7th Annual Mine Rehabilitation Conference

29, 30, 31 March 2017

Muswellbrook RSL Club
113 Bridge Street
Muswellbrook NSW
CONFERENCE ORGANISING TEAM

Tim Roberts, Director, Tom Farrell Institute
Nigel Stace, Project Manager, Tom Farrell Institute
Alec Roberts, Project Assistant, Tom Farrell Institute
Belinda McNab, Executive Officer, Tom Farrell Institute

SCIENTIFIC COMMITTEE

Tim Roberts, Director, Tom Farrell Institute, University of Newcastle
Nigel Stace, Project Officer, Tom Farrell Institute, University of Newcastle
Wendy Timms, Director Postgraduate Studies, School of Mining and Engineering, University of NSW
Simit Raval, Co-Director, Laboratory for Imaging of the Mining Environment (LIME), University of NSW
Corinne Unger, Senior Research Officer, Environment Centres Sustainable Minerals Institute, The University of Queensland
Richard Bush, Pro Vice Chancellor, Faculty of Science and IT, University of Newcastle
Nanthi Bolan, Global Centre for Environmental Remediation (GCER), University of Newcastle
Dee Murdoch, Associate Director, AECOM
Jemma Purandare, Senior Environmental Scientist, AECOM
Peter Elliott, Strategic Consultant, Environment and Sustainability
Jason Desmond, Environmental Officer, Rix’s Creek Pty Ltd
Jessica Blare, Environmental Advisor - Land Management, Hunter Valley Operations, Mt Thorley Warkworth
Kingsley Dixon, Director ARC Centre for Mine Restoration, Department of Environment and Agriculture, Curtin University
Andrew McIntyre, Manager Major Projects, Hunter Central Coast, NSW Office of Environment and Heritage
Michael Hitch, Director and Mitsubishi Chair in Sustainable Mining, Australian Centre for Sustainable Mining Practices
Martin Rush, Mayor, Muswellbrook Shire Council
Louise Pastro, Principal Project Officer, NSW Office of Environment and Heritage
Matthew Newton, Assist. Director Environmental Regulation and Standards, NSW Department of Industry
Carol Bond, Lecturer in Management, University of Queensland Business School

CONFERENCE HOSTS
Muswellbrook Shire Council

SPONSORS
Department of Industry - Division of Resources & Energy – Environmental Sustainability Unit
The NSW Department of Industry - Office of the Chief Scientist and Engineer
NSW Minerals Council

SESSION SPONSORS
Niche Environment and Heritage
University of NSW Mining Engineering
Hunter Coal Environment Group
SUEZ

WITH THANKS

We would like to extend a big thank you to the Hunter Valley mines that hosted our Mine Tours on Wednesday. We were able to view the great rehabilitation work that they are undertaking.

Thank you to:
Muswellbrook Coal Company, Idemitsu
Mount Arthur, BHP Billiton
Mount Thorley Warkworth, Rio Tinto Coal Australia/Coal and Allied, and
Rix’s Creek, The Bloomfield Group.

We acknowledge and respect the Wonnarua and Gringai people, traditional custodians of the land on which this conference is held.
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**VENUE SAFETY ANNOUNCEMENT**

**Muswellbrook RSL Club Safety Announcement**

If the Fire Alarm activates please wait for further instructions from the Club Staff.

In the Event of an Emergency Patrons are asked to move through the Emergency Exit doors to the Eastern Side of the Auditorium.

1 set of Emergency Doors is next to the Gents Toilets and the other set next to the Ladies and the Disabled toilets.

Once through the doors go down the steps and meet on the Bowling Green until further instructions are provided by the staff.

Please do not leave the premises until advised.

Do not use the lift.

The Terrace out the front of the Auditorium is Non Smoking for the 3 Days of our Event therefore food is allowed in that area.

The Gents Toilet is to the left of the Bar just follow the signs.

The Ladies and Disabled Toilet are to the far right of the Bar.

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**Disclaimer:**

The information in this document provided by Sponsors and Presenters does not necessarily reflect the opinions of the Tom Farrell Institute or the University of Newcastle.
Welcome to the Seventh Annual Mined Land Rehabilitation Conference, Muswellbrook 29-31 March 2017

The University of Newcastle, represented by the Tom Farrell Institute for the Environment, the International Centre for Balanced Land Use, the Global Centre for Environmental Remediation, CRC-CARE and Newcastle Institute for Energy and Resources, is proud to bring you our SEVENTH Annual Mined Land Rehabilitation Conference. The theme once again this year is best practice in restoration of mined lands and we bring to one venue, experts in the science and practice of restoring disturbed lands to full function in terms of regrowth, regeneration and reuse.

Muswellbrook, as host city, is ideally suited. Not only because of its proximity to so many working mines and the many examples of rehabilitated land post-mining which are easily seen, but also because Muswellbrook is actively seeking to grow opportunities for the region post-mining through diversification and transitioning to an innovation intensive region. Muswellbrook Shire Council with the University of Newcastle and Hunter TAFE has established a tertiary education precinct in the Muswellbrook CBD. The University and the Council have also collaborated in the formation of The Hunter Region Innovation Precinct with aims to promote economic diversification in the areas of energy technologies and environmental remediation, land use management, soil productivity, water management, climate adaptation, energy efficiency and precision or high efficiency agriculture.

The conference has been slightly expanded this year, will be complemented by three workshops, and conducted tours of rehabilitation in progress on four of the Hunter’s mines, along with a welcome function on Wednesday night and conference cocktail dinner on Thursday 30th March 2017.

It is clear that for successful ecological restoration and rehabilitation of mines and the associated maintenance of offset lands, there is a need for strong and clear planning at a government level, long-term commitment from the mining sector, coupled with technical understanding of what works and what does not work, and diligent monitoring based on best practice. Excellence in mine rehab actual, and as perceived by various publics, is an important part of the mining process, for example maintaining and enhancing social licence. We believe that this conference will lead the way forward along all of these paths.

I hope you find the conference meets and exceeds your expectations and that it delivers on what we promised. I urge you to take advantage of the expanded program to network with colleagues old and new. The mine tours, the poster sessions, the cocktail dinner and breakfasts and workshops offer exciting opportunities to share your ideas and to learn new ones, and to ask the questions you did not get time to ask.

Professor Tim Roberts
Director
Tom Farrell Institute for the Environment
University of Newcastle
ABOUT THE TOM FARRELL INSTITUTE FOR THE ENVIRONMENT

The Tom Farrell Institute for the Environment was established in 2006, as part of the University of Newcastle’s commitment to the ongoing sustainability of our region. Our aim is to build long-term partnerships with industry, business, government and the community in promoting environmental sustainability in our region and beyond.

Our Vision is to champion regional solutions for a sustainable future, both within the University of Newcastle and within the community.

Our Mission
- Be a centre of excellence in environmental research and its application
- Build University and community partnerships to meet the environmental challenges of the future
- Advance the development and application of environmental knowledge
- Integrate cultural, social and economic values into environmental solutions

NATIONAL STANDARDS FOR ECOLOGICAL RESTORATION PRACTICE

Founded in 2011, the Society for Ecological Restoration Australasia (SERA) is a neutral, independent, non-profit organization that connects restoration industries across Australasia and through the peak international body for restoration (SER) globally. SERA's membership includes scientists, planners, administrators, ecological consultants, natural areas managers, growers, community activists, and volunteers, among others.

Our mission is: “to promote ecological restoration as a means of sustaining the diversity of life on Earth and re-establishing an ecologically healthy relationship between nature and culture.”

In 2016 SERA launched the National Standards for the Practice of Ecological Restoration in Australia. The document was drafted over a four year period in close collaboration with 12 Australian Partner NGOs and taking into account comments from a wide cross section of Australian practitioners, policy makers and researchers. This document identifies the principles underpinning restoration philosophies and methods, and outlines the steps required to plan, implement, monitor and evaluate a restoration project to increase the likelihood of its success. The Standards are relevant to - and can be interpreted for - a wide spectrum of projects ranging from minimally resourced community projects to large-scale, well-funded industry or government projects. The document is available on SERA’s website and has been published in the peer-reviewed journal Restoration Ecology 2016, Vol. 24, No. S1, pp. S4–S32. (Available from http://onlinelibrary.wiley.com/doi/10.1111/rec.2016.24.issue-S1/issuetoc)
CONFERENCE HOST
Muswellbrook Shire Council

The town of Muswellbrook is located at the centre of the Upper Hunter – the largest black coal region in Australia by production. Mining activity has developed substantially since 1995 and is projected to develop further.

The town is closely encircled by open-cut coal mining activity on an unprecedented Australian scale. Muswellbrook has the highest proportion of coal mining land-use (intensity) of any local government area in Australia.

The very close proximity of mining development, has created particular challenges around urban growth, land-use conflict, noise, blasting, dust, loss of visual amenity, as well as environmental and heritage impacts. Getting best practice rehabilitation is critical from that perspective, and the Shire is home to both some of the best and some of the worst mining rehabilitation practices in NSW.

As one of the State’s economic ‘heavy lifters’, Muswellbrook has been at the heart of the State’s energy industry for over four decades. The Shire’s two baseload power stations provide 40% of the State’s baseload energy requirements.

Home to Australia’s oldest continuing mining operation, the 109 year old Muswellbrook Coal, the Shire’s thermal coal industry provides 25% of the State’s total thermal coal exports.

Muswellbrook is also the home of the two largest thoroughbred horse studs in the southern hemisphere and approximately 40% of the value of thoroughbred bloodstock in Australia is reared within the Shire.

The Shire accounts for some 40% of the Hunter’s viticulture and is home to the largest dairy industry in the Hunter.

Land use conflict between the Shire’s main export industries has weighed heavily on social cohesion within the Shire.

www.muswellbrook.nsw.gov.au

CONFERENCE PARTNER
Department of Industry - Division of Resources & Energy – Environmental Sustainability Unit

Before any work can begin, any activity related to exploration, mining or production requires an approval known as a title. Titles act as a regulatory framework defining resource types, area, permitted activities and conditions applied to explorers and producers. Titles related to resources in NSW are managed by the Division of Resources & Energy (DRE). Various types of titles include applications, authorities, authorisations, licences, leases and claims.

Rehabilitation commitments and post mining land use objectives are established as part of the development approval/EIS phase of a mining operation and approved by a determining authority such as NSW Planning and Environment (P&E) under the Environment Planning & Assessment Act 1979 (EP&A Act). DRE’s role under the Mining Act 1992 (MA) via a title is to regulate rehabilitation activities to ensure that the conditions of a development approval issued under the EP&A Act are met. A key objective of DRE’s regulatory oversight of mine rehabilitation is that sustainable post-mining land uses are achieved.

MAJOR SPONSOR
The NSW Department of Industry - Office of the Chief Scientist and Engineer

The NSW Department of Industry, Skills and Regional Development leads the state government's contribution to making NSW a fertile place to invest and to produce goods and services, and thereby create jobs and opportunities for our citizens, and supports all areas of economic activity where NSW has competitive strengths. The Department is also responsible for skill formation and development to match industry demand; partnering with stakeholders in stewardship and sustainable use of the state's natural resources; and supporting economic growth in the regions.

