

# Mine Closure 2019

## Proceedings of the 13th International Conference on Mine Closure

3–5 September 2019, Perth, Australia

Volume Two

*Editors*

**Andy Fourie**

The University of Western Australia, Australia

**Mark Tibbett**

University of Reading, UK



CSIRO | The University of Western Australia | Joint Venture

## Copyright

© Copyright 2019. Australian Centre for Geomechanics, The University of Western Australia. All rights reserved. No part of this publication may be reproduced, stored or transmitted in any form without the prior permission of the Australian Centre for Geomechanics, The University of Western Australia.

## Disclaimer

The information contained in this publication is for general educational and informative purposes only. Except to the extent required by law, the Australian Centre for Geomechanics, The University of Western Australia make no representations or warranties express or implied as to the accuracy, reliability or completeness of the information stored therein. To the extent permitted by law, the Australian Centre for Geomechanics, The University of Western Australia exclude all liability for loss or damage of any kind at all (including indirect or consequential loss or damage) arising from the information in this publication or use of such information. You acknowledge that the information provided in this publication is to assist you with undertaking your own enquiries and analyses and that you should seek independent professional advice before acting in reliance on the information contained therein. While all care has been taken in presenting this information herein, no liability is accepted for errors or omissions. The views expressed in this publication are those of the authors and may not necessarily reflect those of the Australian Centre for Geomechanics, The University of Western Australia.

The papers contained in this publication are for general information only, and readers are cautioned to take expert advice.

Front cover photograph courtesy of Iluka.

Back cover photograph courtesy of Emapper.

Production team: Garth Doig, Candice McLennan, Christine Neskudla, Josephine Ruddle, and Stefania Woodward, Australian Centre for Geomechanics.

ISBN 978-0-9876389-3-9

ISSN 2208-8288



CSIRO | The University of Western Australia | Joint Venture

### **Australian Centre for Geomechanics**

The University of Western Australia

35 Stirling Highway (M600)

CRAWLEY, WESTERN AUSTRALIA

AUSTRALIA 6009

Telephone: +61 8 6488 3300

[publications-acg@uwa.edu.au](mailto:publications-acg@uwa.edu.au)

[www.acg.uwa.edu.au](http://www.acg.uwa.edu.au)

ABN 37 882 817 280

# Australian Centre for Geomechanics

The Australian Centre for Geomechanics (ACG) was formally established in 1992 as a University of Western Australia research centre in order to promote research excellence and continuing education in geomechanics, with particular emphasis on its application to the mineral and energy extraction sections of Australia's resources industry.

The Australian Centre for Geomechanics is an unincorporated Joint Venture involving:

- CSIRO Mineral Resources
- The University of Western Australia — Civil, Environmental and Mining Engineering

The ACG draws together staff knowledge, experiences and expertise from within the two groups forming the Centre and facilitates a multi-disciplinary approach to research and education in geomechanics. Research undertaken by the ACG attracts both national and global support and the outcomes of the projects are utilised to promote safer mining and environmental geomechanics practices, operating efficiencies and to meeting community expectations for sustainable mining practices.

With the guidance of strong industry representation on the Board of Management, and close collaboration with senior representatives of the mining industry, research, training and further education activities are tailored directly to the needs of industry. The ACG Board expects the Australian Centre for Geomechanics to be the focal point for industry on geomechanics issues and to address the needs of industry through a collaborative interdisciplinary approach.

## Online Repository of Conference Proceedings



*Accessing geomechanical excellence*

Since 2005, the ACG has published conference papers across the geotechnical mining spectrum, including: underground and open pit mining, paste and thickened tailings and mine closure. To make many of these papers more accessible for industry and academia, the ACG launched the Online Repository of Conference Proceedings in 2017. This repository aims to provide the mining geomechanics fraternity with open access, peer-reviewed conference papers that may assist readers to maintain and develop their skills, knowledge and capabilities.

Aside from allowing users to freely download many past and current conference papers, the site features many useful functions. This highly interactive and searchable repository provides importable citation information in various formats, links to the paper authors' profiles on ORCID, ResearchGate and LinkedIn, as well as the ability to share papers on social media.

