Reclamation of Abandoned Coal Mine Wastes Using Lime Cake Byproducts in Korea

The Appalachian Regional Reforestation Initiative: A Partnership to Promote Reforestation of Mined Lands

THE TRAPPER MINE: A Model of Reclamation Success in the West
“We Will Leave the Land in a Condition Equal to or Better than We Found It.”

Peabody Energy is recognized for innovative stewardship practices that result in superior rangeland, magnificent wildlife preserves, prime farmland and pristine wetlands. It’s all part of our approach to sustainable development... and just being a good neighbor.

Our approach to reclamation is driven by a mission statement that says: “When mining is complete, we will leave the land in a condition equal to or better than we found it.” Peabody reclaims thousands of acres of land each year and plants more than 1 million trees. We have been nationally recognized through more than 30 awards for stewardship in the past five years, which include several awards for “Good Neighbor” programs to promote sustainability, cultural preservation and energy education.

Peabody Energy is the world’s largest private-sector coal company. Our products fuel more than 10 percent of U.S. electricity and 3 percent of the world’s electricity.
2 President’s Message
By David Chenoweth, ASMR President

3 Editor’s Message
By Dr. Jeff Skousen

4 The Trapper Mine: A Model of Reclamation Success in the West

9 You’re Invited to the American Society of Mining and Reclamation 2006 Annual Meeting
March 27-29, 2006 • St. Louis, Missouri

10 2005 Meeting Awards Recipients

11 2005 Meeting Exhibitors

12 Reclamation of Abandoned Coal Mine Wastes Using Lime Cake Products in Korea

19 First Announcement and Call for Papers Billings Land Reclamation
June 6-9, 2006 • Billings, Montana

20 The Appalachian Regional Reforestation Initiative: A Partnership to Promote Reforestation of Mined Lands

22 ASMR Membership Application

24 Index to Advertisers

Cover:
A large field demonstration was established to test the use of lime cake on coal refuse in Korea. See related article inside.
Taking ASMR to New Heights

We have recently completed our annual conference in Breckenridge, Colorado which was entitled “Taking Reclamation to New Heights.” From the testimonials I have received regarding the success of the conference, I feel comfortable in saying that we have taken ASMR to new heights. Thanks to those individuals who worked hard on preparing and presenting technical papers and workshops, we met our goal of the exchange of new reclamation technology. Behind the scenes, the National Executive Committee (NEC) worked hard during two different sessions to find ways to enhance the organization and increase its horsepower as a resource center. All of us on the NEC had a common goal of being able to continually provide valuable and much needed exchange of reclamation ideas and research. Furthermore, we want to be a resource center year-round and not just at the annual conference. Reclamation Matters has provided a great catalyst to ASMR for the exchange of research and case studies on a semi-annual basis. Past and future advertisers deserve special recognition for contributing to the success of the magazine.

Our Web site continues to be expanded as a true resource center. We have added an employment section which allows members to list employment opportunities at no charge. We will be working during the months ahead to create a more comprehensive directory that links material providers, consultants, contractors, researchers, practitioners, and academia together.

The NEC has decided to enhance scholarship amounts to encourage students to pursue studies in reclamation-related college programs. The NEC discussed preparing a PowerPoint presentation that could be used by members to educate corporations, university officials, and others on the benefits of being members and contributing and receiving information on reclamation procedures and research.

Just as biologists and ecologists recognize the need for diversity, the NEC recognizes the benefits of having a diverse group of members. In my opinion, we often times promote the organization as benefiting predominantly those with ties to mining. ASMR can and does provide benefits to those individuals involved in any form of land restoration and reclamation including oil and gas companies, landfill operators, Department of Transportation professionals, and land developers to mention a few. Furthermore, our organization benefits professionals employed as engineers, soil scientists, range scientists, wetland scientists, landscape architects, and land planners, etc.

As an owner of environmental consulting and contracting companies, ASMR has personally enhanced my relationship with experts in our field. I now have some of the top reclamation talent in the nation to call on when my staff and I need advice on tough reclamation issues. ASMR has also increased my business opportunities by providing networking opportunities along with being recognized as professionals in our industry.

