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A Risk-Based Approach to Cost-Effective Spoil Rehabilitation

ACARP PROJECT C8039: Risk Management Strategies for the Surrender of Open Cut Coal Mine Spoil Areas in the Bowen Basin Coalfields

INDUSTRY MONITORS: Alan Davies, BHP Coal; Rob McNamara, MIM Holdings; John Merritt, CapCoal

Introduction
The spoil rehabilitation liability in the Bowen Basin Coalfields has been variously estimated to be in the range from $600 million to $2 billion. This project aims to develop a risk-based tool for the selection of cost-effective, sustainable rehabilitation and future land uses to facilitate the surrender of open cut coal mine spoil areas in the Bowen Basin Coalfields.

Risk assessment and cost-effectiveness
"Risk" has two dimensions, "Likelihood" and "Consequence" and describes the likelihood of harm. Hazard denotes a potential cause of harm. Risk assessment allows the quantification of options and of the likelihood, consequences and costs of failure. The outcome of a risk assessment is described by a "Risk Ranking", which is obtained by some product of the Likelihood and Consequences. The Likelihood and Consequences of a hazard may each be described on a three or five point scale, from which a Risk Ranking may be assigned or calculated. The Likelihood of a hazard occurring may be expressed in terms of a "Probability of Failure", which allows for the uncertainties involved with spoil rehabilitation and lends itself to costing. The cost effectiveness of a given spoil rehabilitation strategy can then be calculated for assigned unit costs.

Issues
The key mine site closure issues are achievement of acceptable post-spoiling land use(s) and acceptable offsite water impacts. "Land Use Risks" include unsuccessful rehabilitation, unwanted flora and fauna, poor onsite water quality, responsibility for ongoing maintenance, and perceptions and aesthetics. The "Offsite Water Risks" include long-term stability of creeks and diversions and potential for breakthrough into final voids, salinity, erosion leading to suspended solids, acidity and other contaminants, water quantity, and perceptions and aesthetics.

Conventional approach to spoil rehabilitation
During the large-scale development of the Bowen Basin Coalfields in the 1970s the expected future land use was sparse grazing. With this in mind, "Conventional" spoil rehabilitation involves reshaping to slope angles of 15% (8°) or flatter, temporary contour banks at about half the mines, downslope waterways at most mines, topsoil application though not in all cases, deep-ripping and seeding mainly with pasture grasses or with native trees in some cases. There has been a tendency to adopt a slope angle of 15% as the "Standard", though this choice remains largely unproven, and is clearly material-specific.

Alternative approaches to spoil rehabilitation
The topography of the Bowen Basin is gently undulating to flat, with some mines set against an escarpment backdrop. There is a variation of slope angles from flat to steep, with corresponding slope lengths from long to short. Vegetation types and other surface covers vary, as do land uses. Overburden removed at open cut mines leaves an altered topography with a range of slope angles and lengths, and a range of exposed spoil materials. There is a recognition that a future sparse grazing land use for spoil areas may not always be appropriate. The possibility of alternative approaches to spoil rehabilitation presents itself. Alternatives could include a range of spoil slope angles up to the angle of repose (75% or 37°), depending on spoil material types, future land use(s) and the consequent cover requirements.

The risk-based tool being developed will allow various alternative approaches to Bowen Basin spoil rehabilitation and future land use(s) to be assessed and defended.

This is a collaborative project between UQ and Golder Associates.

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**CURRENT PROJECTS**

**Tetratheca juncea**

**ACARP Project C8012:**
Understanding the Biology and Ecology of Vulnerable Plant Species: A Case Study with Tetratheca juncea Occurring over Coal Leases

The aim of the project is to undertake research to assist in the development of a recovery management plan for Tetratheca juncea, listed as vulnerable under the Threatened Species Conservation Act (1996). The species often occurs on land leased by coal mining companies as a part of their underground and potential open-cut operations in the Lake Macquarie region. Since its presence can place major restrictions on any clearing or disturbance events, the species is of great importance to the exploration activities and future planning and development of the industry. Sterilisation of significant coal reserves could result if an acceptable conservation and/or recovery plan is not completed.

Work has continued with looking after vegetative material that was collected in July. Breeding system work commenced at The University of New England utilising orphan plants that were collected from Delta Electricity’s Vales Point Power Station and Powercoal’s Newstan Colliery in September 1999. Germination studies conducted on seeds collected last summer have been continually monitored for growth at UQ.