GOLD SPONSOR
NSW Minerals Council

The NSW mining industry works to ensure that impacts of mining are minimised wherever possible and that disturbed land is restored to a safe and stable condition which facilitates beneficial post mining uses for the communities in which we operate.

Mine rehabilitation is considered throughout the lifecycle of a mine, with extensive pre-mining planning, progressive rehabilitation during mining, leading ultimately to relinquishment of the land once all obligations have been met post-mining.

The industry’s approach to mine rehabilitation has improved significantly over time due to improving knowledge and understanding of rehabilitation methods, evolving community expectations and continued company investment.

NSW mine operators pay a significant rehabilitation security deposit to fund rehabilitation work if a company is unable to fulfil its obligations, protecting the government and taxpayer from mine closure costs.

NSW mine operators partner with the community on initiatives such as the Upper Hunter Mining Dialogue, which have been particularly active in overseeing rehabilitation-focused research projects, including cattle grazing trials on rehabilitated land and examining the beneficial reuse of voids.

The NSW Minerals Council is a proud sponsor of this Conference and recognises the importance of mine rehabilitation in securing and maintaining the industry’s social licence to operate as we continue to implement a comprehensive mine rehabilitation and mine closure strategy across industry.

Mr Stephen Galilee
Chief Executive Officer, NSW Minerals Council
www.nswmining.com.au
Alternate link: www.worldclassminers.com.au
SESSION SPONSORS

**Niche Environment and Heritage**

Niche Environment and Heritage is a multidisciplinary consultancy specialising in ecology, cultural heritage management, environmental approvals and biodiversity offsetting. Established in 2009, Niche has successfully delivered more than 2500 projects to clients across eastern Australia. Our 40-strong team includes ecologists, botanists, archaeologists and environmental engineers.

Niche delivers innovative, practical solutions to mine rehabilitation projects. We offer a full range of ecological monitoring and management services - including freshwater and marine ecology - supported by our in house GIS and remote sensing capabilities.

Our highly skilled, multi-disciplinary team has proven experience in the design, implementation and management of mine site rehabilitation and monitoring programs, habitat recreation and restoration, site closure rehabilitation assessment and derelict mine bat surveys.

Niche Environment and Heritage - *Excellence in your environment*

www.niche-eh.com

**University of NSW Mining Engineering**

UNSW Mining Engineering is one of the largest mining schools in the world, with close links to industry and governments, leading to excellent research and producing high-calibre graduates.

We are the largest educator of mining engineers through our undergraduate and postgraduate programs, producing “globally-aware” mining engineers with a balanced combination of technical and management skills, together with appropriate social, cultural and community awareness.

A major strength of our School is the Australian Centre for Sustainable Mining Practices (ACSMP) which is recognised by both government and industry in Australia and internationally as an authority on sustainable mining practices.

www.engineering.unsw.edu.au/mining-engineering/
Hunter Coal Environment Group

HCEG is a networking group of environmental professionals that:

- facilitates the exchange of technical knowledge and practices between operatives in environmental management in the coal mining industry of the Hunter Region.
- promotes excellence in environmental management in the mining industry.
- promotes the benefits and achievements of successful environmental management in the coal mining industry of the Hunter Region.

HCEG Activities

The HCEG provides quarterly forums for the communication and dissemination of information on mining-related environmental issues. Forums have been conducted on water, vegetation and land management issues relating to the mining industry.

Membership

HCEG welcomes applications for membership from all parties that are interested in the information that we distribute. Meetings are held in Singleton. The Annual subscription fee is $50 for individual members and $200 for memberships. Membership enquiries to HCEG.NSW@gmail.com

Our website is www.hceg.com.au

SUEZ

SUEZ is one of the largest processors of urban-generated organics in Australia.

Our network of state-of-the-art facilities across Australia create specialist composted products used in a variety of land remediation and rehabilitation works. We support businesses across a variety of disciplines working to restore eroded and depleted environments into stable and, preferably, vegetated landforms. Our products can be used for:

- Minesite revegetation and rehabilitation
- Erosion and sediment control
- Compost blankets
- Spraygrassing activities such as hydromulching or hydroseeding
- Commercial civil works
- Commercial landscaping works

For more information, contact our Organics specialist Duncan Le Good On 0437753044 or duncan.legood@suez.com. www.sita.com.au
## PROGRAM - THURSDAY

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<th>Start Time</th>
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<th>Presenter and Title of Presentation</th>
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<tr>
<td><strong>Session Sponsor Niche Environment and Heritage</strong></td>
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| 8.30am | 5 min | Tim Roberts, Director Tom Farrell Institute  
Welcome and open first day of conference |
| 8.35am | 5 min | Venue Safety Announcement |
| 8.40am | 5 min | Steve Fordham  
Welcome to Country |
| 8.45am | 5 min | David Blackmore, Director Environmental Sustainability, NSW Department of Industry  
Overview of the Division of Resources and Energy and its role in regards to mine rehabilitation |
| 8.50am | 20 min | Matthew Newton, Assistant Director Environmental Regulation and Standards, NSW Department of Industry  
Rehabilitation regulatory reform project |
| 9.10am | 5 min | Question Time |
| 9.15am | 15 min | Penny Dunstan, University of Newcastle  
Pointy and Flatty - what two Cornish alps can tell us about the interaction of human imagination and post mining landform |
| 9.30 am | 5 min | Question Time |
| 9.35am | 20 min | Travis Peake, Practice Leader Ecology, Umwelt (Australia) Pty Limited  
The landscape benefits of ecological mine rehabilitation - a Hunter Valley perspective |
| 9.55am | 5 min | Question Time |
| 10.00am | 30 min | Poster Presentations (2 min each) |
| 10.30am | 30 min | MORNING TEA |
| **Session Sponsor University of NSW Mining Engineering** | | |
| 11.00am | 5 min | Greg Sullivan, Director Policy, NSW Minerals Council  
NSWMC rehabilitation strategy incorporating policy work, research projects and communication/awareness activities, and overview of Synoptic Plan workshop |
| 11.05 | 20 min | Karin Fogarty, Environmental Advisor – Peabody Energy, Wilpinjong Coal Mine  
Update on current rehabilitation practices at Wilpinjong Coal Mine |
| 11.25am | 5 min | Question Time |
| 11.30am | 20 min | Ben Clibborn, Environment and Community Manager – Oceanic Coal  
Glencore’s Westside Mine |
| 11.50am | 5 min | Question Time |
| 11.55 am | 20 min | Neil Griffiths, Technical Specialist Pastures, NSW Department of Primary Industries  
Heavy metals, trace elements, pasture and cattle observations from the Upper Hunter Mine Grazing Study |
| 12.15pm | 5 min | Question Time |
## PROGRAM - THURSDAY CONTINUED

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<tr>
<td>12.20pm</td>
<td>20 min</td>
<td>Shannon Mulholland, Technical Officer, Department of Primary Industries - Biosecurity and Food Safety</td>
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<td>Mining and biosecurity</td>
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<td>12.40pm</td>
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<td>12.45pm</td>
<td>45 min</td>
<td>LUNCH BREAK</td>
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<td>1.30pm</td>
<td>5 min</td>
<td>Welcome back following break</td>
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<tr>
<td>1.35pm</td>
<td>1 hour</td>
<td>PANEL DISCUSSION - PATHWAYS TO RELINQUISHMENT AND OPPORTUNITIES TO TRANSITION TO PRODUCTIVE ALTERNATE LAND USES</td>
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<td>Chaired by Peter Elliott, Independent Consultant</td>
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<td>Panellists: Gary Ellem, Andrew Keith, Martin Rush, Matthew Newton, Richard Bush</td>
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<td>2.35pm</td>
<td>20 min</td>
<td>Howard Wildman, Chief Scientist, Microbial Management Systems</td>
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<td>Microbial functional diversity - its importance to ecosystem function, and choice as a mine soil restoration objective</td>
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<td>2.55pm</td>
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<td>3.00pm</td>
<td>20 min</td>
<td>Nanthi Bolan, The University of Newcastle</td>
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<td>Sources and management of acid mine drainage</td>
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<td>3.20pm</td>
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<td>3.25pm</td>
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<td>AFTERNOON TEA</td>
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<tr>
<td>3.45pm</td>
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<td>Welcome back following break</td>
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<tr>
<td>3.50pm</td>
<td>20 min</td>
<td>Laura Kuginis, Snr Scientist/ Restoration Science and Implementation, NSW Office of Environment and Heritage</td>
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<td>Towards best practice monitoring and assessment of self-sustainability for ecological rehabilitation of mined land</td>
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<td>4.10pm</td>
<td>5 min</td>
<td>Question Time</td>
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<tr>
<td>4.15pm</td>
<td>20 min</td>
<td>Carmen Castor, CSER Research</td>
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<td>Sustainable ecological communities on mine rehabilitation</td>
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<td>4.35pm</td>
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<tr>
<td>4.40pm</td>
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<td>Andrew McIntyre, Manager Major Projects, NSW Office of Environment and Heritage</td>
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<td>Upper Hunter Strategic Assessment</td>
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<td>5.00pm</td>
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<tr>
<td>5.05pm</td>
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<td>Chair Close Conference for Thursday</td>
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### 7.00pm Conference Cocktail Dinner (Muswellbrook RSL)

Guest Speaker: Dr Alan Broadfoot, Director, Newcastle Institute for Energy and Resources
## PROGRAM - FRIDAY

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| 8.30am     | 5 min    | Tim Roberts, Director Tom Farrell Institute  
Welcome and open second day of conference |
| 8.35am     | 15 min   | Didik Triwibowo, Quality Health Safety Environment (QHSE) Compliance Manager PT Adaro Indonesia  
Managing pit lakes water quality at coal mine of PT Adaro Indonesia |
| 8.50am     | 5 min    | Question Time |
| 8.55am     | 15 min   | Chris Gimber and Brad O'Reilly, Principal Environmental Engineer, KBR  
Backfill or not. Water management considerations during rehabilitation |
| 9.10am     | 5 min    | Question Time |
| 9.15am     | 15 min   | Corinne Unger, Senior Research Officer, Sustainable Minerals Institute  
Facilitating retention of mine rehabilitation and closure knowledge for central Queensland coal mines |
| 9.30am     | 5 min    | Question Time |
| 9.35am     | 15 min   | MORNING TEA BREAK |
| 9.50am     | 20 min   | Simit Raval, UNSW Australia  
High resolution imaging for mine rehabilitation using UAV-Hyperspectral technology |
| 10.10am    | 5 min    | Question Time |
| 10.15am    | 15 min   | Greg Hancock, The University of Newcastle  
Sustainable mine rehabilitation - two decades of soil erosion and landscape evolution modelling |
| 10.30am    | 5 min    | Question Time |
| 10.35am    | 15 min   | Grant Dickins, Naturally Spatial Pty Ltd  
Comparative evaluation of sediment yield from native and fluvial geomorphic reclamation |
| 10.50am    | 5 min    | Question Time |
| 10.55am    | 5 min    | CONFERENCE CLOSES & WORKSHOPS OPEN |
| 11.00am    | 1.5 hours| Workshop Stream 1  
Pathways to relinquishment and opportunities to transition to productive alternate land uses  
Convenors: Peter Elliott and Donna Pershke |
| 12.30pm    | 30 mins  | LUNCH BREAK |
| 1.00pm     | 1.5 hours| Workshop 1 Continues  
Workshop 2 Continues |
| 2.30pm     |          | WORKSHOPS CLOSE |
Matthew Newton
Assistant Director Environmental Standards
Division of Resources & Energy – Environmental Sustainability Unit
Phone: 0249316745  |  Email: matthew.newton@industry.nsw.gov.au

Matthew has been with the Department since 2013, most recently in the role of Assistant Director for Environmental Regulations and Standards.

