Characterizing Subsurface Heterogeneity on Gold Post-Mining Sites[1]

A. A. Adesipo*, B. T. Akande, and D. Freese[2]

Abstract: Gold mining in southwestern Nigeria is dominated by artisanal and small–scale mining (ASM). Despite the ASM-induced landscape impacts and heavy contaminations, farming kept ongoing. To ascertain the sites' agricultural land-use potentials and safety, characterizing the landscape heterogeneity of the sites remains a fundamental requirement and is timely important. However, this is poorly considered in several post-mining land-use studies. Here, we explore the efficiency of Electrical Resistivity Tomography (ERT) for characterizing the horizontal and vertical variations in the subsurface properties of two gold mining sites. The resistivity structure of the sites shows that ASM has greatly impaired their lithological properties. We identified a dug pit backfilled with muds, buried foreign substance and an unnoticeable inappropriate pit left uncovered. The results correspond with the soil textural analysis of the site. In case that allowing the sites for self-recovery is not feasible, we recommend organic manuring, deep-ploughing and top-soiling (if possible) along with other necessary post-mining studies before agricultural use. Also, we advocate further use of other geophysical techniques on post-mining sites for studies such as identification of foreign substances, cavity, pits, hazardous materials, and determination of contaminants prior to its post land-use decisions.

Additional Key Words: Artisanal small-scale mining (ASM), Post-mining land-use, 2D Electrical Resistivity Tomography (ERT), Soil lithology.

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1. Oral paper presented at the 2022 National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.

2. Adegbite A. Adesipo (*presenter), PhD candidate, Department of Soil Protection and Recultivation, Brandenburg University of Technology, Platz der Deutschen Einheit 1, 03046, Cottbus-Senftenberg Germany; Benjamin T. Akande, Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna, Nigeria: Dirk Freese, Department of Soil Protection and Recultivation, Brandenburg University of Technology, Cottbus-Senftenberg, Germany.

Peat Mine Restoration, New Monitoring Technologies, and 7 Years of Progress at the Superior Wetland Bank[1]

N. A. White* and D. Deuschle[2]

Abstract: Construction of the Lake Superior Wetland Bank[3] was initiated in 2015 and is on the way to restore more than 23,000 acres of partially drained bog/fen habitat through permanent removal of a 65-mile ditch network. This includes 160 acres of a former peat mine, which was drained through a series of parallel ditching to allow for scraping, compressing, and excavation of surface peat material. Restoration of the peat mine is being achieved through filling the ditches with vegetation and soil native to the site, in conjunction with restoring overall site hydrology of the surrounding bog/fen. This leads to increased access challenges for ongoing monitoring. The use of drone technology to survey the restoration site, including the peat mine, is used to create a digital elevation model of the site. The drone survey data is also used to evaluate vegetation reestablishment for evaluating floristic quality. The pre-restoration conditions, regulatory process, construction methods, success criteria, and on-going results will be discussed along with lessons learned and adjustments to monitoring techniques. This paper should align with Technical Sessions on Revegetation, Soils, Hydrology, and/or Restoration.

Additional Key Words: native vegetation, soil, watershed restoration, Sax-Zim, Minnesota.

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2. Natalie A. White (*presenter), Sr. Biologist, Associate, Short Elliott Hendrickson Inc., Duluth, MN 55802 and Deric Deuschle, Aquatic Ecologist, Principal, Short Elliott Hendrickson Inc., St. Paul, MN 55110.

3. Work reported here was conducted near 47°12'03.2"N 92°33'48.6"W.

Using sUAS for the Development and Validation of Surface Water Quality Models in Optically Deep Mine Waters[1]

B.K. Holzbauer-Schweitzer* and R.W. Nairn [2]

Abstract: This study was undertaken to demonstrate novel remote monitoring techniques for mining-impacted surface waters utilizing spectral data from two different platforms (multispectral sUAS and handheld hyperspectral sensors) and to highlight the feasibility of using sUAS-derived multispectral imagery to estimate in-situ metal concentrations in two passive mine drainage treatment systems. Results describe strong linear relationships (e.g., $R^2_{adj.} > 0.74$) between multispectral reflectance and various in-situ constituent concentrations (e.g., Fe, Li, Mn, Pb, and Zn). Developed ordinary least squares (OLS) models estimated mean metal concentrations within 1% of the observed value and a 70% confidence interval. Validation at a separate site treating waters of a different geologic origin allowed us to assess the models' site specificity. Validation of some models was not possible within this study's statistical constraints (e.g., ± 25% of the observed in-situ value). However, two models were validated and when the linear relationships were examined with site-specific spectra (i.e., sUAS-derived multispectral imagery), significant improvements to the models were observed. Employing hyperspectral remote sensing techniques yielded a novel identification procedure for optically shallow waters. This exponential relationship (e.g., $R^2 = 0.73$) provides an evaluation of the feasibility of using remote sensing technologies to assess water quality before any model development efforts. A tool capable of identifying remote sensing interferences will be crucial for the future of environmental remote sensing. Using sUAS to estimate in-situ water quality provides a new way to monitor passive mine water treatment systems, potentially advancing the efficiency and cost-effectiveness of monitoring and altering traditional environmental remote sensing strategies.

Additional Key Words: Regression, Remote Sensing, Multispectral, Hyperspectral, Optical Depth.

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2. Brandon K. Holzbauer-Schweitzer (* presenter), Ph.D., and Robert W. Nairn, Ph.D., Professor, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019.
3. Work reported here was conducted near 36.922350, -94.873297 (MRPTS); 34.847659, -95.535299 (HPTS),

Prioritization of Site Selection for Subsidence Mitigation of Abandoned Mine Lands using GIS andAttribute Criteria Hierarchy [1]

Harry Plendl [2]

Abstract: Across the world, countries with historically mined landscapes have begun implementing programs to manage underground abandoned mines and mitigate subsidence, but a need exists to prioritize rehabilitating these sites. This research presented in this discussion hypnotizes a hierarchical criterion for site prioritization, coupled with the use of Geographic Information Systems (GIS) to spatially analyze criteria and data to simplify the complex decision process when attempting to reduce public hazards caused by abandoned mines. Historical records, risk assessment, jurisdictionpolicy, and geologic investigations are all critical components to site priority. The model developed and discussed for this presentation uses Esri's Arc Pro 2.8 Model Builder and has been tested on two study areas for Wyoming Abandoned Mine Lands Program. Results include a prioritization model that highlights an area with criterion for site investigation, potential for reducing human bias througha GIS solution and a means for better community engagement through the publishing of prioritization factors and consistent spatial analysis results.

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1. Oral presentation at the 2022 National Meeting of the American Society of Reclamation Sciences, Duluth,MN. June 12 - 16, 2022.

2. Harry Plendl, MS, GISP, GIS Solution Engineer, Brierley Associates Corp, 1482 Commerce Dr., Unit T, Laramie, WY 82070.

Implementation of an Enterprise Geographic Information System (GIS) for Abandoned Mine LandReclamation Project Data Collection and Efficiency of Client Reporting[1]

Harry Plendl* and Cory Ott*[2]

Abstract: This presentation outlines the evolutionary journey of the data collection, reporting, and management for the Wyoming Abandoned Mine Land (AML) project through the implementation of an Enterprise Geographic Information System (GIS) architecture. Over an eighteen-month period, Brierley Associates made the transition from collecting and reporting data in an analog format to an advanced digital collection solution developed to increase operational efficiency of the project. The purpose of this implementation, the methodology used to bring this vision to fruition, and the challenging technical obstacles encountered throughout this transition provide the substance for this presentation. The former methods of record keeping, and planning left the program vulnerable to lost or unreadable documentation and was tedious for managing dynamic data management of AML mitigation construction projects. Transitioning from static maps and paper record keeping to the industry standard Esri Enterprise GIS made the reclamation project logistically manageable for detailed analysis, delivery, reporting, and data collection. Working with the latest versions of Esri's Arc Server, Portal, ArcGIS Field Maps, and Arc Pro, the Brierley team has a Commercial Off-The- Shelf (COTS) GIS solution for all phases of an AML project. This includes the planning phase, using multi-user versioned editing, offline mobile data collection in remote areas, attractive dynamic projecttracking Dashboards, all the way to the final Construction Summary Report (CSR) published on the web in an interactive Story Map for the best public information tool possible. In addition, Brierley also houses a robust remote sensing program to more readily monitor and manage AML construction projects, which includes high-resolution products such as orthomosaic imagery, digital terrain and surface models, thermal imagery, and LiDAR imaging. Brierley views their recent integration of an Enterprise GIS coupled with supporting COTS software to manage AML project data as an industry leading solution.

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2. Harry Plendl, MS, GISP (*presenter), GIS Solution Engineer, Brierley Associates Corp, 1482 Commerce Dr, Unit T, Laramie, WY 82070 [2]Cory Ott, MA, (*presenter), GIS Analyst, Brierley Associates Corp, 1482 Commerce Dr, Unit T, Laramie, WY 82070.

Drone Use Along with Spatially Balanced Sampling and Route Optimization for Rapid Monitoring of Reclaimed Areas[1]

Michael F. Curran[2]

Abstract: Monitoring reclamation projects is essential to satisfy needs of various stakeholders and to provide information about the status of the reclamation effort. On oil and gas well pads in Wyoming, reclamation monitoring efforts have traditionally been done using qualitative visual estimates or quantitative line point intercept methods along vegetation transects[3]. While visual estimates can be done rapidly, they are subject to high rates of observer bias and error. Line point intercept (LPI) methods are time intensive, subject to high error rates, and transect placement is often based on an individual's judgement which may be highly subjective. Additionally, LPI data is often not linked accurately to a geographical location and is not repeatable should data need additional scrutiny after collection. More recently, handheld imagery has been utilized to reduce observer bias, provide geographical information, and reduce data collection time almost 10-fold. In this study, I introduce the use of drone technology to monitor vegetation and show that it is ~4 times faster in the field than handheld image collection. The travelling salesperson algorithm is used to optimize points which are generated using a spatially balanced sampling design called Balanced Acceptance Sampling (BAS) and the drone is pre-programmed to fly a path to these points to collect imagery. The imagery is comparable to handheld imagery and further advantages of this method will be discussed.

Additional Key Words: Vegetation Monitoring, SamplePoint, Travelling Salesperson Problem, Unmanned Aerial System, UAS, UAV.

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2. Michael F. Curran, PhD, Consultant, Abnova Environmental, Manasquan, NJ, 08736.
3. Work reported here was conducted near 44.3483° N; 106.6989° W.

Remote Sensing and Benefits for Abandoned Mine Subsidence Investigation and Mitigation[1]

Ike Isaacson*, Dave Hibbard, Shane Zentner, and Melissa Bautz[2]

Abstract: While remote sensing has more commonly been utilized for abandoned mine research throughout the United States as of late, integration of this technology has been quintessential for subsidence research, mitigation design, and mitigation management in Carbon and Converse Counties, Wyoming. This includes orthomosiac mapping for baseline conditions prior to mitigation, Digital Terrain and Digital Elevation Models for cut/fill operations and surface waterrunoff, thermal for tracking shallow groundwater movement and subsidence features, and LiDAR for documenting baseline conditions and volumetrics. In conjunction with several Esri products, analysis of this remote sensing information enhances to a rich database also used for logistical planning and mitigation operations. This saves time and money, as well as a platform to improve communication with the public and contractors alike. This presentation discusses specific remote sensing hardware products and applications utilized in congruence with the Abandoned Mine Lands Division in Wyoming.

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1. Oral paper presented at the National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2020. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.

2. Ike Isaacson, P.E., P.G., C.E.G., G.E. (* presenter), Director, Brierley Associates Corp, 2500 W. Fairy Chasm Rd, Milwaukee, WI 53217. David Hibbard, P.G., Project Geologist, Brierley Associates Corp, 1482 Commerce Dr, Unit T, Laramie, WY 82070. Shane Zentner, G.I.S.P., Senior Remote Sensing Specialist, Brierley Associates Corp, 2000 S. Colorado Blvd, STE 410, Denver, CO 80222, and Melissa Bautz, P.G. Project Manager, Abandoned Mine Lands (AML) Division, 510 Meadowview Dr, Lander, WY 82520.

Abandoned Coal Mine Mitigation in High Pressure Artesian Conditions [1]

Dave Hibbard, Josh Zimmerman,* Joel James, and Melissa Bautz [2]

Abstract: As an extension of an AML Pilot Program conducted during the Summer of 2019, there was question as to whether or not void fill grouting as a means of subsidence mitigation was feasible in an area known to exhibit high artesian head pressures. This pilot program provided the foundation and methodology to create a design approach to alleviate any potential risk of abandoned coal mine mitigation to the densely populated overlying sub-division. These potential risks associated with the injection and pressurizing high mobility grout included; displacement of groundwater into building foundations, inducing structural collapse of the mine, infrastructure sub-grade failure through the over saturation of soils and reduction in effective stress and shear resistance leading to additional settlement under footings, and ground surface movement. After extensive analysis of this pilot study, an elaborate and specially designed mitigation program was established for mitigating the mine subjacent to sub-development and took place during the Summer of 2021. This presentation covers surface and subsurface controls to handle high artesian head pressures while mitigating underground abandoned coal mines in a densely populated sub-division.

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2. Dave Hibbard, P.G. Project Geologist, Brierley Associates Corp, 2000 S. Colorado Blvd Suite 410, Denver, CO 80222, Josh Zimmerman*, P.E. (* presenters), Geotechnical Engineer, Brierley Associates Corp, 2482 Commerce Dr, Unit T, Laramie, WY 82070; and Melissa Bautz, P.G. Project Manager, Abandoned Mine Lands (AML) Division, 510 Meadowview Drive, Lander, WY 82520.

Design & Construction of Barrier Berms using Innovative Reclamation Techniques to Benefit Mineland Operational Safety and Community Viewshed[1]

J. Asp* and A.Kramer[2]

Abstract: Design and installation of two barrier berms over 14 acres was completed at a Northern MN[3] active taconite mine operation located in close proximity to two communities. The berms provide a safety barrier between the mine and communities for a visually appealing landscape that aides in minimizing the operational impact through reduction in noise and potential dust and reduces trespass from outside the active operation. Vegetation restoration was completed to promote native species in conjunction with building soil on overburden material. Soils were ameliorated with nutrient and organic matter additions, and hydroseeded to manage soil erosion. Trees and surface soils were salvaged in advance of mineland stripping, then located to the berms to enhance vegetation establishment. The project serves as an opportunity to test alternative reclamation methods to build soil as a growing medium, establish native vegetation, and create a blueprint of best practices to be leveraged when designing reclamation sites, keeping in mind that post-mining landscapes can be a valued community resource for vegetation reestablishment and aesthetically appealing viewsheds from neighboring communities.

Additional Key Words: mining, active operation, soil, material salvage, viewshed, community, safety, native vegetation.

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2. Joel Asp (* presenter), Sr. Ecologist, Short Elliott Hendrickson Inc., St. Cloud, Minnesota 56301; Allyz Kramer, Sr. Biologist, Principal, Short Elliott Hendrickson Inc., Duluth, Minnesota 55802.
3. Work reported here was conducted near 92°31'24.364"W 47°30'0.394"N; 92°32'3.484"W 47°30'33.02"N.

Techniques and Challenges for Material Stabilization within Historically Mitigated UndergroundAbandoned Coal Mines [1]

Joel James*, Dave Hibbard*, and Melissa Bautz [2]

Abstract: This presentation covers subsurface variabilities faced with historic backfilling techniques and how to approach maximizing underground abandoned mine stabilization for long term reliability in subsidence prone areas. Techniques and technology used for abandoned coal mine mitigation have evolved, not only in material sourcing but also in engineering approach over the years. The historic abandoned mine mitigation approach specifically used in Hanna, WY within the Hanna No. 4 Coal Mine, utilized a combination of sand and water ('sand slurry') material injected into the mine under high velocity. While initially thought to reduce existing void space and prevent further structural degradation and eventual mine subsidence, the slurry injected introduced further mine destabilization concerns through erosion and material migration processes within the mine over time due to water movement within the mine. This historic engineering approach has ultimately compounded the potential for subsidence risk and has led to a modified modern day engineering approach to not only stabilize the historically injected material, but also provide a long-term solution to reduce continued risk of subsidence in the area. This presentation will discuss existing geologic conditions, historic mitigation techniques, current mitigation challenges in pre-existing conditions, and a long-term stabilization solution to prevent continued mine subsidence in abandoned underground coal mines.

1, Oral presentation at the 2022 National Meeting of the American Society of Reclamation Sciences, Duluth,MN. June 12 - 16, 2022.

2 Joel James (* presenter), Geological Engineer, 1482 Commerce Dr, Unit T, Laramie, WY 82070; Dave Hibbard, P.G. (* presenter), Project Geologist, Brierley Associates Corp, 2000 S. Colorado Blvd Suite 410, Denver, CO 80222, and Melissa Bautz, P.G. Project Manager, Abandoned Mine Lands (AML) Division, 510 MeadowviewDrive, Lander, WY 82520.

Mitigation of the Rock Springs No. 9 Mine Below Pipeline Utility Corridor[1]

Ryan Reed* and Harold Hutson[2]

Abstract: The Rock Springs Coal Mining District is characterized by extensive underground coal mines. Numerous reclamation projects have been completed by the Wyoming Department of Environment Quality, Abandoned Mine Land Program (AML) to address hazards posed by shallow underground mine workings. The Rock Springs Coal Mining District is located near and in Rock Springs, Wyoming in Sweetwater County. The historic coal mines were crucial for the development of the Union Pacific's transcontinental railway and development of the western United States. The Rock Springs No. 9 mine was crossed by a utility corridor containing 3 high pressure interstate gas and petroleum pipelines. The mine voids were as shallow as 30' from the surface and posed a risk to the critical infrastructure due to subsidence collapse. In addition, a large underground mine fire to the south of the corridor had begun to burn beneath the pipelines. The Wyoming AML program responded by applying lessons learned on past projects utilizing drilling and grouting techniques to stabilize shallow underground mine voids and extinguish underground coal mine fires to mitigate subsidence hazards, extinguish the fire beneath the gas pipelines, and prevent the spread of the fire to the north along outcrop. Special operating procedures were developed in conjunction with the pipeline operators to ensure the safe completion of the work adjacent to the high-pressure pipelines. The reclamation of the Rock Springs No. 9 Mine utility corridor was a rewarding and challenging project for the Wyoming Abandoned Mine Land Program, and mitigated hazards due to past mining practices through the use of multiple methods. The long-term benefits of this project to the include preventing the spread of underground coal mine fire and final stabilization and mitigation of mine voids to prevent damage to critical public infrastructure.

Additional Key Words: Drilling and grouting, subsidence mitigation, mine fire, pipeline.

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2. Ryan Reed PE (* presenter), and Harold Hutson, PE, PG.
3. Work reported here was conducted near 41.621225, -109.173524.

Converting a Former Mine to a Winter Wonderland[1]

Dale Kolstad* and Megan Houdeshel*[2]

Abstract: The Mayflower Mine in Wasatch County, Utah, once produced more gold than the rest of the Park City District mines combined. The mine also produced an abundance of silver, zinc, and copper. After nearly 50 years of dormancy, the mine site is being reclaimed and converted to a ski resort with luxury hotels and residences. The site is enrolled in the Utah Department of Environmental Quality (UDEQ) Voluntary Cleanup Program (VCP) to streamline cleanup efforts and provide assurance to investors. A successful cleanup depended upon a comprehensive permitting and regulatory engagement effort that included integration of requirements of the Utah Department of Environmental Response and Remediation (DERR), Utah Pollutant Discharge Elimination System (UPDES), and United States Army Corp of Engineers (USACE) Nationwide Permit programs. An extensive site characterization was completed to determine the nature and extent of impacts. The investigation revealed an unstable waste rock pile at the mouth of the portal, widespread lead and arsenic in topsoil, portal drainage containing dissolved metals above receiving water standards, and metals-impacted sediments within drainages and wetlands. The remedial design included diverting the portal drainage from the wetlands, removing the sediment, and placing the excavated topsoil and sediment with waste rock in an onsite sealed repository. The repository was purposefully designed to accommodate a range in material quantities and qualities while maintaining a consolidated footprint. The portal drainage is collected and treated with green sand filtration to use for snowmaking operations in winter and routed through constructed wetlands for additional passive treatment in summer. Remedial actions were strategically incorporated into the overall mixed land use redevelopment plan, providing protection of human health and the environment without affecting the building plans or future site aesthetics. The design used cost-effective onsite materials unsuitable for development construction but useful for the repository and compensatory wetlands.

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2. Dale Kolstad, P.E. (*co-presenter). Senior Environmental Engineer and Vice President. Barr Engineering Company. Minneapolis, MN; Megan Houdeshel (*co-presenter). Partner and Co-Chair Energy & Natural Resources Industry Group. Dorsey & Whitney LLP. Salt Lake City, UT.

Alaskan Active Coal Mine Reclamation-Two Bull Ridge[1]

R.C. Sivils[2]

Abstract: Usibelli Coal Mine (UCM) located in Healy Alaska, has completed several large reclamation projects within the Two Bull Ridge (TBR) Permit area in support of achieving additional acres of bond release. 2021 was an outstanding year for the mine and four major projects were completed in support of final reclamation of the site. The first project was the Two Bull (TB) Channel which saw the installation of 17 sets of wingwalls, riprap placement for slope armoring and hydroseeding of 6 acres within the main drainage channel. The second project was the construction of a new sediment settling pond which helped control stormwater runoff during the channel project and will serve a long-term use of regulating stormwater flows within the drainage system. The third project was the regrade and aerial seeding of roughly 100 acres which drain into the TB Channel, which is ongoing into 2022. Accelerating the bond release timeline for the entire TB permit area has been a goal for UCM and these three projects are instrumental in this effort. UCM has applied for final Phase III bond release for a significant portion of the TBR permit acreage in close proximity to the active reclamation areas after successfully completing the required two-year vegetation diversity and cover density studies and should receive approval in 2022 from the State of Alaska Division of Natural Resources.