The 13th International Conference on Mine Closure papers are available on the repository.

Setting a high standard for technology transfer and accessibility, this valuable online resource will continue to develop and grow with future ACG geomechanical mining events.

**[papers.acg.uwa.edu.au](http://papers.acg.uwa.edu.au)**



# University of Reading

The University of Reading was established in 1892 and is now ranked in the top 1% of universities worldwide with a world-class reputation for the quality of its research, teaching and links to business. The university's School of Agriculture, Policy and Development is ranked amongst the top 20 universities globally for agriculture and forestry and aims to provide graduates the knowledge to address the major challenges and opportunities in the sector for the 21st Century. Research within the school focuses on, and integrates aspects of, food production, the sustainability of agro-ecosystems, soil science, restoration ecology, food security, adaptation and mitigation to climate change, food chains and health, animal welfare and behaviour, poverty alleviation, international development, and consumer behaviour and choice.

Research in the area of soil and land remediation mainly takes place within the Centre for Agri-Environmental Research (CAER). CAER was founded in 2000, a move that integrated the university's strengths in agricultural and environmental research, resulting in a facility that consists of the wide ranging set of disciplines that are necessary to address issues related to sustainable agriculture.

The Centre carries out high-quality scientific research with the aim of reconciling the often conflicting demands of land use and environmental protection, as well as developing partnerships with researchers, funding agencies, industry, policy makers, users and stakeholders that enable the application of knowledge and expertise to the design of sustainable agricultural landscapes. CAER enjoys state-of-the-art facilities, with laboratories and teaching facilities in addition to the University's own farm and farm-based research sites that occupy more than 850 ha. This creates a variety of opportunities to link agricultural production and environmental research. The School's Analytical Laboratory provides facilities for a wide range of analyses of soil, plant and animal materials.

Other related work also occurs within the wider remit of the cross-faculty Soil Research Centre (SRC). The SRC is built on a long legacy of soil research at the University of Reading over the last 100 years. Our expertise includes land rehabilitation, biogeochemistry, ecology, hydrology, plant sciences, microbiology, palaeoecology, archaeology, geography, earth observation, modelling, economics and social sciences. This diversity reflects the multiple challenges of understanding the dynamic processes within the Earth's critical zone. Soil is part of Earth's natural capital, where interactions between climate, geology, plants, organisms, water and humans control the supply of ecosystem goods and services, such as food, water and climate regulation, which make human life possible.

The University of Reading has a diverse and thriving postgraduate community in a wide range of environmental topics, including land remediation and ecosystem services and offers an MSc in Environmental Pollution and BSc and MSc in Environmental Management.

