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Journal of the American Society of Mining and Reclamation

The Journal of the American Society of Mining and Reclamation **(JASMR)** promotes the exchange of basic and applied solutions for the reclamation, restoration, and revitalization of landscapes impacted by the extraction of natural resources—including, but not limited to coal, minerals, gas, and oil. Contributions reporting original research, case studies, field demonstrations, or policy dealing with some aspect of ecosystem reclamation are accepted from all disciplines for consideration by the editorial board.

Contributions to JASMR

The Journal of the American Society of Mining and Reclamation publishes contributions under the headings Research Papers, Case Studies, Demonstrations, Policy Papers and Review articles. All papers are peer reviewed. Manuscripts may be volunteered, invited, or coordinated as a symposium.

Research Papers: Emphasis is given to the understanding of underlying processes rather than to monitoring. Applying these principals to specific, replicated laboratory, glasshouse, and field problems dealing with reclamation are encouraged. These reports are grouped into the following ASMR defined groups: ecology, forestry and wildlife, geotechnical engineering, land use planning and design, international tailings reclamation, soils and overburden, and water management.

Case Studies: Papers in this category report on reclamation activities over spatial or temporal scales. Monitoring of the response of ecosystem components (water, soil, and vegetation) to innovative practices are the basis for these case study reports.

Demonstration Studies: Papers in this category report on reclamation activities that do not necessarily include projects where significant amounts of data are collected. These may consist of largely photographic evidence of before and after some reclamation technique is applied. These may be observations that practicing reclamationists have observed that have changed how they continued to enhance the process of returning disturbed landscapes to a more desirable condition.

Policy or Review Papers: Submission of papers dealing with regulatory and procedural issues are welcome. These papers emphasize changing approaches to the science and technology of landscape revitalization. We strive to have them reviewed within 6 weeks.

Other: Letters to the Editor are accepted, and Book Reviews may be invited by the Editor-in Chief.

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Cover photo is curtesy of *National Park Service* planting trees at Flight 93 National Memorial Reforestation Project

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ABSTRACTS OF PAPERS
CASE STUDIES

The Selection and Operation of Earth Moving Equipment for the Rehabilitation of Functional Soil Profiles: An updating of the UK guidance[1]

R. N. Humphries[2], P. Close, and R. J. Smallshaw

Abstract: Soil conservation and replacement can be key factors in the sustainable use of land following mineral extraction. The earth-moving equipment and the methodology used can determine the character and functioning of the rehabilitated soil ecosystem. Practical guidance for the handling of soils by different earth-moving machines was published by the UK's Ministry of Agriculture, Fisheries and Food in 2000. It was in a form which could be understood and used by professionals and machine operators alike and has been widely used across the minerals industry for almost twenty years. Since its publication, there have been significant changes in the availability of machines, health and safety considerations, and alternative practice. As a prelude to the updating of the Guidance, to be published in early 2019, this paper considers the influence that current safe operation practice, equipment capability and planning policy might have on the choice of earth-moving equipment and methodology.

Additional Key Words: excavator, bulldozer, dump-truck, safe working, equipment capability, planning policy

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[1] Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St Louis, MO: ***The Gateway to Land Reclamation***, June 2 – 7, 2018. Published by ASMR, 1305 Weathervane Dr, Champaign, IL 61821.

[2.] R. Neil Humphries, Blakemere Consultants Ltd, Dorchester DT1 3RZ, UK; Peter Close, Government Advice Team, Natural England, Newcastle upon Tyne NE4 7YH; R Julian Smallshaw, Education Officer, Institute of Quarrying, Nottingham NG9 6RZ, UK.

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SELENIUM, URANIUM, AND NITRATE: TREATMENT OF TROUBLESOME CONTAMINANTS IN MINING WASTEWATERS – EBR CASE STUDIES[1]

A. Ola Opara,[2] Jack Adams, Jane Fudyma, and John Bowden

Abstract: Selenium (Se), uranium (U), and nitrate (NO_3) are widespread in many North American mining environments and related industrial waters. These contaminants are often particularly difficult or expensive to remove using conventional water treatment methods, such as chemical coagulation/precipitation, reverse osmosis filtration, ion exchange, etc. Treatment system capital and operating expenses combined with additional costs of sludge or concentrate stream disposal, are driving research and application of biotreatment methods for removal of these contaminants from mining and industrial wastewaters.