Additional Key Words: environmental

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2. Richard C. Sivils, Environmental Manager, Usibelli Coal Mine, Healy Alaska 99743
3. Work reported here was conducted near 63°55’6.62” N; 148°55’4.51” W.

Teaching Young and Old Pups New Tricks [1]

T.J. Toy *, W. Lee Daniels, S. Flath, B. Schadweiler, and A.F. Wick[2]

Abstract: Teaching is typically thought of as being associated with college student interactions, but there are several other resources used to build the knowledge base required for a career in reclamation. As we know, the learning never stops! Dr. Terry Toy has a career filled with creating opportunities both within the university setting and outside of the university with workshops to keep professionals learning and exploring new perspectives. Terry will highlight how he got to a career in teaching, partnerships he formed to create additional opportunities and approaches he's used successfully and not-so successfully. This is part of a comprehensive session exploring partnerships amongst the various careers in reclamation will include four individual presentations addressing efforts in teaching (Dr. Terry Toy, University of Denver, retired), research (Dr. Lee Daniels, Virginia Tech), mining industry (Sarah Flath, North American Coal Corporation), consulting industry (Dr. Brenda Schladweiler, BKS Environmental) and Extension education (Dr. Abbey Wick, North Dakota State University). The individual presentations will be followed by a discussion group facilitated by Wick to answer questions, tell stories from the trenches, and help custom tailor information to guide developing careers or revamp careers looking for new opportunities.

Additional Key Words: Courses, Professional Development.

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2. Terrence J. Toy (* presenter), retired Professor, University of Denver, Denver, CO, 80210; W. Lee Daniels, Professor, Crop and Soil Environmental Sciences, Virginia Tech, Blacksburg, VA 24061; Sarah Flath, Environmental Manager, Coteau Properties Company, North American Coal Corporation, Beulah, ND 58523; Brenda Schladweiler, President, BKS Environmental, Gillette, WY 82717; Abbey Wick, Associate Professor, North Dakota State University, Fargo, ND 58108.

Keeping the Research Relevant [1]

W. Lee Daniels *, S. Flath, B. Schladweiler, T.J. Toy, and A.F. Wick[2]

Abstract: Research is needed to continue to advance our understanding of reclaimed systems and to create practical, science-based approaches to be used in industry. Dr. Lee Daniels excels in this area of improved understanding and practicality. He will talk about following the science and applying it practically to industry to improve the efficiency while protecting the environment. Lee will also talk about how he got into his career, how he's managed to partner with industry in a very effective way along with successes and speed bumps along the way. This is part of a comprehensive session exploring partnerships amongst the various careers in reclamation will include four individual presentations addressing efforts in teaching (Dr. Terry Toy, University of Denver, retired), research (Dr. Lee Daniels, Virginia Tech), mining industry (Sarah Flath, North American Coal Corporation), consulting industry (Dr. Brenda Schladweiler, BKS Environmental) and Extension education (Dr. Abbey Wick, North Dakota State University). The individual presentations will be followed by a discussion group facilitated by Wick to answer questions, tell stories from the trenches, and help custom tailor information to guide developing careers or revamp careers looking for new opportunities.

Additional Key Words: Partnerships, practical, applied, science.

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2. W. Lee Daniels (* presenter), Professor, Crop and Soil Environmental Sciences, Virginia Tech, Blacksburg, VA 24061; Sarah Flath, Environmental Manager, Coteau Properties Company, North American Coal Corporation, Beulah, ND 58523; Brenda Schladweiler, President, BKS Environmental, Gillette, WY 82717; Terrence J. Toy, retired Professor, University of Denver, Denver, CO, 80210; Abbey Wick, Associate Professor, North Dakota State University, Fargo, ND 58108.

Industry Applying Multiple Minds at the Mine [1]

S. Flath*, W. Lee Daniels, B. Schladweiler, T.J. Toy, and A.F. Wick[2]

Abstract: Industry is where the rubber meets the road and Sarah Flath has a career full of opportunities where they've supported and applied input from academia, research, consultants, and Extension to mineland reclamation. As stewards of the land, she knows that it takes a deep understanding of ecosystems and engineering along with innovation to get the job done well. Sarah also has experience linking the approaches back to the guidelines to stay in compliance. She will share her career path, partnerships and opportunities explored and examples of areas where she's had great success. Learning from challenging projects also helps us advance, so Sarah will share some of the challenges she's had along the way. This is part of a comprehensive session exploring partnerships amongst the various careers in reclamation. It will include four individual presentations addressing efforts in teaching (Dr. Terry Toy, University of Denver, retired), research (Dr. Lee Daniels, Virginia Tech), mining industry (Sarah Flath, North American Coal Corporation), consulting industry (Dr. Brenda Schladweiler, BKS Environmental) and Extension education (Dr. Abbey Wick, North Dakota State University). The individual presentations will be followed by a discussion group facilitated by Wick to answer questions, tell stories from the trenches, and help custom tailor information to help guide developing careers or revamp careers looking for new opportunities.

Additional Key Words: Partnerships, practical, applied, science.

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2. Sarah Flath (* presenter), Environmental Manager, Coteau Properties Company, North American Coal Corporation, Beulah, ND 58523; W. Lee Daniels, Professor, Crop and Soil Environmental Sciences, Virginia Tech, Blacksburg, VA 24061; Brenda Schladweiler, President, BKS Environmental, Gillette, WY 82717; Terrence J. Toy, retired Professor, University of Denver, Denver, CO, 80210; Abbey Wick, Associate Professor, North Dakota State University, Fargo, ND 58108.

Extension Ain't Your Grandpa's Program Anymore [1]

A.F. Wick*, W. Lee Daniels, S. Flath, B. Schladweiler, and T.J. Toy[2]

Abstract: Extension education can serve an important role in bringing multiple groups together to share ideas from concepts being taught, research results and industry applications. Dr. Abbey Wick will talk about creative Extension programming using a network approach that can be applied to reclamation. She will talk about how she got to a career in Extension, partnerships that have helped develop programs and some of the successes and failures experienced. This is part of a comprehensive session exploring partnerships amongst the various careers in reclamation will include four individual presentations addressing efforts in teaching (Dr. Terry Toy, University of Denver, retired), research (Dr. Lee Daniels, Virginia Tech), mining industry (Sarah Flath, North American Coal Corporation), consulting industry (Dr. Brenda Schladweiler, BKS Environmental) and Extension education (Dr. Abbey Wick, North Dakota State University). The individual presentations will be followed by a discussion group facilitated by Wick to answer questions, tell stories from the trenches, and help custom tailor information to guide developing careers or revamp careers looking for new opportunities.

Additional Key Words: Partnerships, practical, applied, programs, education

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2. Abbey Wick (*presenter), Associate Professor, North Dakota State University, Fargo, ND 58108; W. Lee Daniels, Professor, Crop and Soil Environmental Sciences, Virginia Tech, Blacksburg, VA 24061; Sarah Flath, Environmental Manager, Coteau Properties Company, North American Coal Corporation, Beulah, ND 58523; Brenda Schladweiler, President, BKS Environmental, Gillette, WY 82717; Terrence J. Toy, retired Professor, University of Denver, Denver, CO, 80210.

Urban Reforestation as Reclamation: Exploring Effects of Forest Development on Plant Community Structure, Water Quality, and Soil[1]

K. L. Sena[2]

Abstract: Urbanization dramatically impacts ecosystem structure and function in both terrestrial and aquatic systems. Forests and other terrestrial ecosystems are cleared for development, and forest remnants suffer from the effects of fragmentation, including significant pressure from competitive introduced species and soil quality impairment. Similarly, aquatic systems are impacted by altered hydrologic regimes driven by impermeable surface area, alongside water quality impairments. Reforestation of key urban areas may present an opportunity to address some of these issues. To this end, tree planting events are increasingly popular for both community engagement and ecological improvement. However, the long-term success and development of community-planted forests is not well understood. This study evaluated plant community structure and soil characteristics for a chronosequence of 20 reforested urban sites planted as part of the Reforest the Bluegrass program in Lexington, KY. In addition, streamwater quality was assessed for four sites with streams. Plant community surveys suggested that forests are developing on these sites: older sites have a diverse canopy of native trees, as well as a shaded understory. However, invasive species are abundant in the understories of some sites, demonstrating the need for ongoing management of these sites. Soil data do not demonstrate strong trends with time since planting but suggest that these sites all have appropriate soil conditions for growth and development of native forests. Finally, water quality data for some sites demonstrate significant reductions in nitrate concentrations between upstream and downstream sampling locations (upstream and downstream of the reforested reach), suggesting that reforestation may significantly improve water quality. Taken together, these results demonstrate that community-planted trees can develop elements of forest structure over time, and that these developing forests can significantly influence the ecosystem as a whole. These data also provide a robust baseline to evaluate ongoing forest ecosystem development into the future.[3]

Additional Keywords: Urban and community forestry, Reforest the Bluegrass, new forests, forest ecology, restoration ecology.

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2. Kenton L. Sena, Lecturer, Lewis Honors College, University of Kentucky, Lexington, KY 40526.

3. This work was performed at sites in Lexington, KY, near 38°02'46.0"N 84°29'49.4"W.

Partnerships in Reclamation [1]

A.F. Wick*, W. Lee Daniels, S. Flath, B. Schladweiler, and T.J. Toy[2]

Abstract: This is a comprehensive session exploring partnerships amongst the various careers in reclamation will include four individual presentations addressing efforts in teaching (Dr. Terry Toy, University of Denver, retired), research (Dr. Lee Daniels, Virginia Tech), mining industry (Sarah Flath, North American Coal Corporation), consulting industry (Dr. Brenda Schladweiler, BKS Environmental) and Extension education (Dr. Abbey Wick, North Dakota State University). The individual presentations will be followed by a discussion group facilitated by Wick to answer questions, tell stories from the trenches, and help custom tailor information to guide developing careers or revamp careers looking for new opportunities. Each career provides an opportunity to have an impact in reclamation science. It's often the partnerships amongst different career paths that are the most effective. The wrap-up discussion to this session will pull it all together in a meaningful way to be applied to any career.

Additional Key Words: Partnerships, practical, applied, programs, education, science, teaching.

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1. Oral paper presented at the 2022 National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.

2. Abbey Wick (*Facilitator), Associate Professor, North Dakota State University, Fargo, ND 58108; W. Lee Daniels, Professor, Crop and Soil Environmental Sciences, Virginia Tech, Blacksburg, VA 24061; Sarah Flath, Environmental Manager, Coteau Properties Company, North American Coal Corporation, Beulah, ND 58523; Brenda Schladweiler, President, BKS Environmental, Gillette, WY 82717; Terrence J. Toy, retired Professor, University of Denver, Denver, CO, 80210.

Early Discoveries and Development of Passive Treatment Systems[1]

Jeff Skousen,* Bob Kleinmann, Bob Hedin, Bob Nairn, Tom Wildeman, and Jim Gusek[2]

Abstract: Passive treatment systems have been promoted as a means of treating mine drainage on abandoned mine sites for decades. This presentation reviews the beginnings, early history (first 20 years) and development of the passive treatment of mine water when it was viewed as a possible way to treat small flows of circumneutral and mildly acidic mine coal mine water. Subsequently, more knowledge and experience along with better designs made it applicable for their use for larger flows and more contaminated mine water including water from metal mines. Since then, the approach has been adapted and used successfully to treat an incredible range of mine water quality and quantities, far beyond what was initially considered by those who pioneered research and application of this treatment science. A brief history will include the five early types of systems and their development: aerobic wetlands, anaerobic wetlands, vertical flow wetlands, anoxic limestone drains, and open limestone channels.

Additional Keywords: Aerobic wetlands, Anaerobic wetlands, Anoxic Limestone Drains, Bioreactors, Limestone, Metal precipitation, Sulfate reduction.

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1. Oral paper presented at the 2022 National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12 - 16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.

2. Jeff Skousen (*presenter), Professor of Soil Science, West Virginia University, Morgantown, WV 26506, jskousen@wvu.edu ; Bob Kleinmann, robert.kleinmann@gmail.com; Robert Nairn, nairn@ou.edu, Bob Hedin, bhedin@hedinenv.com, Jim Gusek, jim.gusek@linkan.biz, Tom Wildeman, twildema@mines.edu.

Mine Drainage Co-Treatment in Municipal Wastewater Sequencing Batch Reactors[1]

C.D. Spellman Jr.*, W.H.J. Strosnider, T. Tasker, B. Roman, and J.E. Goodwill[2]

Abstract: Acid mine drainage (AMD) and municipal wastewater (MWW) are pollutants that each pose serious risks to water quality if left untreated. MWW can introduce pathogenic microorganisms into downstream freshwaters while AMD discharges may result in downstream acidification and increased metal loadings that are harmful to aquatic organisms. MWW and AMD are commonly co-occurring wastes in portions of the United States with mining histories. Many drainage discharges, and operating mines exist near MWW treatment plants making it economically feasible to convey mine drainage to MWW facilities. Treating AMD at existing wastewater treatment plants could represent an innovative, sustainable, and economically viable solution for mine drainage reclamation. As many wastewater facilities are struggling to meet new regulations for nutrient removal, co-treatment could offer a low-cost, sustainable option for improving nutrient removal at existing activated sludge plants. Results presented will address existing research questions related to feasibility of mine drainage co-treatment which currently prohibits commonplace adaptation at scale. Synthetic AMD of various strengths will be co-treated with synthetic MWW in a continuously operating (24 hr./day) bench-scale (~2-liter) sequencing batch reactor (SBR) activated sludge treatment system. The treatment system replicates addition of AMD after aeration but before secondary settling. SBR's will co-treat for approximately one month, where clarified effluent and settled sludge quality will be monitored over time to determine impacts of co-treatment relative to traditional wastewater treatment performance. Key parameters will include pH, residual metals, biochemical oxygen demand, nutrients (nitrogen and phosphorus), and suspended solids. MWW operational implications and sludge disposal considerations will also be considered.

Additional Key Words: Combined treatment; Novel mine water treatment.

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1. Oral presentation presented at the 2022 National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.

2. Charles D. Spellman Jr. (*presenter), PhD candidate, and Joseph E. Goodwill, Assistant Professor, Civil and Environmental Engineering, University of Rhode Island, Kingston, RI 02881; William H.J. Strosnider, Director; Belle W. Branch Marine Field Laboratory, University of South Carolina, Columbia, SC 29208; Travis Tasker, Assistant Professor, and Benjamin Roman, Postdoctoral Fellow; Environmental Engineering, Saint Francis University, Loretto, PA 15940.

The Use of Solar-Powered Float-Mix Aerators to Increase Iron Retention in Topographically Limited Passive Treatment Oxidation Ponds[1]

D.M. Dorman* and R.W. Nairn[2]

Abstract: In the passive treatment of mine drainage, oxidation ponds are the primary cells used to promote oxidation and retention of metals such as iron. Aeration techniques are often applied to increase the oxidation rate by entraining more oxygen into the water column. Aeration in passive treatment of mine drainage is commonly achieved by dissipation of energy from hydraulic head differences. However, this type of aeration is not feasible for sites located in regions with limited topographic relief. This study investigated the effectiveness of custom-designed solar-powered float-mix aerators (FMAs) deployed at the Southeast Commerce Passive Treatment System in the Tar Creek Superfund Site to increase dissolved oxygen (DO) concentrations, degas carbon dioxide (CO_2) and promote iron (Fe) retention from multiple perspectives: (1) with respect to depth in the water column, (2) spatially with respect to the aerator, and (3) spatially within the oxidation pond to examine overall effect of aeration on the performance of the oxidation pond. The study found that the FMAs statistically increased DO saturation and pH at a depth of 0.4 meters and shallower, increased DO saturation up to 9 meters downstream compared to solely passive aeration and increased overall DO saturation by more than 100% compared to when the FMAs were off. The DO increase resulted in CO_2 degassing with subsequent pH increases. The increase in DO and pH promoted Fe oxidation indicated by a larger fraction of the Fe present in the particulate form compared to when the aerators were off. Data comparing influent water quality data to effluent water quality of the oxidation pond showed that the oxidation pond increased DO saturation by over 100%, degassed CO_2, and removed an average 93% of the influent Fe loading when the FMAs were on. Active FMA aeration increased Fe removal rates in the oxidation pond by 17% from 22 g m^{-2} d^{-1} without the FMAs to 26 g m^{-2} d^{-1} with the FMAs. This study shows that FMAs are a viable aeration technology for sites where gravitational energy driven aeration is not feasible due to topographic limitations.

Additional Key Words: aeration, net alkaline water, acid mine drainage, passive treatment systems.

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1. Oral paper presented at the National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL61821.

2. Dayton M. Dorman, PhD Student, and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019.

3. Work reported here was conducted near 36°55’34.04”, 94°52’30.98”.

Passive removal of Mn from mine water by heterogeneous Mn oxidation[1]

R. Hedin,* N. Wolfe, and B. Hedin[2]

Abstract: Manganese ($Mn^{2+)}$ is a common water contaminant at coal and metal mining sites world-wide. At most international mine sites, the effluent limit for Mn is 0.5 mg/L. At U.S. coal mine sites, the standard effluent limit for Mn is 2.0 mg/L, however there are efforts underway in Pennsylvania to lower the limit to 0.3 mg/L. The standard treatment of Mn involves caustic chemicals that are expensive, hazardous, create non-target solids ($Mg(OH)_2$, $CaCO_3$), and can result in violation of pH effluent limits. Passive treatment of Mn, which 25 years ago was considered economically infeasible, has evolved to a reliable and cost-effective alternative to chemical treatment. This presentation will describe passive treatment of Mn using data from several systems installed at coal and metal mine sites. The removal of Mn in chemical systems is through a homogeneous oxidation reaction that has very slow kinetics at pH less than 10. In passive systems Mn is removed by a heterogenous oxidation process that occurs within the bicarbonate buffering system at pH 6.5 – 7.5. Mn^{2+} is adsorbed to a solid where it is oxidized by dissolved oxygen. The surface can be a variety of materials, but the primary sorbing-solid in passive systems is previously precipitated birnessite (MnO_2). Bacteria may also contribute to the oxidation. The typical substrate for passive Mn-removing systems is aggregate whose selection is based on the acidity of the water and local availability. Systems has been built with limestone, dolomite, and granite. The presentation will explain the requirements for the heterogenous Mn oxidation process and present results from installed passive systems at coal mines in the eastern U.S. and metal mines in Brazil, Laos, and Vietnam. The passive systems treat a range of flow rates (40 – 1,200 gpm) and influent Mn concentrations (1 – 30 mg/L). All systems lower Mn to concentrations consistent with permit or restoration targets. The results indicate that compliance with lower effluent Mn limits being considered in the U.S. is feasible with a passive treatment process.

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1. Oral paper presented at the 2022 National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12 - 16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.

2. Robert S Hedin (* presenter), Ecologist, Neil Wolfe, Senior Geoscientist, and Benjamin Hedin, Geochemist, Hedin Environmental, Pittsburgh PA 15228.

Passive Treatment of Manganese-Bearing Postmining Discharge[1]

T.P. Danehy,* D.A. Guy, C.A. Neely, C.F. Denholm, and R.M. Mahony[2]

Abstract: After reclamation of a surface coal mine in Washington County, Pennsylvania, USA a postmining pollutional discharge required treatment to meet permit effluent requirements. A passive treatment system was constructed in 2019 to replace a hydrated lime pump-and-treat active treatment system. Average[maximum] raw discharge characteristics include: 0.79[3.85] Lps (12.6[61.0] gpm), 236[350] mg/L acidity as $CaCO_3$, 14.5[20.6] mg/L total iron, 17.0[24.3] mg/L total aluminum and 34.3[42.3] mg/L manganese. Permit effluent limitations required bimonthly sampling, in which pH is to be maintained between 6.0 and 9.0, alkalinity greater than acidity, and average monthly maximum metal concentrations of 3.0 mg/L total iron, 2.0 mg/L total aluminum, 2.0 mg/L total manganese. After system startup in November 2019 all regulated parameters were treated to within compliance limits except manganese. Initial manganese removal was less than desired until five months after system startup when effluent manganese concentrations dropped from 28.6 mg/L on April 28, 2020, to 0.5 mg/L on May 23, 2020. As the weather continued to warm, manganese removal decreased prompting an organic-based treatment component to be taken offline July 8, 2020. Since August 21, 2020, the passive treatment system has produced compliant effluent with average[maximum] manganese concentrations of 0.1[0.8] mg/L. Aspects of the project to be presented include design, startup, and operational considerations along with monitoring data.

Additional Key Words: Manganese removal, Horizonal Flow Limestone Bed (HFLB), AMD treatment, acid mine drainage, coal mining, Jennings-type Vertical Flow Pond (JVFP).

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1. Oral paper presented at the National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.

2. Timothy P. Danehy, QEP (*presenter) Principal Scientist; Daniel A. Guy, P.G. Senior Geologist; Cody A. "Buck" Neely, P.E. Senior Engineer; Clifford F. Denholm, IV, Senior Environmental Scientist; Ryan M. Mahony, Environmental Scientist, BioMost, Inc., 434 Spring Street Ext., Mars, PA 16046.