I thoroughly enjoy and appreciate the opportunity to serve as your president of ASMR. We have some very exciting times ahead of us in the world of reclamation.
Do you remember why you initially became interested in this reclamation area? Was it thrust upon you by your boss? Some of you may have been assigned to do pre-mining data collection, like environmental surveys for water, plants, and wildlife. You may have been forced to solve an erosion problem, treat water, or plant grasses or trees on disturbed land. You may have been asked why plants were not establishing on a site, and you had to take soil samples to learn more about the soils. Perhaps you were trained as an engineer, but no one in the company had any interest or training in environmental sciences, and you were selected to do it. Maybe you are an outdoor enthusiast and from the start you wanted to work in the environmental and reclamation arena. Some of you simply stumbled onto your jobs and have stayed because you like it.

I grew up on a large farm in the Snake River Valley area of Oregon and Idaho. When I left home to attend college, the last thing I wanted to do was to work so hard again. “Life has to be easier than this,” I reasoned. “No one in his right mind would farm for a living.” I entered college to major in business administration, but I could not shake my love of the outdoors. Upon the urging of my brother, I took the class “Ecology and Living Systems” when I was a sophomore. I learned about ecosystems, their structure and function, and how each system was unique. I found that living and non-living components of that ecosystem fit together, and the species within the ecosystem filled specific roles and could be found in particular places because of their adapted traits. I also realized that the sun, water, soil, and geology were the underpinnings of the ecosystem. Wow! Suddenly, the world was less mysterious, distinct patterns were evident, and I could see them! For me, that ecology class awoke in me the yearning to work outdoors and to learn about wisely using and conserving our natural resources. This was a life-changing experience and I quickly changed my major to range science and soils. I began with big game range restoration in Utah and have worked on coal mines ever since. My passion for learning continues to grow.

Whatever your reason for being involved in mining and reclamation, I hope you find it as interesting and challenging as I do. There are myriads of questions to be answered, hundreds of ecosystems to understand and reclaim, and thousands of people that need help. Members of the American Society of Mining and Reclamation have answers to these reclamation questions, and also have the experience to apply remedial measures. Fortunately, we have several outlets for sharing our knowledge and expertise with others. So, don’t be shy about sharing your experiences. Think about the reasons you work in this field and remember why you started. At the end of the day, I suspect we all can say that we work here because we love the outdoors.
Trapper Mine is a surface coal mine located in northwestern Colorado approximately 6.5 miles south of the city of Craig. The permit area encompasses approximately 10,300 acres. Mining operations are conducted along the Williams Fork Mountains to recover multiple seams of sub-bituminous coal (9800 BTU/lb, 7.5% Ash, <0.5% Sulfur) for delivery to the adjacent Craig Power Station. Elevations at Trapper range from approximately 6,300 to 7,400 feet above mean sea level. The predominant vegetation type at the site is mountain shrub transitioning to big sagebrush in the lower elevations and aspen in the higher portions of the permit area. The average annual precipitation is 16.7 inches, with roughly one-third of this occurring as snowfall. Soils are well developed, generally deep and formed in alluvium and colluvium derived from sandstone and shale parent materials. Topographically, cultivated lowlands of winter wheat or alfalfa/native grass hay give way to rolling upland hills and long steep slopes historically used as rangeland and wildlife habitat with relatively steeper slopes occurring in the higher elevations.

Mining operations commenced at Trapper in 1977. Three Page 752 LR draglines equipped with 32-cubic-yard buckets are the primary earthmovers on the job and operate concurrently in different areas of the mine. Mining operations are oriented along the dip slope axis on slopes averaging approximately 14 percent. With coal seams dipping more steeply than the overlying topography, overburden depths range from a few tens of feet near the outcrops to approximately 160 feet at the economic limits of recovery.

Wildlife Response
During initial permitting and following the start of mining, grave concerns were raised about the devastating effects of surface mining on wildlife populations in the area. Twenty-eight years later, those concerns have proven to be completely unfounded. Here are some reasons that mining has enhanced wildlife at Trapper.

Big Game
Baseline aerial winter surveys of big game animals in the Trapper area were conducted before mining in the mid-1970s. Aerial surveys were again carried out in the mid-1980s and most recently during the winters of 1999-2000 and 2000-2001. Survey results indicate that overall big game use within the study area has increased dramatically (Table 1). Elk numbers have increased by an order of magnitude, while pronghorn antelope have increased from zero animals before mining to being a significant presence in the mine area.

Table 1. Average number of big game species before and during surface mining at the Trapper Mine.