This paper discusses application of the Electro-Biochemical Reactor (EBR) technology for Se, U, and NO_3 bio-reduction and removal from mining wastewaters. Three case studies are presented, based on laboratory bench- and on-site pilot-scale trials with significantly different mining waters (flotation-influenced base metals mine water, leach solution from a gold mine, and coal mine seepage water), each contaminated with varying concentrations of Se, U, and NO_3. Average concentrations of these contaminants were 2,712 µg L^{-1} Se, 2.0 µg L^{-1} U, and 1.53 mg L^{-1} NO_3-N (Site A); 2.9 µg L^{-1} Se, 92.5 µg L^{-1} U, and 189 mg L^{-1} NO_3-N (Site B); and 105 µg L^{-1} Se, 18.4 µg L^{-1} U, and 50 mg L^{-1} NO_3-N (Site C). The EBR technology was demonstrated on all three sites to treat the waters to <0.5 – 3.2 µg L^{-1} Se, <0.1 – 0.8 µg L^{-1} U, and <0.02 – <2 mg L^{-1} NO_3-N.

The high combined Se, U, and NO_3 removal efficiency achieved with EBR treatment, at both laboratory and field scale, has positive implications for future treatment system design at many sites. The EBR process would be applicable and beneficial at sites facing the challenge of mixed contaminant treatment to low discharge standards, simplifying the treatment train to one primary process, and eliminating the need for sludge or concentrate stream treatment/disposal.

Additional Key Words: bio-treatment, electro-biochemical reactor

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[1] Paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St Louis, MO: ***The Gateway to Land Reclamation***, June 2 – 7, 2018. Published by ASMR, 1305 Weathervane Dr, Champaign, IL 61821.

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FLIGHT 93 NATIONAL MEMORIAL REFORESTATION PROJECT: SURVIVAL AND GROWTH OF NATIVE WOODY PLANTS ESTABLISHED ON RECLAIMED MINELAND[1]

M.C. Tyree[2], J.L. Larkin, S.D. Eggerud, P.N. Angel, M.E. French, and C.D. Barton

Abstract. The Flight 93 National Memorial is located in Somerset Co., near Shanksville, PA. The site was surfaced mined and much of the 890 ha of reclaimed land was re-contoured and seeded in the mid 1990's. Starting in the spring 2012, the National Park Service, Office of Surface Mining Reclamation and Enforcement, and others have worked to reforest sections of the total area using native woody trees and shrubs. Each spring for the past six years (2012-17) over 500 volunteers planted a new section, which we have defined as a "Phase," of the National Memorial. *The Flight 93 National Memorial Reforestation Project* was established to evaluate reforestation success and provide data to drive future management decisions. Specifically, this work aims to: O1) Determine abundance and percent stocking for each of the 34 native, woody species planted across the six Phases; O2) evaluate growth of woody plants; and O3) describe level of competing vegetation across each phase. Two hundred and sixteen permanent, fixed radius plots were established randomly throughout the six planting phases with the goal to maintain a minimum target sampling intensity of 10%. Percent stocking, growth, and deer browse data were collected for all planted trees and shrubs within the sampling plots. Competition data was collected using 1 m^2 rectangular sub-plots nested within whole-plot. Of the 102,393 trees and shrubs (1,792 trees ha^{-1}) planted at The Flight 93 National Memorial we sampled a total of 8,673 individual trees and shrubs. Total percent stocking across all six planting Phases was 74.5% ranging from 40-121% within individual Phases, with natural regeneration driving stocking levels above 100% in one of the planting phases. Greatest plant growth was observed in the conifer species with white pine and pitch pine driving this pattern. Among the deciduous trees we observed the greatest growth among the early successional species such as quaking aspen and black locust. Overall, 88% of all plants showed no sign of deer browse, however, this rate is expected to increase as the plants emerge above the competing vegetation. Competing vegetation across all six planting phases was dominated by grasses, sedges, and herbaceous dicots and constitutes the largest limitation to woody plant establishment.