3. Work reported here was conducted near 39° 59' 14.8" N; 80° 1' 59.6" W.

Treating Extreme Acid Mine Drainage with Passive Techniques[1]

S. L. Busler, T. P. Danehy*, D. A. Guy, C.A. Neely, C. F. Denholm, and R. M. Mahony[2]

Abstract: Coal refuse placement in Young Township, Indiana County, Pennsylvania, USA resulted in the most severely degraded coal-related acidic discharge intentionally being addressed with passive treatment techniques known to the authors. Average[maximum] discharge characteristics include: 63[108] L/min (16.6[28.5] gpm), 2.9 pH, 4,477[5,363] mg/L acidity as $CaCO_3$, 951[1,438] mg/L dissolved iron, 439[627] mg/L dissolved aluminum, 16[27] mg/L dissolved manganese, and 4,635[7,079] mg/L sulfate. The current passive system includes a 1,460 m^2 terraced iron formation (TIF#1), 649 tonne limestone-only automatic flushing limestone pond (AFVFP), 890 m^2 settling pond (SP), and a second 520 m^2 TIF (TIF#2). Dissolved iron removal rates in TIF#1 range from 6 to 30 g d^{-1} m^{-2} with an average of 14 g d^{-1} m^{-2}. The AFVFP-SP complex removes an average of 211 grams of acidity per day per tonne of limestone (g d^{-1} t^{-1}) with removal rates ranging from 79 to 351 g d^{-1} t^{-1}. The Neal Run treatment system does not treat the entire pollutant load and is influenced by other alkaline inputs but does affect the following concentration reductions on average: 3,105 mg/L acidity (69%), 789 mg/L dissolved iron (83%), 9 mg/L dissolved manganese (55%), and 273 mg/L dissolved aluminum (62%). Notably, the passive treatment system removes an average of 234 kg d^{-1} of acidity, 66 kg d^{-1} dissolved iron, and 19 kg d^{-1} dissolved aluminum. If a lime-based system were deployed, the expected chemical consumption would be approximately equal to four truckloads (~88 tonnes) of hydrated lime per year. The total capital cost related to the installation of the current passive system is about $200,000. The limestone in the AFVFP is washed about once every other year and the system requires essentially no other maintenance effort, resulting in a cost savings of about $25,000 annually.

Additional Key Words: Passive treatment, Terraced Iron Formation (TIF), Automatic Flushing Vertical Flow Pond (AFVFP), Acid Mine Drainage (AMD), mine drainage operation and maintenance, passive treatment cost.

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1. Oral paper presented at the National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL61821.

2. Shaun L. Busler, GISP, Senior Biologist, Timothy P. Danehy, QEP (*presenter) Principal Scientist, Daniel A. Guy, P.G. Senior Geologist, Cody A. “Buck” Neely, P.E. Senior Engineer, Clifford F. Denholm, IV, Senior Environmental Scientist, Ryan M. Mahony, Environmental Scientist, BioMost, Inc., 434 Spring Street Ext., Mars, PA 16046.

3. Work reported here was conducted near 40° 34’ 1.2” N; 79° 17’ 41.6” W.

Applied Research: Biogeochemical Response of PAG Mine Waste to Bactericides and Vegetation[1]

James Gusek* and Thomas Clark[2]

Abstract: A proposed expansion at a North American gold mine will involve the management of 350 million tonnes of potentially acid generating (PAG) mine waste that contains about 15% pyrite. Until the PAG is backfilled into existing open pits and submerged about 20 years in the future, it is projected to produce acid rock drainage (ARD). Research was conducted to minimize ARD production through the application of anti-bacterial suppressants. A suite of nine kinetic cell tests, each containing about 20 kg of PAG and varying amounts of anti-bacterial amendments (including a control), were monitored for six months. Liquid amendments included sodium lauryl sulfate, sodium thiocyanate, and dilute milk. Two of the KCTs received a layer of biotic soil media, agronomic amendments, and four site-specific species of fast-growing grass seed. As the tests were conducted indoors in the winter, the revegetated KCTs were exposed to grow lights to simulate a natural growing season situation. The biogeochemical response of the PAG-filled KCTs varied; the cells that received diluted milk behaved the best as indicated by a steadily rising pH trend and commensurate decreases in iron oxidizing bacteria, dissolved iron concentration, and sulfate concentrations. Additional observations regarding the KCT responses to vegetation will be provided in the presentation.

Additional Key Words: ARD suppression; pyrite; acid generation; biotic soil media

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2. James Gusek (* presenter) Linkan Engineering Ltd., 400 Corporate Circle, Suite H, Golden, CO 80401 (720) 590-8505 jim.gusek@linkan.biz Solfatara Laboratories LLC, Golden, CO USA.

Sorption of Metals from Mining Polluted Water Bodies and Reusability in Land Reclamation Using Hydrochar[1]

Benjamin Quardey* and Dr. Natalie Kruse[2]

Abstract: Anthropogenetic activities such as mining pose several threats to water bodies from metal and metalloids discharges such as copper, zinc, and cadmium. Hydrothermal carbonization (HTC) is a process that can be used to thermally convert agricultural feedstock biomass into a solid product called hydrochar that can sorb metals from mine polluted water bodies. The objective of this research aims to determine the applicability of hydrochar to remove target metals (Cu, Zn, and Cd), test its sorption kinetics and contact ratio, and its reusability in land reclamation with three hydrochar samples produced via HTC with the same reaction time of 30 minutes and different pyrolytic temperatures of 180 ℃, 220 ℃ and 260 ℃. A synthetic mine water solution was developed at pH 4 and pH 7 to test for the different experimental parameters. Hydrochar samples were tested for metal sorption rate with different masses of hydrochar in both the neutral and acidic synthetic mine water, in addition to the effect of reaction times. The sorption capacity of the 180 ℃ hydrochar sample showed a clear effect of sorbent mass to solution volume ratio in removal rate for pH 4 trials with effective removal seen with 5-10 g of hydrochar treating 35 mL of mine water. At pH 7, there was not a strong influence of increased mass of sorbent, suggesting that solubility and filtration had a greater influence on removal at the higher pH. The research results will seek to confirm the efficacy of hydrochar in water and land reclamation and the potential to close the loop on food-energy-water by diverting food and agricultural waste to water treatment and potentially back to the land for agriculture.

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1. Oral paper presented at the National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.

2. Benjamin Quardey (*presenter), Grad student, Dr. Natalie Kruse, Professor, Environmental Studies, Ohio University, Athens, 45701.

Evaluation of Peat Sorption Media for Metal Removal from Stormwater from a Mineral Processing Facility[1]

C.L. Kairies-Beatty, P. Eger,*, A.D. Vaslow, C. Robb, P. Jones, and D. Green[2]

Abstract: Peat has been used in passive and semi-passive systems designed to treat mine drainage, industrial storm water and other wastewater where trace metal concentrations are above regulatory limits. Peat is known for its natural ability to remove metals through multiple mechanisms, including ion-exchange, surface adsorption, and complexation but has a low hydraulic conductivity. American Peat Technology® (APT) developed a patented process whereby reed-sedge peat is converted into a hardened granular sorption media. The hardened granule maintains the natural ability of the peat to remove both suspended and dissolved metals and increases the hydraulic conductivity of the media to about 0.5 cm/sec, comparable to coarse sand. The purpose of this study was to evaluate removal of zinc (Zn), cadmium (Cd) and lead (Pb) from stormwater obtained from a mineral processing facility using peat media in a laboratory-scale up-flow column. Influent concentrations of Zn (6814 µg/L), Cd (153 µg/L) and Pb (177.1 ug/L) were initially reduced by up to 98.88%, 99.92%, and 98.93%, respectively. By the end of the run, initially high removal of Zn gradually decreased to about 50% and Pb removal remained around 99% throughout. Cd removal decreased to 78.05% by the end of the run. The column treated over 1300 bed volumes of water in a 7-day period. At the end of the run the column was divided into 4 sections and the media was analyzed. Metal concentrations in the media were highest near the inlet and decreased with distance. Maximum zinc concentration in the media approached 2%. Mass balance calculations were done on both the mass accumulated in the media and the mass removed from the influent; estimates were within 12%.[3]

Additional Key Words: zinc, cadmium, lead, ion-exchange, complexation, adsorption, mass balance.

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2. Paul Eger (* presenter), Senior Environmental Engineer, Talon Metals, Tamarack, MN; Candace L. Kairies-Beatty, Professor, C. Robb, and Alex D. Vaslow Department of Geoscience, Winona State University, Winona, MN, 55987; Peggy Jones, Vice President Sales and Research, and Doug Green, President and CEO American Peat Technology, Aitkin, MN 56431.

3. Work reported here was conducted near 44.0474° N, 91.6433° W.

Advances in the Electro-Biochemical Reactor Design for Denitrification[1]

O. Opara*, K. Sims, and B. Myers[2]

Abstract: Nitrate is ubiquitous in mining-affected waters, mainly due to the leaching of residual blasting compounds. The discharge standards for nitrogen species vary from site to site, but the regulatory limits are set in place to protect natural waterways and drinking water resources. Nitrite – an intermediary daughter product of denitrification – prevents hemoglobin from carrying oxygen, causing a condition called infant methemoglobinemia, aka the "blue baby syndrome." Unlike the physical and chemical nitrate removal methods, such as ion exchange or reverse osmosis, which concentrate the contaminants, the Electro-Biochemical Reactor (EBR) destroys nitrate, generating harmless nitrogen gas as a by-product. The direct provision of electrons via voltage potential significantly decreases nutrient requirements, minimizes excess biogrowth, and improves denitrification kinetics. This paper presents two case studies of on-site pilot-scale demonstrations of the EBR technology. The influent nitrate-N concentrations of 14.5 mg L^{-1} to 18.0 mg L^{-1} were consistently removed to below the discharge goal of 2 mg L^{-1}, with the average effluent concentrations of 0.8 mg L^{-1} and 0.3 mg L^{-1} for sites A and B. The treatment was demonstrated successfully in a one-stage bioreactor with short hydraulic retention times (8-15 minutes). The fast kinetics, low power requirements, low chemical dosing, and no concentrated brine generation have positive implications for future installations at many sites. The EBR process has been demonstrated to be best suited for the treatment of nitrate-bearing mine waters, as well as for potable water applications relying on nitrate-contaminated groundwaters.

Additional Key Words: EBR, Nitrate, Bio-treatment.

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1. Oral paper presented at the 2022 National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.

2. Ola Opara (*presenter), Senior Process Engineer, Kirsten Sims, Application Engineer, and Bryce Myers, Group Leader, WesTech Engineering LLC, 3665 South West Temple, Salt Lake City, UT 84115.

Heavy Metal Recovery using Manganese-oxidizing Microbes and Recycled Carpet Fiber[1]

Brandy D. Stewart*, Sharon E. Bone, and Cara M. Santelli[2]

Abstract: The continued use of mined metals for the development and advancement of society requires innovative and cost-effective remediation strategies that both protect the surrounding environment from harmful pollutants, and ideally, allow for recovery of valuable metals from waste streams. Microbially-mediated strategies that remove metals from aqueous waste streams via oxidation-reduction reactions and sorption show promise as eco-friendly solutions. Here we demonstrate the ability of an Mn-oxidizing fungal culture isolated from a high-salinity, mine impacted water to sequester heavy metals Mn, Co, Cu, and Ni efficiently. In addition, we examined the potential of several "sponge" materials (polypropylene, nylon, and polyethylene terephthalate) derived from recycled carpet fibers to enhance the rate and extent of metal removal by the fungus. Polypropylene promoted the greatest amount of metal sequestration as compared to both other sponge substrates and the fungal culture alone. Metal sequestration increased from 30% to 85% for Mn and 60% to 80% for Co, after 72h incubation in the presence of the polypropylene and fungus as compared to the fungal culture only. Additionally, carpet fibers supported dense biomass growth on the substrate and promoted rapid Mn(II) oxidation rates. X-ray fluorescence (XRF) imaging of the biofilm shows a complex network of fungal hyphae with Mn oxide particles and Co, Cu, and/or Ni sequestered throughout.

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2. Brandy D. Stewart (*presenter), Cara M. Santelli, Department of Earth and Environmental Sciences, University of Minnesota – Twin Cities, Minneapolis, MN 55455; Sharon E. Bone, Stanford Synchrotron Radiation Lightsource, Menlo Park, CA 94025.

Opportunities for Carbon Sequestration in Mined Materials[1]

Joel Bandstra*, Rachel Gibson, John Swenson, and Tamara Diedrich[2]

Abstract: Current and legacy mining activities have exposed large quantities of mineral surfaces to weather in reaction with rainwater and atmospheric gases. While the resulting release of contaminants is well known, geochemical reactions in mine waste also represent an opportunity for sequestering CO_2 from the atmosphere as geologically stable carbonate mineral. This process requires release of divalent cations from oxyhydroxide and/or aluminosilicate minerals and subsequent contact with CO_2 dissolved in water. Because the former process is favored by low pH conditions and the latter by high pH, the overall rate of carbon sequestration can show complex dependencies on factors such as mineral composition, water:rock ratio, and gas flux. A geochemical model accounting for these factors was calibrated on kinetic test data for calcium-rich troctolite. Results indicate kinetic coupling of cation leach rates with protons liberated via sulfide oxidation and, therefore, the existence of an optimum sulfur content for stimulating carbonation. Predictive results for carbonation potential in a variety of representative mine wastes will be presented to demonstrate the potential magnitude of CO_2 sequestration using mined materials.

Additional Key Words: Carbonation, Geochemical modeling.

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1. Oral presentation at the 2022 National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12 – 16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.

2. Joel Bandstra (* presenter), Tamara Diedrich MineraLogic, LLC. Duluth, MN 55802; Rachel Gibson, Saint Francis University, Loretto, PA 15940; John Swenson, Dept. Earth & Env. Sciences, Univ. of Minn. Duluth, Duluth, MN, 55812.

Case Study - The Gladden Acid Mine Drainage (AMD) Treatment Facility Project[1]

Eric E. Cavazza* and Thomas A. Gray[2]

Abstract: Tetra Tech, Inc., in partnership with the South Fayette Conservation Group (SFCG), designed and oversaw the construction of the Gladden Acid Mine Drainage (AMD) Treatment Facility[3] through a design-build project (in 15 months during a global pandemic) with funding provided by the Pennsylvania Department of Environmental Protection. The treatment plant, which is located 16 miles south of the Pittsburgh in South Fayette Township, Allegheny County, PA, was designed to treat 2.2 million gallons per day and remove 690 pounds per day of iron pollution from the Chartiers Creek watershed, eliminating one of the largest discharges in the watershed that accounted for over 40 percent of the stream's pollution load. The facility, which became operational in January 2021, is restoring water quality in four miles of Millers Run and three-and-one-half miles of Chartiers Creek to a trout-stocked fishery with improved recreational uses as a result. Millers Run has been on the Pennsylvania Fish and Boat Commission stocking list upstream of the discharge, and for the first time in 2022, the restored section of stream is on the PFBC schedule to be stocked. The sections of both streams that have been restored flow past Meyer and Middleton Parks and are extensively used by canoers and kayakers. The discharge, which ranges from 750 to 1,500 gallons per minute, originates from the abandoned Pittsburgh Coal Company's Montour No. 2 underground mining complex. The plant includes two pumping stations to extract the AMD from the mine pool and bring it to the surface for treatment. Treatment consists of aeration, oxidation with hydrogen peroxide and alkaline addition as needed. The iron is precipitated and settled in a clarifier. The clarified water is then routed through a polishing pond before final discharge to Millers Run. The iron sludge is collected and pumped from the clarifier via a pipeline where it is injected into a distant section of the mine for disposal. The total cost pf the project including engineering, permitting, earthwork, construction, and final grading and seeding was just over $13,000,000. The plant's annual operating cost is estimated to be $300,000 per year, and the plant is currently operated by the SFCG, the primary project partner.

Additional Key Words: Watershed Restoration, Design-Build Project.

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1. Oral paper presented at the National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Eric E. Cavazza, P.E. (*presenter), VP, Legacy Coal Reclamation, Tetra Tech, Inc., OGA Operating Unit, 400 Penn Center Boulevard, Suite 200, Monroeville, PA 15235, and Thomas A. Gray, P.E., Senior Mining Engineer, Tetra Tech, Inc., OGA Operating Unit, 661 Andersen Drive Suite 200, Pittsburgh, PA 15220.

3. Work reported here was conducted near 40° 20' 22.9" N; 80° 10' 11.9" W.

Enforcement of surface coal mine rules and regulations, case study (Wyoming, USA) [1]

Anna Krzyszowska Waitkus[2]

Abstract: According to the federal Surface Mining Coal Reclamation Act (SMCRA) and Wyoming Department of Environmental Quality (WDEQ), Land Quality Division (LQD) Coal Rules and Regulations all active surface coal mining and reclamation operations must be inspected on an irregular basis every month. All inspections must occur without prior notice. As a result of the inspection, a state inspector submits a list of maintenance, recommendation, and monitoring items as well as issuing any violations. The inspector of the WDEQ/LQD assesses mining and reclamation activities, assesses all compliance features, and verifies compliance with regulatory requirements and with permit commitments. Additionally, specific reclamation criteria and performance standards (e.g., backfilling, soil replacement, drainage construction, revegetation, etc.) for bond release purposes are verified in the field by joint inspection of the landowners, permit operator, WDEQ/LQD inspectors, and Office of Surface Mining and Reclamation Enforcement (OSMRE) representatives. For a large surface coal mine, the amount of compliance features could exceed hundreds of items changing with time. The collection and maintenance of inspection features and bond release criteria for the North Antelope Rochelle Mine was organized by developing a geodatabase for the inspection purposes. A spatial system to combine all data for compliance purposes was created using geographic information system (GIS) via ESRI ArcPad mobile computing software and a Trimble GeoExplorer Series handheld GPS. Using geospatial tools proved to be a highly effective method to reduce time needed to prepare inspection report, track all compliance features, and bond release criteria, track the bond release progress, improve the inspector's ability to assess reclamation adequacy and review mining and reclamation progress. Another tool to verify the operator's reclamation effort by the federal and state agencies is the review of the operator's annual report. The major purpose is to review the fulfillment of permit commitments, document deviations from the permit, evaluate monitoring data, and evaluate reclamation bond adequacy. The annual report provides data for each monitoring location of surface and groundwater stations, overburden and backfill quality, and progress of the permanent vegetation. On the basis of submitted information, the state agency is contemporaneously analyzing reclamation efforts and concluding if the operator follows permit commitment and state rules and regulations.

Additional Key Words: Inspections, Enforcement, GIS/GPS, Annual Reports

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2. Anna Krzyszowska Waitkus, Environmental Consulting, 80 Eagle Nest Ln., Laramie, WY 82070, enviro@wyoming.com.

Development of International (ISO) Standards for Mine Reclamation[1]

W. Lee Daniels[2]

Abstract: In 2012, the International Standards Organization (ISO) reactivated Technical Committee (TC) 82 – Mining, which deals with development of standards for many aspects of mining equipment, control processes, practices, and safety. In the USA, participation in the ISO standards process is administered by the American National Standards Institute (ANSI) which subsequently formed Technical Advisory Group (TAG) 82 to manage appropriate input and advice on new mining related standards. The activities of TAG 82 were managed contractually by the Canadian Standards Association (CSA) up to the Fall of 2021. All final votes on ISO proposals are placed by ANSI following input from the managing association(s). In 2014, a new and very broad proposal for the development of standards for mine reclamation was promoted by South Korea and accepted by TC 82. South Korea was the initial lead country (Secretariat); that role was transferred to France in 2018. All reclamation related activities are managed by TC 82 Subcommittee (SC) 7 and various working groups (WG's) were authorized over time. To date, SC-7 has functioned via three approved WG's, Mine Reclamation Terminology (WG-1; Lead - South Korea), Mine Closure and Reclamation Management Planning (WG-2; Lead - Canada), and most recently (2019), Abandoned (Legacy) Mine Management (WG-3; Lead - Australia). Other proposals for new topics such as mine water monitoring and tailings management have been or are being considered. The overall ISO standard development process requires transparency and input from interested and affected stakeholders. Proposed standards advance via consensus from participating countries along a sequential five-step review and approval process which generally takes a minimum of three years to complete. The first two standards described above (Terminology and Planning) were published in 2020 and 2021, respectively. The abandoned mine management standard is in the draft review phase. The adoption of any international reclamation standards raises issues of (a) neutrality with respect to existing national/state/local regulations, (b) applicability to highly variable and site-specific climatic/geologic/mining/socio-political conditions, and (c) avoidance of directly specifying or favoring certain technologies or commercial products. Compliance with any adopted final ISO standards is voluntary. Due to a change in TAC managing associations in the fall of 2021, the USA is no longer a full voting member, but can maintain input status on any WG's as an "observing member."

Additional Keywords: Mine Planning, Mining Terminology, Abandoned Mined Lands.

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1. Oral paper presented at the National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.

2. W. Lee Daniels (* presenter), Professor, School of Plant & Environmental Sciences, Virginia Tech, Blacksburg, VA 24061.