<table>
<thead>
<tr>
<th></th>
<th>Elk</th>
<th>Mule Deer</th>
<th>Antelope</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before Mining</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1973-76</td>
<td>148</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td><strong>During Mining</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982-86</td>
<td>339</td>
<td>120</td>
<td>No data</td>
</tr>
<tr>
<td>1999-2001</td>
<td>1,568</td>
<td>92</td>
<td>43</td>
</tr>
</tbody>
</table>
Mule deer numbers have remained stable since the 1970s. Not only have big game animals increased on the Trapper Mine and surrounding area, they are preferentially selecting reclaimed lands as a forage base. A peak aerial count of nearly 4,000 head of elk was documented on Trapper reclaimed lands during December 1999. To put this figure in perspective, in some Western states, total elk populations are fewer than 4,000 head.

Trapper big game surveys convincingly refute the concerns that mining devastates big game species. To the contrary, Trapper reclamation has proven to be a magnet for big game species and has become a highly preferred foraging area (Picture 1).

**Columbian Sharp-Tailed Grouse**

Populations of Columbian sharp-tailed grouse in the western United States have diminished significantly. The species currently occupies less than 10 percent of its former range. Numerous factors, such as habitat degradation from land use changes, have contributed to this decrease. On Trapper reclaimed lands however, Columbian sharp-tailed grouse populations are thriving. In the year 2001, the average sharptail lek (strutting ground) density documented in northwestern Colorado was 0.07 leks/1,000 acres. Lek density on Trapper reclaimed lands is 1.07 leks/1,000 acres, exceeding the average value by a factor of 14. To ensure the continued success of this species, Trapper is working with the Northwest Colorado Columbian Sharp-tailed Grouse Work Group and the University of Idaho to identify specific reclamation practices that aid in favorable habitat establishment. Trapper hopes to re-establish viable populations of the Columbian sharp-tailed grouse on their areas, as well as adjacent lands.

**Other Wildlife**

Numerous other wildlife species continue to flourish in and around the mining and reclamation operation. Examples include predators such as mountain lion, black bear, badger, coyote, and red fox. Even smaller mammals are increasing like porcupines, mink, weasels, ground squirrels, deer mice, and rabbits. With increases in the mammal populations, birds of prey have grown. Waterfowl are also abundant in wet and pond areas.

A primary factor to the success of wildlife is likely the sheer productivity of the reclaimed lands as compared to pre-mining productivity. Diverse, adapted, sustainable reclaimed plant communities provide suitable forage for a wide range of species. Habitat diversity is enhanced by replacing overly mature, relatively unproductive tracts of mountain shrub community with grass dominated stands containing healthy forb and shrub elements. The “edge effect” that occurs along the margin of reclaimed lands and undisturbed plant communities provides additional landscape diversity. Micro scale features constructed on reclamation areas, including livestock water tanks and shrub islands, provide topographic diversity, thermal shelter, cover from predators, and water resources for all types of wildlife to exploit.

**Vegetation Establishment**

Vigorous reclaimed plant communities anchor the reclamation achievements experienced at Trapper. Standard methodologies for reclaiming disturbed lands are employed along with site-specific enhancements developed to maximize reclamation success.
Seed Mix Selection

Trapper utilizes diverse seed mixtures of primarily native forbs, grasses and shrubs (Picture 2). Seed mixtures and seeding methods are carefully selected to result in the most diverse reclaimed plant communities possible. Trapper has worked closely with government and academic research institutions over the years in arriving at successful methods and species selected, and the results can be seen in the wildlife use of these areas.

Mature Shrub Transplants

A Trapper reclamation goal is establishment of native shrubs on reclaimed areas for wildlife use. To attain this goal, mature shrubs are transplanted directly from areas prior to mining via front-end loader to recontoured and topsoiled areas after mining. In this fashion shrub islands are established encompassing approximately 1.6 acres. About 250 mature shrub pads (front-end-loader transplants) are placed in an island to provide optimum hiding cover for big game. The islands are established 1,400 feet apart and are normally constructed in the late fall when the shrubs are dormant. Trapper has constructed more than 30 shrub islands on reclaimed lands.

Forage Base

Available forage on reclaimed range land at Trapper is five times greater than that available in undisturbed mountain brush habitat. In spite of heavy grazing by wildlife, the forage base on Trapper reclaimed lands remains productive (average 1979-1980 pre-mining production = 56.5 g/m² versus average 2001 post-mining production = 271.2 g/m²). Productive and diverse reclaimed plant communities replace pre-mine mountain shrub communities that are generally over mature and somewhat homogeneous (Picture 3).

