mining rehabilitated landform. However, the inclusion of additional parameters on top of those specific assessments would not meet scientific rigour standards as the additional parameters were not used to identify and map pre-mining LSC and BSAL. It is for this reason that separate assessments were proposed in the EIS and have been outlined in detail within the Draft Rehabilitation Management Plan. Below is a summary of the various parameters and assessments, which are proposed to be undertaken over the entire mine rehabilitation areas. Further detail about these assessments is provided within the Draft Rehabilitation Management Plan.

Soil Function: The term soil function includes the following parameters or purpose of the soil profile:

- **Physical stability and support** – Soil acts as a medium or foundation for plant growth. It has the ability to maintain its porous structure to allow passage of air and water, withstand erosive forces, and provide a medium for plant roots. The post mining landform and soil profile will be assessed by visual inspection for its ability to:
    - hold and sustain vegetation upon the landscape, including the stability of mature trees,
    - allow infiltration and internal drainage of water, and
    - withstand the erosive forces of rainfall and surface water flow.

- **Habitat for soil organisms** – Soil supports the growth of a variety of plants, animals, and soil microorganisms, usually by providing a diverse physical, chemical, and biological habitat. This will be assessed by in field soil inspections and sampling of the soil to identify and count indicator species of soil biota and compare with reference sites.

- **Nutrient cycling** – Soil stores, cycles, and moderates the release of nutrients and other elements. During these biogeochemical processes, analogous to the water cycle, nutrients can be transformed into plant available forms, held in the soil, or even lost to air or water. Nutrient cycling will be assessed through vegetation health assessments supplemented with soil testing for essential nutrients.

- **Hydraulic buffer** – Soil can regulate the drainage, flow and storage of water and solutes, which includes nitrogen, phosphorus, pesticides, and other nutrients and compounds dissolved in the water. With proper functioning, soil partitions water for groundwater recharge and for use by plants and soil animals. This parameter will be assessed by using indicator species and analogue sites to show vegetation survival during dry periods and droughts. Excavated soil profile assessments will also include drainage parameters and moisture content ratings in each horizon and throughout the profile.

- **Filtering and chemical buffer** – Soil acts as a filter to protect the quality of water, air, and other resources. Toxic compounds or excess nutrients can be degraded or otherwise made unavailable to plants and animals. This parameter will be assessed by vegetation survival and growth, and soil testing against nearby analogue reference sites.

Soil Resilience: The term “soil resilience” refers to the ability of the soil system to remain viable under stressful conditions and return to normal function within a reasonable period of time after these conditions are removed. The key disturbances for rehabilitated land include the following:

- **Drought** – Periods of dry climatic conditions are a natural part of the Australian landscape and rehabilitated land needs to be resilient against drought when compared to nearby analogue reference sites. Soil resistance to drought will be measured using vegetation health indicators during dry periods.

- **Agricultural practices** – The proposed final land use will include agricultural use such as grazing and possible cultivation activities. The rehabilitated landscape needs to be resilient against the mechanical and physical impacts of agriculture as assessed against nearby analogue reference sites.

- **Fire** – Fires are a natural part of the Australian landscape, and rehabilitated land needs to be resilient against potential fires. This will be assessed through vegetation growth and maturity. Small assessment sites may also be considered using predictive fire modelling tools or low impact burns once the rehabilitation has matured to determine confidence levels of fire resilience.

Agricultural Productivity: The aim for the proposed rehabilitated landscape is to match the agricultural productivity of surrounding land of similar BSAL or LSC class. There are various ways to assess agricultural productivity, however the underlying principle is to form a scientifically robust comparison between mine rehabilitation and nearby unmined land of equal BSAL or LSC class. Parameters which may assist in this purpose include (but are not limited to): pasture quality analysis, pasture production or Feed on Offer (FOO) in kilograms of dry matter per hectare, stocking rates and carrying capacity, livestock growth rates, time to slaughter, slaughter weights and quality, cropping yields, persistence of pasture and maintenance of ground cover. NSW DPI are currently running large scale grazing trials comparing these types of parameters between mined land rehabilitation and unmined land. Details of these trials and preliminary results are summarised in **Section 6**.