An Argument for Long-Term Care and Maintenance at Reclaimed Mine Sites[1]

Peter Werner[2]

Abstract: The 2020 report to Congress on Abandoned Hard Rock Mines (GAO-20-238) carries some alarming statistics on the state of abandoned mines on public lands and the potential liabilities they pose to the environment, to public health and safety, and to the American taxpayer. In short, approximately $3B dollars has been spent by federal agencies on abandoned mine work between 2008 and 2017, with annual expenditures running close to $300M. Future costs for managing our abandoned mine sites will run billions more. Granted many of these abandoned mine sites pre-date modern mining regulations when little to no reclamation was required, however, for current and future mining operations, we have the tools to prevent, or at least minimize, the financial burden from their default and abandonment. Most current federal mining regulations require a reclamation performance bond whose intent is to place the burden for reclamation on the operator. Arriving at a reasonable cost for reclamation, and more importantly any attendant long-term care and maintenance requirements, can be difficult. Responsible planning requires a shift away from an approach based on engineering time and towards one that acknowledges that many closed mine facilities may need to remain functional far into the future. With this type of exercise comes the inevitable requirement to make projections of future needs based on incomplete information. Using simple risk analysis tools, one can begin to quantify out-year care and maintenance requirements and move closer to minimizing any future financial burden. What follows is one approach for identifying, evaluating, and quantifying the costs associated with long-term care and maintenance for closed mining operations.

Additional Key Words: Landform, optimism bias, risk analysis, discounted cash flow, trust fund.

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1. Oral presentation presented at the 2022 National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12 - 16, 2022. Published by ASRS;1305 Weathervane Dr., Champaign, IL 61821.

2. Peter Werner, Mining Engineer, USDA-Forest Service, Bozeman, MT 59715.

Forest Restoration on the Exposed Sediments along the Elwha River: Assessing Riverbank Lupine's (*Lupinus rivularis*) Influence on Conifer Growth, Vegetation, and Mycorrhizal Fungi[1]

Jenise M. Bauman*, James Kardouni, Andy Labay, and Rebecca A. Bunn[2]

Abstract: Until recently, much of the Elwha River was inaccessible to anadromous fish species due to the Elwha and Glines Canyon Dams. Dam deconstruction resulted in approximately 325 hectares of formerly inundated lake beds in place of forested and riparian corridors. Revegetation has been met with varying results; fine sediments along the valley walls quickly recovered via forest succession, while coarser substrate formed novel terraces that were more difficult to revegetate. One seeded species, riverbank lupine (*Lupinus rivularis*), quickly established on the coarse textured terraces. Riverbank lupine is a pioneering species that assimilates nitrogen through nitrogen-fixing bacteria in a form that is readily available to plants. The purpose of this study was to investigate lupine's influence on conifer establishment regarding seedling growth, nitrogen acquisition, mycorrhizal colonization, and plant community composition. To test this, the growth of three-year-old restoration conifers were measured, foliar nitrogen was quantified, mycorrhizal fungi were sampled from seedling roots, and plant communities surrounding conifers were surveyed under three lupine abundances: sparse, medium, and dense. Conifers in the medium lupine cover plots were larger (height and root collar diameter; $P=0.001$) than conifers in the sparse plots. Also, conifers growing in both medium and dense cover plots had significantly greater foliar nitrogen concentrations ($P<0.001$), which correlated to distance to neighboring lupine ($P= 0.004$). Plant community composition differed among sites ($P=0.003$); higher lupine coverage resulted in lower species richness, however, excluded exotic species, which were more abundant in sparse plots. Regarding mycorrhizal fungi, conifers in dense and medium lupine plots had significantly lower root fungi than seedlings growing in the sparse plots ($P=0.03$). Greenhouse studies are currently being conducted to better understand the decrease in mycorrhizal fungi and these results will be presented during this oral presentation. These data will be synthesized into best management practices for future revegetation projects where dam removal, coupled with active revegetation, restores forest and river processes vital to salmonid habitat.

Additional Key Words: legumes, nitrogen-fixing plants, herbaceous facilitation

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2. Jenise M. Bauman (*presenter), Professor, College of the Environment, Western Washington University, Bellingham, WA, 98225, James Kardouni, Water Quality Lead, Department of Ecology, 1143 Capitol Way S, Olympia, Washington, 98504, Andy Labay, Graduate Student, Western Washington University, Bellingham, WA 98225, and Rebecca Bunn, College of the Environment, Western Washington University, Bellingham, WA, 98225.

3. Work reported here was conducted near 48° 00' 07" N; 123° 36' 00" W.

Bringing Back the Forest: Reforestation Provides Climate Mitigation Opportunities for Mining Regions of the World[1]

Christopher Barton,* Michael French, and Nardia Grant[2]

Abstract: Sequestration of carbon by forests has been identified as a tangible method for limiting the rise of CO_2 in the atmosphere and mitigating climate change. The Intergovernmental Panel on Climate Change (ICPP) recently reported that an increase of 1 billion hectares of forest on Earth could limit global warming to 1.5^0C by 2050. Where these 1 billion hectares, or approximately 1 trillion trees, will go is a tricky question. With concern about global food shortages and increased wildfires in a changing climate, forest establishment on productive agricultural lands and areas near urban centers would be discouraged. However, disturbed lands that were previously forested and marginal agricultural lands would be suitable if soils can facilitate forest growth. Since 1977, over 1.7 million acres of Appalachian forest have been destroyed by surface mining, producing significant economic, environmental, and ecological challenges. Successfully reestablishing the hardwood forest ecosystem that once dominated these areas will provide a renewable, sustainable multi-use resource that will create economic opportunities while enhancing the local and global environment. Green Forests Work (GFW) was created to restore forests on these mine impacted landscapes. Since 2009, over 300 tree planting projects/events have been held in Appalachia. Those events involved over 21,000 volunteers and resulted in the planting of nearly 4 million trees on lands impacted by the legacy of coal mining. Following GFWs approach, similar reforestation projects have been initiated on mined lands in Australia and interest is growing in other countries. Successful rehabilitation and revegetation of mine-impacted land is vital for the current and future prosperity of mining regions across the globe. A commitment to improving conditions on reclaimed mined land for the future seems like a worthwhile investment. By improving our ability to rehabilitate mined land we create new opportunities for lands that are often considered marginal, and we stand a chance of contributing significantly to the development of a sustainable future.

Additional Key Words: native plants, legacy lands, carbon sequestration, jobs.

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1. Oral paper presented at the National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.

2. Christopher Barton (*presenter), Professor, Forestry and Natural Resources, and Michael French, Director of Operations, Green Forests Work, University of Kentucky, Lexington, KY 40546; and Nardia Grant, Principal Owner, Unearthed Environmental Services, Bulimba, Queensland, Australia 4171.

Overcoming Arrested Succession and Invasive Species on Older Reclaimed Surface Mines [1]

J.A. Franklin* and M. Aldrovandi [2]

Abstract: Coal mines in the eastern USA that were reclaimed between 1977 and 2010 were commonly compacted tailings planted with non-native grasses and legumes. Natural succession on these sites is greatly delayed with limited tree and shrub establishment even after 30 years, and without efforts to mitigate compacted soils, competitive herbaceous vegetation, and browsing by wildlife, tree growth and establishment is often poor. We reduced soil compaction on 10 ha in 2015 and another 9 ha in 2017 by using a sub-soiler to loosen soils to a depth of 1.2 m. A variety of native trees and shrubs were planted on a 2.4 by 3 m spacing. To re-establish native herbaceous species, we tested two seed mixtures along with unseeded control plots in 2015. In 2017 we tested 9 fast-growing annual species for their ability to replace persistent invasive grasses. Disturbance alone reduced the dominance of herbaceous perennials: on all sites, including unseeded controls, the cover of invasive species decreased from >90% to less than 50% in the first year, and herbaceous vegetation was quickly dominated by native perennials. Planted annual species performed poorly, but many planted herbaceous perennial species established well and increased the diversity of the site. Autumn olive (*Elaeagnus umbellata*) spread quickly once control was discontinued. Hardwood establishment was slow, likely due to heavy deer browse, however on the older site, overstory species are now emerging on areas over which a dense shrub layer had established. The development of vegetation in this area is highly variable, and strongly influenced by site and micro-site factors.

Additional Key Words: reforestation, community composition, legacy mines.

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1. Oral paper presented at the 2022 National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.
2. Jennifer A. Franklin (* presenter), Professor, Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville, TN, 37996; and Matthew Aldrovandi, Area Forester, Tennessee Division of Forestry, LaFollette, TN, 37766.
3. Work reported here was conducted near 36°32’07” N; 83°51’50” W and 36°31’18” N; 83°51’40” W.

Beneficial Use of Dredge Sediment for Reclamation of Mining Sites [1]

M. M. Patelke *, S. Post, and L. M. Zanko[2]

Abstract: Between 2011 and 2019 fine grained dredge sediment from the Duluth Superior Harbor has been transported and placed on three different mining sites in northeastern Minnesota to evaluate the beneficial use of the material for revegetation. Each demonstration project is located in a different mine-related setting. Sites included use of 30,000 cubic yards (cy) on a barren tailings basin at Keewatin Taconite (2011-2012), 3,700 cy at a Hibbing Taconite gravel pit (2012-2014), and 4,500 cy on a historic waste rock stockpile (2014-2019) located at the Virginia Landfill. At each site, sediment was placed at varying thicknesses between 6 and 12 inches and in different plot configurations, then a variety of tree and/or shrub seedlings were planted. Sediment was placed at the first two tailings basin and gravel pit sites and planted without follow up evaluation until 2019. Harbor dredge sediment promotes vegetation growth on disturbed land in areas of low soil fertility. In general, a thicker sediment layer can have a positive effect on survival rates for some tree species. However, evidence of overgrowth of grasses and weeds was observed at the sites. Trees were found "buried" by thick vegetation that had caused stress, deformation, and sometimes death. This competition from other vegetation likely affected the survival and growth of tree seedlings at all three sites. Application of dredge sediment enhances re-establishment of grassy type vegetation.

Additional Key Words: revegetation, soil fertility, tree growth.

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2. Marsha Meinders Patelke (* presenter), Researcher-Geologist, Sara Post, Researcher – Geological Engineer, and Larry M. Zanko, Senior Research Fellow – Geological Engineer, Natural Resource Research Institute University of Minnesota Duluth, Duluth, MN 55811
3. Work reported here was conducted across the Mesabi Iron Range in Northeastern Minnesota, USA.

An Examination of Pipeline Site-Preparation Methods for Improving Plant Establishment [1]

Jarrett Lardy,* Tom DeSutter, Miranda Meehan, Kevin Horsager, Nathan Derby, Aaron Daigh, and James Staricka [2]

Abstract: Energy development and construction, specifically construction of natural gas pipelines, has expanded across western North Dakota within the Williston Basin (Bakken and Three Forks formations). This expansion challenges reclamation when vegetative plant establishment is limited post-installation. Limited vegetation establishment increases soil erosion, water runoff, and provides an environment with the potential to allow invasive plant species to encroach, resulting in numerous, expensive attempts of reseeding right-of-ways. This study examines three site-preparation methods near Williston, ND, and their effects on water runoff, sediment loss, and vegetation establishment under rainfall simulation during a severe drought in a semiarid climate. The treatments used in this study were wood-fiber hydromulch, land imprinting, wheat-straw crimping, the combination of hydromulch and imprinting, and bare ground (control), all on 2% and 5% slopes within the same catena. Rainfall simulations were completed in September 2020, and again in June 2021 to examine the treatments over time. Crimping straw, one the most economical options, was the only treatment which reduced runoff long-term with an equivalent depth of 0.7 cm of water, compared to 1.8 cm of water for the control. However, hydromulch and imprinting with hydromulch were the only treatments which reduced sediment load, both reducing erosion by over 58% when compared to the control. Plant establishment was not significant for any treatment, likely due to the severe drought conditions. Cover is necessary in times of drought when plants fail to establish, with straw crimping being the best option during an extended drought.

Additional Key Words: Hydromulch, Land imprinting, erosion, runoff, and rain simulation.

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2. Jarrett Lardy (* presenter), Master Student, Soil Science, North Dakota State University, Fargo, ND 58102; Thomas DeSutter, Professor, Soil Science, North Dakota State University, Fargo, ND 58102; Miranda Meehan, Assistant Professor, Animal Science, North Dakota State University, Fargo, ND 58102; Kevin Horsager, Research Specialist, Soil Science, North Dakota State University, Fargo, ND 58102; Nathan Derby, Research Specialist, Soil Science, North Dakota State University, Fargo, ND 58102; Aaron Daigh, Associate Professor, Soil Science, North Dakota State University, Fargo, ND 58102; and James Staricka, Soil Scientist, Williston Research Extension Center, Williston, ND 58801

3. Work reported here was conducted at the Williston Research Extension Center at Williston, ND, near 48°07'18.0"N, 103°44'12.3"W.

Calcium Acetate: an alternative for gypsum in improving water flow in oilfield, brine impacted soils[1]

Annalie Peterson*, Thomas DeSutter, Nathan Derby, Miranda Meehan, and Aaron Daigh[2]

Abstract: High concentrations of sodium chloride dominate oilfield produced waters (brine) of the Williston Basin (USA). When accidental spills of produced waters occur, there's an immediate need to reduce concentrations of chloride to protect surface and groundwater systems and to reduce concentrations of sodium in soil to prevent any unwanted swelling and dispersion in soil. Swelling and dispersion of soils will likely occur if sodium adsorption ratio (SAR) values are too high, and the electrical conductivity (EC) drops below a certain threshold that is required to maintain flocculation. To prevent this, a calcium amendment can be applied to replace sodium with calcium on soil exchange sites. Historically, gypsum has been the most common calcium amendment used for improving brine impacted soils. Flue gas desulfurization gypsum is available in North Dakota but is still a sparingly soluble amendment. The time required for in-situ remediation is thus controlled by the volume of water needed to exceed gypsums solubility and to flush chloride from soil. The purpose of this research is to investigate the use of calcium acetate as an amendment for brine impacted soils as compared to gypsum. Calcium acetate has a similar concentration of calcium compared to gypsum and is also over 100 times more soluble that gypsum. Additionally, we hypothesize that the acetate could serve as an available carbon source for soil microbes. This laboratory experiment will compare how varying levels of gypsum and calcium acetate can influence soil hydraulic conductivity, chemical and physical properties when mixed with oilfield brine impacted soils.

Additional Key Words: Hydraulic Conductivity, Produced Water, Sodium Adsorption Ratio, Electrical Conductivity

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2. Annalie Peterson (* presenter), Master's Student, Soil Science, North Dakota State University, Fargo, ND 58108; Thomas DeSutter, Professor, Soil Science, North Dakota State University, Fargo, ND 58108; Nathan Derby, Research Specialist, Soil Science, North Dakota State University, Fargo, ND 58108; Miranda Meehan, Assistant Professor, Animal Science, North Dakota State University, Fargo, ND 58108; and Aaron Daigh, Associate Professor, Soil Science, North Dakota State University, Fargo, ND 58108.

Vegetation Response to Surface Soil Undulation Height[1]

Gwendelyn Geidel* and Jake Niles[2]

Abstract: This case study examines and compares the variation in plant species, height and type within a reclaimed tailings pond that was subject to two different reclamation strategies; one reclaimed with the addition of limestone and organic material and then a surface undulation of furrows 0.7 m high and 1.0 m wide and the other strategy included the addition of limestone and organic material but a minimal surface undulation of approximately 0.1 m high and 0.1 m wide. During the extraction and processing of kyanite ore from the Graves Mountain mine, Lincoln County, Georgia, fine grained tailings were produced. The tailings were transported by slurry pipeline to various tailings ponds which were created by the construction of dams using on-site materials. The tailings pond in this study, referred to as the West Tailings Pond (WTP), was constructed and filled in the 1970's and early 1980's and was reclaimed in 1995-98, by surface reconfiguration and the addition of soil amendments. Approximately 75% of the 12 ha (30 ac) site was reclaimed initially with a thin soil cap. Subsequently, amendments were added but the amendments were only harrowed in 0.1 m (4 in.) and then site seeded. The 25% eastern end of the tailings pond was filled, amendments added and harrowed to create ridge and furrow undulations 0.7m by 1.0m and then seeded. Similar seed mixes were used for the entire tailings pond. Over the course of 20 years, the eastern, 25% of the tailings pond with greater undulations, succeeded quickly from grass to shrub and now has a significant tree population. The 75% of the pond with only a 0.1m undulation has not succeeded beyond low grasses and mosses. Some of this diversity is attributed to higher moisture levels measured in the greater undulations and some is attributed to wind born seed species of trees captured in the greater undulations. Comparisons will also be made to a second tailings pond (ETP) which also had surface undulations of furrows 0.7 m high and 1.0 m wide.[3]

Additional Key Words: Acid soils, reclamation, tailings

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2. Gwendelyn Geidel (* presenter), Distinguished Research Professor Emerita, School of the Earth, Ocean and Environment, University of South Carolina, Columbia, SC 29208; Jake Niles, former USC student, currently with Pancon Resources, Jefferson, SC, 29718.
3. Work reported here was conducted near 33° 44' 11" N; 82° 31' 25" W.

Mine Soil Health on 2- to 32-Year-Old Reclaimed Pasturelands[1]

Jeffrey G. Skousen,* Katie Stutler, and Eugenia M. Pena-Yewtukhiw[2]

Abstract: West Virginia has over 200,000 ha of surface mined land. Many mine sites were reclaimed with salvaged topsoil to depths of 15-30 cm to aid revegetation, but many are rocky and contain low organic matter and plant-available nutrients. Mine soil health is presumed to improve with time since reclamation. Objectives of this study were to determine soil health indicators and to compare two methods (NRCS Soil Quality Test Kit measurements vs standard laboratory/field methods) on mine soils of different ages since reclamation. Four northern West Virginia mine soils with topsoil and reclaimed to pasture (2, 11, 16 and 32 years since reclamation) were selected and soil samples were taken to determine soil health indicators. The results confirmed that soil health improved with time on these mine soils. Using standard tests, bulk density (BD) decreased from 1.53 to 1.37 Mg m^{-3} over 30 years, wet aggregate stability (WA) increased from 5.7 to 6.1 mean weight diameter, saturated hydraulic conductivity (Ks) improved from 0.073 to 0.175 cm min^{-1}, pH went from 6.1 to 7.3, electrical conductivity (EC) increased from 0.20 to 0.44 dS m^{-1}, and soil respiration (RESP) increased from 25 to 78 kg CO_2-C ha^{-1} day^{-1}. Most measurements between the two methods were similar: pH (NRCS: 6.4; Standard: 6.4), Ks (0.117 vs 0.114 cm min^{-1}), and RESP (45 vs 57 kg CO_2-C ha^{-1} day^{-1}). This study indicated that mine soil health improves with time since reclamation and that soil health indicators can be evaluated with the NRCS Soil Quality Test Kit.[3]

Additional Key Words: aggregate stability, bulk density, electrical conductivity, hydraulic conductivity, microbial respiration, mine soil genesis, pH.

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2. Jeff Skousen (* presenter), Professor of Soil Science; Katie Stutler, MS Student; Eugenia Pena-Yewtukhiw, Associate Professor of Soil Science, West Virginia University, Morgantown, WV 26506.

3. Work reported here was conducted near 39º38’37.46” N; 80º02’12.56” W.

Superfund Remediation at Tar Creek [1]

S.R. King*[2]

Abstract: Highlight work conducted by the Quapaw Nation on superfund remediation work ongoing at the Tar Creek Superfund Site in Northeast Oklahoma, including project successes and failures. Restoration tools at remediation projects expands with every project completed, and now includes use of new technologies at the site to save clean soils, native vegetation, composting for soil reclamation, and future watershed revegetation.

Additional Key Words: NA

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2. Summer R King (* presenter), M.S., CC-P™, Environmental Scientist, Quapaw Nation, Quapaw OK 74363.
3. Work reported here was conducted near 36.99026, -94.87152.

Forest Soil Response Three-Years after Aerial Liming Application in West Virginia[1]

Jeff Skousen,* Loren Gormley, and Stephanie Connolly[2]

Abstract: Soil acidity in forests across the globe has increased due to anthropogenic acid deposition, which is leading to a decline in forest health. The soils in the Monongahela National Forest (MNF) in West Virginia are acidic due to leaching of base cations, uptake of Ca and Mg by vegetation, and release of organic acids by organic matter (OM) decomposition, and acid deposition has exacerbated the acid soil conditions.[3] In anticipation of a large liming project, soils at 10 sites were sampled and analyzed in 2009 by the United States Forest Service (USFS). In 2018, lime was applied by helicopter to a total of 323 ha in the MNF near Richwood, WV. Liming material particle size varied from silt to chip size and the liming rate was 10 Mg ha^{-1}. One year after liming, the same 10 sites sampled in 2009 representing five limed and five unlimed areas were resampled in 2019 using the same procedures and analyzed. The objectives were to determine whether soils had changed in acidity between 2009 and 2019, and to evaluate changes in soils due to liming in 2019 for pH, acidity, and aluminum (Al) and calcium (Ca) concentrations. Unlimed sites sampled in 2019 showed slightly higher pH in O, A, and upper B horizons compared to 2009, suggesting that soils had changed only slightly in the 10-year interval. Liming increased soil pH in O horizons from 4.6 to 5.9. Liming reduced acidity values by 73% and Al concentrations by 80% in O horizons. Liming increased Ca concentrations by at least three times in O and A horizons. Based on these first-year results, liming had a significant effect on soil properties of O and A horizons. A second resampling of these 10 sites was completed in the summer of 2021, three-years after liming, which followed the same procedures done in the past. Samples were collected and sent to the University of Maine for analysis. The new data will show whether the liming effects documented after the first year have continued to the third year.

Additional Key Words: acid deposition, aluminum, acidity, calcium, pH.