Erosion Control

Erosion control efforts at Trapper are particularly challenging due to the long steep slopes that characterize the site. This situation is exacerbated by the erosive nature of the unconsolidated spoil and topsoil during reclamation and before vegetation establishment. A wide variety of erosion control techniques, drainage control strategies, and soil erosion control materials have been employed over the years.

Reconstructed Drainages

Trapper has employed numerous techniques including the use of synthetic erosion control fabrics, rock check structures, brush matting, brush filters, and woody seedling transplants to stabilize and armor reclaimed channels. The application of these types of technologies at Trapper provided insight to the advantages and disadvantages associated with each technique and product. Rock check structures have proven to be both effective and economical (Picture 4). These structures are used to dissipate the energy of flowing water within the drainage channel. Debris and sediment tend to be deposited and trapped upstream of the structures, which in turn enhances the establishment of vegetation in the channels and further acts to stabilize the features (Picture 5). These materials are salvaged prior to topsoil stripping operations in an area and are utilized both to mat drainage channels and to repair erosion features that develop on the reclamation. The combination of woody stems and the small amount of topsoil recovered in the brush salvaging operation is ideal for these types of applications (Picture 6).

Water-Harvesting Diversions

Slope lengths at Trapper commonly exceed 5,000 feet, so uncontrolled runoff conveyed over these distances concentrates water and results in the formation of gullies and headcuts. Trapper constructs gently

![Picture 2: A variety of grasses, forbs, and shrubs are planted at the Trapper Mine.](image-url)
sloped, water-harvesting diversions to intercept overland flow and convey water along the contour into reconstructed drainage channels. These channels are reinforced to withstand high-volume water flow. This approach effectively reduces the slope lengths and associated erosion. Once vegetation is established, the diversion channels can be removed. Well established permanent vegetative cover (grasses, forbs and shrubs) provides long-term erosion stability required of successfully reclaimed lands.

Livestock Watering Tanks

Trapper has constructed many livestock watering tanks or stock ponds on reclaimed areas to provide watering sites for wildlife and livestock. Under pre-mining conditions, naturally occurring water sources are sparse. After reclamation, livestock watering tanks provide evenly distributed sources of water allowing animals to more fully utilize the available forage in the area.

Long-term Benefits to the Community

Trapper enjoys a sterling reputation in the community as an outstanding corporate citizen and neighbor and has earned accolades including the Governor’s Environmental Award, the Colorado Corporate Responsibility Program’s Ethics in Business Award (environmental category), and the Colorado Association of Commerce and Industry’s Colorado Company of the Year Award (energy and minerals division). These awards reflect Trapper’s unwavering commitment to the local environment and community.

In addition to the related benefits of providing steady employment and economic stability, Trapper has assisted with
Treat Acid Mine Drainage Continuously, without Power!

Don’t get eaten alive by the cost of treating acid mine drainage. Treat streams with Aquafix, an ingenious device that uses water power to continuously apply dry chemicals to flowing water.

Minimize Labor costs.
Treat water more effectively.
Treat water continuously with Aquafix.
Write or call for full details.

(304) 329-1056
(304) 329-1217 FAX
mjj@aquafix.com

www.aquafix.com

community development projects in the Craig area. Trapper was directly responsible for establishing the Trapper Health Club, a recreational facility that continues to serve the residents of Craig and the surrounding area. Significant contributions of time, equipment, people, and money were also directed toward the construction of the back nine holes of the local Yampa Valley Golf Course. Loudy Simpson Park is yet another community asset Trapper resources played an important role in establishing. Trapper has long emphasized a philosophy of giving back to the local community and proactively seeks out opportunities to do so.

Awards
Trapper’s efforts in mining and reclamation have resulted in several awards. They were recognized in 1991 with an OSM Excellence in Surface Coal Mining and Reclamation award. In 2004, they were the recipients of the OSM’s Good Neighbor “Gold” Award, along with a “Bronze” level recognition from OSM in 2002 as one of the three best examples of mined land reclamation during the first 25 years of SMCRA. They were also given a 1993 Sentinels of Safety award from the Mine Safety and Health Administration as the country’s safest surface coal mine that year. Trapper Mine is proud of its legacy of successful reclamation, community involvement, and safety.