Species Composition and Density: The assessment of targeted woodland ecosystems relies heavily on the vegetation being within a specific range of species composition and species density for the rehabilitation to be classed as a specific community. Species composition and density will be assessed using scientifically sound and well accepted ecological survey methods through the use of representative areas or transects to identify the type and number of individual units of species.

Ecological Succession: Ecological Succession is defined as the gradual process by which ecosystems change and develop over time. Primary succession is the series of community changes that occur on an entirely new habitat which has never been colonized before, as is the case with a newly formed post mining landscape. Secondary succession is the series of community changes which take place on a previously colonized, but disturbed or damaged habitat. Ecological Succession in mine rehabilitation is used to assess the vegetation and soil characteristics to ensure the overall ecosystem is on a trajectory towards achieving post mining rehabilitation goals. There are various tools to assess ecological succession for example, Landscape Function Analysis (LFA) (CSIRO, 2005) combined with annual rehabilitation inspections and audits. This tool offers an evidence based assessment of succession factors such as ground cover, vegetation growth, maturation of dominant species, flowering, seeding and the emergence of new trees via natural processes, and the development of various habitats and micro habitats for wildlife.

Table 1 provides a summary of the additional rehabilitation assessment methods proposed for the Project.

Table 1 Summary of Rehabilitation Assessment Methods

Rehabilitation Targets		Method of Assessment (Post Mining)
Biophysical Strategic Agricultural Land (BSAL)		Interim protocol for site verification and mapping of BSAL (April 2013)
		As a replacement fertility criteria, the following information is proposed: 1. Tracking and recording of original parent soil material type; and 2. Cation Exchange Capacity (CEC)
Land and Soil Capability (LSC)		The land and soil capability assessment scheme (OEH, 2012) - second approximation
Soil Function	Physical stability and support	Hold and sustain vegetation upon the landscape, including the stability of mature trees
		Allow infiltration and internal drainage of water
		Ability to withstand the erosive forces of rainfall and surface water flow
	Habitat for soil organisms	In field soil inspection and sampling of soil to identify and count indicator species of soil biota
	Nutrient cycling	Vegetation health assessments
		Soil and pasture testing for essential nutrients
	Hydraulic buffer	Indicator species and analogue sites to show vegetation survival during dry periods and droughts
		Soil profiles will also be assessed to include drainage parameters and moisture content throughout the profile
	Filtering and chemical buffer	Vegetation survival and growth
		Subsurface water monitoring and chemical testing against nearby analogue reference sites
Soil Resilience	Drought	Vegetation health indicators during and post dry periods
	Agricultural practices	Comparison of analogue reference sites (refer to Agricultural productivity)
	Fire	Vegetation growth and maturity
		Small assessment sites using predictive fire modelling and/or low impact burns once the rehabilitation has matured

Rehabilitation Targets	Method of Assessment (Post Mining)
Agricultural Productivity	Comparison of analogue reference sites for: Pasture quality analysis, pasture production or Feed on Offer (FOO) in kilogram of dry matter per hectare, stocking rates or carrying capacity, livestock growth rates, time to slaughter, slaughter weights and quality, cropping yields, persistence of pasture and maintenance of ground cover.
Species Composition and Density	Scientifically sound and well accepted ecological survey methods through the use of representative areas or transects to identify the type and number of individual units of species
Ecological Succession	Landscape Function Analysis (LFA)
	Regular rehabilitation inspections and audits also offer an evidence based assessment of succession factors such as ground cover, vegetation growth, maturation of dominant species, flowering, seeding and the emergence of new trees via natural processes, and the development of various habitats and micro habitats for wildlife.

6 CASE STUDIES ON MINE REHABILITATION TO AGRICULTURAL USE

There are several examples of mine sites in the Hunter Valley and throughout Australia and the world, which have undertaken mine rehabilitation to a targeted agricultural land use or capability class for that land to be used for agriculture. The examples provided below are shown to have either achieved an agricultural productivity level comparable to surrounding land or have reinstated the landform and soil profile to a land capability class which allows highly productive agricultural uses.

6.1 Coal and Allied – Alluvial Lands Project

Project approval granted in 1993 for Coal & Allied's Hunter Valley Operations Mine enabled the mining of 34 million tonnes of coal from 165 hectares of floodprone alluvial land within its mining lease adjacent to the Hunter River. Prior to mining some of the land was considered to have a Class 1 & 2 land capability as per the Soil Conservation Service Land Capability Classification System which identified it as being suitable for cropping.

