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.
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.
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:

<table>
<thead>
<tr>
<th>Test</th>
<th>Rehabilitated Paddocks</th>
<th>Natural Paddocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2012</td>
<td>2014</td>
</tr>
<tr>
<td>pH (water)</td>
<td>Neutral - Alkaline</td>
<td>Neutral - Alkaline</td>
</tr>
<tr>
<td>Phosphorus (Colwell test)</td>
<td>Moderate-High (5-63)</td>
<td>Moderate-High (9.9-39)</td>
</tr>
<tr>
<td>Nitrogen (Nitrate)</td>
<td>Low (0.9 -7.2)</td>
<td>Low (1.7 -4.5)</td>
</tr>
<tr>
<td>Sulphur (KCl 40)</td>
<td>Low-High (4.4 -24)</td>
<td>Low-High (2.9 -15)</td>
</tr>
<tr>
<td>Potassium (meq/100g)</td>
<td>Adequate (0.46-0.77)</td>
<td>Adequate (0.51-0.86)</td>
</tr>
<tr>
<td>Calcium (meq/100g)</td>
<td>Moderate (4.1 – 9.5)</td>
<td>Moderate (4.4 – 10)</td>
</tr>
<tr>
<td>Trace Element (Copper)</td>
<td>Adequate (0.60 – 2.1)</td>
<td>Adequate (0.94 – 1.6)</td>
</tr>
<tr>
<td>Salinity (EC Sat Ext)</td>
<td>Satisfactory – Elevated (0.4 – 1.6)</td>
<td>Satisfactory – Elevated (0.6 – 1.4)</td>
</tr>
<tr>
<td>Sodicity (ESP)</td>
<td>Satisfactory – Elevated (0.5 – 6.3)</td>
<td>Satisfactory – Elevated (0.5 – 6.4)</td>
</tr>
<tr>
<td>Cation Exchange Capacity</td>
<td>Moderate (10.4-18.9)</td>
<td>Moderate (10.9-17.3)</td>
</tr>
<tr>
<td>Organic Carbon %</td>
<td>Low-Medium (0.8 - 2.5)</td>
<td>Low-Medium (0.9 - 4.6)</td>
</tr>
</tbody>
</table>
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

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

<table>
<thead>
<tr>
<th>Rehabilitation Paddocks</th>
<th>Natural Paddocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhodes grass</td>
<td>Red grass (native)</td>
</tr>
<tr>
<td>Couch</td>
<td>Wiregrass (native)</td>
</tr>
<tr>
<td>Kikuyu</td>
<td>Weeping Grass (native)</td>
</tr>
<tr>
<td>Setaria</td>
<td>Paspalum</td>
</tr>
<tr>
<td>Green Panic</td>
<td>Barbwire grass (native)</td>
</tr>
<tr>
<td>Lucerne</td>
<td>Kangaroo Grass (native)</td>
</tr>
<tr>
<td>Medic (annual)</td>
<td>Native lovegrasses</td>
</tr>
<tr>
<td>Ryegrass</td>
<td>Wallaby grass (native)</td>
</tr>
</tbody>
</table>
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.

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

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

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

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

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