Summary
In the final analysis, wildlife species may well be the primary direct beneficiaries of the reclamation actions taken at Trapper. Trapper is a model for mined land to be reclaimed into stable and productive acres suitable for a variety of uses including wildlife habitat, grazing, recreation, and crop production. Moreover, the surrounding community will enjoy a lasting positive future of flexible and productive land use. ■
The 2006 ASMR annual meeting will be held in conjunction with the SME Meeting, and will include additional sponsors such as ICARD, ADTI, RMRHSRC, IMWA, INAP, and MEND. The 2006 SME technical program is large and diverse with more than 1,000 presentations from the mining and construction industry, academia, and service companies. The program covers all aspects of mining and minerals for every type of professional in the following topic areas:

- Coal & Energy
- Construction Materials and Aggregates
- Environmental
- Geology
- Industrial Minerals
- Mining
- Mineral & Metallurgical Processing
- International

The Environmental Section, primarily composed of ICARD and ASMR sessions, will have a plenary session at 1 p.m. on Monday, followed by four concurrent sessions over the next 2½ days, including poster and oral sessions. The following technical sessions are organized:

- Mine Management
- Mining Legacy – Abandoned Mine Lands
- Social/Government/Sustainability Issues
- Forestry/Ecology
- Case Studies
- Characterization
- Impacts: Surface and Subsurface
- AMD Prevention and Control
- AMD Prediction
- AMD Treatment
- Pit Lakes/Backfill Issues
- Soils and Overburden
- Mine Water Issues – IMWA
- Emerging Technologies
- Closure/Land Use Issues
- Monitoring

- More than 500 exhibits will be in the huge conference center.
- Several Short Courses and Field Trips will be available for participants.
- The ASMR Social Program will involve:
  > Reception in the Exhibit Hall Sunday to view posters, March 26
  > Buffet lunch on Tuesday, March 28
  > Reception prior to the ASMR Banquet, Tuesday, March 28
  > ASMR Awards Banquet, Tuesday evening, March 28

This meeting will be well worth your time to attend. Registration materials will be in the 2006 Spring Reclamation Matters magazine. Watch for it in February 2006.

**Author Deadlines:**
Draft Papers: September 30, 2005
Final Papers: December 31, 2005
Meeting: March 26-28, 2006

Further information can be found at
http://www.smenet.org/meetings/AnnualMeeting2006/index.cfm
or http://ces.ca.uky.edu/asmr/ICARD.htm
2005 Award Winners, Scholarship Winners, and Golden Sponsor Awards

Awards

William T. Plass Award
Gerald Schuman • High Plains Grasslands Res. Sta.

Reclamationist of the Year
William R. Kirk • Coteau Properties Co., ND

Reclamation Researcher of the Year (Tie)
Dr. Peter D. Stahl • University of Wyoming

Special Awards
Dr. Donald H. Graves • University of Kentucky

Reclamation Researcher of the Year (Tie)
Dr. Jon Bryan Burley • Michigan State University

Membership Recruiter Award
Jeff Skousen
A Special Thanks Goes Out to Terry Toy for Chairing the Organizing Committee for the Meeting.

Scholarships • Memorial Scholarship Recipients

Recipient for 2004, MS
Abbey Wick • University of Wyoming

Recipient for 2004, PhD
William J. Andrews • Oklahoma University

Golden Sponsor Awards

Paul Kos Accepting Golden Sponsorship for Applied Hydrology International

Brenda Schladweiler accepting Golden Sponsorship for BKS Environmental Associated

Jamie Salisbury accepting Golden Sponsorship for Western States Reclamation

Vern Pfannenstiel accepting Golden Sponsorship for Peabody Western Coal Co.
2005 Meeting Exhibitors

Western States Reclamation

USGS

Truax

ACZ Laboratories Inc.
www.acz.com

Arkansas Valley Seed
www.seed solutions.com

Bowman Construction Supply
www.biosol.com

Applied Hydrology Intern.
pkos@appliedhydrology.com

Bitterroot Restoration
www.bitterrootrestoration.com

Colorado Division of Minerals and Geology
http://mining.state.co.us

Aqua Fix
www.aquafix.com

Granite Seed Company
www.graniteseed.com

BKS Environmental Association
www.bksenvironmental.com
Reclamation of Abandoned Coal Mine Wastes Using Lime Cake Byproducts in Korea

J. Yang is at the Division of Biological Environment, Kangwon National University, Chunchon, Korea; J. Skousen is at West Virginia University, Morgantown, WV, USA; Y.S. Shim, J.P. Kim, K.S. Nam, Y.C. Lim, S.W. Choi, C.H. Won, and J.M. An are at the Coal Industry Promotion Board (CIPB), Chongro-Gu, Seoul, Korea.