Additional Key Words: competing vegetation, deer browse, surface-mine reclamation

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[1] Paper presented at 2017 American Society of Mining and Reclamation and Appalachian Regional Reforestation Initiative (ARRI) Joint Conference. Morgantown, WV. April 10, 2017.

[2] Michael Tyree is an Assistant Professor, Department of Biology, Indiana University of Pennsylvania, Indiana, PA 15705; Jeffrey Larkin is a Professor, Department of Biology; Scott Eggerud and Patrick Angel are with the Office of Surface Mining Reclamation and Enforcement; USDI; Michael French with Green Forests Work; and Christopher Barton is a Professor, Watershed Management, University of Kentucky, Lexington, KY 40506.

Click below for full paper or the DOI.

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Demonstration Paper

CONCEPTUAL MODEL FOR HYDROLOGY-BASED GEOMORPHIC EVAPOTRANSPIRATION COVERS FOR RECLAMATION OF MINE LAND[1]

Z. F. Zhang[2] N. Bugosh, T. Tesfa, M. J. McDonald, and J. A. Kretzmann

Abstract: Currently, there are about half a million abandoned mine sites in the U.S. and an estimated 15,000 in New Mexico alone. Surface mining imposes severe ecological effects on the land because it not only alters the vegetation, soils, bedrock, and landforms, but also changes the surface hydrology, groundwater, and flow paths that ultimately result in degraded ecology and water quality. Two relatively new methodologies, fluvial geomorphic landform design and evapotranspiration (ET) waste covers, offer solutions to reclaim these sites for long-term, maintenance-free reclamation. GeoFluv™ is a specific geomorphic grading design method that uses natural analogues for post-mining landscapes and uses design input values taken from stable natural landscapes to make a reclamation design that provides hydrological function, supports ecosystem integrity, and is cost-effective, sustainable, and more visually attractive. It has documented ability to produce surface runoff water quality at least equal to adjacent undisturbed lands and has been used for disturbed lands, including active and abandoned mine sites. Surface ET covers have been used to manage the subsurface hydrology above landfills, waste sites, and mine lands. ET covers protect the underlying materials against erosion, provide a medium for vegetation growth, store precipitation within the cover, and release the stored water into atmosphere so that the infiltration of precipitation is minimized. A conceptual design study is carried out based on an actual, typical abandoned mine site near Raton, New Mexico, to which common problem conditions at abandoned mine sites are assumed. The purpose of this study is to present the concept that covers can be designed by integrating two remediation technologies (geomorphic grading and ET cover) as a geomorphic ET (GET) cover to improve performance. The overall shape of the GET cover can mimic the natural topography of the surrounding area, while the thickness and layering of the cover can be optimized for best vegetation growth and infiltration control. The application of GET cover technology on mine land is expected to substantially improve the reclamation effects by coupling the benefits of the geomorphic cover (drainage reduction, runoff management, vegetation diversity) with the benefits of ET covers (vegetation growth and sustainability, percolation reduction, protection of surface and groundwater).

Additional Key Words: Tailings; Geotechnical; Water Management; Vegetation

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[1.] Oral paper presented at the 2018 National Meeting of the American Society of Mining and Reclamation, St Louis, MO: ***The Gateway to Land Reclamation***. June 2-7, 2018. Published by ASMR, 1305 Weathervane Dr. Champaign, IL 61821.