<http://www.reading.ac.uk/apd>

<https://www.reading.ac.uk/soil-research-centre/>

<https://business.facebook.com/UniRdgAPD>



# Australian Organising Committee

**C Bagnall** *BHP, Australia*

**K Beckett** *Fortescue Metals Group Ltd, Australia*

**MP Dobrowolski** *Iluka Resources Limited and The University of Western Australia, Australia*

**SJ Finucane** *Bioscope Environmental Consulting Pty Ltd, Australia*

**AB Fourie** *The University of Western Australia, Australia*

**R Green** *Rio Tinto, Australia*

**AH Grigg** *Alcoa of Australia, Australia*

**C Lockhart** *BHP, Australia*

**S Mackenzie** *Mine Earth Pty Ltd, Australia*

**DP Murphy** *Golder Associates Pty Ltd, Australia*

**J Ruddle** *Australian Centre for Geomechanics, Australia*

**J Stevens** *Department of Biodiversity, Conservation and Attractions, Australia*

**M Tibbett** *University of Reading, UK*

**C Waygood** *Golder Associates Pty Ltd, Australia*

# International Advisory Committee

**R Courtney** *University of Limerick, Ireland*

**AB Fourie** *The University of Western Australia, Australia*

**B Lottermoser** *RWTH Aachen University, Germany*

**R Mackay** *Latrobe Valley Mine Rehabilitation Commissioner, Australia*

**MA Naeth** *University of Alberta, Canada*

**J Parshley** *SRK Consulting (US) Inc., USA*

**M Paul** *Wismut GmbH, Germany*

**M Schultze** *Helmholtz-Centre for Environmental Research - UFZ, Germany*

**G Spiers** *Laurentian University, Canada*

**M Tibbett** *University of Reading, UK*

**B Ulrich** *Stantec Consulting Services Inc., USA*

**B Warr** *BetterWorld Energy Ltd., Zambia*





# Technical Reviewers

The dedicated efforts of the peer reviewers have resulted in the high quality of the technical programme and the papers compiled for this publication. The editors thank the following people who contributed their time and expertise as reviewers of manuscripts for the proceedings of the 13th International Conference on Mine Closure held in Perth, Australia. A technical and critical review of each paper was undertaken by a minimum of two reviewers for the production of these proceedings.