Development consent for the mining project required completion of open cut mining to be followed up with rehabilitation and reinstatement of 63 hectares of land to Class 1 & 2 cropping capacity with the remainder of the area to be returned to Class 4 classification. Rehabilitation completion criteria included a requirement to achieve Class 1 & 2 capability by growing a lucerne crop and harvesting it at district average production levels of hay for three consecutive years.

The target level was nominated at 15 tonnes / year. The Department of Primary Industries – Agriculture was nominated to provide verification of the lucerne species, productivity measurement and agronomic practices.

A three year trial of the rehabilitation methods was monitored and completed prior to commencing the main rehabilitation project. The operations required selective handling and reinstatement of 630,000 cubic metres of subsoil to a depth of one metre, along with 252,000 cubic metres of topsoil to 0.4 m depth

The entire process followed particular rigour with tolerance for the final land surface set to be within half a metre of the pre-mining survey. The alluvial lands area was progressively back filled with overburden material after completion of mining. Then topsoil and subsoil was placed onto a basement constructed 1.4 metres below the designed surface level. A series of legume based 'green manure' crops were sown on the area and cultivated into the soil to improve organic matter levels prior to sowing lucerne.

Regular inspections and meetings with officers from NSW DPI's Environmental Sustainability Branch and the NSW DPI's regional agronomist have demonstrated Coal & Allied's compliance with yield, quality and monitoring requirements for reinstatement to Class 1 & 2 land capability.

Whilst no BSAL assessment has been undertaken on this land, the rehabilitated land has been classified as Land Capability Class 1 and 2 which is reflective of it's high to very high agricultural productivity. It should also be noted that the Hunter Valley alluvial lands are trigger mapped as BSAL according to NSW Government.

6.2 BSAL Reinstatement

SLR Consulting has recently undertaken a BSAL verification assessment on mine rehabilitation at a NSW site, with results concluding that adequate sampled sites satisfied the BSAL Criteria and that BSAL quality land has been established on mine rehabilitation. SLR are hopeful that the results of this investigation will be made available to the public domain in the near future, so the knowledge of the rehabilitation, management and results may be shared.

6.3 Upper Hunter Mine Rehabilitation Grazing Study

This four-year project is investigating the effects of cattle grazing on rehabilitated mine land and whether it can sustainably support productive and profitable grazing livestock. The project is being managed by the NSW Department of Primary Industries in collaboration with Upper Hunter Mining Dialogue's joint working group on Land Management. The group is made up of representatives from local grazing and community groups, government and mining companies.

The final weigh in occurred on 1st June 2017, where it was confirmed that steers reared on mine rehabilitation were found to be 100 kilograms heavier on average than cattle grazed on unmined farming land. In summary, this demonstrates there is clear precedence of mine rehabilitation being suitable for agricultural production. The study is continuing and will be closely monitored for further evidence of the creation of productive agricultural land post mining.

6.4 Liddell Grazing Trial

In December 2012, Glencore Coal Assets Australia commenced a cattle grazing trial at Liddell open cut coal mine located in the Upper Hunter. The trial objectives were to assess and compare performance of a rehabilitation grazing site against an adjoining un-mined grazing site. Details of the trial are provided in **Appendix 1**. The results of the trial demonstrated that over the first 18 months of the trial the 'rehabilitation' cattle grew significantly quicker and overall average weight difference at the end of this period was rehabilitation cattle +68.5kg over cattle grazing unmined pastures. Stocking rates were maintained over the duration of the trial without feed supplements. Improved weight gain and condition of cattle coming off rehabilitation pastures translated to a greater financial return of $220 per head on average for the carcases, which is nearly 25% greater return than was achieved by cattle grazing natural pastures sold into the same market.

6.5 Bengalla Class III land

An example of soil profile reconstruction and rehabilitation of high value agricultural land has been demonstrated at Bengalla Mine in Muswellbrook, NSW. Bengalla Mine gained approval for the restoration of rural land capability Class III land. Bengalla established an area of approximately 5.7 ha of an existing overburden emplacement area Class III land where slopes are less than 3% and Black Vertosol soils have been applied to create a soil profile approximately 1.4 m deep (BMC, 2013).