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ABOUT THE AUTHORS

Dr. Jack Adams is President of Inotec, applying his 30+ year experience in applied environmental biotechnology and microbiology, geomicrobiology, industrial microbiology, and biotreatment to solve water treatment issues. Dr. Adams headed US Army and US Bureau of Mines Biotechnology Programs, founded and directed bioprocess development and bioremediation centers at the University of Utah and Weber State University and has held Research Professor Appointments at the three top Utah Universities. He was the Dept. of Army director for an international team for biotechnology assessment. Dr. Adams is an internationally recognized expert in metals and inorganic contaminant removal and bioprocess development and has developed and implemented innovative full-scale metal and inorganic removal biotechnologies for the mining industry in North and South America. He has conducted numerous pollution prevention assessments, waste minimization studies, technology assessments, feasibility evaluations, and has multiple patents in environmental biotechnology and water treatment areas. Professional experience covers expert witness on microbial and environmental processes; development and application of new biological processes and treatment systems for water, sediment, and atmospheric environments; development of environmental treatment and contingency plans; and investigation of microbes and microbial processes in diverse environments.

Patrick N. Angel, Ph.D., is a native of eastern Kentucky and has been employed by the Office of Surface Mining Reclamation and Enforcement (OSMRE), United States Department of Interior, in London, Kentucky since the implementation of the Surface Mining Control and Reclamation Act (SMCRA) in 1978. Dr. Angel supervised the inspection and enforcement operations for OSMRE in the coal fields of Kentucky until he was appointed Senior Forester and Soil Scientist for the agency in 2005. He is currently promoting reforestation partnerships on active, abandoned, and legacy surface mines through the Appalachian Regional Reforestation Initiative and Green Forests Work. Dr. Angel is a graduate of Stephen F. Austin State University, Nacogdoches, Texas with a BS and MS in Forestry. He is also a graduate of the University of Kentucky, Lexington, Kentucky with a Ph.D. in Soil Science. The focus of his studies was the reforestation of surface mines.

Dr. Christopher D. Barton, is the Director of the University of Kentucky's Appalachian Center and Professor of Forest Hydrology and Watershed Management in the Department of Forestry and Natural Resources. Dr. Barton is currently working in the areas of ecosystem restoration, reforestation and remediation primarily in stream and wetland habitats and mined lands. In addition, improved methods for preventing water quality degradation from logging and mining activities are currently being examined. Dr. Barton is an Associate Editor for the International Journal of Phytoremediation and the International Journal of Mining, Reclamation and Environment. Dr. Barton is also currently serving as the co-Team Leader of the Appalachian Regional Reforestation Initiative's Science Team and founder of the Green Forests Work program. Dr. Barton was the recipient of several National awards including the American Society of Mining and Reclamation's 2015 Richard and Lela Barnhisel Researcher of the Year Award. For more information visit: www.greenforestswork.org and www.facebook.com/Greenforestswork

John Bowden is Pilot Systems Operator at Inotec. John plays a pivotal role in all aspects of field testing, from pilot system design and construction, to system commissioning, operation, and troubleshooting. John assists in the design and installation process of pilot systems, interpreting the requirements specified by the research team and understanding the technical obligations. Once deployed, John is skilled at managing field work, performing all aspects of system operation, sampling, monitoring and testing, and has the ability to work safely in adverse settings and various climate conditions. When not in the field, he assists with laboratory bench-scale water treatment design and testing, water analysis, shop testing, and maintenance of pilot-scale equipment. The mix of field deployment and fundamental lab work provides John with a well-balanced skillset between process engineering, system operations, and microbiology. John holds a Bachelor of Science degree in Environmental Science with a minor is Hydrogeology from the State University of New York at Plattsburgh (2013).

Nicholas Bugosh, holds B.S and M.S. degrees and lives in Cleveland OH and is the Technical Director for Carlson Software and the inventor of a new approach to land grading that returns disturbed lands to natural function and appearance that is known as GeoFluv™. In 2009, he formed the company GeoFluv to provide training, coaching, and consulting services in this innovative landform design method. The GeoFluv approach forms the heart of the Carlson Software ***Natural Regrade*** module that was released in 2005.

He has conducted field research on bedload transportation in mountain streams, worked for state agencies in South Dakota, Montana, and Idaho and worked as Senior Hydrologist for a mining company the New Mexico.