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2. Jeff Skousen, (*presenter), Professor of Soil Science, and Loren Gormley MS Student, West Virginia University, Morgantown, WV 26506; Stephanie Connolly, Forest Soil Scientist, US Forest Service, Elkins, WV. 26241.

3. Work reported here was conducted near 38º22’37” N; 80º27’56” W.

Scram Tailings Mineland Reclamation 3-year Case Study and Recommendations[1]

A. Kramer*, J. Asp, and N. White [2]

Abstract: Minnesota's robust reclamation standards have proven results in the taconite mining industry. Reclamation of overburden spoils, lean ore spoils and fine tailings from taconite production has generally been successful on the Iron Range, using a low input standard reclamation practice. However, new breakthroughs in iron ore scram mining technologies are producing fine and coarse tailings that have not been encountered nor reclaimed in northern Minnesota.[3] This presentation is the culmination of three years of innovative research to investigate potential successful reclamation strategies for scram mining tailings in Minnesota. This presentation will focus on the results of the 3-year study (2016-2018) by briefly summarizing Phase I (Year 1 research proposal and bench scale results), subsequent Phase II (design and Year 2 field trial results), and finally the Phase III (Year 3 results and reclamation recommendations). The research program will also describe collaboration between private industry and a public agency to provide research funding support. This paper should align with Technical Sessions Revegetation, Soils and Overburden, and/or Refuse and Tailings.

Additional Key Words: native vegetation, soil, ecological restoration, mine closure, Chisholm, Minnesota.

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2. Allyz Kramer (* presenter), Sr. Biologist, Principal, Joel Asp, Sr. Ecologist, and Natalie White, Sr. Biologist, Associate, Short Elliott Hendrickson Inc., 418 W. Superior Street, Suite 200, Duluth, Minnesota 55802.

3. Work reported here was conducted near 47° 28' 07.5" N; 92° 50' 23.5" W.

Short and Long-Term Groundwater Impacts Associated with the Reclamation of Acid-Water Seeping Historical Tailings in the Central and West Rand Basins, South Africa[1]

R.A. Gebrekristos* and G. Trusler[2]

Abstract: Gold mining has been ongoing in the Eastern, Central and Western Rand Basin of South Africa since the 1880s. The region was the largest gold producer in the world for many years until the 1980s after which large scale mining started to decrease. This has generated many tailings storage facilities (TSFs) in the region with estimated 3 - 4 billion tons of tailings. Most of the TSFs are acid-generating owing to their high sulfide content combined with limited neutralization potential. The TSFs are almost all unlined and have contaminated the nearby shallow aquifers (e.g., sulfate up to 3500 mg/L), deeper aquifers where they overly workings or dolomites and surface streams where surface erosion continues. The old tailings often contain gold and uranium with economic value. There are a number of companies reclaiming and reprocessing these surface deposits. These reprocessed tailings are deposited on a combination of large new facilities, back onto old TSF footprints or in pits and underground. The interconnections between old working areas are not easy to determine neither is the ability of the tailings to flow underground. In addition to economic contributions, the remining and removal of the unlined TSFs from surface has positive impact on the groundwater environment as the sources of contamination are removed. This contribution is only net positive if the impacts from where the tailings are deposited are understood and better than where they were before. Filling underground voids with tailings minimizes the available space for oxidation reactions and acid generation and should improve geotechnical stability. The tailings have a high pH (10-11), and this increases the pH and alkalinity of the mine void water in one case from a pH of about 2.8 in 2013 to 6.5 in 2021. This has a knock-on effect on reducing the total dissolved solids (TDS) as many of the metals have precipitated from the mine water (e.g., Fe decreased from 520 mg/L to 0.01 mg/L during the same period). This paper looks at the net benefit to be gained from reclaiming and depositing tailings into old mine voids.

Additional Key Words: groundwater, aquifer contamination, AMD, TSF.

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2. Robel Gebrekristos (*presenter), PhD, Hydrogeologist at Digby Wells Environmental and Graham Trusler, Chemical Engineer and CEO at Digby Wells Environmental. Turnberry Office Park, Digby Wells House, 48 Grosvenor Street, Bryanston, South Africa.

Effect of Forestry Reclamation Approach Practices on Soil Water Chemistry[1]

A. Hass,* J.G. Skousen, and R. Cantrell[2]

Abstract: Proper reclamation of surface mined lands is essential for restoration of ecosystem services. Reclamation practices, especially those in mountainous / steep-terrain areas, tend to incorporate spoils of different weathering stages (e.g., saprolite, blast-rock fragments), mixed at different proportions with and without soil as topsoil-replacement material. This is likely to greatly alter soil properties as compared to the pre-existing native soils (e.g., organic matter, pH, free iron/manganese oxides, etc.), and which affect soil biogeochemical processes. In this presentation we emphasize the role of redox as a process that promotes dissolution and release of constituents in reclaimed mine sites. Sites[3] reclaimed using sandstone spoils of different weathering stages, placed at different compaction efforts, were instrumented with water sampling devices 12 years after reclamation. Water samples were collected weekly during the 3-year study and analyzed for total metals concentrations, ionic composition, total alkalinity, and dissolved organic carbon, in addition to *in-situ* measurement of dissolved oxygen, pH, temperature, total dissolved solids (TDS), and redox potential. On average, solution attributes were similar to that of stream water from non-disturbed watersheds and did not exceed regulatory thresholds values (e.g., TDS < 300 $\mu S\ cm^{-1}$). Yet, wide within-season fluctuation was observed, resulting in many (statistical) 'outliers.' For example, TDS fluctuated during the 2017 growing season in non-compacted brown mine soils as much as an order of magnitude, from 178 to 1,762 $\mu S\ cm^{-1}$, which was associated with corresponding increases in pH (5.47 to 6.73). Both pH and TDS were inversely correlated with changes in Eh (from 363 down to 67 mV, respectively). The TDS values exceeding the regulatory thresholds were mostly associated with low Eh and circumneutral pH values, pointing to the role of redox in promoting dissolution (rather than acid dissolution). The high variability in the data likely pointed to a limited ability of the soil to buffer changes in moisture, pH, and redox potential. The results are discussed in the context of current FRA practices and of expected future trends as soil development continues.[3]

Additional Key Words: redox-potential, spoil, TDS, buffer capacity.

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2. Amir Hass, (*presenter), Associate Research Professor, Agricultural and Environmental Research Station & Biology Department, West Virginia State University, Institute, WV 25112; Jeffery G. Skousen, Professor, Division of Plant and Soil Sciences, West Virginia University, Morgantown, WV 26506; and Robert Cantrell, Soil, Water and Natural Resources Lab manager, Agricultural and Environmental Research Station, West Virginia State University, Institute, WV 25112.

3. Work reported here was conducted near 38° 02' 42" N; 81° 30' 30" W.

Field Testing of Geomorphic Landform Design Features in Central Appalachia[1]

Iuri Lira Santos*, Leslie C. Hopkinson, John D. Quaranta, Levi Cyphers, and Paul Ziemkiewicz[2]

Abstract. Restoration of abandoned mine lands from bond forfeited mining permits and pre-law sites is on-going in Appalachia and across the United States. One potential reclamation technique to reclaim these areas is geomorphic landforming that attempts to approximate the long-term, steady state landform condition. The objectives of the research described herein were to design, implement, and monitor a pilot test design of the geomorphic landform with a cap and cover system at a coal refuse site in Greenbrier County, West Virginia. Both constructability and performance were considered. First, a 1133-m^2 field site was designed to demonstrate and test geomorphic reclamation features. The field site was composed of three test plots (60% refuse with 40% paper fiber, 80% refuse with 20% paper fiber, 100% refuse) that centrally drained into a geomorphic channel. A hydraulic barrier composed of compacted refuse and slopes up to 2H:1V were included. Ground cover, infiltration of vegetation layer and hydraulic barrier, compaction, water quality, and surface temperature were monitored. Infiltration rates of the hydraulic barrier were 9.7%-20.6% less than the refuse before disturbance despite being lower than the required compaction density. Vegetation was reseeded to meet ground cover greater than 30%. Surface temperature varied 11°C across the plots, affecting grass germination. Mixing the paper fiber with the refuse prior to placement resulted in the most reliably mixed growth layer. Lessons learned from this pilot study will be used to inform geomorphic reclamation at a larger scale.[3]

Additional Key Words: Cap and cover system, water balance cover, abandoned mine land, short paper fiber

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2. Iuri Lira Santos (* presenter), Ph.D. Candidate; Leslie C. Hopkinson, Associate Professor; John D. Quaranta, Associate Professor; and Levi Cyphers, Graduate Research Assistant, Civil and Environmental Engineering; West Virginia University, Morgantown, WV 26506; and Paul F. Ziemkiewicz, Director of the West Virginia Water Research Institute, West Virginia University, Morgantown, WV 26506.

3. Work reported here was done near 38°00'50.4"N 80°36'05.2"W.

Designing a Meaningful Baseline for Reclamation Monitoring[1]

Kevin Krogstad[2]

Abstract: Monitoring for mining-related impacts to the environment means looking for change. In order to identify a change, we must establish a baseline. The problem is, baselines are not always consistent. Natural conditions vary, and over the life of a mine the natural variation can be significant. Baseline data must, above all, be representative of the undisturbed condition of the target area. Undisturbed does not mean static. In order to fully represent the undisturbed condition, baseline data must include the range of natural variation and any regional trends unrelated to mining disturbance. Particularly when comparison to a baseline determines acceptability for bond release or violation of a rule, it is critical to understand the nature of the entire baseline dataset. New challenges appear from time to time. When baseline data is being collected before a mine is open, every effort is made to address all reasonable issues. Standards change, practices change, conditions change, and we may need to adapt to meet unforeseen problems. In reclamation, baseline is our goal, but if it keeps moving it can be challenging to meet it.

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1. Oral paper presented at the National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.

2. Kevin Krogstad, Hydrologist, Montana Department of Environmental Quality, Helena, MT.

Teaching Reclamation to Non-Majors: Experiences from Silviculture and Honors Natural Science Courses[1]

B. D. Pinno and K. L. Sena[2]

Abstract: Many courses in reclamation and restoration are part of relevant major curricula—students enrolling in the course primarily do so to fulfill major or minor requirements and typically have already fulfilled a set of prerequisites. In contrast, teaching reclamation to non-major students lacks the prior knowledge of pre-requisite courses but presents opportunity to expose curious students to new ways of thinking, new problems, and new sectors of knowledge. In this presentation, Brad Pinno will share about teaching his Silviculture course to non-majors, and Kenton Sena will share about incorporating reclamation in his Honors courses in natural sciences. Pinno's Silviculture course engages students from both Forestry and Land Reclamation programs; he uses group discussions and projects, as well as field-based activities, to cultivate a successful learning experience for his diverse students. Conversely, Sena's Restoration Ecology course engages students from mostly non-science majors and may be the only science course some students take in their careers. Sena uses interdisciplinary and participatory pedagogy to invite students to leverage their particular backgrounds and interests in their exploration and discussion of the course content, and grounds these conversations in field-based service and research experiences. Overall, we hope to show that real-world reclamation can be leveraged for high-impact pedagogical practices, serving interdisciplinary students from diverse majors and with diverse levels of prior knowledge.

Additional Keywords: Pedagogy; High-impact teaching; Interdisciplinary; Restoration Ecology; Natural History; Environmental Literature

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2. Brad Pinno, Assistant Professor of Silviculture, Department of Renewable Resources, University of Alberta. Edmonton, Alberta, Canada. T6G 2E3; Kenton L. Sena, Lecturer, Lewis Honors College, University of Kentucky, Lexington, KY 40526.

Using Experiential Learning in an Upper-level Forestry Class to Teach Reclamation Techniques[1]

J.A. Franklin[2]

Abstract: Students majoring in Forestry at the University of Tennessee choose one of four concentrations, one of which is Restoration and Conservation Science. The curriculum includes core forestry courses, hydrology, and three courses central to the concentration: Conservation, Ecological Restoration, and FWF 324: Applied Ecosystem Restoration. Third- and fourth-year forestry students make up around 70% of the class in FWF 324, with the remainder from related majors including Wildlife and Fisheries Science, and Environmental and Soil Sciences, and generally have a good set of basic skills and knowledge. Hands-on learning gives them an opportunity to practice and improve their skills, aids knowledge retention, and connects the classroom with real-world application. Over the course of 15 weeks, students learn some common techniques used in reclamation through monitoring an on-campus site where restoration was initiated by past classes, and through the development of a restoration plan for a small adjacent area. Because the impact of past classes on the site is substantial and easy to discern, and the site is on campus and in a location that has high public visibility, most students feel a sense of ownership and put substantial effort into this class work. Over the past 6 years, a number of monitoring techniques have been tested and evaluated for the time and equipment required, and accuracy of resulting data. Several monitoring techniques with which a class can produce reasonably reliable data with minimal supervision will be presented.

Additional Key Words: pedagogy, revegetation, monitoring, field laboratory.

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2. Jennifer A. Franklin, Professor, Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville, TN, 37996.
3. Work reported here was conducted near 35°56’58.10” N; 83°56’27.82” W.

"Reclamation of Disturbed Soils" - A West Virginia University Senior-level Course[1]

Jeff Skousen[2]

Abstract: A Reclamation course has been taught at West Virginia University since 1975. Richard M. Smith first taught the class from 1975 to 1978, and then John Sencindiver took over from 1978 to 1985. Jeff Skousen has taught the class since 1986. Student enrollment varies from 40 to 60, and student majors include plant and soil sciences, natural resources, forestry, wildlife, geology, biology, and mining and civil engineering. The course is lecture-based and course topics include mining and reclamation history, coal resources and mining regions, underground and surface mining methods, pre-mine planning and permitting, assessing land disturbance impacts, evaluating soil and overburden properties using Acid-Base Accounting, handling and placing geologic materials, replacing soils, revegetating disturbed areas, evaluating water quality and hydrologic properties, controlling and treating acid mine drainage, and developing productive post-disturbance land uses after reclamation. Eighteen problems are assigned which require the students to calculate such things as coal tonnage, drilling and blasting costs, overburden volumes and moving costs, hydrologic measurements, acid mine drainage, Acid-Base Accounting, overburden handling and placement plans, application of lime and alkaline waste materials to mine soils, revegetation species and seeding rates, USLE, and design and costs of active and passive treatment of acid mine drainage. Two, one-day field trips to an active surface mine and to an acid mine drainage treatment facility are required.

Keywords: Academic teaching, Calculations, Coal mining, Problem solving, Reclamation technologies.

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2. Jeff Skousen, Professor of Soil Science, West Virginia University, Morgantown, WV 26506, jskousen@wvu.edu.

Teaching Reclamation through Applied Curricular and Co-Curricular Experiences[1]

N.A. Kruse Daniels[2]

Abstract: Students in Environmental Studies and related departments at Ohio University have several opportunities for applied learning in reclamation. While in-class learning is a key tool in developing reclamation professionals, hands-on application allows those students to truly retain the information and gain those skills. Three key examples of these applied student experiences are good models for using applied learning experiences in curricular and co-curricular settings: in-class applied projects, undergraduate or graduate thesis or independent research, and client-based projects. In courses Field Methods in Environmental Studies and Watershed Management, students must complete real-world final projects creating sampling plans, collecting data, and developing management plans for real projects, real problems, and real watersheds. Where possible, students are connected with community organizations that manage the watershed or treatment project. During both the undergraduate and graduate Environmental Studies degrees, these are an option for culminating experience. By designing thesis projects in partnership with faculty engaged in reclamation projects and staff members who maintain and sample those projects, students are able to connect their research questions and methods to problems that need to be solved. Students in the Master of Science in Environmental Studies have the option of completing a practicum rather than a thesis in which they conduct a professional project for a client based on client needs. Practicum students have frequently worked with local watershed groups to develop projects, conduct reconnaissance, prioritize project sites, and write watershed planning documents. One student collected the data to develop a project, wrote the Ohio EPA approved watershed planning document for the project, and wrote a grant with multiple partners to get the project completed. These examples of using applied learning in multiple ways are only a sampling of methods we can use to train future reclamationists.

Additional Key Words: student learning, community engagement, project-based learning

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1. Oral paper presented at the 2022 National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.

2. Dr. Natalie A. Kruse Daniels, Professor, Environmental Studies Program, Voinovich School of Leadership and Public Service, Ohio University, Athens, Ohio 45701.

Eighteen Years of Natural Infrastructure Research Partnerships through the Center for Restoration of Ecosystems and Watersheds at the University of Oklahoma[1]

Robert W. Nairn*, Julie A. LaBar, Nicholas L. Shepherd, Dayton M. Dorman, Juan Arango, Brandon K. Holzbauer-Schweitzer, Zepei Tang, and Robert C. Knox[2]

Abstract: The University of Oklahoma (OU) Center for Restoration of Ecosystems and Watersheds (CREW)[3] grew organically from ongoing research efforts in the School of Civil Engineering and Environmental Science (CEES) in 2004. From the start, mined land and water reclamation dominated CREW's research portfolio, with a concentration on watershed biogeochemistry and ecological engineering. In the context of reclamation and restoration, CREW has evolved to emphasize natural infrastructure and ecosystem services through conservation of natural systems and creation and restoration of human-made systems. Over 70 graduate research assistants, 80 undergraduate researchers, and several faculty, staff, post-doctoral fellows, and visiting scholars have supported CREW research. The CREW approach is holistic and multidisciplinary, using an understanding of watershed and ecosystem biogeochemistry to develop sustainable nature-based solutions to complex environmental challenges. Work is conducted on the watershed- and ecosystem-scale, examining environmental impacts and developing remediation and restoration technologies based on ecological engineering techniques. CREW is a field-oriented research team but provides ample opportunities to couple full-scale applications with replicable laboratory and greenhouse microcosm and/or mesocosm experimentation. CREW research is inherently and unavoidably collaborative; partnerships with multiple state agencies (especially the Oklahoma Department of Environmental Quality), tribal nations, municipalities, non-profit organizations, and university collaborators are critical to success. CREW recently began a second ten-year research agreement with the Grand River Dam Authority (spanning 2009-2029), has long-term (>20 years) collaborations with the Quapaw Nation of Oklahoma and Local Environmental Action Demanded (a non-profit organization) and works closely with several university entities. Five water quality research case studies will be briefly described: an urban stormwater low impact development paired watershed project; an examination of the role of an environmental buffer in indirect potable reuse; several full-scale passive treatment system implementations for ecotoxic metal-contaminated mine waters; a challenging irrigation water treatment project in the developing world; and possibilities for large-scale Engineering With Nature applications (a current U.S. Army Corps of Engineers initiative). Given the inescapable global significance of water quality, quantity, security, availability and supply, CREW's local watershed-scale efforts will be presented in a comprehensive context and global linkages will be demonstrated.

Additional key words: Reclamation science, Engineering with Nature, nature-based solutions, academic programs, student success.

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2. R.W. Nairn and R.C. Knox, Professors; N.L. Shepherd, D.M. Dorman, Graduate Research Assistants, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019; J. Arango, City of New York City, NY; B.K. Holzbauer-Schweitzer, Linkan Engineering, Golden CO, Z. Tang, North Carolina A&T State University, Greensboro, NC and J.A. LaBar, Centenary University, Hackettstown, NJ.

3. Work reported here was conducted throughout North and South America but managed near 35°12'39" N, 97°26' 32" W.

Translating International Experience to Graduate School[1]

Apsana Kafle[2]

Abstract: Globalization has made movement so accessible with young professionals relocating for career upliftment more than ever. Therefore, a part of professional development skills for early professionals should include preparing for working and translating experience in a different context. I am currently an International Graduate student in Canada with past working experience across different countries and continents, which has given me a different perspective on environmental and social issues than many of my peers. I will highlight the importance of bringing diverse opinions and ideas in a broad discipline like environmental studies and looking at a problem through multiple lenses. Secondly, I will outline how different experiences have helped me upgrade my personal skills like adaptability, communication, and confidence. Finally, I will conclude with tips and ideas for young professionals who are considering working in a new environment.

Additional Key Words: professional development, career upliftment, young professionals.

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2. Apsana Kafle, Graduate Student, Department of Renewable Resources, University of Alberta, Edmonton, Alberta, Canada T6G 2E3.

My Experience as a MSC Candidate Studying Reclamation[1]

K. Trudel[2]

Abstract: As graduate students our goals, expectations, and backgrounds coming into a Master's degree are different. At the start of our program, we believe our project will define our career when in actuality our project provides us with a unique skillset that is applicable across many academic and professional fields. The opportunities afforded to us to be able to communicate openly within our lab, work with outside organizations and grow as individuals is invaluable to young professionals. The opportunity to have open communication with your supervisor and lab group can help you with the processes for dealing with the challenges of entering a graduate program in various areas of school and life. Graduate school presents many challenges including, but not limited to, working in project management, remote locations, field work, online learning, data interpretation and working within a growing lab. I will present on my experience as an MSc candidate at the University of Alberta and my approach for overcoming these challenges and the rewards of doing so.

Additional keywords: Graduate Student, Mining, Experiential Learning.

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2. Keana Trudel, MSC Student, Silviculture Research Group, University of Alberta, Edmonton, AB T6G 2R3.