7 EQUINE CIC

The PAC acknowledged there are currently no operating thoroughbred enterprises in the Bylong Valley. However, the PAC also suggested the "*key strategic and physical components*" associated with the identification of Equine Critical Industry Cluster (CIC) would remain if the landscape was not mined, and therefore the capability of the identified areas of the CIC would be retained to contribute to future expansion of the thoroughbred industry.

The Upper Hunter Strategic Regional Land Use Plan (SRLUP) defines CICs as "*concentrations of highly productive industries within a region that are related to each other, contribute to the identity of that region, and provide significant employment opportunities*." Therefore, it should be emphasised again that there is no operating equine facilities and therefore no significant equine related employment opportunities currently available within the Bylong Project Boundary.

The verification and revision of the Equine CIC maps were made in January 2014, and given legal effect via an amendment to the *State Environmental Planning Policy (mining Petroleum Production and Extractive Industries) 2007*. The verification process used evidence of current commercial activity. The maps were exhibited in October and November 2013 to ensure the process captured all relevant enterprises. The verification and revision process in 2013/2014 was based on commercial activity and current enterprises, with no new biophysical or land criteria being applied to define Equine CIC properties.

The PAC referred to the "*key strategic and physical components*" which identified Equine CIC. The Upper Hunter SRLUP defined the mapping criteria for the Equine CIC as requiring the following strategic and physical components:

> *The equine cluster is spatially defined as land having a slope of equal to or less than 18 degrees and falling within the buffers: In the Mid Western Regional, Muswellbrook and Upper Hunter LGA's – within 5km of the Bylong Valley Way or Martindale Road or Baerami Creek Road or Widden Valley Road*.

This criteria is the only "*strategic and physical components*" that are used to define Equine CIC. Therefore, it needs to be clarified that the proposed rehabilitated landform of the Project will also fulfil the "*strategic and physical components*" used to identify the Equine CIC, as defined above by the Upper Hunter SRLUP. Upon final shaping and rehabilitation of the post mining landform, the site will be available for any future equine endeavours, should the equine industry return to the Bylong Valley at mine closure. Furthermore all existing equine related infrastructure located on KEPCO owned properties will remain and therefore will be available for future use if required.

8 CONCLUSION

The Bylong Coal Project PAC Review Report identified perceived uncertainties in regard to reinstating BSAL and how BSAL and LSC classes were to be assessed on post mining landforms, and how other soil and rehabilitation parameters were to be included in post mining assessments. This report has clarified that rehabilitation will be assessed under separate protocols for BSAL and LSC. The other general soil and rehabilitation parameters outlined in **Table 1**, which are important in confirming successful rehabilitation but are not included in the abovementioned protocols, will be measured as part of a general monitoring and completion criteria assessment program, and typically compared to analogue reference sites nearby.

The results of the internal assessment at a NSW mine demonstrate to SLR that BSAL quality land can be established on mine sites in line with the Interim Protocol. The methodologies employed at this site are consistent with those proposed for the Bylong Project.

The Project will not impact on any commercial equine activities in or nearby the Project as there are no such enterprises located on or near the Project site. During mining operations, the Project will temporarily impact on the "*strategic and physical components"* of part of the mapped equine CIC, however, these components will be available on the post mining landform and therefore no long term impact will result.

Appendix 1

Glencore Coal Assets Australia

Liddell Grazing Trial

Technical Paper

GLENCORE COAL ASSETS AUSTRALIA (GCAA)

Liddell Grazing Trial

Technical Paper

BACKGROUND

Some sections of the community, particularly in the NSW Upper Hunter Valley, do not believe that the industry has demonstrated that land which has been mined for coal can be rehabilitated to sustainable grazing land.

Although grazing of cattle on rehabilitated pastures has been undertaken over at least the past two decades, there are limited documented examples to evidence the success of this type of rehabilitation in NSW. Earlier trials in the Upper Hunter in the 1980s were of small scale and were not well recognised.

In December 2012, Glencore Coal Assets Australia (GCAA) commenced a cattle grazing trial at our Liddell open-cut coal mine located midway between Singleton and Muswellbrook in the Upper Hunter.

The trial aims to address the concerns of the community: that is, can rehabilitated mine land support cattle grazing on a sustainable basis and on a scale at least equivalent to its pre-mining capacity?

The project will assist Glencore and the broader industry to identify gaps in knowledge and opportunities for further trials or research to support rehabilitation back to grazing pastures.