Some of the key functions include the development and implementation of standards, guidelines, policies and procedures based on best practice to improve mining / exploration rehabilitation outcomes across the state of NSW.

With approximately 21 years of experience in environmental assessment and management, he has been involved in a range of environmental projects relating to mining operations situated throughout NSW, QLD, VIC, WA and the USA. He has worked as a consultant as well as in site-based roles with a particular focus on rehabilitation and mine closure projects including the development and implementation of a mine closure plan, including government sign-off, of closure activities at Glencore’s New Wallsend No.2 Colliery in Newcastle.

DRE’s Rehabilitation Regulatory Reform Project

The Division of Resources & Energy (DRE) is responsible for facilitating sustainable resources development for New South Wales. DRE’s role under both the Mining Act 1992 and Petroleum (Onshore) Act 1991, extends throughout the lifecycle of a mining or petroleum project from exploration through to the operational and closure phases.

The implementation of best-practice mine site rehabilitation is critical to ensuring NSW has a sustainable minerals industry. The aim of regulating mine rehabilitation is for land, affected by mining activities, to be returned to a condition at least as good or better as before any disturbance. As the lead regulator for mine rehabilitation, DRE will ensure rehabilitation is an ongoing priority for operators, after project approvals are issued and throughout the life cycle of the project.

As discussed at the 2016 Rehabilitation Conference, DRE is reforming its regulatory principles by adopting a risk-based and outcomes focussed model which will allow for:

DRE resources allocated to activities that pose the greatest risk to regulatory outcomes;

- increased focus on risk-control effectiveness as a means to drive better rehabilitation outcomes, prevent rehabilitation failure as well as promote industry education and compliance;
- better transparency in regards to rehabilitation progress, including the introduction of a spatial data portal for industry to submit actual and forecast rehabilitation plans to the Department;
- introduction of rehabilitation key performance indicators;
- industry innovation to achieve best practice rehabilitation outcomes;
- trust to be restored from the community in the mining and petroleum industry as well as government; and
- industry social licence to operate.

DRE’s presentation will focus on the core elements of the regulatory reform project, which pending the outcomes of stakeholder consultation, it will aim to implement during 2017.
Pointy and Flatty: What two Cornish Alps can tell us about the interaction of human imagination and post mining landform.

Cornwall (UK) landscapes are pock marked by china clay mine sites. Set up in the 1700’s, the kaolin mines continue to supply porcelain clay across the world. The changing post mining landscapes record progressive understandings about the stability of land form in post mining environments. In the 1960’s, mining technology produced steep sided hills known, with some irony, as the Cornish Alps.

Pointy and Flatty are two important Cornish Alps just behind the village of St Dennis. So important to the town that they have become part of the village as delineators of town identity, even featuring as the school crest.

In this paper I argue that rehabilitation isn’t just about overburden and stability of final form. Nor is it about the development of novel ecosystems in highly disturbed and unnatural landscapes. Final rehabilitation of landform is about relationships that build between people and land. By being conscious of design choices when constructing an environment it is possible to make a landscape that may become imbued with intimate meaning and perhaps even sacredness.

It is not as hard as it sounds. I would like firstly to give an example of the power of land form in mine rehabilitation in Cornwall and then a local version, Rix’s Creek, where the principle has been understood intuitively.
Travis Peake has worked for 22 years in the field of biodiversity survey, management, restoration and impact assessment, across Australia but particularly in NSW. He has prepared and led numerous investigations into vegetation survey, mapping and classification, threatened species management and ecological reconstruction. He has had a particular focus on the Hunter Valley, having prepared the first comprehensive vegetation map of the Central Hunter Valley, including the main coal mining district. Travis has worked closely with government, private industry and landholders through his career. He is the Practice Leader for a large team of Ecologists at Umwelt’s Newcastle Office.


The effects of past land clearing practices on native biodiversity are widespread in the Hunter Valley. Current land management practices continue to challenge the resilience and longevity of a range of threatened plant and animal species, and the composition of native vegetation types has been substantially altered. Consequently, the Hunter Valley supports a large number of plants, animals and ecological communities that are listed under legislation. Despite historical trends and current patterns, there have been numerous worthwhile actions that have benefitted and will improve the outlook for the native biota. These range from property-scale action by landholders and strategic actions by mining companies, through to strategic planning by government. Although coal mining has contributed to the challenges faced by many threatened species, it also provides a potentially very significant opportunity for ecological reconstruction. This opportunity will be realised, in part, as an outcome of the continuously improving steps towards impact avoidance, impact mitigation, and biodiversity offsetting that are now routinely undertaken by mines. The other very critical contribution will come from successful, coordinated ecological mine rehabilitation. This presentation examines the ways in which ecological mine rehabilitation can and will contribute to the landscape ecological reconstruction of the Hunter Valley.
Karin Fogarty
Environmental Advisor – Peabody Energy
Wilpinjong Coal Mine
1434 Wollar Road
Work Phone Number: +61 (02) 63702543
Mobile: +61 (0488222354)
Email: kfogarty@peabodyenergy.com

Karin Fogarty is Wilpinjong Coal’s Environmental Advisor, with over eight years’ experience employment in the coal mining industry in both central Queensland and NSW. Karin has practical knowledge and experience implementing rehabilitation and mine closure planning at a site level. Karin’s vision is to see an integrated mine planning approach throughout the life of the mine, enabling rehabilitation objectives to be defined with mine closure in mind. Karin holds a Bachelor of Science (Environmental Science and Environmental Earth Science) from James Cook University and a Master Mineral Resources (Environment) from University of Queensland.

Current Rehabilitation Practices at Wilpinjong Coal Mine

Wilpinjong Coal Mine is located near Mudgee in NSW and is owned and operated by Peabody Energy Australia. Wilpinjong is an open cut coal mining operation with a low strip ratio and current approvals to produce 16 Mtpa of ROM coal. Disturbance areas since Peabody acquisition in 2006 have been progressively rehabilitated with species characteristic of native woodland and mixed woodland/pasture. The approved post mine land use has biodiversity corridors linking the Munghorn Gap Nature Reserve and Goulburn River National Park with interlinking grazing areas. To date, Wilpinjong has completed approximately 375ha of rehabilitation of previously mined land.

Karin will present on the current rehabilitation practices at Wilpinong, current and proposed trials and projects including:

• Wilpinjong’s approach to integrated planning and implementation
• Operational trials including:
  ○ Soil testing and the use of different ameliorates
  ○ Green manure crops
  ○ Microbe investigations
  ○ Proposed rehabilitation prescribed burn
• Current investigation into Final Landform Drainage System Design.
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Ben commenced the role of Environment and Community Manager at Glencore’s Oceanic Coal complex in the Lake Macquarie area in October 2015, after being attracted to the role by the opportunity to be involved in mine closure planning and works. The Oceanic complex comprises of several underground mines, Westside Open cut and the Macquarie Coal Preparation Plant. The complex completed mining coal in 2016 with the site now working through mine closure activities expected to take several years to complete.  

Ben has been working in mining for 12 years as a site environmental practitioner being involved in various aspects of mine site rehabilitation, environmental management and community liaison.  

Industry Update on Westside Mine  
Westside mine near Lake Macquarie in NSW operated between 1992 and 2012, producing approximately 1 million tonne of coal per year for domestic power generation use.  

A strong focus on progressive rehabilitation throughout the operational phase allowed rehabilitation to be completed in April 2012, just two months after final mining operations ceased. The site has since been managed under a post closure monitoring and maintenance program with some rehabilitation areas now ready for relinquishment having achieved closure criteria accepted by Government. The overall objective is to return the site to native bushland comprising native vegetation communities that are characteristic of the local environment and landform type. On-going monitoring has confirmed that natural ecosystem functions are returning, with recent surveys identifying 69 fauna species in the rehabilitation, including 11 threatened species.  

The final void on the site has no highwall as the mining sequence allowed dumping against the highwall in the final stage of mining giving a safer final land form. The void is currently being allowed to fill with predictions of water inflows and evaporation rates estimating the void to fill by 2029. Water quality analysis indicates the final discharge will be similar to background levels in the creek, and is not considered a significant risk. A long term monitoring program is in place to confirm modelling results.
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Neil Griffiths has been NSW Department of Primary Industries District Agronomist and Technical Specialist Pastures based in the Hunter Valley since 1985. Most of his work is particularly relevant to the dairy and beef industries and seeks to balance need for production and profit with environment and sustainability issues. While having a broad general knowledge of agronomy issues Neil has specialised in pasture management with emphasis on grazing management, forage conservation, soils and fertilisers and use of alternatives such as poultry litter. Other issues include pastures species adaptation, feed quality and irrigation management.

Neil now leads the team working on the Upper Hunter mine grazing study.

Heavy metals, trace elements, pasture and cattle observations from the Upper Hunter mine grazing study

The Upper Hunter mine grazing study is in its third year and new replacement steers have been introduced at both the Singleton and Muswellbrook sites. The first round of the study which monitors rehabilitated mine land and adjacent native pasture analogue sites showed a link between soil fertility, pasture growth and cattle weight gain. The average value of steers produced on rehabilitated mine land was higher than the average value of steers grazing the native pasture analogue areas. The second round of the study will monitor pastures and cattle to see if these results are repeated. Soils, pastures and cattle were sampled and analysed to measure major nutrients, heavy metals and trace elements. Soil tests showed that heavy metals were well below levels of concern except for nickel which was marginal at one site. Pastures may vary in nutrient levels due to pasture species, growth stage or part of plant tested, growing conditions and time of year. Pasture analysis results were below level of detection on all samples for arsenic, cadmium, lead and selenium. Nickel in pasture samples was in normal range with even the highest test results well below toxicity levels. Zinc results varied widely with some results low and some high. Boron and copper levels were normal to low. Blood samples were taken by a vet from Local Land Services and tested for selenium, lead, copper and zinc. Results were within normal range except for selenium which varied at each site but showed no difference between rehab and analogue at either site.
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Shannon Mulholland is a Technical Officer for NSW Department of Primary Industries – Biosecurity and Food Safety. Shannon has been involved in community engagement and education programs to heighten awareness of biosecurity matters, in addition to her work in plant pathology and entomology. Shannon has spent over a decade working in the Hunter Valley specializing in weed and feral animal management within the mining industry as well as extensive experience in post-mining rehabilitation management and monitoring. Her current work involves project management for science and research projects and investigating plant pathogens affecting horticulture industries.