Assessing Fate and Potential Reuse Hard Rock Mine Drainage Passive Treatment Residual Solids[1]

J.I. McCann* and R.W. Nairn[2]

ABSTRACT: Ecologically engineered mine drainage passive treatment systems rely on a series of biogeochemical reactions to decrease concentrations of ecotoxic trace metals and have proven to be an effective way to improve water quality in watersheds impacted by mining, especially in areas where access or funding is limited. Passive treatment systems require minimal regular maintenance, but occasional rehabilitative maintenance is necessary to ensure continued efficacy of the systems. These efforts include addressing residual solids by removal of iron oxyhydroxides from oxidation ponds and replacing of spent organic material from vertical flow bioreactors to restore optimal hydraulic and biogeochemical performance. In this study, iron oxyhydroxides and organic materials from two passive treatment systems located in the Tar Creek Superfund Site in the Tri-State Lead-Zinc Mining District[3] were examined for total and leachable trace metals concentrations. The USEPA's toxicity characteristic leaching procedure (TCLP) and synthetic precipitation leaching procedure (SPLP), as well as the USGS's field leach test (FLT), were performed to evaluate the leachability of arsenic, cadmium, lead, manganese, nickel, zinc, and other trace metals from the residual solids. The total metal concentrations of the iron oxyhydroxides and organic matter exceeded some consensus-based toxicity benchmarks for soil and sediment. The leachate produced from TCLP tests did not exceed Resource Conservation and Recovery Act limits for any of the contaminants of concern, but SPLP and FLT leachates did exceed some guidelines from the Oklahoma Water Resources Board. Although it is not necessary to dispose of the mine drainage residual solids examined in this study in a hazardous waste repository, further research is necessary to determine the feasibility of reuse of the solids in subaqueous or subaerial environments.

Additional Key Words: TCLP, SPLP, FLT, biochar, biosolids, coal combustion residuals.

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2. Justine I. McCann (*presenter), PhD student, and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019.

3. Work conducted near 36° 55' 20.4" N; 94° 52' 24.4" W.

Determination and Prediction of Rare Earth Element Geochemical Associations in Acid Mine Drainage Treatment Wastes[1]

Benjamin C. Hedin*, Charles A. Cravotta III, Mengling Y. Stuckman, Christina L. Lopano, Rosemary C. Capo, Robert S. Hedin[2]

Abstract: Acid mine drainage (AMD) has been proposed as a novel source of rare earth elements (REE), a group of elements that include critical metals for clean energy and modern technologies. REE tend to be sequestered in the Fe-Al-Mn-rich solids produced during the treatment of AMD. These solids are typically managed as waste, but could be a low-cost, readily available REE source. Here, results from field sampling, solids characterization, and geochemical modeling are presented to identify the mechanism(s) of REE attenuation and determine the minerals/solid phases in AMD solids that are enriched in REE. This study reveals that solids produced from low-pH AMD treated by limestone or NaOH contain elevated concentrations of REE with Al, Fe, and/or Mn. AMD solid characterization via sequential extraction and synchrotron microprobe both demonstrate that REEs are mainly associated with Al/Mn phases and only selected REEs (Gd, Dy) are associated with Fe phases, despite the chemical diversity of AMD solids. Additionally, sequential extractions demonstrate that acidic and/or reducing extractions are required to mobilize the REE. Finally, the "CausticTitrationREYs.exe" geochemical equilibrium model developed in this study indicates that the observed dissolved REE attenuation can be explained via surface complexation on Fe, Al, and Mn oxides/hydroxides. The model accurately predicts the pH dependent removal of dissolved REE, and that Al and Mn oxides/hydroxides are largely responsible for dissolved REE removal, consistent with the characterization results. The results presented here can be used to identify conditions favorable for accumulation of REE-enriched AMD solids and possible chemical treatment(s) to mobilize REE. The geochemical model can be applied to active and/or passive AMD treatment systems to predict REE attenuation with Fe, Al, and Mn during treatment and what phases may be enriched in REE. This information can be used to engineer AMD systems to produce specific phases enriched in REE.

Additional Key Words: REE, AMD, geochemical modeling

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2. Benjamin C. Hedin (* presenter), and Robert S. Hedin, Hedin Environmental, Inc., 195 Castle Shannon Blvd., Pittsburgh, PA, 15228; Charles A. Cravotta III, US Geological Survey, 215 Limekiln Rd, New Cumberland, PA 17070; Mengling Y. Stuckman and Christina L. Lopano, National Energy Technology Laboratory, U.S. Department of Energy, 626 Cochrans Mill Rd, Pittsburgh, PA 15263; Rosemary C. Capo, Department of Geology and Environmental Science, University of Pittsburgh, Pittsburgh, PA, 15260; Corresponding author, ben.hedin@hedinenv.com.

Using "Big Science" to Evaluate Metal Removal[1]

Brandy Stewart*, Paul Eger, Brandy Toner, and Cody Sheik[2]

Abstract: X-Ray Absorption Spectroscopy (XAS) is a powerful tool to examine the oxidation state and chemical form of metals removed during treatment that offers an alternative to the time consuming and often less definitive sequential extraction methods traditionally used. Peat media that had been effectively removing chromium, cadmium and zinc from stormwater was analyzed to identify the form of the attenuated chromium. Based on the chemistry of the input water, much of the chromium appeared to be present as a fine particulate. The peat media has a size distribution similar to coarse sand which typically can filter particles 10 – 20 microns in size but is not expected to remove the fine chromium particles. The media has also removed similar fine particulate copper and aluminum from mine water. The removal of fine particulate chromium and the lack of any chromium release in a standard TCLP test suggest that the mechanism might involve some type of chemical bonding or microbial removal as opposed to filtration alone. Understanding the specific removal mechanisms will help to predict how effective the media may be with retaining other metals from various mine wastewater streams. In 2018 samples of the media were collected to help identify the specific retention mechanisms. DNA was extracted from solid peat samples and incubations containing hexavalent chromium and spent peat media were setup in both aerobic and anaerobic conditions. Samples were analyzed with X-ray fluorescence mapping and X-ray Absorption Spectroscopy to identify the location of chromium relative to peat particles and form of the removed metals. Preliminary data show that microbial reactions do not appear to play a major role in chromium removal and that the removed chromium is associated with the media and is present primarily as a chromium organic complex and as chromium hydroxide.[3]

Additional Key Words: chromium, x-ray absorption spectroscopy, peat sorption media, X-ray fluorescence mapping.

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2. Brandy Stewart (* presenter), Post Doc, University of Minnesota, Department of Soil, Water & Climate University of Minnesota - Twin Cities, MN 55455; Paul Eger, Senior Environmental Engineer, Talon Metals, Tamarack MN 557876; Brandy Toner, Professor, Department of Soil, Water, & Climate, University of Minnesota - Twin Cities, MN 55455; and Cody Shiek, Assistant Professor, Department of Biology, Large Lakes Observatory, University of Minnesota Duluth, Duluth, MN 55812.

3. Work reported here was conducted near 42° 36' 11.03" N; 83° 155' 57" W.

Reducing Seed Dormancy in Southern-Adapted Native Forage Grasses[1]

Brian Baldwin,* J. Brett Rushing, and Jesse I. Morrison[2]

Abstract: When Europeans arrived in North America they brought grazing animals, hay, and seed of familiar Old-World forages. Prior to arriving in North America, that germplasm had already undergone years of selection to tolerate close continuous grazing and rapid germination. This research focused on North American native grass species. These species have shown promise for use as forage, pasture, wildlife habitat and in land reclamation projects as well as biofuels. Most of these species are cross pollinated. As such, these native grass populations have large amounts of innate genetic variability that allows continued selection and improvement. Native warm-season perennial grasses are notoriously slow to establish, making the seedlings poor competitors with weeds, especially weedy grasses. An important obstacle to the cultivation of these grasses is seed dormancy. Large percentages of seed often fail to germinate or emerge when planted. Seed dormancy is present in all perennial native grass species and can provide a selective advantage under varying, unpredictable environmental conditions, but it is a strong disadvantage in a situation where quick establishment and cover are desirable. The objective of this project is to use recurrent phenotypic selection to reduce seed dormancy in these native grass species. Reducing the seed dormancy period will allow these grasses to respond quickly to planting, enhancing their role in forage production, conservation, habitat establishment, and as a source of biomass for alternative fuels while reducing cost of establishment. Seven species are currently undergoing seed increase in preparation for marketing.

Additional Key Words: genetic variation, reclamation, recurrent phenotypic selection.

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2. Brian Baldwin (*presenter), Professor, Plant & Soil Sciences, Mississippi State University, MS 39762, J. Brett Rushing Associate Professor, Coastal Plain Branch Expt. Station. Newton MS 39532, Jesse I. Morrison, Assistant Research Professor, Plant & Soil Sciences, Mississippi State, MS 39762.

3. Work reported here was conducted near 33.4504° N, 88.8184° W.

Development of Locally Adapted Native Germplasms for Commercial Use[1]

Anthony D. Falk* and Keith A. Pawelek[2]

Abstract: Successful reclamation or native restoration of large-scale projects is dependent on large-scale commercial seed availability; however, not all native seed is created equal. The Texas Native Seeds Program (TNS) at the Caesar Kleberg Wildlife Research Institute has developed a proven method for selecting native plant material, developing native germplasms, and partnering with commercial producers to make locally adapted native germplasms available at the commercial scale. The unique process quickly screens several source populations for favorable characteristics. This is achieved by using a system that combines rankings and measurements that are collected at the population level. Following data collection and selection, individual populations are increased in isolation to maintain genetic integrity. During the isolated seed increase phase, several small-scale research plantings are conducted using the produced seed. These plantings help refine areas of adaptation and provide proof to consumers that the new releases can effectively restore native grasslands. Following isolated increase, new germplasms are formally released through the Natural Resource Conservation Service, and production is licensed through Texas A&M-Kingsville. The staff members at Texas Native Seeds then partner with commercial seed producers to ensure large scale production of each new germplasm release. This is a critical step in our process because the production of each new species can be maximized with slight changes in management strategies. Through our unique process and partnerships, TNS has made 35 locally adapted native germplasms commercially available, working with 3 different producers across Texas. This process has enabled the industry to produce enough seed to plant roughly 25,000 ha annually.[3]

Additional Key Words: restoration, seed availability, seed production

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1. Oral paper presented at the National Meeting of the American Society of Reclamation Sciences, Duluth, MN June 12-16, 2022. Published by ASRS 1305 Weathervane Dr., Champaign, IL 61821.
2. Anthony D Falk (*presenter), Research Scientist, and Interim-Director, Texas Native Seeds, Caesar Kleberg Wildlife Research Institute, Texas A&M-Kingsville, Kingsville TX 78363.
3. Work reported here was conducted near 27.53256° N, 97.53256° W.

Seed-Spec: A Native Seed Blend Development Tool[1]

R.W. Cook * and G. Peacock[2]

Abstract: Establishing native vegetation in any reclamation project can be a challenging task. The species and varieties that match the site must be identified and used to help ensure adequate establishment and persistence. Data exists to help project managers identify what species are native to a given area and commercially available, but can be cumbersome, not user friendly, and time consuming. Bamert Seed Company has worked with Colorado State University to develop a web application to easily identify a project area of interest (AOI) and provide information on native species composition for the AOI. The tool will provide a list of commercially available species that correspond to the plants that grow natively in the AOI and intuitively walk the user through developing a site-specific native seed blend. The recommended seeding rate from NRCS will be used to calculate the pounds of pure live seed (PLS) that will be needed for the project. Users will have the ability to adjust the seeding rate based on their establishment objectives and seeding method they will be using. Having this tool will allow the reclamation specialist a timely way to determine the best blend for their AOI and get the seed blend to a vendor/seed dealer with knowledge that the species selected will work for their specific site. Rob will discuss the importance of native plants and the benefits they bring to reclamation projects such as adding biodiversity and improving soil health. He will discuss and present version 1 of the tool and ask attends to provide input on what other functionality/data would be useful on their operations for version 2.

Additional Key Words: Biodiversity, Ecosystem Services, Revegetation, Reclamation, Species Selection.

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1. Oral presentation at the 2022 National Meeting of the American Society of Reclamations Sciences, Duluth, MN. June 12 – 16, 2022

2. Rob W. Cook (*presenter), Director of Business Development, Bamert Seed Company, Muleshoe TX 79347, George Peacock, Developer, Object Modeling Systems Laboratory, Colorado State University, Fort Collins CO 80523.

Buried Wood in Reclamation Soils: Impacts on Soil Nutrients and Tree Growth [1]

B.D. Pinno*, K. Trepanier, and L. Manchola Rojas [2]

Abstract: Buried wood is an important component of forest soils in both natural and anthropogenic environments, such as reclaimed mine sites, by providing a long-term store of carbon and nutrients, habitat for various organisms, and increasing soil water holding capacity. However, buried wood may also reduce site productivity due to nutrient immobilization during wood decomposition. In a greenhouse study, we evaluated the effects of buried wood on soil nutrients and trembling aspen seedling growth in four different reclamation soils from the mineable oil sands region of northern Alberta, Canada. Buried wood decreased nitrogen and phosphorus availability with the greatest impact on the most fertile soils. Most other nutrients were controlled more by soil type than buried wood. Aspen seedling growth was also reduced by buried wood addition with the greatest reduction occurring in the most productive soils. Operationally, although buried wood may reduce site productivity, subsequent field measurements indicated that most reclamation field sites in the region have lower buried wood amounts than tested in our experiment and are unlikely to be negatively impacted.

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1. Oral paper presented at the National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12 - 16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.

2. Brad Pinno (*presenter), Assistant Professor, Kaitlyn Trepanier, completed MSc student, and Laura Manchola Rojas, completed MSc student. Department of Renewable Resources, University of Alberta. Edmonton, Alberta, Canada. T6G 2E3.

Bamboo as a Potential Option for Land Reclamation and Restoration[1]

Apsana Kafle* and Kwabena Akodwaa Boadi[2]

Abstract: Bamboo is an umbrella term used to represent over 1600 species of related grasses, native across every continent except Europe. Bamboo applications have been expanding for food to fuel, timber to paper, engineering structures to landscape restoration. Bamboo has the potential for being used for land reclamation and ecosystem restoration across the world. Examples of successful land reclamation and restoration using bamboo from degraded gold mine sites in Ghana, coal mines in Indonesia, brick mines in India, degraded mountainsides in Nepal, and eroded coastlines in Thailand will be presented. The main features of bamboo that make it such a successful reclamation species are its extensive root system and self-regeneration capability. Land reclamation projects using bamboo can help to achieve the three pillars of sustainable development, namely environmental stability, economic viability, and social equity. For instance, bamboo is one of the fastest-growing plants and can provide early investment returns as it can be used for the shoot in less than a month and timber harvest within 3 years in addition to sequestering large amounts of carbon. Lastly, simple management and propagational techniques that can be used across different landscapes will be presented.

Additional Keywords: sustainable development, carbon sequestration, degraded landscapes.

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2. Apsana Kafle (* presenter), Graduate Student, Department of Renewable Resources, University of Alberta, Canada; Kwabena Akodwaa Boadi, Global Fellow, World Bamboo Organization, USA.

Planning, Implementation, and Analysis of Success in Revegetating Lignite Mines in Texas[1]

Jeremiah McKinney[2]

Abstract: Large lignite mining operations in Texas span a variety of vegetation communities from the piney forests of the east to the semi-desert thornscrub at the Mexican border. This diverse expanse of ecoregions presents numerous challenges during surface mine reclamation and requires detailed planning of revegetation practices and annual large-scale commercial seed availability. Since June of 2013, Blackland Environmental LLC has consulted the Texas lignite mining industry in the successful revegetation of thousands of forested and grassland habitats state-wide. These efforts have afforded Blackland the opportunity to test and evaluate various planting methods, seed sources, varieties, and germplasms as well as best management practices to achieve the applicable revegetation success performance standards. Through years of experience in evaluating reclaimed mined lands Blackland has also identified opportunities to enhance the post-mine lands for wildlife through modified revegetation practices and revised land management concepts.

Additional Key Words: numerous challenges, revegetation success standards, opportunities to enhance.

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2. Jeremiah McKinney, Managing Member, Blackland Environmental LLC, Garden Ridge, TX 78266.

A 'Two-Roads Approach' Evaluation of Oil Sands Mine Closure Plans for Traditional Land Uses[1]

C.A. Daly,* B. Arrobo,* S.C. Gerlach, A. Davies Post, and D. McCarthy[2]

Abstract: The sustainability of a landscape and its host community post-mining depends on effective mine reclamation and closure planning. For mines operating on the traditional territories of Indigenous rights holders, where communities' history, culture, livelihoods, and traditions are intimately and permanently connected to their ancestral homelands, this issue is further exacerbated by the exclusion of Indigenous voices from planning and decision-making. This research, known as the Co-Reclamation Project, is focused on social-ecological mine reclamation and closure planning in service of a movement towards a participatory and inclusive process (United Nations 2015)[4]. This paper highlights insights developed collaboratively with members of the Fort McKay First Nation about their lived experience with the persistence of oil sands mine activities on their traditional territory in North-East Alberta, Canada[3] and requirements for reclaimed lands. A 'Two-Roads Approach' methodology was selected as the overarching framework and strategy for Fort McKay and academic co-researchers to design this cross-cultural research project, co-gather data and co-develop new knowledge because it supports knowledge co-production between cultures. The research (1) evaluated two cultural activities—art and storytelling combined, and talking circles—for their effectiveness in empowering intercultural dialogue and guiding creation of an aligned post-closure vision between a First Nation and an oil sands energy company; and (2) using a meta-analysis, systematically reviewed oil sands mine closure plans to understand whether or not mine companies are incorporating Indigenous Knowledge and addressing the land use needs and rights of local Indigenous communities. We share perspectives, barriers, and opportunities for intercultural understanding and participation in mine reclamation and closure decision-making to ameliorate environmental, social, and cultural land use impacts.

Additional Key Words: Co-Reclamation; Co-Visioning; Indigenous Research Methodology; Mine Closure Vision; Social, Cultural and Landscape Reclamation; Art; Storytelling; Talking Circle; Meta-analysis.

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2. Christine A. Daly (*co-presenter), PhD Candidate, and S. Craig Gerlach, Professor, School of Architecture, Landscape and Planning, University of Calgary, Alberta, Canada T2N 1N4; Bori Arrobo (*co-presenter), Director, Sustainability Department, Fort McKay First Nation, Fort McKay, Alberta, Canada T0P 1C0; and Alexandra Davies Post, MSc Student, and Dan McCarthy, Associate Professor, School of Environment, Resources and Sustainability, University of Waterloo, Ontario, Canada ON N2L 3G1

3. Work reported here was conducted near 57º 10' 46"; 111º 38' 06" in the Fort McKay Traditional Territory.

4. United Nations. 2015. *Transforming our world: The 2030 Agenda for Sustainable Development*, Goal 16.7. United Nations. https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E.

Indigenous Led Environmental Monitoring, Trends and Best Practices across Canada[1]

A. Davies Post,* J. L'Hommecourt, B. Arrobo, G. Donald, D. McCarthy, C.A. Daly, and S.C. Gerlach[2]

Abstract: Indigenous peoples' practice of environmental monitoring is not a new phenomenon. Since time immemorial Indigenous peoples have been close observers and stewards of their traditional homelands. Over the last four decades there has been a notable rise in Indigenous-led environmental monitoring programs, often referred to as Guardian, Stewardship or Watchmen programs. This increase if often attributed to re-establishment of rights to self-government, more collaborative governance arrangements between Indigenous and settler governments, concern of impacts of extractive industry and availability of funding opportunities. Despite the rise in these programs few studies have been conducted to evaluate the impact of these programs on communities, the land and water. This paper explores how Indigenous-led environmental monitoring can evaluate the re-establishment of traditional land use capability on reclaimed oil sands mines and in situ footprints located in the Traditional Territory of Fort McKay First Nation (FMFN). The research was designed and executed in collaboration with FMFN and applied the Two Roads approach developed by the Two Roads Research Team (2012). The researcher conducted 15 semi-structured interviews with 19 participants including five academics experts, nine Guardian program leads and five Indigenous Guardians, Watchmen and Stewards. This presentation will highlight the inputs, outputs, and outcomes of Indigenous-led environmental monitoring and describe the current opportunities and challenges for communities, including FMFN, to implement these programs.

Additional Key Words: Indigenous-led monitoring; Community-based monitoring, Guardians, Participatory Action Research, Semi-structured Interview.

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2. Alexandra Davies Post (* presenter), MES Candidate, and Dan McCarthy, Associate Professor, School of Environment, Resources and Sustainability, University of Waterloo, Ontario, Canada ON N2L 3G1; Jean L'Hommecourt, Traditional Land Use Researcher and Bori Arrobo Director, Sustainability Department, and, Fort McKay First Nation, Fort McKay, Alberta, Canada T0P 1C0; and Gillian Donald, Donald Functional & Applied Ecology Inc. Calgary, AB, Canada; and Christine A. Daly, PhD Candidate, and S. Craig Gerlach, Professor, School of Architecture, Landscape and Planning, University of Calgary, Alberta, Canada T2N 1N4

3. Work reported here was conducted near 57º 10' 46"; 111º 38' 06" in the Fort McKay Traditional Territory.

Abundance of Lichens and Mosses on the Restored Landscape in the Nickel-Copper City of Greater Sudbury, Ontario, Canada[1]

P. Beckett,* S. Wainio, and T. Miller[2]

Abstract: Over the past forty plus years the globally recognized Sudbury Regreening Program, on the nickel and copper mining and smelter impacted landscape has evolved from activities that involved application of dolomitic limestone, fertilizer, seeding of agricultural grasses, legumes, and planting of tree seedlings to a more complete biodiverse restoration strategy using over 75 species. By 2022, approximately 3500 ha has received soil amelioration treatments, with over 10 million trees and shrubs being planted for approximately Can.$33.5 million while employing over 4800 part-time individuals. A chronosequence established in 2021 using 5m transects covering 0 – 40 years was compared to an earlier investigation in 1996. Over 25 species of lichen and 10 species of moss have invaded the ground in the developing open woodland ecosystem. The most numerous lichens are members of the *Cladonia* ('Pixie Cup' and 'Reindeer") group together with several N-fixing lichens (*Stereocaulon* and *Peltigera* species). Over time mosses of open areas (*Pohlia nutans* and *Polytrichum juniperinum*) are replaced by woodland mosses such as *Pleurozium schreberi Thuidium* spp, *Dicranum* spp,. Lichens on restored land contain low concentrations of nickel and copper and other metals but contain lesser amounts than lichens growing in adjacent non-treated areas. For a healthy restored ecosystem, it is important that attention be paid to non-vascular species as well as seed-producing plants.