Specific objectives of the Liddell grazing trial are to:

- Assess and compare performance of a rehabilitation grazing site against an adjoining un-mined (natural) grazing site across a range of soil, pasture and livestock parameters;
- Inform the development of guidance material relating to completion criteria for grazing rehabilitation areas and management of grazing on rehabilitation areas; and
- Demonstrate viability of cattle grazing as a sustainable post-mining land use option to stakeholders.

TRIAL PLANNING AND DESIGN

The Liddell grazing trial was designed and is being overseen by a former Upper Hunter District agronomist, assisted by GCAA and our pastoral company Colinta Holdings (Colinta), a wholly-owned subsidiary of Glencore.

Colinta's beef cattle operations span across much of Glencore's land surrounding the mining company's operations in NSW, Queensland and the Northern Territory.

The trial at Liddell Mine consists of mine rehabilitation pasture areas and adjoining un-mined pastures (natural pastures), which are considered representative of unimproved pastures throughout the district.

The rehabilitation and the un-mined areas are approximately 70 hectares each, with the rehabilitation areas ranging from approximately three years to more than 10 years since sowing.

Each of the rehabilitation and natural pasture areas has been divided into two paddocks to allow for rotation of livestock and spelling of pastures in response to pasture availability and quality.

The initial phase of the trial involved 60 Charbray steers (Charolais x Brahman breed), which were sourced from the local breeding stock of Colinta. The steers were randomly allocated into two groups of 30, with each animal weighed and tagged before being placed into the rehabilitation or natural pasture paddocks.

The Liddell land was stocked at a rate of about one steer per 2.4ha, which is within the range suggested by the NSW Department of Primary Industries but slightly above district averages for year round stocking.

MONITORING

A monitoring program has been implemented to assess and compare performance of the rehabilitation grazing site against the natural pasture grazing site.

Monitoring has included both baseline and on-going (periodic) measurements.

The program includes a range of soil, water (stock water quality), pasture and livestock parameters, assessed using scientifically accepted methods commonly applied to agricultural operations. Blood tests were also performed on ten steers from each group to provide baseline data on their mineral nutrient status.

The cattle were weighed on entry into the trial and every two to four months to coincide with their rotation between paddocks. Importantly, there were no significant weight differences between the natural pasture and rehabilitation steers at the start of the trial.

Regular inspections have been carried out to assess the suitability of the stocking rates, pasture availability and condition, as well as the health and condition of the cattle themselves.

Eighteen months later, in June 2014, the cattle from the first phase of the trial were weighed and blood tested for a final time before being taken to market for sale.

RESULTS

Soils

Samples were analysed from topsoil 0-10 cm in representative sites across the rehabilitation and natural paddocks.

The topsoil analysis results were variable.

Rehabilitation soils are alkaline in nature, whereas the soils in the natural paddocks were mildly acidic.

Salinity and sodicity in rehabilitation paddocks were elevated in comparison to natural paddocks.

These results are typical of spoils and topsoils used in rehabilitation programs in Hunter Valley.

However, importantly soil conditions in the rehabilitation paddocks are suitable for pasture growth and persistence as demonstrated by pasture results.

In native paddocks pasture species present are mostly species that can persist on low fertility soils.

An analysis is provided below:

Test	Rehabilitated Paddocks		Natural Paddocks	
	2012	**2014**	**2012**	**2014**
pH (water)	Neutral - Alkaline	Neutral - Alkaline	Mildly Acidic	Mildly Acidic
Phosphorus (Colwell test)	Moderate-High (5-63)	Moderate-High (9.9-39)	Moderate (5.7 -10)	Moderate (10-14)
Nitrogen (Nitrate)	Low (0.9 -7.2)	Low (1.7 -4.5)	Low–Medium (6.7 – 19)	Low (2.7 -3.9)
Sulphur (KCl 40)	Low-High (4.4 -24)	Low-High (2.9 -15)	Low-Moderate (3.5 -6.7)	Low-Medium (4.2 -11)
Potassium (meq/100g)	Adequate (0.46-0.77)	Adequate (0.51- 0.86)	Adequate (0.54- 0.64)	Adequate (0.47- 0.74)
Calcium (meq/100g)	Moderate (4.1 – 9.5)	Moderate (4.4 – 10)	Low (2.1 – 2.8)	Low (2.0 – 2.8)
Trace Element (Copper)	Adequate (0.60 – 2.1)	Adequate (0.94 – 1.6)	Adequate (0.30 – 0.70)	Adequate (0.46 – 1.0)
Salinity (EC Sat Ext)	Satisfactory – Elevated (0.4 – 1.6)	Satisfactory – Elevated (0.6 – 1.4)	Satisfactory (0.3 – 0.7)	Satisfactory (0.4 – 0.4)
Sodicity (ESP)	Satisfactory – Elevated (0.5 – 6.3)	Satisfactory – Elevated (0.5 – 6.4)	Satisfactory (2.4 – 3.5)	Satisfactory (1.6 – 3.4)
Cation Exchange Capacity	Moderate (10.4- 18.9)	Moderate (10.9- 17.3)	Low (5.2 – 7.2)	Low (1.7 – 2.5)
Organic Carbon %	Low-Medium (0.8 - 2.5)	Low-Medium (0.9 - 4.6)	Medium (1.9- 2.4)	Medium (1.7- 2.5)

Stock Water

Baseline monitoring of water quality, including Total Dissolved Solids (Salinity), Acidity or Alkalinity and Toxic Elements (iron, magnesium and nitrates) confirmed that stock water in dams and other watering points within the rehabilitation and natural paddocks is of suitable quality for grazing cattle.

Pastures

Rehabilitated Pasture **Natural Pastures**

Rehabilitation pastures comprise several introduced tropical pasture species and legumes, with the balance being regenerating native grasses.

Our pasture quality measurements showed that rehabilitated pasture areas generally had a higher feed quality and were more readily grazed by cattle, resulting in better cattle performance.

In comparison, un-mined pasture areas have lower legume content and fewer responsive winter/spring pasture species.

These pastures were made up of a native and naturalised pastures common across the district, including red grass, wiregrass, paspalum and weeping grass, which were generally of a lower quality in terms of a feed source.

Pastures: Most Common Species

Rehabilitation Paddocks	Natural Paddocks
Rhodes grass	Red grass (native)
Couch	Wiregrass (native)
Kikuyu	Weeping Grass (native)
Setaria	Paspalum
Green Panic	Barbwire grass (native)
Lucerne	Kangaroo Grass (native)
Medic (annual)	Native lovegrasses
Ryegrass	Wallaby grass (native)

The pasture quality assessment highlights that short/fresh regrowth of most species (both native and sown) provides the highest quality feed. Feed quality drops as species grow tall and rank, which decreases cattle intake.

The aim is to maintain ground cover above 70% to minimize the potential for erosion. Average ground cover levels have been maintained above the 70% level throughout the trial.

	Pasture Quality Measures		
	Crude Protein (%)	**Digestibility (% of DM)**	**Metabolisable Energy (MJ/kg DM)**
Rehabilitated Pasture			
Short Rhodes Grass (May 2013)	8.3	54.6	7.8
Rank Rhodes Grass (May 2013)	2.8	44.3	6.0
Rank Rhodes Grass (Aug 2013)	2.8	44.3	6.0
Short Kikuyu (Nov 2013)	22.0	71.8	10.7
Short Rhodes Grass (Nov 2013)	8.9	58.5	8.4
Short Rhodes Grass (Mar 2014)	13.4	62.0	9.1
Short Lucerne (Dec 2013)	21.2	57.8	8.3
Natural Pasture			
Red + Wiregrass (May 2013)	3.9	42.4	5.7
Wiregrass (Aug 2013)	5.5	44.3	6.0
Weeping Grass (Aug 2013)	11.6	59.0	8.5
Weeping Grass (March 2014)	22.5	72.9	10.9
New Growth - several species (Nov 2013)	8.9	52.8	7.5
Rank Growth –several species. (Nov 2013)	3.9	31.9	3.9

Cattle

All the cattle from the first phase of the trial were removed from the trial and sold in June 2014 because they were in a marketable weight and condition.

Over the 18 months of the first phase of the trial (December 2012 to June 2014), weight gain of all cattle was hindered by poor seasonal conditions and reduced pasture availability and quality, which was common across the district.

Despite these conditions, results were encouraging.

Between December 2012 and June 2014 rehabilitation cattle grew significantly quicker and the overall average weight difference at the end of this period was rehabilitation cattle +68.5kg over cattle grazing un-mined pastures.