Introduction

In Korea, more than 300 coal mining operations have been closed or abandoned since the late 1980s due to the depression of the mining industry. Most of these mined areas are located in steep mountain valleys along the eastern coast of South Korea (Picture 1). Enormous amounts of coal mine waste have been left and abandoned on slopes and acid mine drainage (AMD) from waste piles and associated mine portals has been discharging directly to streams, causing detrimental effects on soil and water qualities (Picture 2). The environmental disruptions caused by the closed mines are very serious in Korea.

The Coal Industry Promotion Board in Korea has spent more than $15 million (U.S.) annually to remediate the mine-related damages and to improve the environment. Most of the costs are directed to passive AMD treatment and forest restoration. However, the investment has not been very effective due to the large number of sites, large amounts of AMD, and budget limitations.

A lime byproduct (lime cake) is waste material produced from the Solvay process in manufacturing soda ash. In Korea, more than 3 million tons of lime cake are stock piled. This material has been used in the past to reclaim disturbed lands, but due to recent concerns from environmental groups the lime cake has not been used in reclamation and remains in stockpiles with no plan for proper disposal. The lime cake has very fine particles, low hydraulic conductivities (10^-8 to 10^-9 cm/sec), high pH, and high EC due to the presence of CaO, MgO, CaCl₂ and NaCl as major components (Yang et al., 2002). Due to these physical and chemical properties, the lime cake has potential to be used as a neutralizer for acid-producing materials. The objectives of this research were to determine the effectiveness of using lime cake for reclamation.
Materials and Methods

Ten treatments were installed on a large, abandoned coal waste pile to test the application of the lime cake for reclamation of these piles (Picture 3). The slope of the coal waste site was 29 degrees (56 percent). Each plot was 20 x 5 m (L x W) in size and separated by plastic boundaries. Table 1 contains the plot number and treatments. The lime requirement (LR) for the coal waste was determined and lime cake treatments consisted of 25 percent, 50 percent and 100 percent of the LR. The lime cake and calcite were either layered between the coal waste and topsoil or mixed with coal waste and topsoil. Each plot was hydroseeded with grasses and planted with trees. Surface coverage by grasses was determined by computer image analysis.

In each plot, a flume and gutter were connected to a water reservoir to collect all the runoff and leachate from each plot (Picture 4). Three pipes, 5 cm in diameter, were buried in each plot and connected to the reservoir to collect the leachate. Chemical properties such as pH and ion concentrations of the runoff and leachate were analyzed periodically. Efficiency of the lime cake in coal waste reclamation was assessed based on surface cover by plants, neutralization of runoff and leachate, and soil quality.

Table 1. Treatment design and revegetation on the coal waste pile.

<table>
<thead>
<tr>
<th>Plot Number</th>
<th>Treatments</th>
<th>Lime Treatment Methods</th>
<th>Vegetation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coal waste only</td>
<td></td>
<td>Grass and trees</td>
</tr>
<tr>
<td>2</td>
<td>Coal waste + Lime cake (LR 100%)</td>
<td>Mixed</td>
<td>Grass and trees</td>
</tr>
<tr>
<td>3</td>
<td>Coal waste + CaCO3 + topsoil</td>
<td>Layered</td>
<td>Grass and trees</td>
</tr>
<tr>
<td>4</td>
<td>Coal waste + CaCO3 + topsoil</td>
<td>Mixed</td>
<td>Grass and trees</td>
</tr>
<tr>
<td>5</td>
<td>Coal waste + Lime cake (LR 100%) + topsoil</td>
<td>Layered</td>
<td>Grass and trees</td>
</tr>
<tr>
<td>6</td>
<td>Coal waste + Lime cake (LR 100%) + topsoil</td>
<td>Mixed</td>
<td>Grass and trees</td>
</tr>
<tr>
<td>7</td>
<td>Coal waste + Lime cake (LR 50%) + topsoil</td>
<td>Layered</td>
<td>Grass and trees</td>
</tr>
<tr>
<td>8</td>
<td>Coal waste + Lime cake (LR 50%) + topsoil</td>
<td>Mixed</td>
<td>Grass and trees</td>
</tr>
<tr>
<td>9</td>
<td>Coal waste + Lime cake (LR 25%) + topsoil</td>
<td>Layered</td>
<td>Grass and trees</td>
</tr>
<tr>
<td>10</td>
<td>Coal waste + Lime cake (LR 25%) + topsoil</td>
<td>Mixed</td>
<td>Grass and trees</td>
</tr>
</tbody>
</table>

*Grasses: Orchard grass (Dactylis glomerata), Kentucky Bluegrass (Poa pratensis) and Eulalia (Miscanthus sinensis); Trees: Pine tree (Pinus densiflora), Birch (Betula platyphylla) and Alder (Alnus firma)
LR: Lime requirement as CaCO3

Table 2. Chemical characteristics of the lime cake, coal wastes, and topsoil.