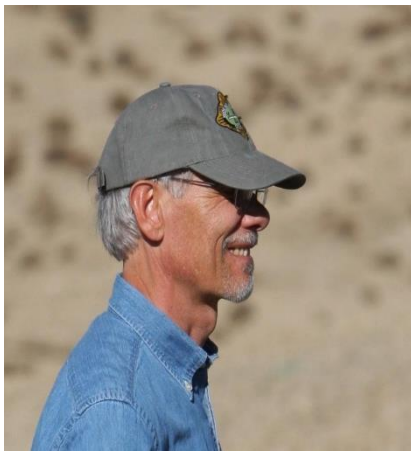
Peter Close has a Post-Graduate Diploma in Agricultural Engineering and is a Chartered Surveyor. He is the Lead Adviser on soils and land use in Natural England's Government Advice Team (part of an executive non-departmental public body, sponsored by the UK Government's Department for Environment, Food & Rural Affairs) focusing mainly on minerals and waste planning & reclamation, agricultural land classification, resource protection, strategic planning and review of associated technical guidance. Peter also has extensive experience in the UK advising on land drainage, pollution control, farm management & diversification, and investigations arising from Agricultural Land Tribunals and the EIA (Agriculture) Regulations, etc.

Scott Eggerud is a forester with the Office of Surface Mining Reclamation and Enforcement. Scott has a B.S. degree in Forest Management and Integrated Resource Management from the University of Wisconsin-Stevens Point. Scott has done various forestry work and reclamation work for the state of West Virginia and the U.S. Government. Scott specializes in restoration forestry. Scott has worked restoring native forest habitats on surface mines all over Appalachia for the last 18 years. Scott was one of the founders of the Appalachian Regional Reforestation Initiative (ARRI).

Michael French is a graduate of the University of Kentucky (BS and MS) and has been working in the field of mined land reforestation and American chestnut restoration for more than a decade. He is currently the Director of Operations for Green Forests Work. Prior to his current position, he worked as a reforestation coordinator for a private company, supervising the planting of millions of trees on surface mines across Appalachia.

Jane Fudyma is a Laboratory Manager at Inotec, where she plays a vital role in the overall safety and performance of the laboratory. Her responsibilities include assisting in preparation of testing proposals, writing test reports, and management of data and testing results. She runs and manages testing programs and R&D projects and participates in development of testing protocols and lab procedures. Jane holds a Bachelor of Science degree in General Science with focuses in Biology and Chemistry from Seattle University (2013).

Neil Humphries has been involved in restoration research and its practice since the early 1970s. Currently he works part-time as the Natural Resources Manager for a coal mining company in the UK, provides consultancy to the UK aggregates industry, and is working with the minerals Industry professional body, the Institute of Quarrying, and the UK Government's Policy Advice Team (English Nature) in the updating of the UK's soil handling guidance. He is also researching soil conservation monitoring and its reporting at the University of Reading. Neil is a Life Member for ASMR, recipient of its William T Plass Award 2013, and has regularly published in the ASMR Conference proceedings and JASMR.



John A. Kretzmann, P.E. is a licensed civil engineer in New Mexico. He is currently Program Manager of the New Mexico Abandoned Mine Land Program, where he has worked in abandoned mine safeguarding and reclamation for over 26 years. This included design of reclamation of historic coal mine waste piles, where he developed unique, in-place, steep slope reclamation approaches appropriate in a semiarid environment on eroding mine wastes high in clay content and moderately sodic. He also developed novel approaches to safeguarding and closing abandoned mine openings, including structures suitable for bat habitat preservation in underground workings. Previously, he worked on municipal, highway, pump station, storm drainage, and dam spillway design and construction monitoring. He will retire from State of New Mexico Service in June 2018.

Jeffery L. Larkin, Ph.D., is a Distinguished Professor of Biology at Indiana University of Pennsylvania and the Eastern Forest Birds Habitat Advisor for the American Bird Conservancy. His research combines his expertise in forestry, wildlife ecology, and habitat restoration. During his time at IUP, Dr. Larkin and his students have assisted state and federal agencies and other conservation groups with understanding the ecology and associated management implications for numerous wildlife species. In addition to research efforts, Dr. Larkin directs a team of conservation planners and foresters who assist USDA Natural Resource Conservation Service with the delivery of private lands conservation programs that target forest wildlife and their habitats. Dr. Larkin is also a member of the Appalachian Regional Reforestation Initiative's Science Team.