Mining and Biosecurity

Biosecurity is the protection of our environment, economy and community from harmful pest and disease threats. Biosecurity is a shared responsibility that involves industry, the community and government agencies working together. An important goal for NSW DPI is to prevent new pest, disease and weed species from entering or moving around NSW. In the event of an incursion these threats need to be quickly found and eradicated before they can spread, otherwise we are forced into a management regime and the long term damage they cause can be very costly (both economically and environmentally). Most mine sites typically experience high numbers of personnel and vehicle movements between sites, between regions and interstate, all of which will inevitably pass through areas that contain pests considered to be biosecurity threats to NSW. Imagine for a moment a 4WD vehicle, where this vehicle would typically travel on site, and the multitude of spaces where tiny insects, weed seeds, soil or plant borne diseases could hide and be shipped between sites. A biosecurity incursion on site could not only pose a threat to local primary industries but also offset areas and post-mining rehabilitation. An effective biosecurity strategy is crucial for protecting the environment and economy of NSW.
Pathways to relinquishment and opportunities to transition to productive alternate land uses

**Background:** Using the relinquishment process to transition to alternate productive land uses potentially has significant benefits for all parties; mining companies, regulators and communities. However, there are also a number of challenges in achieving this transition to the benefit of all. The challenges include:

- Current regulatory and land tenure frameworks
- Providing for the long term management of residual risk / liability for a site if a future land use fails
- Lack of current mechanisms to facilitate the alignment of mining companies and investors in post mining land uses, with regional development plans

**Purpose:** The purpose of this workshop is to explore the frameworks and pathways which could facilitate transition of mine sites to alternative productive land uses that are acceptable to regulators, valued by the community and provide a more certain route to relinquishment of liability for mining companies. The intent of the workshop is to develop recommendations for improved relinquishment and land use transition processes which will be taken forward by the Tom Farrell Institute for further discussion with interested parties. The workshop will discuss:

1. Existing frameworks and pathways to mine relinquishment that satisfy stakeholders (government, future landowner and community).
2. Who is responsible for different parts of the transition and relinquishment process and where a mining company’s responsibility for facilitating a future land use stops and the new land user’s starts.
3. The role of government in facilitating a transition to a productive land use.
4. Who needs to be involved in the relinquishment and transition process and why.
5. The alternate future pathways for transition and relinquishment that could be possible and current barriers to achieving these pathways now.
6. What needs to change in terms of policy and/or practice to achieve alternative pathways and the outcomes identified.
7. Recommendations for possible alternate frameworks for relinquishment and land use transition.
Peter Elliott
Independent Consultant

Peter Elliott is an independent consultant providing strategic management and environmental advice and solutions to complex problems including mine closure and relinquishment. Peter has had a long history of facilitating and leading integration of sustainable principles into both mine and other infrastructure projects. He worked for the resource sector for over 20 years including Alcoa World Alumina and Western Mining where he was instrumental in developing good practice in Mine closure and Completion. In 2006 he was a prime author of Mine Closure and Completion booklet produced as part of the leading practice sustainable development program for the Australian Mining Industry produced by the Australian government Department of Industry Tourism and Resources.

He has assisted the Australian Centre for Minerals Extension and Research part of the Sustainable Mining Institute with mine closure workshops, with a focus on the integration of socio-economic aspects of mine closure into Mine Closure Plans. He has provided advice to the WA Department of Mines and Petroleum and Office of the Environmental Protection Authority in the development of Guidelines for preparing Mine Closure Plans.

Peter’s background includes being a member of the world benchmark bauxite mine rehabilitation team that received the David Judd Award, the Alcoa environmental excellence award. He developed the first agreed set of mine closure completion criteria developed in Australia. He is currently involved in developing the negotiated net benefit approach for mine closure and the development of more realistic outcomes based assessment and completion criteria and alternative land use options with several clients in WA.

Gary Ellem
Tom Farrell Institute for the Environment

Dr Ellem, a conjoint academic with the Tom Farrell Institute at the University of Newcastle, is a national thought leader in sustainability working mainly in the areas of transport, energy and regional innovation. He has a penchant for identifying system scale opportunities which combine technology, business and regulatory innovation. His recent work has focused on modelling the scale and economics of alternative energy, sequestration and land management systems, as well as the development of innovative biomass technologies such as microalgae. Gary has published peer reviewed papers in the fields of biofuels, electrified transport and global fossil fuel resources. He has IP in the fields of wireless signal communications, the thermal processing of Biomass and microalgae photobioreactor design.
Martin Rush
Mayor
Muswellbrook Shire Council
Martin grew up in Young in country New South Wales. He graduated in economics and law from the University of Newcastle and studied international law at the University of Jerusalem as a recipient of the Sir Zelman Cowan Trust Scholarship. He came to Muswellbrook in 2000 as a solicitor with a local firm. Since 2004, he has practiced as a barrister in equity, safety and industrial law. He has been the Mayor of Muswellbrook since 2008.

Andrew Keith
Market Director - Resources
Aurecon
Andrew Keith is Aurecon’s Market Director for Resources in ANZ and Asia. Andrew has a leadership role in providing strategic and early stage advice to mining and resources companies and in delivering to meet Aurecon’s mining clients’ strategic business goals. Andrew has a long history of planning and managing design of infrastructure for mining projects, especially in remote locations having spent 12 years managing Aurecon’s Indonesian operations and delivering work for the Indonesian coal and nickel mining industries. Andrew’s strategic role is to coordinate the company’s expertise to provide the solutions needed by the mining industry in the context of the challenges of declining head grades, increasing remoteness, and critical importance of license to operate in the 21st Century.

Matthew Newton
Assistant Director Environmental Standards
Division of Resources & Energy – Environmental Sustainability Unit
Matthew has been with the Department since 2013, most recently in the role of Assistant Director for Environmental Regulations and Standards.
Some of the key functions include the development and implementation of standards, guidelines, policies and procedures based on best practice to improve mining / exploration rehabilitation outcomes across the state of NSW.
With approximately 21 years of experience in environmental assessment and management, he has been involved in a range of environmental projects relating to mining operations situated throughout NSW, QLD, VIC, WA and the USA. He has worked as a consultant as well as in site-based roles with a particular focus on rehabilitation and mine closure projects including the development and implementation of a mine closure plan, including government sign-off, of closure activities at Glencore’s New Wallsend No.2 Colliery in Newcastle.
Richard Bush
Director
International Centre for Balanced Land Use

Professor Richard Bush is a prominent Australian geoscientist and founding Global Innovation Chair to the International Centre for Balanced Land Use. Based at the University of Newcastle's (UON) Newcastle Institute for Energy and Resources (NIER), the Centre is a multimillion dollar collaboration with New South Wales Department of Primary Industries and the Department of Industry's Division of Resources and Energy. The Centre draws together the research expertise within NSW DPI, NSW DRE, and the University to collaborate with industry and communities on projects of critical importance to the growth and sustainability of NSW.

Professor Bush has a central role in developing world-class research programs, facilitating cross-institutional collaboration and influencing national and international policy. Balanced land-use management is a benchmark for successful regional community development and robust communities. Evidence based policy that incorporates objectives for economic, environmental and social balance are the foundation for balanced land use in practice.

Professor Bush is a specialist in the area of land and water management, natural resource assessment, land use planning and geoscience based technologies. He has worked with industry, government and academia, published over 200 scientific reports and in the past 10 years has won in excess of $10 million dollars of competitive funding to support his research.
Dr. Howard Wildman is chief scientist at Microbial Management Systems (MMS), a laboratory that undertakes microbiological testing of soil, organic matter and water — as well as providing microbial solutions for soil management, bioremediation and waste management issues. Prior to establishing MMS, he worked for over 20 years in the pharmaceutical and biotechnology industries in the United Kingdom and Australia. MMS has undertaken projects to monitor the effects on soil microbial communities of soil disturbance, storage and replacement, the time required to develop stable soil communities on rehabilitating sites, biological soil crust development on rehabilitating arid soils, and the effectiveness of soil amendments on establishing microbial communities on degraded soils.

**Microbial functional diversity – its importance to ecosystem function, and choice as a mine soil restoration objective**

Microorganisms are not part of any predetermined regulatory criteria to show that mined land has been restored to a stable, productive, and self-sustaining condition. So why should a company spend money monitoring them?

Most obviously, microbial communities mediate critical ecosystem processes including nutrient cycling, plant establishment, geochemical transformations and soil formation. They are the major living component of topsoil, which is the most important rehabilitation asset on a mine site.

Additionally, the regulatory environment is changing and it is likely that future restoration standards will require ecosystem function monitoring. For example, the recent National Standards for the Practice of Ecological Restoration in Australia, prepared by the Society for Ecological Restoration Australasia has examples of ecological restoration objectives which include an ecosystem function attribute of “Positive change in microbial functionality parameter xx”. That is, for soil microorganisms, it is recommended that one or more quantitative determinants are used consistently throughout the life of the restoration project to ensure that the functional diversity of soil microbial communities is restored.

I will describe microbial functional diversity and its choice as a restoration objective in preference to “Microbiological indicator genera xxx and yyy are present on zz zones”. Some simple microbial functional diversity indices will be outlined and results presented of their use on mine sites over a 10 year period.
Dr Nanthi Bolan is a Professor of Environmental Chemistry at the University of Newcastle. His teaching and research interests include agronomic value of manures, fertilisers and soil amendments, soil acidification, nutrient cycling, pesticide and metal pollutants interactions in soils, soil remediation and waste and waste water management.

Nanthi is a Fellow of American Soil Science Society, American Society of Agronomy and New Zealand Soil Science Society and was awarded the Communicator of the Year award by the New Zealand Institute of Agricultural Sciences. He has supervised more than 40 postgraduate students, and was awarded the Massey University Research Medal for excellence in supervision. He has published more than 250 papers and was awarded the M.L. Leamy Award in recognition of the most meritorious contribution to soil science.

Sources and management of acid mine drainage

Acid mine drainage (AMD) from both active and abandoned derelict mine sites is a major environmental issue for the mining industry. The term AMD is used to describe any seepage, leachate or drainage affected by the oxidation products of sulphide minerals in mine sites when exposed to air and water. The AMD is typically characterised by low pH and high levels of dissolved metal salts, as well as high concentrations of acidity, sulphate, iron and other metals. Once the AMD process begins, it is difficult to control, often accelerates and is likely to persist for decades or centuries. In the absence of natural or added neutralising materials (carbonate minerals such as calcite or dolomite), the AMD is likely to contain toxic levels of heavy metals such as Fe, Al, Mn, Cu, Pb, Zn, Cd etc. which can cause serious environmental problems in soil and water systems.

Regulations in many countries have developed ways to address the issue of AMD at the permitting stage rather than as an afterthought. Since AMD generation is a site-specific phenomenon, effective control and treatment measures have been directed towards fulfilling the problem on site rather than to providing universal solutions. This presentation describes the sources, and chemical and biological reactions resulting in acid mine drainage. It also covers the measures to prevent AMD formation and the methods to manage their environmental impacts.
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20+years experience within government, rehabilitating and restoring ecosystems (wetlands, including constructed wetlands, riverine ecosystems, grassy woodlands, derived native grasslands and rehabilitated mined land, including derelict mine sites. I have also focused on understanding the ecological processes critical to groundwater dependent wetland and terrestrial ecosystems. Recent work has focused on the monitoring and assessment of self-sustainability for ecological rehabilitation of mined lands.