<table>
<thead>
<tr>
<th>Sample</th>
<th>pH (1:5)</th>
<th>EC (1:5)</th>
<th>OM</th>
<th>P2O5</th>
<th>LR</th>
<th>Exchangeable Ca</th>
<th>Mg</th>
<th>K</th>
<th>Na</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dS m⁻¹</td>
<td>g kg⁻¹</td>
<td>mg kg⁻¹</td>
<td>Mg ha⁻¹</td>
<td>-----</td>
<td>cmolₑ kg⁻¹</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Lime Cake</td>
<td>11.2</td>
<td>19.6</td>
<td>8.3</td>
<td>7.9</td>
<td>-</td>
<td>233</td>
<td>50.2</td>
<td>2.3</td>
<td>77.9</td>
</tr>
<tr>
<td>Coal Waste</td>
<td>3.5</td>
<td>0.2</td>
<td>16.5</td>
<td>9.1</td>
<td>16.5</td>
<td>4</td>
<td>0.3</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Topsoil</td>
<td>6.5</td>
<td>0.1</td>
<td>0.8</td>
<td>15.7</td>
<td>0.4</td>
<td>4</td>
<td>0.5</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

OM: Organic matter based on the loss on ignition (LOI)
LR: Lime Requirement (as CaCO₃)
Results and Discussion

Chemical Properties of the Coal Waste, Lime Cake and Topsoil

The pH of coal waste was 3.5, and 16.5 Mg of CaCO₃ per ha (7.3 tons/ac) (table 2) were needed to adjust the pH to 7.0. The lime cake was high in bases such as Ca, Mg and Na with a high pH (11.2) and high electrical conductivity (EC: 19.6 dS m⁻¹). The topsoil was obtained from a nearby road cut and was low in fertility.

Effects of Lime Cake on pH of Coal Waste

The pH of the coal waste was 3.5 but increased to 7.5 when mixed with lime cake without the topsoil (plot 2) (Figure 1). However, plots treated with CaCO₃ and lime cake either layered or mixed with the lime requirement of 25%, 50% and 100% (plots 3 to 10) were stabilized at about 6.0 irrespective of the amounts of lime cake. This might be due to the pH buffer capacity of the topsoil. The neutralizing effects of lime cake were equivalent to the calcite. This result indicated that coal waste had less buffering capacity for pH than the topsoil. Thus, the combined treatment of lime cake with topsoil neutralized the acidic coal waste.

Effects of Lime Cake on Chemical Properties of Runoff and Leachate

Figure 2 shows the pH of the runoff and leachate collected in the tanks at the bottom of experimental plots. Data were averaged over measurements from April to August. The runoff pH of the coal waste was 4.3 but increased significantly to the range of 6.7 to 7.1 with treatments of calcite and lime cake. There were no significant differences in runoff pH among treatments of calcite and lime cake, layered or mixed, or amounts of lime cake. This is due to the combined effects of lime cake and buffering capacity of the topsoil.

Table 3. Vegetation cover percentage at each treatment plot during June to August.

<table>
<thead>
<tr>
<th>Treatment Plots*</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>26</td>
<td>22</td>
<td>30</td>
<td>25</td>
<td>26</td>
</tr>
<tr>
<td>August</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>27</td>
<td>46</td>
<td>46</td>
<td>40</td>
<td>37</td>
<td>37</td>
<td>46</td>
<td>53</td>
<td>61</td>
</tr>
</tbody>
</table>

*Refer to Table 1 for the treatment combination.
Vegetation cover was around 50% after the first growing season on the coal waste plots treated with lime cake by-products and limestone.

Initial Al concentrations in the runoff ranged from 30 to 60 mg/L, but those levels were sharply decreased with time to less than 2 mg/L (Yang et al., 2004). Concentrations of Fe in the runoff fluctuated with date and precipitation, but decreased from around 10 mg/L initially to <1 mg/L with lime cake treatments.