**N Amoah**

Karara Mining Ltd, Australia

**AD Ashby**

Department of Mines, Industry Regulation and Safety, Australia

**R Atkins**

Golder Associates Ltd., Canada

**NC Banning**

Stantec Australia Pty Ltd, Australia

**U Barnekow**

Wismut GmbH, Germany

**A Basson**

Aurecon Group, South Africa

**T Baumgartl**

Federation University Australia, Australia

**T Bell**

Anglo American, Australia

**M Bellitto**

Golder Associates Inc., USA

**B Biggs**

Biggs and Associates, Australia

**KA Bocking**

Golder Associates Ltd., Canada

**GS Boggs**

The Western Australian Biodiversity Science Institute, Australia

**MF Braimbridge**

Mine Earth Pty Ltd, Australia

**K Brand**

BHP, Australia

**D Brock**

International Council on Mining and Metals, UK

**G Byrne**

Niboi Consulting, Australia

**D Cameron**

Independent Consultant, South Africa

**PJ Chapman**

Golder Associates Pty Ltd, Australia

**P Chiaramello**

Golder Associates Ltd., Canada

**H Cifuentes**

The University of Queensland, Australia

**JS Collyard**

SLR International Corporation, USA

**R Courtney**

University of Limerick, Ireland

**J Crosbie**

MMG Limited, Australia

**A Cross**

Curtin University, Australia

**J Cumbers**

Stantec Consulting Services Inc., USA

**G Davies**

Rio Tinto, Australia

**MM Davis**

Stantec Consulting Services Inc., USA

**MI Daws**

University of Reading, UK

**V de Oliveira**

University of Reading, UK

**J Dixon**  
Fortescue Metals Group, Australia

**MP Dobrowolski**  
Iluka Resources Limited, Australia

**D Doley**  
The University of Queensland, Australia

**J Drake**  
Murrang Earth Sciences, Australia

**J Edwards**  
SRK Consulting (South Africa) (Pty) Ltd, South Africa

**TE Erickson**  
The University of Western Australia, Australia

**A Feigl**  
State Government of Victoria, Australia

**SJ Finucane**  
Bioscope Environmental Consulting Pty Ltd, Australia

**L Ford**  
Golder Associates Ltd., Canada

**S Foster**  
Golder Associates Ltd., USA

**AB Fourie**  
The University of Western Australia, Australia

**WJ Gemson**  
ERM Australia Pty Ltd, Australia

**R Getty**  
SRK Consulting (Australasia) Pty Ltd, Australia

**N Grant**  
EMM Consulting Pty Ltd, Australia

**R Green**  
Rio Tinto, Australia

**S Gregory**  
Mine Earth Pty Ltd, Australia

**AH Grigg**  
Alcoa of Australia, Australia

**R Hastie**  
Office of the Latrobe Valley Mine Rehabilitation  
Commissioner, Australia

**R Hattingh**  
Sierra Rutile Limited, Sierra Leone

**BL Heemink**  
Environmental Resources Management, Australia

**J Heyes**  
BHP, Australia

**I Hollingsworth**  
Horizon Environmental Soil Survey & Evaluation,  
Australia

**EJ Howard**  
Landloch Pty Ltd, Australia

**L Huang**  
The University of Queensland, Australia

**RN Humphries**  
Blakemere Consultants Ltd, UK

**DA Jasper**  
Stantec, Australia

**M Katz**  
Mineral Development Consultant, Australia

**I Kelder**  
Landloch Pty Ltd, Australia

**ME Kragt**  
The University of Western Australia, Australia

**P Kumari**  
Anglo American South Africa, South Africa

**HWB Lacy**  
Mine Closure Management Services Pty Ltd, Australia

**J Lake**  
SRK Consulting (South Africa) (Pty) Ltd, South Africa

**S Lange**  
Knight Piésold and Co., USA

**D Limpitlaw**  
University of the Witwatersrand, South Africa

**CM Linklater**  
SRK Consulting (Australasia) Pty Ltd, Australia

**A Littleboy**

The University of Queensland, Australia

**C Lockhart**

BHP, Australia

**PJ Lombard**

GHD Australia Pty Ltd, Australia

**BG Lottermoser**

RWTH Aachen University, Germany

**R Mackay**

Latrobe Valley Mine Rehabilitation Commissioner,  
Australia

**S Mackenzie**

Mine Earth Pty Ltd, Australia

**T Marañón**

Institute of Natural Resources and Agrobiology of  
Seville, Spain

**JF Martín-Duque**

Complutense University of Madrid and Geosciences  
Institute, Spain

**LL May**

Golder Associates Ltd., Canada

**CD McCullough**

Mine Lakes Consulting, Australia

**MB McLeary**

Golder Associates Pty Ltd, Australia

**N McNaught**

BHP, Australia

**I Meek**

Energy Resources of Australia Ltd, Australia

**TK Morald**

The University of Western Australia, Australia

**A Morrison-Saunders**

Edith Cowan University, Australia

**M Mozina**

State Government of Victoria, Australia

**L Mucina**

Murdoch University, Australia

**DP Murphy**

Golder Associates Pty Ltd, Australia

**S Narendranathan**

GHD Pty Ltd, Australia

**J Pearce**

Mine Waste Management Pty Ltd, Australia

**S Pearce**

Mine Environment Management Ltd, UK

**A Richards**

Golder Associates Pty Ltd, Australia

**S Robinson**

Fortescue Metals Group, Australia

**T Rohde**

SGM Environmental Pty Ltd, Australia

**U Salmon**

Okane Consultants Pty Ltd, Australia

**N Schmidt**

Golder Associates Ltd., Canada

**PFR Scholtz**

Aurecon Group, South Africa

**M Schultze**

Helmholtz-Centre for Environmental Research - UFZ,  
Germany

**A Scrase**

ENGIE Australia Pty Ltd, Australia

**T Silveira**

Rio Tinto, Australia

**N Slingerland**

University of Alberta and Golder Associates Ltd., Canada

**E Smedley**

Mine Earth Pty Ltd, Australia

**D Springer**

BHP, Australia

**J Stevens**

Department of Biodiversity, Conservation and  
Attractions, Australia

**C Strachan**

Stantec Consulting Services Inc., USA

**J Straker**

Integral Ecology Group, Canada

**M Tibbett**

University of Reading, UK

**B Ulrich**

Stantec Consulting Services Inc., USA

**P Waggitt**

Independent Consultant, Australia

**B Warr**

BetterWorld Energy Ltd, Zambia

**R Watkins**

Environmental Geochemistry Services, Australia

**C Waygood**

Golder Associates Pty Ltd, Australia

**TR Weaver**

ERM Australia Pty Ltd, Australia

**B Weeks**

Golder Associates Ltd., Canada

**MA Welch**

Department of Environment and Energy, Australia

**B Wernick**

Golder Associates Ltd., Canada

**P Whiting**

Delta Group, Australia

**P Whittle**

Hydrobiology, Australia

**B Williams**

Flinders Power Partnership, Australia

**DJ Williams**

The University of Queensland, Australia

**F Winde**

University of the North West, South Africa

**T Worthington**

Rio Tinto, Australia

**M Yellishetty**

Monash University, Australia

# Preface

The 13th International Conference on Mine Closure returns to Perth, Australia where it was first held in 2006. Since then, mine closure has become a necessary focus of mining and, with a global revival in the mining industry, the topic of mine closure is now more relevant than ever. Minimising financial costs while satisfying stakeholder expectations and achieving sustainable closure are now considered essential in planning the mining process.