Meghan J. McDonald, P.E. is the Principal Engineer with the New Mexico Abandoned Mine Land Program. She has an education and professional background in civil and mining engineering. Since joining the Abandoned Mine Land Program, Ms. McDonald has worked on a multi-phase subsidence mitigation project in Western New Mexico which involved investigation and stabilization of a large sinkhole above abandoned coal mine workings. Ms. McDonald has also worked on safeguarding of abandoned hard rock mine projects within the state. She previously worked as a consulting engineer on a variety of geotechnical engineering projects, including shallow and deep foundation design, pavement design, slope stability and excavation support, and ground improvement.

Dr. A. Ola Opara is the Vice President at Inotec, where she directs the Bioprocess Development Laboratory. With nearly a decade of experience in industrial water treatment, Dr. Opara was instrumental in development of the EBR technology, from bench and pilot-scale tests to a full-scale implementation. Her testing and engineering experience concentrates in the United States and Canada, with several other projects in Central and South America, Europe, and Africa. Dr. Opara's experience includes treatment evaluations and troubleshooting of biological, chemical, and RO membrane systems for active, passive, and in-situ water treatment applications. She has worked with a variety of clients, including large mining corporations, smaller mining outfits, as well as state DEQ offices and the EPA. Dr. Opara completed her M.Sc. and Ph.D. degrees in Environmental Engineering from a joint program at the Department of Metallurgical Engineering and the Department of Civil and Environmental Engineering, University of Utah. She currently holds an Adjunct Assistant Professor position at the University of Utah, where she teaches coursework on energy resources, water issues, and sustainability.

Julian Smallshaw has worked in the extractives industry all his life. After graduating from the University of Leeds with a BSc in Quarrying he focussed on operational management. He ran a range of mineral extractives sites throughout the UK but more recently managed multi million tonne operations in the Middle East. Latterly he joined the Institute of Quarrying as Head of Educational Development working closely with stakeholders and educational institutions to develop and run a range a qualifications and training for the industry. He is a Fellow of the Institute of Quarrying and a Fellow of the Higher Education Academy in the UK.

Teklu K. Tesfa, a PhD in civil and environmental engineering from Utah State University. He is currently a scientist at the Pacific Northwest National Laboratory, in the hydrology group, located in Richland WA. His research focusses mainly on improving representation of land surface processes in land surface/hydrologic models Earth System Model. He developed a new topography-based subgrid structure for the E3SM Land Model of the Department of Energy that captures topographic heterogeneity and spatial variability of climate and vegetation. He also evaluated the impact of various representations of landscape on surface fluxes in land surface models.

Michael C. Tyree, Ph.D., is an Assistant professor of Applied Plant Ecology within the Department of Biology at Indiana University of Pennsylvania. He earned a B.S. in forest biology from Penn State University and an M.S and Ph.D. from Virginia Tech. Academic interests include understanding the effects of forest disturbance on plant health and carbon cycling. Current projects include 1) using tree-ring analysis to understand the timing and severity of hemlock wooly adelgid infestation in Pennsylvania forests; 2) measuring survival and health of blight-resistant American chestnut hybrids planted on reclaimed surface mines; 3) understanding the effects of disturbance on water-use and carbon metabolism of managed southern pine.

Dr. Fred Zhang received his Ph.D in the University of Guelph, Canada, in soil physics. He currently serves as an environment engineer at the Pacific Northwest National Laboratory. He has expertise in vadose zone hydrology in the areas of site characterization, monitoring, modeling of multi-phase fluid flow and contaminant transport, and theoretical development. Dr. Zhang has been primarily involved in the applied research environment remediation. He has led multiple projects such as remediation assessment using numerical simulations, developing the numerical simulation capability, and vadose zone monitoring.