Towards best-practice monitoring and assessment of self-sustainability for ecological rehabilitation on mined land

The establishment of self-sustaining ecosystems is increasingly the aim of post mine rehabilitation within Australia. However, there is little consensus on how to measure progress towards self-sustainability and indeed how to determine when an ecosystem can be considered self-sustainable. On the basis of our review of available literature we will briefly 1) define the key elements of a self-sustaining ecosystem within the context of rehabilitated mined land; 2) outline the preferred characteristics of performance indicators for tracking development towards self-sustaining native ecosystems; and 3) suggest a suite of practical performance indicators for monitoring progress towards self-sustainability. We will conclude with a brief discussion of how these indicators and their monitoring data might be used in the context of completion criteria for self-sustainability.
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Carmen Castor acquired her PhD in South America studying seed dispersal and germination in the Andes. In 2003 she joined the University of Newcastle and has since researched methods of coal mine rehabilitation and restoration of offsets. She also worked for a year at OEH gaining insight into government policy. Currently she continues to work as a Conjoint Lecturer at the University of Newcastle and also is working as Senior Scientist at CSER Research a consulting company for research and monitoring on coal mines.

Sustainable Ecological Communities on Mine rehabilitation
A growing number of mine sites have increasingly strict rehabilitation conditions placed on them by government agencies to produce sustainable Ecologically Endangered Communities (EEC’s). We still have no real evidence that re-establishing EEC’s is possible, or becoming sustainable.
We investigated the use of forest topsoil, substitute capping materials, and organic ameliorants (coarse wood mulch and OGM) seeded with species drawn from local EEC’s and adjacent vegetation, in a statistically valid field design covering 0.7ha.
Results for 50 species on 9 treatments (n=6) are shown together with an analysis of hypothetical sustainability of plant populations.
Most of the species seeded emerged initially. Many other species were also contributed by substrates which already contained a native soil seed bank totalling 120 native species. On further analysis, 80 species had at least 6 individuals, a number arbitrarily chosen to represent a possible “sustainable” population.
Data was compared to the ideal species mix found in EEC’s but successfully established communities on the different substrate types are all moving away from the desired EEC composition.
We conclude that establishment of a larger than expected variety of species is possible on mine rehabilitation, but that attaining a desired composition may be more difficult.
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Andrew manager major projects in the Hunter Central Coast at the Office of Environment and Heritage. In this role he continues the development of key policy initiatives for the Upper Hunter Strategic Assessment, including the proposed impact management system and the cumulative impact assessment and risk assessments. Andrew is also responsible for the public exhibition of key documents including the Biodiversity Management Plan and Strategic Assessment Report.

Andrew has a long career in the public sector in the environmental field as a forest ecologist, threatened species officer and has held a number of senior management roles in OEH.

Upper Hunter Strategic Assessment

The audience will be familiar with the Upper Hunter Strategic Assessment having followed its progress over the past four years. The project has reached a key milestone and is currently on public exhibition. This presentation covers a number of key components of the assessment including guidelines for ecological restoration of mined land and cumulative impact assessment of biodiversity values.

The strategic assessment aims to protect the unique biodiversity of the Hunter region, while allowing the region to continue to benefit economically from the extraction of high quality coal resources.

A new management system based on the avoid, mitigate and offset policy framework has been developed, informed by a cumulative impact and risk assessment of potential impacts to threatened communities, populations and species. The management system is designed to protect species and communities that are most at risk.

The mine site rehabilitation guidelines aim to achieve high quality rehabilitation of mined sites and new mitigation guidelines have been developed which are tailored specifically for the Hunter region.

The NSW Government is currently seeking feedback from the community of the adequacy and appropriateness of the strategic assessment.
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Didik is Quality Health Safety Environment (QHSE) Compliance Manager of PT Adaro Indonesia, a major coal producer in Indonesia. Prior to his current position, he worked as Chief Engineer Regional and Long Term Hydrology at PT Freeport Indonesia 2010-2012, a major copper and gold producer in the world.

One of his main roles within these two companies is dealing with managing significant environmental impacts of mine operation that is acid rock drainage (ARD) or acid mine drainage (AMD). Along with this task, he leads team working on post mine closure study and preparation i.e. pit lakes utilization study. He also leads environmental monitoring team of Adaro to ensure the result of environmental management programs such as water quality, reclamation and revegetation, biodiversity, hazardous waste, emission has been complied with government regulations. Currently he is focusing on preparation of the closure of Paringin Pit.

In 2007, he received Australian Partnership Scholarship (APS) award from Australian Government to pursue master degree on Environmental Management from the University of Queensland, Australia and completed the study in 2008.

Managing Pit Lakes Water Quality at Coal Mine of PT Adaro Indonesia, Indonesia

PT Adaro Indonesia is one of the biggest coal producer in Indonesia from its single location in South Kalimantan, Indonesia. It produces 50 Mt/year of thermal coal from three mine pits: Tutupan, Paringin and Wara. Paringin Pit is expected to be mined out in 2021 while the two others still continue in operation.

This paper discusses the final void plan of Paringin pit for ensuring environmentally and socio-economically sound of future pit lake. Currently there is a pit lake with an area of 21 ha in Paringin pit resulted from previous mine operation. The water quality monitoring has been conducted regularly to monitor water quality of the existing pit lake. The result of monitoring data will be used for evaluation and prediction of another pit lake created in the future. In 2021 there will be one big final void created in Paringin with total volume estimated 320 million m3 of fresh water.

With the annual rainfall of the site is 3,000 – 4,000 mm/year, it will be challenging for PT Adaro Indonesia for ensuring the mine void geotechnically and geochemically stable and safe. At the end when the void filled up with water, it should be environmentally and socially functional as fresh water storage.
Backfill or not? Water management considerations during rehabilitation

A key consideration for many open cut mining operations is how to manage mine voids at closure. One of the main decisions to be made during decommissioning and rehabilitation is whether or not to backfill mine voids. Often the economics of backfilling result in this method of site management being deemed unfavourable and it is quickly ruled out, although there is increasing pressure on the mining community as part of its social and environmental responsibilities to properly consider and schedule mining to enable backfilling to occur. This paper discusses the practical water management considerations that arise during the process of backfilling mine voids, and draws on experience from a number of operations that have undertaken backfilling.

Most operating open cut mines have the ability to store large volumes of stormwater runoff in mine voids, and subsequently undertake release from these voids in a controlled manner when water quality is acceptable for discharge. As mine voids are progressively backfilled the capacity to store water diminishes and operators must transition into a new stormwater release regime that involves minimal or no storage and in-line stormwater treatment. Careful planning and management strategies are required to schedule bulk earthworks required for backfilling with landform rehabilitation for source control. Changes to licencing and sediment controls will also be necessary.

In this paper a case study is presented from a mine that backfilled its mine void to minimise its environmental liabilities and ensure it met corporate responsibilities. The catchment draining to the mine void prior to rehabilitation was considerable, so when backfilling occurred a very large sediment basin would have been required if the traditional sediment settling approach was used. Instead, a much smaller basin was installed with an in-line flocculation dosing system (High Efficient Sediment basin), enabling a storage volume of roughly 25% of that required for a traditional sediment basin. The flocculation system will be removed when the catchment is fully revegetated and the sediment loads have stabilised.

Water management difficulties that arise during backfilling are manageable provided they are anticipated and planned for.
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Corinne Unger (BSc Dip Ed Dip Geoscience), has more than 30 years’ experience in land rehabilitation, 28 of those years in mine rehabilitation and closure planning mostly in industry but also in government, consulting and research. A Churchill Fellowship in 2009 enabled Corinne to undertake research on leading practice abandoned mine rehabilitation and post-mining land use in Europe and Canada. She began working part time at SMI in March 2011 with a focus on managing mining legacies and more recently on knowledge management for coal mine rehabilitation and closure. Corinne is Chief Investigator for the ACARP funded MRC-wiki project.

“MRC-Wiki” – a mine rehabilitation and closure knowledge management tool for coal mine practitioners

This paper is based on original research exploring the ways to facilitate retention of mine rehabilitation and closure knowledge for Central Queensland coal mines. The research project was developed in response to the loss of valuable knowledge gained over several decades as practitioners left the region and the workforce. Mining boom and downturn cycles have exacerbated the loss of knowledge due to rapid changes at mines in this region. Some of the most experienced rehabilitation practitioners in central Queensland, especially, are approaching the end of their careers and want their valuable, and often less formal knowledge, retained. This research has been undertaken in cooperation with the Central Queensland Mine Rehabilitation Group (CQMRG) with the following objectives: to guide users to appropriate knowledge, decision support and other management tools already available through ACARP and other sources; capture the (less formal) long-term knowledge of rehabilitation practitioners and stakeholders in a rehabilitation manual and discussion forum format; encourage discussion and ensure the accessibility of this unpublished knowledge in perpetuity and be able to be maintained by industry groups like CQMRG, over time. The research team found that an innovative Mine Rehabilitation and Closure wiki (MRC-Wiki) was the most suitable tool to retain the wealth of practitioner knowledge that has accumulated over the last 20+ years. This paper describes both the methodological process of developing the Wiki and distils learnings from knowledge management theory and this project that have potential to inform knowledge management in other regions, commodities and disciplines, and thus have a far wider application.
Dr. Simit Raval has over 20 years of combined experience in mining industry and academia. At present, his research and teaching is primarily focused on Mine Environmental Monitoring and Management.

Simit is unique among mining engineers/academics in Australia in his considerable mining engineering experience coupled with development of applied remote sensing techniques. His mining engineering background and the remote sensing skills provide a uniquely valuable strength to visualise, identify and monitor the environmental footprints of mining activities - a critical research focus that is attracting much interest from researchers internationally and that the mining industry is currently seeking to peruse.

High resolution imaging for mine rehabilitation using UAV-Hyperspectral technology

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A quantitative record of the mined landscape is deemed to aid qualitative assimilation of the knowledge of the mined land and design of an efficient rehabilitation strategy. Cutting edge technologies such as Unmanned Aerial Vehicle (UAV) and hyperspectral sensors enable physiochemical insights into the biota. With the UAV hyperspectral system, it is now possible to spatially chart an ‘Eco-Space’ for species distribution, diversity, natural chlorophyll levels, photosynthetic activity, foliage cover and much more. In this study, we exhibit a framework to fingerprint a Mine Eco-Space for its natural functionality. A Fabry–Pérot interferometer (FPI) type lightweight hyperspectral sensors has been used to generate geo-spatialised classified raster products unique to a mine environment. The UAV flight campaign was performed at ecologically complex swamp environment within a mine lease located in the New South Wales. The presentation will include the resultant classified raster maps for the species composition as well as the derived biophysiochemical attributes of the species at a very high spatial resolution.
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Greg has worked in the area of landscape assessment and mining rehabilitation for the past 20 years. He has particular expertise in the use of computer based landscape evolution models for both current and proposed landscape assessment. He has worked across a wide range of projects, sites and climates both here in Australia and internationally for government agencies, mining companies as well as consultancy firms. He has published over 107 research and conference papers as well as numerous industry research reports.