The material presented at this year's mine closure conference, and the information contained in the conference proceedings, will provide assistance to owners, operators and consultants who are currently facing the challenges of managing, or planning for, closure of mines. The themes covered in this year's conference once again deal with key, perennial issues such as planning and financing mine closure with consideration of issues such as community engagement, rehabilitation and remediation providing key topics. Fundamental matters such as how to achieve much sought after relinquishment, and the vexing issue of how to deal with and manage legacy sites, along with concerns of ongoing liabilities, are all considered in the conference and these proceedings. The section on stakeholders and community engagement emphasises the priority that ever more companies are giving to considerations of social performance. Finally, a number of well-documented case studies provide information on how specific and sometimes unique challenges have been addressed.

The papers within the proceedings feature information and ideas that will be of continuing interest and use by planners, designers, contractors, operators, owners and regulators alike. In a rapidly evolving field such as mine closure, the benefits of having a truly international representation of delegates, such as at Mine Closure 2019, is evident from the quality and variety of topics covered in these proceedings.

These proceedings are also freely available from the ACG Online Repository of Conference Proceedings courtesy of Open Access Sponsors: GHD Pty Ltd and Mine Earth Pty Ltd. The papers can be accessed by scanning the QR code or from [papers.acg.uwa.edu.au/mc2019](http://papers.acg.uwa.edu.au/mc2019).

Professor Mark Tibbett, University of Reading, UK  
Co-editor and Conference Co-chair





# Conference Sponsors

The Australian Centre for Geomechanics proudly acknowledges the generous contribution by the Principal and Major Sponsors of the 13th International Conference on Mine Closure.

## PRINCIPAL SPONSOR

# BHP

## MAJOR SPONSORS







# Table of Contents

iii	Australian Centre for Geomechanics
v	University of Reading
vii	Committees
ix	Technical Reviewers
xiii	Preface
xv	Conference Sponsors

## Waste rock piles

839	<b>Harnessing risk to guide mine rock stockpile closure and long-term cost reduction</b> <i>SC Lamoureux, Okane Consultants Pty Ltd, Australia; MA O’Kane, Okane Consultants Inc., Canada</i>
855	<b>Rio Tinto’s framework for evaluating risks from low sulfur waste rock</b> <i>R Green, Rio Tinto, Australia; C Linklater, SRK Consulting (Australasia) Pty Ltd, Australia; S Lee, L Terrusi, K Glasson, Rio Tinto, Australia</i>
871	<b>Key outcomes of functional benchmarking for waste rock landform closure at a Western Australian iron ore mine</b> <i>SL Robinson, formerly Bioscope Environmental Consulting Pty Ltd, Australia; SJ Finucane, Bioscope Environmental Consulting Pty Ltd, Australia</i>
883	<b>Optimising waste management assessment using fragmentation analysis technology</b> <i>S Pearce, Mine Environment Management Ltd, UK; D Brookshaw, Caulmert Ltd, UK; S Mueller, Boliden Mines, Sweden; A Barnes, Geochemic Ltd, UK</i>
897	<b>A demonstration of the cessation of spontaneous combustion in a coal overburden spoil pile</b> <i>A Garvie, SRK Consulting (Australasia) Pty Ltd, Australia; K Donaldson, B Williams, Flinders Power, Australia; J Chapman, SRK Consulting (Australasia) Pty Ltd, Australia</i>
911	<b>Biological manganese removal from mine drainage in a fixed-bed bioreactor at pilot-scale</b> <i>J Jacob, BRGM, France; I Raignault, Rio Tinto SA, France; F Battaglia-Brunet, BRGM, France; C Mailhan-Muxi, Rio Tinto SA, France; J Engevin, M Djemil, BRGM, France</i>