The cattle in the rehabilitated paddocks recorded an average overall weight gain after 533 days of 256kg, with an average weight gain of 0.5kg per day.

Meanwhile the steers from the natural pastures gained an overall average of 177kg by the end of the trial period, putting on an average of 0.3kg per day.

Stocking rates were maintained over the duration of the trial without feed supplements.

Cattle Weights

Paddock	17/12/12 Ave start weights	30/4/13 Ave weight & gain (kg/day)	2/8/13 Ave weight & gain (kg/day)	26/11/13 Ave weight & gain (kg/day)	23/1/14 Ave weight & gain (kg/day)	26/3/14 Ave weight & gain (kg/day)	30/4/14 Ave weight & gain (kg/day)	3/6/14 Ave weight & gain (kg/day)	17/12/12-3/6/14 (533 days) Ave weight gain (kg/day)
Rehabilitation	406 kg	510 kg (0.8 kg/day)	485 kg (-0.3 kg/day)	512 kg (0.2 kg/day)	566 kg (0.9 kg/day)	597kg (0.5 kg/day)	638 kg (1.2 kg/day)	662 kg (0.63 kg/day)	**256 kg (0.5 kg/day)**
Unmined	418 kg	480 kg (0.5 kg/day)	447 kg (-0.4 kg/day)	463 kg (0.1 kg/day)	517 kg (0.9 kg/day)	541 kg (0.39 kg/day)	577 kg (1.0 kg/day)	597 kg (0.57 kg/day)	**177 kg (0.3 kg/day)**

Improved weight gain and condition of cattle coming off rehabilitation pastures translated to a greater financial return at sale. Our results show that the extra weight and condition of the rehabilitation cattle realised an average of $220 per head more for the carcases, which is nearly 25% greater return than was achieved by cattle grazing natural pastures sold into the same market.

Carcass Comparisons

Averages per Steer	Natural Pasture	Rehabilitated Pasture	Difference
Carcass Weight (kg dressed)	309 kg	342.7 kg	+ 33.7 kg
Fat Depth (mm P8)	2.6 mm	3.0 mm	+ 0.4 mm
$ per kilogram Dressed	$2.96	$3.42	+ $0.46
$ per head	$958.05	$1,177.65	+ $216.60
$ per 30 head in each treatment	**$28,741.50**	**$35,329.50**	**+ $6,588**

In the initial phase of the trial blood sampling found that within the cattle grazing on the rehabilitation pastures there was a deficiency of copper in the blood below what can be considered normal levels.

However, copper deficiencies are not uncommon and it can be economically treated via a number of products.

Importantly in this case, there were no outward signs of mineral deficiencies in the trial cattle, as demonstrated by their weight gains, condition and market performance.

Mineral nutrient status of the cattle, including blood copper levels will be further assessed in future phases of the trial, which will help ascertain trends and consider the requirement for treatment.

FUTURE DIRECTION

Whilst initial results are encouraging, they are not conclusive.

The trial is on-going with a second load of cattle entering the trial in late 2014.

This will allow monitoring of cattle performance, soils and pastures to continue to ascertain trends over a reasonable time frame and range of seasonal conditions.

In particular, monitoring will ascertain whether the initial positive cattle performance achieved in rehabilitation areas can be sustained (using inputs comparable to common district practices), whilst maintaining good soil fertility and pasture quality.

FAST FACTS

Rehabilitated Pastures

- Stock type: 30 Charbray steers / 70ha (1 steer/2.4 ha)
- Pasture: Rhodes grass dominant, couch, kikuyu, clovers, medic
- Avg start weights (17/12/12): 406kg
- Avg weight at sale (03/06/14): 662kg
- Avg weight gain (after 533 days – 03/06/14): 256kg @ 0.5kg/day
- Avg Sale price per head: $1177.65

Natural (unmined) Pastures

- 30 Charbray steers / 70ha (1 steer/2.4 ha)
- Pasture: Red grass / wiregrass dominant, paspalum, weeping grass.
- Avg start weights (17/12/12): 418kg
- Avg weight at sale (03/06/14): 597kg
- Avg weight gain (after 533 days – 03/06/14): 177kg @ 0.3kg/day
- Avg Sale price per head: $958.05

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