Additional Key Words: biodiversity, ecological restoration, urban forest.

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2. Peter Beckett (* presenter), Professor Emeritus, Shelley Wainio, former student, and Tori Miller, student, Vale Living with Lakes Centre, School of Natural Sciences, Laurentian University, Sudbury, Ontario, P3E 2C6 Canada.

3. Work reported here was conducted near 46° 29.690' N; 80° 50.443' W.

Analyzing Floodplain Reconnection as a Restoration Method [1]

N.A. Kruse Daniels,* A.J. Gurrola, J. Pazol, N. Sullivan, J. Bowman, and K. Johnson [2]

Abstract: This study characterized the the effect of stream restoration through floodplain reconnection in Southwest Pennsylvania, USA, on sediment and nutrient transport. In these study sites, the aim of restoration was to improve connectivity between the stream channel and its adjacent floodplain by implementing wetland riparian zones, regrading the stream channel, and removing legacy sediments. This design was expected to improve the ecological function of the ecosystem by minimizing the effects that floods have on water velocity and erosion. Three unrestored and six restored study sites with varying drainage areas were analyzed for water storage capacity, sediment transport mechanisms, and nutrient cycling throughout the surface water, pore water, and sediment. The sites were sampled over low, base, and high flow conditions in July and November 2020 and March 2021. Surface water and pore water samples were collected for total suspended solids and nitrogen and phosphorus analysis. Water storage was measured by salt tracer tests that captured channel and vadose zone flow and compared with channel flow. Sediment pit traps were used to collect sediment deposited within the channel which was then analyzed for grain size distribution and nitrogen and phosphorus concentrations. Differences in water storage, sediment grain size, surface water nutrients, and sediment nutrients were assessed between sites based on flow regime, stream size class, and restoration status. In-channel flow rate impacted sediment transport, sediment grain size makeup, and surface water nutrient loading dynamics. Restoration status had a positive influence on the abundance of nitrogen and phosphorus in the sediment as well as the proportion of fine grain sediment. These data enhance a limited collection of assessments on floodplain reconnection. These results can be used to conceptualize the effect of floodplain reconnection in regions that exhibit a similar climate.

Additional Key Words: Streams, headwaters, nutrients, sediment.

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2. Natalie A. Kruse Daniels (* presenter), Professor, Annika J. Gurrola, M.S. Student, Jordan Pazol, B.A. Student, Nora Sullivan, Environmental Specialist, Jennifer Bowman, Environmental Program Manager, Environmental Studies Program, Voinovich School of Leadership and Public Service, Ohio University, Athens, OH 45701, and Kelly Johnson, Associate Professor, Biological Sciences Department, Ohio University, Athens, OH 45701.
3. Work reported here was conducted near 39°59’14” N; 80°28’50.6” W.

The Use of the Palmiter Method of Stream Restoration, Adapted to Protect Infrastructure, and its Effect on Streams[1]

Jonathan S. Viti* and Natalie Kruse Daniels[2]

Abstract: This study was designed to analyze the effect of the Palmiter method of stream restoration, adapted for infrastructure protection. Many roads and most bridges in the U.S. were built along or across rivers and streams. Rivers and streams are morphologically dynamic and naturally alter their channel over time, leading to bank erosion that can impact the stability of nearby infrastructure, requiring intervention in some cases, commonly by dumping riprap along the erosional surface. Riprap does not halt the problem and in some cases can exacerbate it. The Palmiter method uses mostly on-site material and manual labor to relocate the channel away from the erosion issue by shifting the stream power away from the erosional area. Over time, the stream will erode the opposite bank and aggrade the restored bank. Eight sites, including three target reaches where the Palmiter method was used, three control reaches upstream of their respective target reaches, and two reference streams, were sampled four separate times (late July 2021, early September 2021, late October 2021, and late January 2022). Data on total suspended solids (TSS), flow, water chemistry (field parameters), pebble size distribution, bank retreat, habitat quality, and the macroinvertebrate community were collected and analyzed statistically to determine associations between the Palmitter method and stream health. Most measures of stream health in this study were found to not be significantly different between target, reference, and control reaches. The exception was in stream cover assessed as part of the habitat evaluation and some of the smaller grain sizes in the pebble counts. This suggests that the Palmiter method can protect infrastructure without impairing stream health and can be applied to bank erosion leading to non-emergent infrastructure damage.[3]

Additional Key Words: Engineering, Watershed Management, Geomorphology.

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2. Jonathan S. Viti (* presenter), MS Student, Natalie Kruse Daniels, Professor, Environmental Studies, Ohio University, Athens, OH 45701.
3. Work reported here was conducted near 39.3292° N, 82.1013° W.

Evaluating the Water Quantity and Quality of Mine Drainage Discharges in a Hydrologically and Topographically Challenging Location[1]

N.L. Shepherd[*] and R.W. Nairn[2]

Abstract: Artesian net-alkaline mine drainage (MD) discharges from underground abandoned lead-zinc mining operations in the Picher mining field have been contaminating Tar Creek for over 40 years[3]. Although two existing passive treatment systems (PTS) have been successfully treating MD that historically contaminated Tar Creek, the greatest MD contributions originate further upstream, near Douthat, Oklahoma and remain untreated. The intersecting ground elevations and nominal head elevations of the mine pool at Douthat result in highly variable flow rates from multiple discharges, including boreholes and mine shafts. The objective of this study was to evaluate the water quality and quantity of these MD discharges to determine if passive treatment was a viable option. Regular water quality sampling occurred from 2018 through 2021 at five discharges. Weirs with pressure sensors were installed to estimate flow rates at 15-minute time intervals at the three largest discharges. The combined median flow rate was 4,046 lpm with a maximum calculated flow rate of 154,000 lpm. The peak flow rates only occurred for short periods of time, typically <37 hours. The flow weighted average totals metals concentrations of the five discharges were 0.022 mg/L Cd, 22.6 mg/L Fe, 0.045 mg/L Pb, and 5.76 mg/L Zn. The study concluded that despite highly variable flow rates, the water quality and quantity of the Douthat discharges is treatable via PTS, in part because the existing PTS remediate MD with greater metals concentrations and treatment wetlands with designed flow rates exceeding the median and maximum flow rates have been successfully implemented elsewhere.

Additional Key Words: Tri-State Mining District, Tar Creek, Passive Treatment.

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2. Nicholas L. Shepherd (* presenter), PhD candidate, and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019.

3.Work reported here was conducted near 37°57’30” N, 94°50’ 42” W.

Spatial Variations in Trace Metal Concentrations in Stream and Reservoir Sediments Downstream of the Tri-State Mining District, USA[1]

Carlton A. Folz* and Robert W. Nairn[2]

Abstract: Nearly a century of historic lead-zinc mining ceased in the 1970s in the Tri-State Mining District, leaving behind a suite of environmental issues leading to the derelict mining district being home to several EPA Superfund sites. This study aimed to evaluate concentrations of trace metals (Pb, Zn, and Cd) in and downstream of the Tri-State Mining District in northeastern Oklahoma, southeastern Kansas, and southwestern Missouri. Two methods of evaluating spatial contamination of sediments were made: comparison to known sediment metrics and distance moving away from known contamination sources. Stream and reservoir sediment collection occurred in Tar Creek, the Neosho River, the Spring River, and Grand Lake O' the Cherokees[3]. The collected samples were analyzed using inductively coupled plasma-optical emission spectrophotometry for a suite of trace metal concentrations. There was a substantial decrease in the severity of trace metal concentrations moving downstream from the mining district and trace metal concentrations were compared to consensus-based and Tri-State Mining District-specific sediment quality guidelines. A significant decrease ($p<0.05$) in Cd, Pb, and Zn concentration occurred with increasing distance from the mining impaired areas. It was concluded that there were substantial areas of elevated contamination compared to sediment quality guidelines near sources of known mining impaired areas. However, the degree of contamination decreased downstream with increasing distance from the mining district. As trace metals are continually entering the streams and rivers, the degree of contamination may change, warranting further study and potential risk to humans and the environment.

Additional key words: mine drainage, tailings, chat, Tar Creek, Superfund.

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1. Oral paper presented at the National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL61821.

2. Carlton A. Folz, (*presenter), Graduate Research Assistant and Robert W. Nairn, Professor, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, the University of Oklahoma, Norman, OK, 73019.

3. General Study Location: 36°56'00N - 94°51'00"W.

Evaluating Sources, Mass Loadings and Fate of Total and Dissolved Metals to Prioritize Restoration in a Mining-Impacted Watershed[1]

Robert W. Nairn*, Nicholas L. Shepherd, and Julie A. LaBar[2]

Abstract: Surface and ground waters in the Tar Creek and adjacent watersheds[3] of the Oklahoma portion of the Tri-State Lead-Zinc Mining District were deemed to be degraded due to "irreversible man-made damages" over 35 years ago. This administrative decision resulted in minimal effort to address risk from legacy mine waters. Stream water quality is degraded by both artesian mine water discharges (point sources) and waste pile leachate and runoff (nonpoint sources). Stream water quality is net alkaline with circumneutral pH and elevated concentrations of iron, zinc, lead, cadmium, nickel, sulfate, calcium, magnesium, and sodium. Stream hydrology is flashy and event-driven, with discharge rates ranging from near zero to greater than 30 million m^3/day for the period of record (1989-2022). A long-term comprehensive analysis of stream water quality and quantity data demonstrates the distinct influence of artesian discharges, which tend to be ferruginous, with iron concentrations several orders of magnitude greater than those found in waste pile leachate and runoff. Artesian discharge volumetric flow rates are seasonally variable and considerable, and typically provide mass loadings of more than one million g/day of metals to the streams. Tens of millions of tons of mining waste remain on the land surface, contributing contaminated leachate and runoff to local streams, as well as providing physical disturbance to aquatic and riparian habitats through erosion and subsequent deposition. Analysis of this dataset indicates that both point and nonpoint sources of ecotoxic metals contribute to stream degradation, and comprehensive watershed management is necessary for successful environmental restoration. Although land reclamation activities have been ongoing, with particularly increased efforts over the past decade, and two full-scale passive treatment systems are treating specific artesian discharges, a holistic reclamation strategy has not been implemented. By analyzing stream loading data i) upstream of mining influences ii) in stream reaches with solely nonpoint influences, and iii) in stream reaches with both point and nonpoint influences, prioritization plans for targeted reclamation activities may be developed.

Additional key words: Passive treatment, water quality geochemical modeling, stream ecology.

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1. Oral paper presented at the National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASMR; 1305 Weathervane Dr., Champaign, IL 61821.

2. Robert W. Nairn, Professor and Nicholas L. Shepherd, Graduate Research Assistant, Center for Restoration of Ecosystems and Watersheds, School of Civil Engineering and Environmental Science, University of Oklahoma, Norman, OK 73019; Julie A. LaBar, Assistant Professor, Science Department, Centenary University, Hackettstown, NJ, 07840

3. Work reported here was conducted near 36°57’29” N, 94°50’41” W.

Water Quality of Reclaimed Mountaintop Removal Valley Fill Mine Site 15 Years After Final Reclamation – An Unexpected Remedy[1]

A. Hass,* R. Lester, W. Haynes, I. Wolford, and R. Cantrell[2]

Abstract: Mountaintop removal valley fill (MTR-VF) mining operations conducted for many years in Central Appalachia coal fields, the legacy and long-term impact of which on stream water quality were deemed irreversible (Palmer 2010, Science, DOI: 10.1126/science.1180543). In this paired-watershed study, conducted in South Central WV, we compared stream hydrology and water quality of MTR-VF watershed 25 years after mining ended and 15 years after final reclamation bond-release stage completed to that of adjacent non-disturbed watershed of similar size and aspect (ca. 140 acre each, SW aspect). In-situ stream water measurements of pH, dissolve oxygen, oxidation-reduction potential, temperature, and electrical conductivity (EC) were conducted every two weeks during grab-samples collection at selected longitudinal locations upstream and downstream from the VF toe, and at the outlet of the non-disturbed watershed. Water samples were further analyzed for alkalinity, dissolved carbon, and major ionic and metal content. In addition, a weather station was installed on the connective ridge and the two streams were instrumented with flumes, pressure transduces, and multiparameter sondes for continuous (15 min interval) monitoring of meteorological conditions and stream water flow and quality. Fifteen years after final reclamation MTR-VF was found to still drastically impact stream water quality. Significant longitudinal and temporal variation and elevated levels of all measured parameters were observed upstream along the MTR-VF watershed compared to the non-disturbed watershed. With EC, for example, exceeding regulatory threshold (300 µS cm^{-1}) during much of the growing season (annually fluctuating from 229 to 592 µS cm^{-1}). Yet, a beaver-restored sediment pond into wetland seemed to alleviate both the seasonal fluctuations and the levels of measured parameters; with EC, for example averaging 169 µS cm^{-1} (fluctuating between 93 to 284 µS cm^{-1}) downstream from the pond. It is noteworthy that 'removal' of sediment ponds upon final reclamation is expected and indeed encouraged by regulatory agencies in order to regain pre-mining stream flow patterns… Results are discussed with respect to on-going practices and regulations amid the apparent invaluable role of the (beaver-) conversion of sediment ponds into wetlands in regulating MTR-FV water quality, years after such ponds concluded their perceived and intended role.

Additional Key Words: TDS, Electrical conductivity, wetland, sediment pond

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2. Amir Hass (* presenter), Associate Research Professor, Agricultural and Environmental Research Station & Biology Department, West Virginia State University, Institute, WV 25112; Randal Lester, Assistant Manager, West Virginia NRCS Plant Material Center, Alderson, WV; Warren Haynes, Field Technician Specialist, West Virginia NRCS Plant Material Center, Alderson, WV; Isaac Wolford, Manager, West Virginia NRCS Plant Material Center, Alderson, WV; and Robert Cantrell, Soil Water and Natural Resources Lab manager, Agricultural and Environmental Research Station, West Virginia State University, Institute, WV 25112.

The Use of Agricultural Waste to Remove Heavy Metals from Mine Water[1]

E. Abbiw* and N. A. Kruse Daniels[2]

Abstract: Scientists have been working towards a more environmentally friendly, cost-effective, and sustainable approach to addressing environmental pollution. There is growing attention to adapting sorption techniques using low-cost agricultural byproducts and waste to remove heavy metals from contaminated and polluted water systems, including mine water. This study evaluates the capacity of agricultural waste materials such as plantain and banana peels, bamboo stems, coconut coir, goat, and sheep dung as low-cost sorbents for removing specific heavy metals in synthetic-mine water. The study follows a batch sorption experiment mixing different masses of biosorbents to remove metals from a synthetic mine water solution, considering sorbent mass and pH as the optimized adsorption parameters. In the first trial, dry masses, 0.1, 0.5, 1, and 2 g of plantain peel, banana peel, bamboo stems, coconut coir, sheep dung, and goat dung were weighed and added to 35 mL working volume of synthetic mine water containing mercury, cadmium, lead, copper, zinc, and arsenic in a 50 mL centrifuge tube. The mixture was treated at a pH of 7 at initial concentrations of 0.33, 1.03, 1.33, 7, and 20.42 mg L^{-1} for Cd, Cu, Zn, Pb, and Hg, respectively. The mixture was placed on a shaker at 150 rpm for 1,440 minutes and allowed to establish equilibrium for 4,320 minutes. After this time period, the metal-enriched sorbent was separated from the solution, and an Elmer Opima 4300DV ICP-OES was used to analyze the final concentration of the mine water. The experiment was conducted at room temperature, and at the end of first trial, the biosorbents showed a relatively high adsorption capacity for coconut coir, sheep dung, and banana peel. The amount of adsorbed metals per unit mass of adsorbent at equilibrium decreased as the mass of biosorbant used increased. It was a common trend for all sorbents.

Additional Key Words: Biosorbant, Adsorption, low-cost-agricultural-byproducts.

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1. Poster paper presented at the National Meeting of the American Society of Reclamation Sciences, Duluth, MN. June 12-16, 2022. Published by ASRS; 1305 Weathervane Dr., Champaign, IL 61821.
2. Edward Abbiw (* presenter), Master's Student, and Natalie Kruse Daniels, Professor of Environmental Studies in the Voinovich School of Leadership and Public Service at Ohio University.

Particle Tracking Velocimetry Employing Aerial Thermography[1]

Peter Assaf*, Jenna Beitel, Marlena Jacobs, Br. Marius Strom[2]

Abstract: The present study demonstrates a proof-of-concept particle tracking velocimetry (PTV) system based on aerial thermography taken from a small, unmanned aircraft system (sUAS). In this work, both visible light and thermal video is collected by sUAS, allowing observation of tracers appropriate to each data source. While visible light tracers were brightly colored plastic spheres that had to be recovered after use, the thermal tracers were ice cubes: discrete, rigid, and thermally visible tracers. To locate these cubes and mitigate the effect of vehicle motion, large quantities of ice located at fixed points along the stream were also used as ground references. The present work demonstrates a video analysis program to analyze this imagery and derive quantitative flow information that compares well with flow measurements taken with traditional instruments. The program uses OpenCV for image pre-processing, along with open-source software OpenPTV for particle tracking and velocity estimation. The pre-processor, developed in this work, is employed to account for incidental vehicle motion during data collection by automatically detecting and referencing ground references in each frame. In addition, OpenPTV and a postprocessing script are employed to produce continuous velocity fields. In its current state, when implemented on a straight, gravel-lined channel, the surface velocities estimated by this system differ from handheld acoustic-doppler velocimeters by approximately 15%. While further testing and development is needed, the program shows significant promise to enable a low-impact, ad-hoc flow measurement system ideal for evaluating flow structures in abandoned mine drainage (AMD) treatment systems.

Additional Key Words: Unmanned aircraft system, Python, OpenCV, OpenPTV, abandoned mine drainage

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2. Peter Assaf (* presenter), undergraduate in Pre-Engineering, Franciscan University of Steubenville, Steubenville, OH 43952, Jenna Beitel and Marlena Jacobs, undergraduates in General Engineering, Saint Francis University, Loretto, PA 15940, Br. Marius Strom, Engineering Laboratory Instructor, Saint Francis University, Loretto, PA 15940.

High School Students are the Next Generation of Environmental Stewards and Can Play a Part in Mine Reclamation Projects[1]

Mason Beiswenger*, James Eckenrode, Ben Roman, Rachel Wagner, and Travis Tasker[2]

Abstract: A short drive from Saint Francis University (SFU) in Loretto, PA is the Kittanning Run watershed, a 2,240-acre watershed with a 3.7-mile stream in Blair County, PA that is severely impacted by acid mine drainage (AMD). The Altoona Water Authority (AWA) and Center for Watershed Research and Service (CWRS) at SFU received support from the Woodard and Curran Foundation and PA Department of Environmental Protection to work on restoring Kittanning Run while also engaging the community in the remediation process. The next generation of environment stewards will be responsible for the future of mine reclamation and water remediation; it is our responsibility to engage, inform, and excite them about restoring watersheds like Kittanning Run. The goal of this study was to involve High School students in mine reclamation through a series of informative lectures on acid mine drainage in their own backyard, hands-on activities in building water quality sensors, and field-based sampling campaigns in the Kittanning Run watershed. Learning outcomes were assessed for each activitythrough student surveys at the end of the program. Students were also asked about their interest in future projects related to mine reclamation after helping restore Kittanning Run. Findings from this work will help inform professionals and educators how various types of education andoutreach programs can excite the next generation of environmental stewards.

Additional Key Words: Engaging High School students in mine reclamation, Education,Learning outcomes, Mine reclamation learning activities for students.

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2. Mason Beiswenger (* presenter), undergraduate, James Eckenrode, Ben Roman, and Travis Tasker, Faculty in Engineering at Saint Francis University, Loretto, PA 15940.

Determining the Effect of Mine Drainage Residuals on Phosphorus Sequestration and Rye Grass Yield[1]

Matthew Berzonsky*, James Eckenrode, Robert Hedin, William Strosnider, and Travis Tasker[2]

Abstract: Throughout historic mining regions of the United States, waterways are impacted by metalliferous mine drainage. Efforts to treat mine water often result in large quantities of solids, also known as mine drainage residuals (MDRs). These are typically disposed by burial, landfilling, or pumping back into mine pools. We hypothesize that MDRs could be beneficially reused in agriculture applications to sorb water extractable phosphorus, potentially increasing the amount of bioavailable phosphorus for crop growth and reducing nutrient mobility. To test this hypothesis, a greenhouse study was designed to determine if MDRs from mine water treatment could be used to sorb phosphate from cow manure, reduce phosphorus leaching, and improve ryegrass yield. Before the greenhouse study, sorption experiments confirmed that phosphates in manure could sorb onto the MDRs, and bioavailability leaching experiments demonstrated that the sorbed phosphorus was available for plant growth. An additional experiment was performed to determine if MDRs would be stable under anaerobic conditions in slurry tanks or water saturated soils. For the greenhouse experiments, varying amounts of MDRs were mixed with cow manure before applying to a nutrient deficient soil, planting with rye grass, and growing in a greenhouse. The addition of the MDR to the manure, even at the highest rate, did not negatively impact rye grass yield. Both MDR and positive control treatments had similar yields but were greater than the yields from the negative control. The addition of MDRs to dairy manure was found to decrease bioavailable phosphorus by 13.1% and dissolution of MDRs under anaerobic conditions would not release significant amounts of phosphorus due to the formation of other non-soluble minerals. The results obtained from this study strongly support the potential for use of MDRs as a sustainable nutrient pollution control strategy.