Sustainable mine rehabilitation: two decades of soil erosion and landscape evolution modelling

G R Hancock1, G R Willgoose 2
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Environmentally sustainable and cost-effective rehabilitation design is crucial for the long-term stability of post-mining landforms. The goal for any closure strategy is to engineer a rehabilitation program that allows for a “walk away” at the end of operations. To achieve a “walk away” result it is expected that a significant research effort is required as structures such as waste rock dumps and tailings storage facilities are considered one of the greatest long-term post-mining liabilities.

Computer based landscape evolution and soil erosion models are a tool which can greatly assist mine rehabilitation. Here we describe rehabilitation practices and the use of landscape evolution models which can greatly improve rehabilitation outcomes and the rehabilitation design process. The focus here is on the SIBERIA landscape evolution model which has been used by the mining industry for the past 25 years. Here we outline the history of landscape evolution models and SIBERIA, the model functionality as well as model calibration process. We place a particular focus on testing and evaluation of the model for both natural and post-mining landscapes. As the expectation is that the model can accurately and reliably predict soil erosion and landscape evolution at decadal time scales and longer, we also explain the need for long-term test sites to be established. Finally, future developments to the SIBERIA model are discussed.
Grant Dickins, a geospatial consultant, founded Naturally Spatial to improve the way degraded and damaged landscapes are managed. By demonstrating to decision makers that superior alternatives to traditional approaches exist, his goals are to advance mine closure methods by focusing on improved mine closure landform designs. Grant is working towards a zero tolerance for inadequate post-closure designs and hopes to never see a constant gradient batter again!

Through Naturally Spatial, Grants professional experience includes projects for state and local governments, regional bodies, research groups, industry leading oil, gas and mining companies and senior roles at professional consultancies. Grant studied Geomatics (BAppSc) at RMIT and he is a certified GeoFluv designer.

### Comparative Evaluation of Sediment Yield from Native and Fluvial Geomorphic-Reclamation Watersheds

This research study was carried out by the San Juan Coal Company (SJCC) at its La Plata Mine in New Mexico, USA. The SJCC reclaimed 743 ha (1,835 acres) at its La Plata Mine using the GeoFluv fluvial geomorphic reclamation design method from 1999 (Bugosh, 2000) through 2008. Beginning in 2011, the SJCC began quantifying sediment production rates on fluvial geomorphic reclamation projects to evaluate sedimentation rates occurring using fluvial geomorphic design methods versus surrounding undisturbed native landforms.

Fluvial geomorphic reclamation is an established and international approach used to achieve long-term stability against erosion, reduced maintenance, and increased biodiversity as compared to traditional reclamation methods. In Australia, state agencies are now favourably considering fluvial geomorphic landform designs over traditional designs. We present these results along with supporting observations from design and construction projects using the GeoFluv method from all over the world (North and South America, Europe and Australia).

The study provided data from precipitation events sufficient to cause sediment transport from the end of 2012, through 2013, to the beginning of 2014. The results showed the greatest sediment yield came from an undisturbed native site (9.53 t/ha/yr), compared to a geomorphic design with topdressing and poorly established vegetation (8.25 t/ha/yr; a 13% lower sediment yield) and a geomorphic design with topdressing and significant vegetation (5.65 t/ha/yr; 41% lower).

The results of this study, supported by qualitative inspections of completed reclamations, confirm the benefits of fluvial geomorphic reclamation methods. This methodology has significant potential for similar long-term sediment monitoring research into the benefits of fluvial geomorphic reclamations.

Study Authors: Bugosh, N, Epp, E. G., 2015.
Robert Scanlon
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Robert has been working for the last two years as a research assistant at CSER Research and the University of Newcastle. He was recently accepted as a PhD candidate at the University of Newcastle and is looking forward to learning more about the interactions between soils, plants, microbes and their implications for restoration.

Impact of Soil Type and Treatment on the Survival of Perennials in the Ground Layer

Soil is of great importance to the survival of plants, not only providing a stable location to live but also providing the essential nutrients required to grow and reproduce. Similarly, the plants of the ground layer are very important to an ecosystem providing ground cover to reduce erosion and in local EEC’s accounting for large amounts of diversity. Our study examined the survival of six perennial species (mostly forbs) over one and a half years and has related their survival to combinations of soil types and treatments used; spoil, subsoil, OGM and mulch. The study found that there was no universal treatment that benefited every species with the strongest result coming from the addition of mulch which increased the survival of 5/6 species but decreased survival in one species. The study concludes that each species has a niche that it is best suited to and therefore, even though all species come from one community, they will survive best in different soil conditions. Therefore, the use of broad scale homogenous soil types and treatments may not be the best way to increase plant diversity and the creation of smaller patch landscapes would be a better restoration method.

Co authors on any presentation will be Carmen Castor and Yvonne Nussbaumer
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Hannah has completed her Bachelors and Masters Biology degree from University of the Philippines-Diliman. She is currently finishing her thesis on the phytoextraction of mercury and gold from contaminated mine tailings and biosolids for the degree PhD Chemistry at the University of Melbourne. She is also a full-time faculty member at the Institute of Biology, University of the Philippines-Diliman, where she handles both undergraduate lecture and laboratory classes. Her research interests include stress physiology, phytoremediation, and mine rehabilitation and has published several research papers and has given oral presentations in international conferences in these fields.

Spatial distribution of mercury and gold in roots of cassava (Manihot esculenta) by micro-PIXE

Removal of mercury (Hg) by plants offer new options to clean up Hg-contaminated sites and at the same time harvest gold (Au). Localization of Hg and Au in the root tissues of a potential phytoremediator, cassava (Manihot esculenta), was investigated by micro-Proton Induced X-ray Emission (micro-PIXE) spectrometry to gain a better understanding of Hg and Au uptake. Plants were exposed to different Hg and Au concentrations for 6d. Qualitative elemental micro-PIXE analysis revealed that Hg and Au was found inside the root tissues for both 50 µM and 100 µM. Interestingly, plant exposure to equimolar concentrations (50 µM Hg + 50 µM Au) revealed both elements to be localised only in the epidermis, in contrast to when the plants were exposed to either Hg or Au alone. Lastly, when the Hg concentration is increased relative to the Au concentration (100 µM Hg + 50 µM Au), Au was found to be strongly localised in the epidermis while Hg was found inside the roots. These results suggest a plausible metals uptake competition. Given its ease in cultivation and harvest as well as the high Hg and Au accumulation in the roots, cassava is a suitable candidate for Hg and Au phytoremediation.
Charles Lee
University of Newcastle, Singapore Campus

Dr. Charles Lee obtained his BSc from the University of Guelph, Canada, and his MSc and PhD from the University of Hawaii, USA. He has more than 25 years’ experience in environmental research, teaching and consulting in North America, and Asia-Pacific countries. His experience encompasses consulting at one of the top environmental consulting firms in the USA, R&D at the Agency for Science Technology and Research (A*Star), and academic teaching and research at UON. He is active in teaching and managing the Bachelor of Environmental and Occupational Health & Safety program. His research areas include environmental sustainability, environmental waste management, environmental health, and biotechnology solutions to industrial waste treatment.

Sustainable Mining in the Philippines.
Rios, A., CC Lee, FA Monsada, and JR Bacani
Since the 1500s, mining has played a critical part in the economic development of the Philippines. With an estimated $840 billion of mineral resources yet to be mined, the opportunities for growth are tremendous. However, several reforms must be considered to ensure that mining contributes to sustainable development. President Duterte’s ‘responsible mining’ policy, while a good framework and sets the direction of the industry, is lacking in defining specific action plans and the governance to implement the plan.

Several factors must be considered in the setting of these action plans. While various environmental and mining regulations already exist, there is poor and inconsistent implementation of these regulations due to the lack of clarity of the roles of local and national governments in policing wayward operators, which often lead to individual or collective conflict of interest. The mandatory environmental impact assessment (EIA) study is often the only tool for seriously looking at significant impacts of individual mine development. The EIA studies takes into consideration: (a) lessons learned from previous incidents; (b) the vulnerabilities of the site and the community; (c) man-made and natural disasters such as flooding, severe typhoons and earthquakes; and (d) reviewing available technologies and methods for minimizing adverse impacts. There are however, very few examples of such studies. This paper contains examples of mine sites and community actions found to have successfully adopted sustainable operational practices that does not lead to long-term degradation of the environment.
Angus Carnegie
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Dr Angus Carnegie is a Principal Research Scientist with NSW Forest Science (NSW Department of Primary Industries) with over 25 years experience in forest health, pest and disease management, and biosecurity. He is internationally recognised for forest health surveillance and management of key plantation pests and diseases, including biocontrol and tree breeding, as well as impact and management of myrtle rust. He has over 80 publications in peer-reviewed journals with national and international collaborators. He represents the forest industry and NSW DPI on national committees, and is Chair of the Forest Health and Biosecurity Subcommittee.

Managing the potential impact of myrtle rust in mine rehabilitation.

Myrtle rust (Puccinia psidii) is an exotic disease from South America that was detected in New South Wales in 2010 and is now established along the east coast of NSW and Queensland and locally in Victoria, Tasmania and the Northern Territory. It infects new shoots and leaves, causing distortion and shoot death, and dieback and tree mortality in severe cases. It has a host range of over 450 species across more than 70 genera within Myrtaceae, and has long been recognised as a significant threat to Australia's native ecosystems and industries reliant on Myrtaceae. In the six years that myrtle rust has been established in native ecosystems in Australia, it has caused significant impact to highly susceptible species, including dieback, tree mortality, and cessation of fruiting and reproduction. Regeneration of susceptible species, including after fire and for bush-regeneration, has also been impacted, with the species composition at some monitoring sites changing as non-susceptible species dominate. This has implications for mining rehabilitation, with failure likely if highly susceptible species are selected. Current research indicates selection of resistant or tolerant provenances/seedlots could assist in reducing the impact of myrtle rust on mine rehabilitation sites.

*The additional author for this research is Geoff Pegg, Queensland Department of Agriculture and Fisheries, Brisbane Qld*
POSTER PRESENTERS

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Andrew Keith is Aurecon’s Market Director for Resources in ANZ and Asia. Andrew has a leadership role in providing strategic and early stage advice to mining and resources companies and in delivering to meet Aurecon’s mining clients’ strategic business goals. Andrew has a long history of planning and managing design of infrastructure for mining projects, especially in remote locations having spent 12 years managing Aurecon’s Indonesian operations and delivering work for the Indonesian coal and nickel mining industries. Andrew’s strategic role is to coordinate the company’s expertise to provide the solutions needed by the mining industry in the context of the challenges of declining head grades, increasing remoteness, and critical importance of license to operate in the 21st Century

Closing your mine while improving your bottom line

As part of the AusIMM’s Life of Mine Conference 2016, Aurecon held a workshop entitled "Closing your mine while improving your bottom line", for representatives from government environmental and mining departments, scientific research organisations, universities and major mining and engineering corporations to brainstorm mine closure possibilities.

Adopting a design-led innovation approach, the day produced a number of mine re-purposing suggestions ranging from research facilities to adventure parks. One concept, “the blank canvas solution” became an enabler for other ideas and offers stakeholders the chance to completely rethink rehabilitation and mine closure. This idea advocates the establishment of an umbrella agency to create sustainable regional communities by providing expert advice and coordinating the right providers throughout the mine’s operating and closure stages.