## Post-mining land use

923	<b>Applying ecosystem services assessment in closure planning to enhance post-mining land-use outcomes: learning from bauxite mining in Brazil and Australia</b> <i>JCS Rosa, University of São Paulo, Brazil; A Morrison-Saunders, Edith Cowan University, Australia; North-West University, South Africa; LE Sánchez, University of São Paulo, Brazil; M Hughes, Murdoch University, Australia; D Geneletti, University of Trento, Italy</i>
937	<b>Pre- and post-mine land-use trends across the New South Wales and Queensland coal industry</b> <i>K Fogarty, ME Kragt, B White, The University of Western Australia, Australia</i>

- 951 Applying a regional land use approach to mine closure: opportunities for restoring and regenerating mine-disturbed regional landscapes**  
*R Hattingh, DJ Williams, G Corder, The University of Queensland, Australia*
- 969 Maximising post-mining land use: Queensland Government reforms**  
*S Cooper, Queensland Government, Australia*
- 983 Post-closure land uses – defined through a strategic land use planning approach**  
*DF Pershke, PE Elliott, Pershke Consulting Pty Ltd, Australia*
- 997 Uranium mining: post-closure land uses – a personal global review**  
*PW Waggitt, Consultant, Australia*

## Mine closure planning

- 1005 Strengthening BHP's closure framework: a strategy to realise enduring value**  
*J Heyes, T Cooper, BHP, Australia*
- 1013 Systems thinking: embedding closure planning within the management operating system is the key to drive closure performance**  
*HWB Lacy, Stantec, Australia; M Slight, Mike Slight and Associates, Australia; A Watson, Stantec Consulting Services Inc., USA*
- 1023 Digitalisation of continuous mine closure planning and management: an EIT RawMaterials initiative**  
*T Kauppila, Geological Survey of Finland, Finland; G Bellenfant, French Geological Survey, France; L Solismaa, Geological Survey of Finland, Finland; P Mittelstädt, DMT GmbH & Co. KG, Germany*
- 1031 Mine closure plans assumptions and optimism**  
*G Byrne, Niboi Consulting Pty Ltd, Australia*
- 1039 Why mines should look at total life to achieve tailings facility closure**  
*SE Aitken, JP Burr, Beca Ltd, New Zealand*
- 1051 Closure planning challenges associated with mining adjacent to large creek lines**  
*P Bussemaker, KL Pang, P Barnes, CL Latham, F McClenaghan, Rio Tinto, Australia*
- 1063 Setting objectives: the key to successful mine closure**  
*M Fawcett, T Laurencont, Coffey International Ltd, Australia*

## Case studies and remote survey

- 1073 Methods for assessing acid and metalliferous drainage mitigation and carbon sequestration in mine waste: a case study from Kevitsa mine, Finland**  
*RJ Savage, Cardiff University, and Geochemic Ltd, UK; S Pearce, Mine Environment Management Ltd, UK; S Mueller, Boliden Mines, Sweden; A Barnes, Geochemic Ltd, UK; P Renforth, D Sapsford, Cardiff University, UK*

- 1087 A case study: consolidation properties of Hazelwood Power Station ash**  
*S Narendranathan, J Anders, GHD Pty Ltd, Australia; J Faithful, ENGIE, Australia; N Patel, GHD Pty Ltd, Australia*
- 1101 Quality management during closure works at the Telfer mine: a case study**  
*E Smedley, Mine Earth Pty Ltd, Australia; B Stokes, Newcrest Mining Ltd, Australia; M Gallacher, Newcrest Mining Limited, Australia; S Mackenzie, Mine Earth Pty Ltd, Australia*
- 1113 Using aerial drones to select sample depths in pit lakes**  
*DN Castendyk, BJ Straight, JC Voorhis, MK Somogyi, Golder Associates Inc., USA; WE Jepson, Montana Department of Environmental Quality, USA; BL Kucera, Thompson Creek Mining Company, USA*
- 1127 The analysis and validation of landform stability using unmanned aerial vehicles**  
*J Kelcey, Astron Environmental Services, Australia; D Blaxland, Gold Fields Australia Pty Ltd., Australia; B Smith, A Gove, Astron Environmental Services, Australia*
- 1139 Selection of a representative dolerite waste sample for use in erosion assessments using remote sensing techniques**  
*EJ Howard, Landloch Pty Ltd, Australia; MD Bettison, BHP, Australia*