As the flowering season has commenced, several field trips are planned to the populations selected for intense study. A geographical positioning system (GPS) will be taken in the field to re-record the exact site locations and visual descriptions of each site visited will be captured on video. The first field trip for the quarter is scheduled for the last week in November, where all selected sites will be visited. This trip will involve collection of further cuttings; flowering phenology work, and completion of floral visitor surveys.

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**Research Initiatives in Pasture-based Rehabilitation**

**ACARP Project C8038:** Completion Criteria for Pasture-based Rehabilitation in the Bowen Basin

The aim of this project is to develop ecologically-based criteria for assessing the success of pasture-based rehabilitation, ultimately paving the way for lease surrender. Information collected as part of the review phase has provided a picture of how the pastures behave in their currently ungrazed state. Dominated by buffel grass, these pastures can accumulate large quantities of dry matter, but there is very little information on just how productive they are and what the most important limiting factors might be. This gap in our knowledge is being addressed in the sister project C9038, which is focussed on the capacity of the pastures to support grazing.

Beyond the initial establishment phase, vegetative cover has the greatest effect on surface stability. The graph displays erosion pin data from sites encompassing a range of surface media, rehabilitation age and slope gradient and length. The data support the reported ‘threshold’ of approximately 50% for effective erosion control in central Queensland. Fires are capable of completely removing the accumulated dry matter. While recovery in overhead cover is rapid, reaching pre-burn levels within 6 months given good conditions, cover in actual contact with the ground surface takes much longer. Buffel grass is a tussock grass, with less than 10% contact cover, so the litter layer must play a significant role in maintaining surface stability.

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**WARATAH**

A database of information on the germination of tree and shrub species native to New South Wales.

It consists of:
- Species information
- Source details
- Germination techniques
- Ecological information
- Photographs

Further information on the database, including how to obtain a copy, can be obtained from:
Mary-Anne Murray (07) 3365 8552 waratah@cmlr.uq.edu.au
**Researching Understorey Plants**

**ACARP Project C7010: Native Understorey Species Regeneration at NSW Coal Mines**

As part of research for the establishment of a native understorey on post mined land, further laboratory and field experimentation has been undertaken. Germination optimisation studies have included viability tests, which have enabled the determination of those species which may have dormancy mechanisms in place. Dormancy breaking tests have the potential to increase germination in some of those species previously difficult to germinate in “ideal” laboratory conditions. The use of these additional species can increase the species richness for mine site rehabilitation and contribute to our general knowledge of native species germination requirements.

![Image](image.png)

In addition to laboratory trials, several field experiments focusing on establishment techniques have been set-up in the Hunter Valley. The aim of these trials is to remove one or more of the variables encountered in field conditions to enable the determination of species success in a good season.

The first of these trials includes an irrigated field trial, in collaboration with the Department of Land and Water Conservation’s ‘Native Grasses Establishment Project.’ The trial itself involves the use of three water treatments (control, temporary and permanent) on bare topsoil, mulched topsoil and spoil, at Mount Owen Mine. It aims to determine the differences between species emergence, establishment and survival over time, under various media treatments.

A second series of field trials have been established at three open cut coal mines in the upper and lower Hunter Valley regions, under a pre-existing canopy. Many areas previously rehabilitated with native canopy species have very little ground or lower canopy cover, except where weeds or exotic pasture species are present. Since understorey vegetation plays an important role in ecosystem development, the addition of such species to revegetated areas will move it towards a more stable, self-maintainable system.

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**Impacts of Subsidence**

**ACARP Project C8018: Effect of Longwall Mine Subsidence on Plant Production on Cropping Land**

The aim of the project is to investigate the effect of subsidence on crop productivity and the main physical properties of the soil. Four surface attributes have been selected at two mines (Crinum and Kestrel) near Emerald. These attributes consist of unsubsided land, land that is directly above a mine pillar, subsided land that extends part way into the panel and land in the middle of the subsided panel. These areas were planted with wheat and during the season measurements of various soil properties were taken. These included moisture content, bulk density, soil strength, and matric suction. Further work is being undertaken to measure particle size distribution, chemical composition and other soil physical properties. The crop was harvested in October and results so far at the Kestrel site indicate very little differences in plant yield between surface attributes (see Figure). Wheat protein and moisture contents were also analysed and likewise show similarity between surface attributes.

As soon as there has been sufficient rain, a second crop of soybean will be sown and further soil sampling will commence. Water infiltration studies in the field will also be undertaken some time in the New Year.