This solution recognises and serves the complex and competing needs of the three main stakeholder groups critical to developing sustainable communities: the mining company, government and the community. It provides a mechanism which through early and continual involvement from mine planning through to close the "wicked" problem of achieving positive social, environmental AND financial outcomes can be mobilised through collaboration.

The paper will present the outcomes of the workshop and reflections of participants from the industry post workshop as a catalyst to continue the conversation.
Yilu Xu
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I am studying as a Ph. D. candidature of soil remediation of University of Newcastle. With a background in environmental science and ecology, my research interests include soil carbon sequestration and microbial carbon use efficiency, and heavy metal contaminated soil quality assessment and remediation. I have been working on ‘Soil Carbon Assimilation and Dynamics in Relation with Microbial Carbon Use Efficiency’ as part of my Ph.D. program.

Heavy metal speciation and availability on soil microorganism activities.

The heavy metal(loid)s contamination is pronounced in soils adjacent to mine sites. As an important habitat to thousands of organisms, soil health condition is crucial to their actives. Consequently, soil microbial functioning exposed to long-term contamination by heavy metals affects the role of soils as a carbon sink. Heavy metal toxicity to soil microorganisms are highly depends on their (potential) availability. Therefore, a thorough research on understanding the relation between heavy metal(loid)s and microorganisms will help to detect soil fertility and contribute to soil organic remediation.

We studied the effects of heavy metal speciation and availability on soil microorganism activities at different cadmium and lead contamination gradients, separately as well as jointly. Soil microbial respiration, microbial biomass carbon were investigated. Microbial PLFAs were also extracted and analysed by gas chromatography combined with GC–MS, HP 5973. Potential and bio-available heavy metal concentration were extracted by 0.05 M EDTA and 0.1 M CaCl2, respectively. Results showed that depending on the solubility and mobility of the heavy metals, the potential bioavailable heavy metal concentration varied between Cd and Pb. In addition, microbial activity and biomass were both reduced because of metal toxicity.
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I am a passionate PhD student from the University of Newcastle (UON). My thesis title is “Biogeochemical mechanisms of biosolids application on carbon sequestration in soils”. I use biosolids which is treated sewage sludge to limit greenhouse gas emission, and enhance soil carbon sequestration, thereby mitigating climate change. Before joining to the UON, I studied at University of South Australia (UniSA), Adelaide. I was fortunate to receive the prestigious International Presidential Scholarship (IPS) to conduct my Ph.D studies at the Center for Environmental Risk Assessment and Remediation, UniSA. I obtained B.Sc (Special) degree in Environmental Science and Natural Resources Management from University of Sabaragamuwa and M.Phil degree in Environmental Science from University of Peradeniya, Sri Lanka. I was a Research Assistant to the Chemical and Environmental Systems Modelling Laboratory, Institute of Fundamental Studies, Kandy. My hobby is disseminating science to Sri Lankan students in my native language.

Microbeads in biowastes

Hasintha Wijesekara 1, Lauren Bradney 1, Balaji Seshadri 1, Ramesh Thangavel 1, 2, Nanthi Bolan 1
1. Global Centre for Environmental Remediation (GCER), Advanced Technology Centre, Faculty of Science, The University of Newcastle, Callaghan, NSW, 2308, Australia. 2. Division of Natural Resource Management, Indian Council of Agricultural Research (ICAR) Research Complex for North Eastern Hill Region, Umiam, Meghalaya, 793103, India

Microbeads are plastic particles in the environment that are generally smaller than 1 mm down to the micrometer range. They are derived from a variety of sources, including cosmetics, clothing, and industrial processes. There are two sources of Microbeads: (i) primary microbeads are manufactured and are a direct result of anthropogenic use of plastic-based materials; and (ii) secondary microbeads are plastic fragments derived from the breakdown of larger plastic debris. Both types persist in terrestrial (i.e., soil) and aquatic (i.e., marine) ecosystems. Because plastics do not break down readily, they can be ingested and incorporated into and accumulated in the bodies and tissues of many terrestrial and aquatic organisms. UNEP (2016) identified that large quantities of microbeads ending up in the marine environment have originated from land-based sources. However, the majority of scientific research into microbeads has focused on their effects in aquatic environments. The results indicate that microbeads impact aquatic environments through long range transport of pollutants as a result of adsorption-desorption processes, as affected by the respective pollutant concentrations in a given area.

Terrestrial ecosystem is a major source of microbeads reaching aquatic ecosystem through sediment transfer during soil erosion. Microbeads reach terrestrial ecosystem through their indiscriminate disposal in landfills and also through biowastes application including biosolids and composts. There have been renewed interest in the large scale application of these biowastes especially to mine soils mainly to increase soil health and also to enhance revegetation of these disturbed soils. Although microbeads reach terrestrial environments, the degradation of many synthetic polymers is very slow and are likely to persist in soil over a long period of time. Along with physical breakdown, biologically initiated degradation also strongly influences chemical degradation. Adsorption and desorption processes of pollutants in microbeads in the soil environment are influenced by microbial activity. While the high surface area of microbeads not only aids adsorption/absorption of contaminants, but also supports chemical transport of the pollutants through leaching. In this presentation, the sources, fate, and environmental impact of biowaste-derived microbeads in terrestrial ecosystem will be examined. The paper will also aim to link the transport of microbeads from terrestrial ecosystem to aquatic ecosystem.
The Waterberg Plateau Park had 50% vegetation cover of Anthephora pubescens in the 1980’s at the site called Anthephora, but due to the establishment of a water point nearby, it led to overgrazing drastically reducing the population of climax grasses. The study was conducted to find out if A. pubescens and Brachiaria nigropedata will be able to re-establish. A game proof fence was erected at Anthephora, and 60 (2m x 4m) plots were demarcated in Nested Complete Randomized Block Design with two fixed effects (fertilizer and no fertilizer). Germination trials were done to test the viability of the seeds, with 20% of the seeds germinating. Due to the low rainfall received for January-March 2016 (274.6 mm) all the plots were watered (10 mm) for the first 10 days. A species inventory was done and all herbaceous plants in 24 of the sowed plots were clipped for production measurements. Unexpectedly, none of the sowed grasses established in any of the plots. Most of the plots were dominated by Urochloa brachyura, Setaria pumila and other annual plant species. Further experiments will be done in the greenhouse to investigate optimum conditions required for the germination and establishment of the two grass species.
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I am a final year M.Sc natural resources student at the Namibia University of Science and Technology. In 2015 I worked for Windhoek Municipality under the environment department dealing with EIAs and biodiversity issues in the city. This is where my interest in environmental protection developed. My current research is at the B2Gold mine and involves environmental rehabilitation with top soils.

The Otjikoto mine is located in the central area of Namibia. The mine has huge waste rock dumps that need to be covered with top soil as part of the rehabilitation process. The top soil on the mine is limited and needs to be used sparingly. The study focuses on top soil studies both in a greenhouse, under controlled conditions, and field trials. In the greenhouse experiment top soils dumped in the years 2012, 2013, 2014 and 2016 were collected. The nutrient contents were tested using ICP-MS machine. Cenchrus ciliaris grass was planted in the different top soils to test germination. In the natural environment the different top soils were laid on waste rock at different slope angles of 18°, 25° and 30°. C.ciliaris seeds were planted. This was to test erosion rate on the slopes and seed establishment. In the greenhouse the older top soils from 2012 and 2013 had 50% higher C. ciliaris germination as compared to the later soils of 2014 and 2016. In the natural environment the seeds planted on the 18° and 25° slope showed good germination and survival with minimal soil erosion during the rainy season as compared to the 30 degree slope.
John Ritchie is a civil engineer with 20 years experience working with mines throughout the country to design and deliver critical specialist infrastructure that keep mines functioning. Recently, John has become more closely aligned with the environmental industry which includes offering specialist techniques that International company Menard uses throughout the world to economically remediate contaminated sites.

Mine subsidence protection in populated areas

Grout stabilisation of mine voids is an effective way of treating mine subsidence, even in populated built-up areas. This was demonstrated through a project completed by Menard Oceania at Lambton near Newcastle in 2015.

Mine workings in the area date back to 1906 where borehole seam and welsh bord & pillar workings have been carried out over an extensive mine life, including some areas of pillar extraction. The Mine Subsidence Board developed a strategy with a two pronged approach to addressing ongoing subsidence in the area. The first stage sought to urgently address ongoing subsidence in a localised area of instability, followed by a second stage which sought to strengthen areas of increased pillar abutment loading, particularly around the perimeter of the subsidence goaf, and to fill larger voids in the overburden, each of which risked contributing to future subsidence in the local area.

The project involved pumping 4000m³ of a pre-designed grout mix through twenty two cored holes some 30m deep in the heart of a residential neighbourhood. Critically, disruption to the residents in the area needed to be kept to a minimum, through noise and dust mitigation, whilst speed and safety were also critical to the success of the operation.
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Bikram Banerjee has a Bachelor’s degree in Electronics and a Master’s degree in Remote Sensing. He is presently pursuing PhD in Australian Centre for Sustainable Mining Practices, School of Mining Engineering, University of New South Wales, Sydney, Australia. He is exploring the potential using high resolution spectral and LiDAR imaging for mapping biophysiochemical attribute of endangered swamp vegetation communities.

Towards precision mine rehabilitation with UAV hyperspectral and LiDAR technologies
Rehabilitation of mined land is a complex process that requires a detailed understanding and frequent assessments of numerous geo-physical as well as bio-chemical parameters that influence success of a mine closure. It is critical to monitor these parameters such as geomorphology, surface minerology, and soil water content of land as well as vegetation health conditions including their nutritional requirements. Precision mine rehabilitation aims to provide an economically sustainable mine closure solution. Present day technologies such as imaging spectroscopy (hyperspectral) and light detection and ranging (LiDAR) from close range flying platforms such as unmanned aerial vehicles (UAVs)/drones are promising tools towards precision mine rehabilitation. This poster aims to demonstrate a decision support system to formulate optimised and holistic designs to achieve desired post mine landscape with efficient stream segmentation, seeding pattern, fertilizer application workflows using the aforementioned technologies. A regenerating ecosystem remains in a vulnerable state until the complete recovery is attained, thus, careful monitoring of the stress levels is essential for timely interventions. In this regard, ability of these technologies to measure variation in photosynthetic activity to identify areas of water stress, nutritional stress, and pest infestation will also be discussed.
Perennial grasses as energy crops grown using different types of wastewater

The reuse of wastewater is a good practice for both increasing water supplies to agriculture and managing their disposal issues. The benefits being the plant’s use of the nutrients present in wastewater and therefore a reduction in the pollution load that wastewater contributes to the surface water bodies. The aim of the experiment was to produce energy crops using four types of water, thereby studying the nutrient supply to plant growth and the resultant biomass production. Growth of crops in wastewater depends on wastewater quality mainly nutrient concentration, pH and electrical conductivity (EC). The nitrogen (N) and phosphorus (P) concentration of piggery wastewater were 359.77 and 52.97 mg/L and that of dairy farm wastewater were 422 and 27.76 mg/L, respectively. The pH of winery wastewater was slightly acidic (4.73) and that of others were nearly neutral (6.44 to 7.59). After 100 days, the plants were harvested and dried after measuring the fresh biomass weight. Piggery wastewater showed the highest biomass yield (Napier grass-206.27 g/pot; Giant reed-150.67 g/pot), whereas winery wastewater showed the lowest.
EXHIBITOR PROFILES

Vital Chemical
Australian company Vital Chemical, offer a wide range of revegetation products and services designed specifically for all mine rehabilitation projects. Our products enable best practice technologies in the re-establishment of resilient vegetation and mine-site redevelopment. From the supply of nutrient infused soil stabilisation polymers through to our unique bonded fibre matrix hydromulch products, Vital Chemical and joint venture partner, B & K Revegetation will supply and/or install our products on your project sites Australia-wide. Our environmentally certified products and services ensure that the most cost effective solutions are matched to each projects specific requirements.