## Managing tailings

- 1151 Elliot Lake, Ontario uranium mines a legacy perpetual care case study**  
*DS Berthelot, BHP, Canada; D Place-Hoskie, D Willems, K Black, BHP, USA*
- 1165 Life cycle assessment of tailings management options: a conceptual case study in Western Australia**  
*A Carneiro, AB Fourie, The University of Western Australia, Australia*
- 1185 Wind erosion design considerations for closure of tailings storage facilities in South Africa: a case study**  
*SJ van Wyk, J Hatting, ASH Haagner, Agreeco Environmental Projects (Pty) Ltd, South Africa*
- 1201 Three case studies: mechanisms other than spillage and leaks that change groundwater quality and inhibit closure certification**  
*TL Patterson, M Trevor, SLR International, USA*
- 1217 Integrated life-of-mine waste characterisation, scheduling, and quality control for progressive closure at Martabe multi pit gold mine**  
*SK Grohs, PT Agincourt Resources, Indonesia; S Pearce, Mine Environment Management Ltd, UK*

## Mine reclamation

- 1233 Rehabilitation of the North End Box Cut dump at Tom Price mine operation: a legacy management case study**  
*T Worthington, R Green, CL Latham, B Yaqub, Rio Tinto Iron Ore, Australia*
- 1241 Problematic pit: closure liability to operational opportunity**  
*CL Latham, C Lazo-Skold, Rio Tinto, Australia*

- 1255 Evaluating the effectiveness of Sunnyside Gold Corporation's reclamation, San Juan County, Colorado, USA**  
*S Lange, Knight Piésold and Co., USA*
- 1267 An approach to an ecosystem restoration standard for Ranger Uranium Mine**  
*RE Bartolo, J Nicholson, Department of the Environment and Energy, Australia; M Rudge, The University of Queensland, Australia; D Loewensteiner, T Whiteside, Department of the Environment and Energy, Australia; P Erskine, The University of Queensland, Australia; M Barnes, CL Humphrey, Department of the Environment and Energy, Australia*
- 1281 Environmental assessment and reclamation of abandoned marl mining dumps in the Northwest Caucasus**  
*AV Alekseenko, Saint Petersburg Mining University, Russia*
- 1289 Vegetation development and the condition of natural regeneration after coal mine reclamation in East Kalimantan, Indonesia**  
*T Yunanto, Ministry of Energy and Mineral Resources, Republic of Indonesia; R Mitlöhner, R Bürger-Arndt, Goettingen University, Germany*
- 1303 Mine reclamation period to successfully meet criteria in Indonesia**  
*F Amanah, T Yunanto, Ministry of Energy and Mineral Resources, Republic of Indonesia*
- 1315 Implementation of offshore reclamation methods on an old tin mining area on Bangka Island, Indonesia**  
*IA Syari, University of Bangka Belitung, Indonesia; J Sudrajat, HA Octaviano, Ministry of Energy and Mineral Resources, Indonesia; B Hutahaean, R Adnis, OA Taruk Allo, PT TIMAH Tbk, Indonesia*

## Water management

- 1337 Simplified method to predict final void water levels**  
*H Morgan, WRM Water & Environment, Australia; A Hocking, BHP, Australia; S Henderson, Henderson Geotech Pty Ltd, Australia*
- 1353 Hydrogeological modelling to inform closure planning for Hazelwood Mine**  
*R Gresswell, G Foley, GHD Pty Ltd, Australia; J Faithful, ENGIE, Australia*
- 1367 Key considerations that can make or break a closure-focused groundwater-monitoring program**  
*WJ Gemson, TR Weaver, BL Heemink, Environmental Resources Management Australia*
- 1377 The application of an agro-hydrological model for a data limited closure study of a bauxite mine in Australia**  
*HH Bulcock, J Heaslop, Klohn Crippen Berger, Australia*
- 1391 Evaporation from coal mine pit lakes: measurements and modelling**  
*D McJannet, A Hawdon, B Baker, K Ahwang, J Gallant, Commonwealth Scientific and Industrial Research Organisation, Australia; S Henderson, A Hocking, BHP, Australia*
- 1405 Modelling the long-term water balance of a pit lake with recreational end uses**  
*AM Carlino, Golder Associates Pty Ltd, Australia; CD McCullough, Mine Lakes Consulting, Australia*