Additional Key Words: Mine Drainage Residuals, Phosphorus Removal, Manure, Reduced Nutrient Runoff.

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2. Matthew Berzonsky (*presenter), and James Eckenrode, undergraduates in Environmental Engineering at Saint Francis University, Loretto, PA 15940; Robert Hedin, Hedin Environmental, Pittsburgh, PA 15228; William Strosnider, Director Baruch Marine Field Laboratory at the Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina: Travis Tasker, Assistant Professor in Environmental Engineering at Saint Francis University, Loretto, PA 15940.

Treating Mine Drainage in Batch Using BOLTS (Batch Operating Limestone Treatment System) Limestone Beds Can Lower Treatment Costs[1]

Griffin Burt*, Jared Oakes, Tim Danehy, Buck Neely, Cliff Denholm, William Strosnider, Julie LaBar, James Eckenrode, and Travis Tasker[2]

Abstract: There are approximately 5,000 miles of acid mine drainage (AMD) impacted streams in Pennsylvania alone, requiring various types of treatment systems to improve water quality. The most common are active and passive treatment systems, which use oxidation, alkalinity generation, settling, among other options to treat AMD. One unique system is a passive treatment system in Portage, Pennsylvania utilizing a novel limestone bed design that allows batches of AMD to be treated for a set hydraulic retention time (HRT). This system treats the Puritan Mine Discharge which has an average flow of 150 gallons per minute and contains a mean 20 mg/L of iron, 15 mg/L aluminum, an acidity of 200 mg/L, and a pH of 3.5. At the site, the Puritan Discharge first flows into a holding pond that stores the AMD until a limestone bed has completed treating a volume of the AMD for a set HRT. Once the holding pond is full and the limestone bed is empty and ready to accept new raw AMD, a float switch is triggered, allowing the limestone bed to fill via a relatively rapid influx. Once the limestone bed is full, the influent valve to the limestone bed closes and treats the AMD for a set HRT. After treating for the set HRT, the water is flushed from the limestone bed and into a sedimentation basin. This process repeats once the holding pond has enough AMD to refill the empty limestone bed. During high flows of AMD, the holding pond has an additional piping system that connects to a separate flushable limestone bed that treats AMD in a traditional flow-through design where the AMD flows into a limestone bed and is flushed every 24 hours to remove precipitates. We hypothesize that treating AMD in the novel BOLTS (Batch Operating Limestone Treatment System) method in comparison to the traditional flow-through configuration can treat AMD more effectively with smaller limestone volumes. We tested this hypothesis by monitoring the influent and effluent water quality from the two differently designed limestone beds at the Puritan Discharge. After monitoring for several months, acidity balances were performed to determine which treatment method was the most effective.

Additional Key Words: Mine water treatment.

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2. Griffin Burt (*presenter), Jared Oakes, undergraduates, James Eckenrode, Engineering Faculty, and Travis Tasker, Assistant Professor in Environmental Engineering at Saint Francis University, Loretto, PA 15940; Tim Danehy and Buck Neely, BioMost, Inc., Mars, PA 16046: Cliff Denholm, Stream Restoration Inc., Mars, PA 16046: William Strosnider, Director, Baruch Marine Field Laboratory, University South Carolina; Julie LaBar, Assistant Professor of Environmental Science, Centenary University.

Treating Mine Drainage in the Middle of a City Where Space is Limited[1]

Ashlyn Campagna*, James Eckenrode, and Travis Tasker[2]

Abstract: For the last decade, various groups have been trying to come up with a solution for remediating acid mine drainage (AMD) from Bethlehem Mine #72 which discharges from a mine shaft into the Stony Creek River near its confluence with the Little Conemaugh River in Johnstown, PA. The AMD discharges near the center of the city in close proximity to the Inclined Plane and immediately across the river from Point Stadium in downtown Johnstown, PA. The AMD degrades water quality in the Stony creek River (and downstream in the Conemaugh River) but also causes local odor and aesthetical impacts that affect the socioeconomic quality of the downtown area. Since 2008, various solutions for dealing with the AMD have been considered, including: 1) collecting the discharge and piping it 600 yards downstream away from the city center, 2) collecting the discharge and piping it 3 miles downstream, 3) Collecting the discharge and piping it 300 yards into an existing sewer network to be treated at a local wastewater treatment plant, 4) and lowering the mine pool elevation by constructing a pumping station and treating with hydrated lime. While many solutions have been considered, none of them have been realized. Saint Francis University, Tetratech, and the Headwaters Charitable Trust recently received a Growing Greener Grant from the PA DEP to develop a 20% design for treating the AMD. The team is currently characterizing the flowrate and water chemistry from the discharge, performing experiments for proof of treatment design concepts, collaborating with local industries to consider feasibility of treating the AMD in local industrial treatment processes, and reviewing mine and property maps to propose areas where the mine pool could be lowered by pumping and treating. Findings from previous engineering studies in addition to findings and preliminary designs from ongoing work will be discussed along with challenges with treating the Bethlehem Mine #72 discharge located near a city center.

Additional Key Words: Mine water treatment.

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2. Ashlyn Campagna (* presenter); undergraduate, James Eckenrode, Engineering Faculty, Travis Tasker, Assistant Professor, Saint Francis University, Loretto, PA 15940.

Excel Macro for Continuous Instream Monitor (CIM) Data Correction[1]

Rachel Gibson*, James Eckenrode, Travis Tasker, Joel Bandstra[2]

Abstract: Continuous water-quality monitoring has become an essential part of gauging the current conditions of surface water. Sondes, a popular choice for continuous monitoring, can be deployed in bodies of water to record data for as long as the batteries will last. Drawbacks of this method are that as the sonde sits in the water, it can collect sediment or biological material on the sensors. As a result, the data can show evidence of fouling error. Another factor that can introduce error into sonde readings is calibration drift. Drift and fouling error can be corrected based on readings from the sonde at the end of the deployment period when the sonde is cleaned and the calibration is checked. Sonde data that is not corrected for these types of fouling and drift errors can be inaccurate. Therefore, the objective of this project was to develop a free and user-friendly Visual Basic for Applications (VBA) macro that performs fouling and calibration corrections on sonde data. The VBA macro was developed based on the United States Geological Survey (USGS) protocol for continuous instream monitoring data correction, which assumes that fouling and drift occurs linearly and can be corrected from the initial to final data points. The accuracy of the VBA macro in correcting sonde data was tested by deploying sondes for approximately seven weeks at locations where significant fouling was expected. Each week, a second clean and well calibrated field meter was used to collect water quality data next to the deployed sondes. At the end of the deployment period, the differences between the sonde data and well calibrated field meter measurements were compared. The data was in good agreement with the field meter measurements; however, additional work is underway to determine if assumptions for linear drift and fouling are valid and the best option for correcting sonde data.

Additional Key Words: Macro, Sonde, Fouling.

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2. Rachel Gibson (* presenter), undergraduate in Environmental Engineering; James Eckenrode, Engineering Faculty; Travis Tasker, Assistant Professor; Joel Bandstra, Professor, all at Saint Francis University, Loretto, PA 15940.

Low-Cost Pressure Sensor for Quantifying Flowrates from Mine Discharges

Thomas Hockensmith*, Br. Marius Strom, James Eckenrode, and Travis Tasker[2]

Abstract: Quantifying the flowrate of a mine discharge is one of the first steps in developing a plan for remediation. Flowrates are typically measured using weirs, pressure sensors, pipes, acoustic doppler velocimeters, among others. Of these methods, a weir in conjunction with a pressure transducer can be used to continuously measure flowrates over an extended period of time, allowing quantification of daily and seasonal fluctuations in flowrate from mine discharges. While pressure transducers are great for continuously monitoring flowrate, they are often in excess of 500 dollars, making it cost prohibitive for volunteer-based groups and watershed organizations. The purpose of this project was to develop a low-cost pressure logger that could be used for water reclamation projects, education and outreach activities, and monitoring efforts by citizen scientists. To create this sensor, low-cost electronics similar to those used in commercial pressure transducers were researched, purchased, and mounted to a circuit board designed in EAGLE that could measure atmospheric pressure and water pressure while storing the pressure data, date, and time on an SD card. After several prototypes, a low-power battery timer was also added to the circuit board, conserving battery power, and allowing the sensor to function for months on 4 C-cell batteries. The circuit board and the sensor assembly instructions were also simplified, allowing easy assembly for students and volunteers interested in building the pressure logging system. Thus far, the sensor has been tested under lab conditions and is able to accurately record pressure data over various time intervals. Future experiments will help confirm that the sensor can be deployed in the field for long periods of time while collecting and recording accurate data.

Additional Key Words: Pressure transducer, monitoring flowrates, citizen science, do ityourself.

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2. Thomas Hockensmith (* presenter), undergraduate in Environmental Engineering; Br. Marius Strom and James Eckenrode, Engineering Faculty, Travis Tasker; Assistant Professor in Environmental Engineering, all at Saint Francis University,Loretto, PA 15940.

Hydrology and Agricultural sediment Pollution in the Bloody Run Swamp of Ohio[1]

K.M. Ositimehin and N.A. Kruse Daniels[2]

Abstract: Intensive agricultural practices on farmlands leading to discharge of sediments and nutrients (nitrogen and phosphorus) creates several environmental problems which accounts for almost half of all U.S water pollution challenges. The movement of sediments and nutrients from these agricultural lands to streams and watersheds causes eutrophication, water quality degradation, alteration of water flow, siltation and, consequently, a reduction in water depth. The Bloody Run Swamp in Ohio; an historical swamp that was drained for agriculture and the resulting stream and ditch network is affected by sediments, hydromodification, and altered water flow. Planned stream restoration and wetland construction to mitigate nutrient and sediment pollution is planned on a former agricultural field that drains to Bloody Run with the aim of retaining water, sediment, and nutrients on the 80-acre site. Pre-restoration hydrology and sediment loading behavior were assessed at 2 sites on channels in the former Bloody Run Swamp. For this study, flow measurements and water depths were measured in the ditch network and downstream on the receiving river, the South Fork of the Licking River. The meteorological data from Newark Heath Airport station in Licking Country, Ohio was used to calculate Antecedent Precipitation Index. Flashy flow response to precipitation drives erosion, thereby resulting in transportation of higher concentrations of sediments and nutrients. The site in the ditch network had a high-water depth in summer compared to the South Fork of the Licking River and with respect to API, showing the flashy response to precipitation and increased sediment loading in the ditches. At the pre-construction stage, sediment movement increases with the water level in the ditches. The sites are expected to retain sediments and water as well as a reduction in flashiness with the stream restoration and wetland construction that will begin at the site in mid-2022.[3]

Additional Keywords: Water quality, Sediment, Nutrients, Hydrology.

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2. Kehinde M. Ositimehin*, Masters student, and Dr. Natalie A. Kruse Daniels, Professor, Environmental Studies, Ohio University, Athens 45701.
3. Work reported here was conducted near 39° 56’ 2.04” N; -82° 28’ 51.41” W.

BOD and Phosphate Removal Rates of Wastewater Cotreated with Acid-Mine Drainage[1]

Vittoria LaRosa*, B. Roman, C.D. Spellman Jr., T. Tasker, W.H.J. Strosnider, and J.E. Goodwill[2]

Abstract: Acid-mine drainage (AMD) is a persistent source of water pollution throughout the United States. Numerous treatment technologies exist but are often decentralized and expensive. An alternative to conventional AMD treatment is utilizing existing wastewater treatment plants (WWTPs) to intake AMD discharges. The benefit of combining these waste streams is that wastewater typically has high pH buffering capacity, and the metals present in AMD will adsorb phosphate and precipitate out of solution. However, there are concerns about how adding AMD to a WWTP may impact the treatment performance. The purpose of this study is to determine the rate at which organic matter (i.e., BOD) is removed from wastewater when mixed with AMD. The kinetic rates of BOD removal were examined for raw municipal wastewater (pH = 8.33) mixed with 10% or 40% additions of AMD from various sources in Central Pennsylvania or distilled water (DI; controls). The AMD or DI and wastewater were gently mixed in 2 L Phipps & Bird jars for 2 min and allowed to settle for 2 hr. (simulating primary clarification in WWTPs), after which pH was recorded, and samples were taken from the supernatant to be used for analysis. The kinetic rate of BOD removal in the supernatant was also determined using BODTrak II respirometers that were seeded with return activated sludge collected from the local WWTP and held at 20ºC for 7 days. Phosphate concentrations were determined using the ascorbic acid method. For both mixing ratios, the kinetic rate of BOD removal was roughly 20% greater in the samples mixed with AMD compared to DI. This increase in BOD removal is likely due to kinetic rates being greatest between pH 6-8, which could be a benefit to treatment performance of alkaline wastewaters. In addition, the pH of the AMD mixed solutions remained circumneutral (8.02 for 10% AMD and 7.10 for 40% AMD), exhibiting the strong pH buffering capacity of wastewater. Phosphate removal in the 10% AMD solution was 15-40% greater than 10% DI, and 60-100% greater in the 40% mixed solutions, illustrating the capability of phosphate adsorption and precipitation with metals in AMD.

Additional Key Words: Sustainable design in reclamation, novel mine water treatment.

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2. Vittoria LaRosa (*presenter) undergraduate, Benjamin Roman, Postdoctoral Fellow, C.D. Spellman Jr, PhD student, and T. Tasker, Assistant Professor in Environmental Engineering at Saint Francis University, Loretto, PA 15940; W.H.J. Strosnider, Director of Baruch Marine Field Laboratory at the Belle W. Branch Institute for Marine and Coastal Sciences, University of South Carolina, Columbia, SC 29208; J.E. Goodwill, Assistant Professor in Civil and Environmental Engineering at the University of Rhode Island, Kingston, RI 02881.

Overcoming matrix effects in acid mine drainage samples analyzed for metal concentrations by ICP-OES[1]

Kevin Rowland*, James Eckenrode, and Travis Tasker[2]

Abstract: Acid mine drainage (AMD) samples are subject to matrix effects when analyzed for metal concentrations by ICP-OES. Fortunately, the matrix effect can be minimized by proper sample preparation. This work aimed to determine the best way to prepare and analyze an AMD sample for analysis by ICP-OES such to obtain the most accurate results. An AMD sample was collected from Cambria County, PA and sent to five different certified labs in Pennsylvania where it was analyzed for Fe, Al, Mn, alkalinity, and acidity. The same sample was analyzed at Saint Francis University for metal concentrations on an ICP-OES using several different methods: 1) dilution prior to analysis, 2) no dilution and spiking with an internal standard prior to analysis, and 3) no dilution and no internal standard added prior to analysis. Results from the certified labs were compared to each other as well as the analyses at SFU to determine expected error in reported metal concentrations of AMD samples. Determined concentrations from the different analysis methods as SFU were also compared to the most probable concentrations reported by the certified labs. Preliminary testing at SFU indicated that diluting AMD samples by a factor of 10 and spiking them with Yttrium was found to give the most accurate results when compared to the most probable concentrations reported by the certified labs. At this dilution, the concentration of the matrix was diluted enough to overcome matrix interferences, and the analyte was concentrated enough to avoid reaching the detection limits of the equipment.

Additional Key Words: Mine Drainage Residuals, Phosphorus Removal, Manure, Reduced Nutrient Runoff

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2. Kevin Rowland (*presenter), undergraduate in Environmental Engineering; James Eckenrode, Engineering Faculty; Travis Tasker, Assistant Professor, all at Environmental Engineering at Saint Francis University, Loretto, PA 15940.

Coarse Woody Debris as a Reclamation Amendment in the Athabasca Oil Sands[1]

K. Trudel* and B. Pinno[2]

Abstract: Coarse Woody Debris (CWD) plays an essential role in boreal ecosystems. In both natural and anthropogenic ecosystems, CWD functions as an organic matter addition, source of nutrients, carbon store, fuel load, habitat for plants and animals, erosion control and alters water cycling. Incorporating CWD as a reclamation amendment may help in achieving some of these benefits on reclaimed sites. Reclamation cover soils in the mineable oil sands of northern Alberta, Canada, are mainly upland derived Forest Floor Mineral Mix (FFMM) and lowland derived Peat Mineral Mix (PMM). FFMM and PMM are considered a primary driver of successful reclamation effecting seedling establishment, moisture regimes, soil stability, nutrient availability and more. However, the impact of CWD may vary by soil type and by the amount of CWD applied. We analyzed the effects of CWD at a 6-year-old reclamation site that includes both FFMM and PMM soils on soil physical characteristics (bulk density, moisture, temperature) and the regenerating plant community (% cover, tree density, tree height). In general, cover soil is the major controller of ecosystem properties, but CWD does affect soil physical properties, in particular soil depth and bulk density. In preliminary findings soil depth was higher and bulk density was lower with the addition of CWD when compared to control sites. Bulk density appears to be higher above CWD on the hillslope. This likely reflects CWD acting as an erosion and compaction control barrier in these young reclamation sites. There does not appear to be any influence of CWD on other soil properties on the regenerating plant community at this early stage, but the long-term effects are not known.

Additional keywords: Soils, Regeneration, Mining.

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2. Keana Trudel (* presenter). MSC Student, and Brad Pinno, Assistant Professor, Silviculture Research Group, University of Alberta, Edmonton, AB T6G 2R3.
3. Work reported here was conducted near 57° 23' 33.8748" N; -111° 37' 45.5874" W.

Novel Biogeochemical Approach for Removing Nutrients from Eutrophic Retention Ponds[1]

L. McKercher*, T.L. Messer, A.R. Mittelstet, and S.D. Comfort[2]

Abstract: Urban retention ponds are a popular stormwater control measure (SCM) for receiving and treating urban runoff. However, after years, or even decades, of stormwater receipt, retention ponds are likely to become eutrophic when internal nutrient loads of nitrogen and phosphorus over accumulate within pond water and sediment. Eutrophic conditions promote excess algal growth which may result in a plethora of unintended environmental effects (hypoxia, foul odors, fish kills). Thus, additional management strategies are often required to mitigate internal nutrient loading to improve water quality. Our objective was to design a novel biological-chemical approach to remove nutrients from a eutrophic urban retention pond using a 37 m^2 floating treatment wetland paired with slow-release lanthanum composites to remove nitrogen and phosphorus from the eutrophic pond. The design was implemented at the Densmore Pond in Lincoln, Nebraska, USA in 2020 and 2021. Field sampling results showed nitrate-N and phosphate-P concentrations were reduced from 50 $\mu g\ L^{-1}$ to < 10 $\mu g\ L^{-1}$ following two years of treatment in 2020 and 2021.[3]

Additional Key Words: Rare earth elements, nutrients.

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2. L. McKercher (*presenter), Graduate research assistant, University of South Carolina, Columbia, SC 29210; T.L. Messer, Assistant Professor, University of Kentucky, Lexington, KY 40506; A.R. Mittelstet, Assistant Professor, and S.D. Comfort, Professor, University of Nebraska-Lincoln, Lincoln, NE 68583.

3. Work reported here was conducted near 40.7375015°N, -96.7044619°W.

Avenues for Indigenous Influence of Oil Sands Reclamation [1]

S.L. Lipman* and J.R. Parkins[2]

Abstract: The oil sands industry in northern Alberta, Canada has intertwined environmental and cultural implications for Indigenous lands. In response to these complex impacts, ecological reclamation is levied as a key means of mitigating impacts from oil sands disturbances. Given the long-term impact on local Indigenous community health and wellbeing, these communities' participation throughout the reclamation process is important in both determining and achieving reclamation success. Not only does Indigenous leadership in oil sands reclamation make ecological sense, but Albertans have a legal and moral imperative to support Indigenous-influenced reclamation. Despite calls for increased involvement and some recent shifts in consultation protocol, there remains insufficient 'accommodation' and Indigenous leadership in oil sands reclamation. Using scoping and chronological approaches to a grey literature review, we identified (1) types of literature that discuss Indigenous engagement in oil sands reclamation, (2) the literature's proposed strategies for Indigenous influence of reclamation, and (3) trends in Indigenous influence of reclamation. Key findings demonstrate that current opportunities are limited, while support for Indigenous influence of oil sands reclamation is increasing. There is an overarching call for increased sovereignty for Indigenous Peoples to direct the entire process of reclamation from planning to execution to monitoring. Future opportunities should focus on the transition from extractive engagement to equitable leadership and on targeted capacity building. As large oil sands mines near closure and reclamation technologies continue to improve, members of the public, regulators, industry, and government can support the momentum of increasing avenues for Indigenous influence of reclamation.

Additional Key Words: consultation and accommodation, engagement, Indigenous rights, literature review, oil sands, participation, reclamation, reconciliation

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2. Skylar L. Lipman (* presenter), Masters Student, and John R. Parkins, Professor, Resource Economics and Environmental Sociology, University of Alberta, Edmonton, AB T6G 2R3.