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Creative Water Technology
Creative Water Technology™ develops revolutionary industrial wastewater products.

CWT’s flagship GENESIS Series™ performs wastewater treatment, desalination, water creation, blow-down recovery and process cooling.

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EXHIBITOR PROFILES

HLM Australia
Hunter Land Management (HLM) is a Hunter Valley business specialising in land management services, from planning through to on-ground works. Our fields of expertise include;

• Weed Management
• Revegetation and Seed Collection
• Vertebrate Pest Control
• Riparian/Erosion Management
• GIS Mapping
• Project Management and Consulting
• Bushfire Management

HLM acquired Muswellbrook Forest Nursery (MFN) from Forests NSW in 2012. Our aim is a return to local production of tubestock, with HLM providing seed collection for MFN ensuring local provenance seed wherever possible. MFN can provide services ranging from seed collection to contract propagation of your own stock, to sales of tubestock and advanced plants.


Sky Land Management
Sky Land Management is an innovative organisation that provides high quality, tailored land management solutions. We have extensive industry experience and knowledge that we use to provide a complete solution to our clients from sound project planning and management, to practical completion, monitoring and reporting.

We employ leading edge technology in the form of our Yamaha Rmax Unmanned Aerial Vehicle (UAV) in conjunction with traditional land management strategies. Our clients include RioTinto, Hanson Quarries, Local and State Government, Water NSW, Hunter Water, MACH Energy and agricultural companies.

Our UAV provides safe, effective and efficient solutions such as:
• Aerial weed control;
• Aerial seeding;
• Aerial fertilizing.

Mine site applications:
• Dams / tailings dams;
• Topsoil stock piles;
• Windrows;
• Rehabilitation areas;
• Magazine bund walls;
• Steep, uneven or difficult to access ground.

Benefits:
• Safety of personnel;
• More cost effective than most ground based applications;
• Safe treatment of previously inaccessible and/or hazardous areas;
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Further details: www.skylandmanagement.com.au
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SUEZ is one of the largest processors of urban-generated organics in Australia.

Our network of state-of-the-art facilities across Australia create specialist composted products used in a variety of land remediation and rehabilitation works. We support businesses across a variety of disciplines working to restore eroded and depleted environments into stable and, preferably, vegetated landforms. Our products can be used for:

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- Erosion and sediment control
- Compost blankets
- Spraygrassing activities such as hydromulching or hydroseeding
- Commercial civil works
- Commercial landscaping works

For more information, contact our Organics specialist Duncan Le Good on 0437753044 or duncan.legood@suez.com. [www.sita.com.au](http://www.sita.com.au)

**Robotic Systems**


**Menard Oceania**

Menard Oceania (MO) is a design and construct specialist geotechnical contractor offering expertise in ground improvement for sites with poor soils. We offer remediation solutions for operational sites and management of pollution seepage so you can undertake your construction projects on safe ground. As part of the Soletanche Freyssinet Group, our team brings local know-how combined with international experience developed by the group across 100 countries over the past 45 years. Our scope includes small to large infrastructure based solutions across a broad range of market segments including Transport, Dams, Ports, Industrial and Commercial Buildings, Heavy Industry and Mining.

WORKSHOPS

WEDNESDAY 3.00pm - 5.00pm

Landform evolution modelling for mine rehabilitation - EAMS-SIBERIA workshop

Wednesday 3.00pm - 5.00pm

Presenter: Prof Garry Willgoose, School of Engineering, The University of Newcastle (also Member of NSW Petroleum and Mining Gateway Panel)

Location: Upper Hunter Tertiary Education Centre, Lower Hill Street, Muswellbrook

Topic

The developers of the leading landform evolution model, EAMS-SIBERIA, used for the design and assessment of environmentally sustainable mine rehabilitation systems will be give a short course on the latest version (V5) of this software. The course will cover (at a level accessible to mine managers and planners, and government regulators)

• The history of soil erosion and landscape evolution models and their strengths and weaknesses
• The principles underpinning the SIBERIA landform evolution model
• The principles of the EAMS mine rehabilitation tool built around the SIBERIA package
• Comparison of EAMS-SIBERIA with other environmental mine rehabilitation tools
• Examples of application of the EAMS-SIBERIA tool in mine rehabilitation practice in Australia and overseas.
• Examples of some advanced applications involved cover design from the uranium mining and nuclear waste industry
• Some brief hands-on experience using some simple examples

There will be ample time for discussion and questions about both the (1) general topic of landform evolution modelling and its usefulness for the industry, and (2) EAMS-SIBERIA specifically.
Pathways to relinquishment and opportunities to transition to productive alternate land uses.
Friday 11.00am - 2.30pm Stream 1
Convenors: Peter Elliott and Donna Pershke
Location: Muswellbrook RSL

Background: Using the relinquishment process to transition to alternate productive land uses potentially has significant benefits for all parties; mining companies, regulators and communities. However, there are also a number of challenges in achieving this transition to the benefit of all. The challenges include:

• Current regulatory and land tenure frameworks
• Providing for the long term management of residual risk / liability for a site if a future land use fails
• Lack of current mechanisms to facilitate the alignment of mining companies and investors in post mining land uses, with regional development plans

Purpose: The purpose of this workshop is to explore the frameworks and pathways which could facilitate transition of mine sites to alternative productive land uses that are acceptable to regulators, valued by the community and provide a more certain route to relinquishment of liability for mining companies. The intent of the workshop is to develop recommendations for improved relinquishment and land use transition processes which will be taken forward by the Tom Farrell Institute for further discussion with interested parties. The workshop will discuss:

• Existing frameworks and pathways to mine relinquishment that satisfy stakeholders (government, future landowner and community).
• Who is responsible for different parts of the transition and relinquishment process and where a mining company’s responsibility for facilitating a future land use stops and the new land user’s starts.
• The role of government in facilitating a transition to a productive land use.
• Who needs to be involved in the relinquishment and transition process and why.
• The alternate future pathways for transition and relinquishment that could be possible and current barriers to achieving these pathways now.
• What needs to change in terms of policy and/or practice to achieve alternative pathways and the outcomes identified.
• Recommendations for possible alternate frameworks for relinquishment and land use transition
WORKSHOP STREAM 2  FRIDAY 11.00am - 2.30pm

New practices to advance mine rehab in the Hunter Valley.
Friday 11.00am - 2.30pm Stream 2
Convenors: Simit Raval, Michael Hitch, and Wendy Timms
Location: Muswellbrook RSL

The Australian Centre for Sustainable Mining Practices are conducting a workshop on practices to advance mine rehabilitation in the Hunter Valley.

This will include:

- Corporate social responsibility and sustainable practices
- Smart sensing for mine environments
- Balancing site water accounts – focusing on aquifer interference and mine discharge

This will be an interactive workshop with worked examples and discussion.

Participants are requested to bring a notebook computer with Excel.

Presented and facilitated by A/Prof Michael Hitch, Dr Simit Raval, and Dr Wendy Timms.

www.mining.unsw.edu.au
www.acsmp.unsw.edu.au

Smart sensing for mine environments - Dr Simit Raval

- Fundamentals of Remote sensing.
- What satellite images are available? How to get it?
- How to perform a basic image analysis and what do we get out of that?
- Emerging sensors and platforms (UAVs/drones) – capabilities and applications for mine environments.

Balancing site water accounts – focusing on aquifer interference and mine discharge - Dr Wendy Timms

Overview of the Water Accounting Framework. Guide & spreadsheet are here: Minerals Council of Australia

Worked example of site water account. Participants to use their own PC with Excel

Summary of site water accounts across Hunter Valley, Timms et al 2016, Water International journal

How to account for aquifer interference and mine discharge. Tips and tricks discussion

Social License and Sustainability: The cornerstone of corporate social responsibility - A/Prof Michael Hitch

- Redefining Social license
- Applying Principles of social license in mature mining camps
- Actor Mapping and Analysis
- Losing social license
- Free of weed seed and pathogens
- Produced from the finest 100% NASAA certified organic sugar cane mulch and 100% recycled paper pulp
- Homogenises easily in all tanks ready for spraying
- A natural product that is long lasting and promotes growth of vegetation
- Australian family business
- Packaged in high quality, easy to handle, UV-stabilised compression bales

For more information contact Matt Keith at mattk@rpmulching.com.au or call on (07) 5670 4800
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Mining and Biosecurity

“MRC-Wiki” – a mine rehabilitation and closure knowledge management tool for coal mine practitioners.

Muswellbrook Shire Council

N

Nanthi Bolan
National Standards for Ecological Restoration Practice

Neil Griffiths
New practices to advance mine rehab in the Hunter Valley.

Niche Environment and Heritage
NSW Minerals Council

P

Pathways to relinquishment and opportunities to transition to productive alternate land uses
Pathways to relinquishment and opportunities to transition to productive alternate land uses.

Penny Dunstan
Perennial grasses as energy crops grown using different types of wastewater

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Pointy and Flatty: What two Cornish Alps can tell us about the interaction of human imagination and post mining landform.

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Smart sensing for mine environments - Dr Simit Raval

Sonia Shilpi
THE UNIVERSITY OF NEWCASTLE – ENVIRONMENTAL LEADER

The University of Newcastle makes a substantial commitment to the environment and environmental sustainability, through its Strategic Plan and its many active researchers, research centres, and its institutional commitment to sustainability.

The Tom Farrell Institute for the Environment (TFI) aims to pursue environmental research and to build long-term partnerships with industry, business, government and the community in promoting environmental sustainability in our region and beyond.

The Newcastle Institute for Energy and Resources (NIER) was established with a clear agenda, to provide a multidisciplinary model for transformational research in energy and resources.

The International Centre for Balanced Land Use (ICBLU) addresses the challenges faced by NSW and globally with food and energy security, and economic, environment and social balance.

The Global Centre for Environmental Remediation (GCER) aims to safeguard people’s social, economic and physical health and wellbeing by developing innovative, cost-effective and sustainable technologies and solutions that reduce the impact of pollutants on the environment.

The Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE), is a research network covering the whole of Australia to tackle the critical areas of contamination assessment and remediation, with the goal of cutting Australia’s pollutants and improving the health of its people, cities, food, soil, air and water.

The Hunter Region Innovation Precinct. A partnership with Muswellbrook Shire Council to promote economic diversification in the areas of energy technologies and environmental remediation, land use management, soil productivity, water management, climate adaptation, energy efficiency, and precision or high efficiency agriculture.