## Mine relinquishment

- 1423**     **Engaging stakeholders to achieve rehabilitation completion: a case study of the BHP Beenup Project**  
*R Norrish, B Lyon, W Russell, G Price, BHP, Australia*
- 1437**     **Overcoming adverse stakeholder perception affecting tenement relinquishment**  
*MKJ Finucane-Woodman, SJ Finucane, Bioscope Environmental Consulting Pty Ltd, Australia*
- 1451**     **Mine relinquishment policy in Australia**  
*CD Tiemann, Curtin University, and Independence Group NL, Australia; MC McDonald, Society for Ecological Restoration Australasia, Australia; G Middle, KW Dixon, Curtin University, Australia*
- 1461**     **Relinquishment criteria verification: quality assurance/quality control using unmanned aerial vehicles**  
*PL Jones, Flinders Power, Australia; C Franklin, CLD Mining, Australia*
- 1477**     **Engineering a path to relinquishment: an Australian case study in ecological conservation**  
*R Marten, C Bagnall, BHP, Australia*
- 1491**     **Contamination assessment of mine infrastructure areas for closure and relinquishment: Hazelwood Coal Mine, Victoria, Australia**  
*TR Weaver, PS Fridell, MB Ospina, Environmental Resources Management Australia Pty Ltd, Australia; R Brooker, MK Schenkel, AM Scrase, ENGIE Australia Pty Ltd, Australia*

## Drainage management and erosion

- 1499**     **How long is long enough? Adopting a risk-based approach to inform drainage management in closure designs**  
*E Smedley, S Mackenzie, S Gregory, Mine Earth Pty Ltd, Australia*
- 1509**     **Global acid and metalliferous drainage management standard: BHP's approach to reducing global acid and metalliferous drainage closure risk**  
*JP Pearce, Mine Waste Management, Australia; T Cooper, J Heyes, BHP, Australia*
- 1519**     **Development of a vulnerability assessment framework to evaluate potential effects of mine water discharges from Ranger Uranium Mine, Northern Territory**  
*DL Richardson, G Bourke, D Rissik, GW Fisk, BMT Australia Pty Ltd, Australia; M Iles, Energy Resources of Australia Ltd, Australia*
- 1533**     **Stress testing geomorphic and traditional tailings dam designs for closure using a landscape evolution model**  
*N Slingerland, NA Beier, GW Wilson, University of Alberta, Canada*
- 1545**     **Acceptable erosion rates for mine waste landform rehabilitation modelling in the Pilbara, Western Australia**  
*EJ Howard, RJ Loch, Landloch Pty Ltd, Australia*
- 1561**     **Integration of field erosion measurements with erosion models and 3D civil design tools for development of erosion resistant cover systems**  
*R Peroor, SRK Consulting (US), Inc., USA; EJ Howard, Landloch Pty Ltd, Australia; T Braun, SRK Consulting (US), Inc., USA; T Chesal, S Chataut, BHP Copper Inc., USA*

## Cost and financial aspects

- 1577 Repurposing closure cost estimation tools: a Gold Fields case study of the benefit of integration**  
*R Getty, SRK Consulting (Australasia) Pty Ltd, Australia; D Caporn, Gold Fields Ltd, Australia; D Kyan, J Beltran, SRK Consulting (Australasia) Pty Ltd, Australia*
- 1587 Financial concepts for mine closure: information document**  
*D Brock, International Council on Mining and Metals, UK; M Slight, Mike Slight & Associates, Australia; C McCombe, Minerals Council of Australia, Australia*
- 1593 Spatial data-based closure costing integrated with life of mine planning: a key enabler facilitating value realisation**  
*P Kumari, Anglo American PLC, South Africa; M Cooper, Deswik Mining Consultants Pty Ltd, South Africa*
- 1607 Progressive release of security to incentivise and fund closure**  
*KA Bocking, Golder Associates Ltd., Canada; K Lewis, Lupin Mines Incorporated, Canada*
- 1615 Proceedings Author Index**