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**MASTERS OF MINERAL RESOURCES**

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- Graduate Certificate in Mineral Resources (Mined Land Rehabilitation)

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CMLR Student Wins AMEEF Award

Suzie Reichman, a PhD Scholar at CMLR, has won the 2000 AMEEF LITERATURE REVIEW AWARD with her paper entitled “The Responses of Plants to Metal Toxicity: A Review.” The AMEEF judging panel described Suzie's paper as a “Thorough, well structured and current review of a complex subject of increasing importance to the industry, government regulators and policy makers, interest groups and researchers.” The Literature Review Award is designed to contribute to the transfer of current technical information relevant to environmental issues of the Australian minerals and energy industries. Suzanne's review will be published by the Foundation early next year. Adapted from the AMEEF Media Release, October 2000.

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MCA Student Award to CMLR Graduate

Bronwyn Paddon has won the Minerals Council of Australia Student Research Award at the 4th International and 25th National Environmental Workshop, held in Perth from 29th October to 2nd November 2000. The award aims to recognise excellence in environmental research and communication, and the winning paper was entitled “Investigation into the effects of soil storage on native seed germination.” Bronwyn completed her Honours degree through the CMLR in 1999 and her research provides key information for maximising germination from broadcast seeds used for revegetation of minesites.

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Grazing on Rehabilitated Pastures

ACARP Project C9038: Sustainable Grazing on Rehabilitated Lands in the Bowen Basin

The aim of this project is to determine the impact of grazing on the stability of rehabilitated pastures in central Queensland, and seeks to provide guidelines for sustainable grazing as a post-mining land-use. The project builds on our knowledge of these systems in the absence of cattle under ACARP Project C8038. Grazing trials are now in operation at Blackwater, Norwich Park and Goonyella Riverside mines. Pasture condition under different grazing pressures is being closely monitored. The associated impacts on surface stability will be assessed in the first quarter of next year, using rainfall simulation equipment and subsequent modelling.

The wider implications of preliminary findings are also being explored, drawing on the experience of returning cattle to rehabilitated lands in the Hunter Valley, and setting reconstructed pastures in central Queensland in their regional context.

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TECHNICAL TRANSFER

Decommissioning of Tailings

ACARP Project C9030: Decommissioning of Coal Tailings Dams

The project will develop procedures for rehabilitating existing coal tailings dams, leading to licence relinquishment. Issues involved include long term stability of the final landform, seepage, cover function, and cover construction and design. Computer modelling, supported by laboratory tests and field measurements, is being used to investigate the mechanisms affecting long term performance of the dams.

Exploratory analysis of data collected from fifteen mines in the Bowen Basin and Hunter Valley showed that variation of properties within a site could be as great as variation between sites. It appears that wash plant processes obscure inherent geographical differences. However, the impact of clay mineralogy is still apparent in plasticity and water-holding behaviour.

Preliminary computer modelling has been carried out using upper and lower bound properties inferred from the collected data. Under monthly average climatic data for Clermont, there is sustained upward movement of solute from the tailings into the cap. A 1:100 ARI 12 hour storm event pushed the salt plume back towards the base of the capping. Further modelling is underway to study whether such effects are only temporary, or whether individual storm events dominate solute movement. Work will also focus on the effects of capping properties, and behaviour under Hunter Valley climatic inputs. CMLR is about to commence a laboratory testing program on tailings and capping from ten minesites. This will provide sample-matched classification, basic chemistry, load-deformation, and unsaturated flow properties, and also characterisation of permeability versus soil water suction.

This is a collaborative project between The Minserve Group, OMLR and Dr Brian Richards of Geotech Research Pty Ltd.

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LONG PROPOSALS

Submitted for ACARP funding – 2001

Native Species Research for Increasing Diversity on Mined Land
Andrew Grigg and Sean Bellairs
The Development of a Rehabilitation Monitoring Program using High Resolution Remotely Sensed Data
Michael Stanford, Stuart Phinn and David Mulligan
Management of Waste Open Gear Lube in the Coal Mining Industry

RECENT PUBLICATIONS


HCEG Presentation

Andrew Grigg presented at the recent Hunter Coal Environment Group Meeting held in Singleton, NSW. The presentation, based on the Centre’s work on pasture rehabilitation in central Queensland, aimed to facilitate a cross-flow between the two regions of information regarding grazing of rehabilitated pastures. His presentation was entitled “Current Research Initiatives Examining Pasture Rehabilitation at Open-Cut Coal Mines in Central Queensland”.

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