**Effects of Lime Cake on Revegetation of the Coal Wastes**

Table 3 shows the percentage of grass cover in each treatment plot during June to August (Pictures 5 and 6). Seeding of orchard grass (*Dactylis glomerata* L), Kentucky bluegrass (*Poa pratensis* L) and Eulalia (*Miscanthus sinensis* Anderss) were done at the end of May. The grasses covered only 16 percent of the coal waste plot in June but the cover increased with time to 33 percent in August. Growth of grasses was enhanced with the combined treatments of lime cake and topsoil (plots 5 to 10). The increase in surface cover from June to August was higher with the 25 percent lime cake treatments (plots 9 and 10), which is probably related to the high salt content of the lime cake. Bioassay tests in the greenhouse revealed that seed germination of these grasses was highest when lime cake was applied at 25 percent of the lime requirement (LR) but germination was significantly suppressed at the 50 percent and 100 percent treatments. The results suggest that high salts content of the lime cake might be a limiting factor in revegetation of coal waste.

**Summary**

Field plots were used to test the effects of the lime cake on the reclamation of coal wastes by examining the chemical qualities of soil and water (runoff and leachate) and surface cover of grasses. Lime cake treatments increased the pH of the coal waste from 3.5 to 6, and raised the pH of runoff and leachate from coal waste from 4.3 to 6.7. Concentrations of Al and Fe in the runoff and leachate were significantly decreased with lime cake. Surface cover of grasses on coal waste was significantly increased with the lime cake. The amount of lime cake at 25 percent of the lime requirement was sufficient to neutralize the acidic coal waste and allowed germination of grasses. Either layering the lime cake between the coal waste and topsoil or mixing with coal waste could be adopted as reclamation methods. The combined treatment of lime cake and topsoil is recommended for revegetation in the coal waste piles.

**References**


First Announcement and Call for Papers

June 6 - 9, 2006 in Billings, Montana

Reclamation: Supporting Future Generations

The Billings Land Reclamation Symposium is an established conference with a 25-year history emphasizing innovations in public policy, mining, reclamation, and land management issues. The General Program Committee invites the submission of abstracts for oral presentation during technical sessions. For more information go to: http://billingslandreclamationsymposium.org

Technical Sessions / Workshops / Field Tours

- Hydrology
- Soils and Overburden
- Engineering
- Wildlife/Fisheries
- Natural Resource Damage
- Tools/Statistics
- Revegetation
- Land Use/Design
- Coal Bed Methane
- International Perspectives
- Case Studies
- Superfund Remedy

Stormwater BMPs • Passive Water Treatment • Trend Analysis & Environmental Decision Making • Soil Ecology • Geomorphic Design • Monitoring Techniques – Soils, Vegetation, Water, Wildlife • GIS/GPS/Mobile Computing • Ecological Engineering • Landscape Stability • Principles of Successful Riparian Remediation/Restoration • Invasive Species Management • Restoration in Yellowstone Park • Coal Bed Methane/Coal Reclamation • Reclamation at the Only Active Platinum/Palladium Mine in the United States • Roadside Revegetation • Reclamation and Restoration on the Boulder River Priority Watershed and the Upper Clark Fork River Superfund Sites • Watershed Restoration/Reclamation • Acid Rock Drainage • TMDLs • Aquatic Health • Refuse Tailings Management • Geochemistry • Carbon Sequestration • Bond Release • Water Quality • Success Criteria • Innovative Techniques • Bioengineering • Phytoremediation
The Appalachian Regional Reforestation Initiative: A Partnership To Promote Reforestation of Mined Lands

The goal of planting more native hardwood trees on active and abandoned coal mines in the Appalachian region is one step closer to reality.

Getting more hardwood trees planted on coal-mined lands is the goal of an agreement signed Dec. 15, 2004 by a broad-based partnership including the coal industry, the federal government, and seven Appalachian states.

Meeting to sign the agreement at Stone Wall Jackson Lake State Park in West Virginia—the heart of Appalachian coal country—were representatives of the U.S. Office of Surface Mining (OSM); the U.S. Forest Service; the federal Department of Energy; the Appalachian coal mining states of Kentucky, Maryland, Ohio, Pennsylvania, Tennessee, Virginia and West Virginia; the coal industry; environmental organizations; land companies; and academia (Picture 1).

Together they form the Appalachian Regional Reforestation Initiative (ARRI). The Statement of Mutual Intent creates a new state and federal project to promote and encourage the reforestation of coal mined lands.

“We’re here to share our experience,” said Butch Lambert of the Virginia Department of Mines, Minerals and Energy. “We’re here to make a commitment to promote reforestation, to develop an initiative through which we can get coal companies involved in planting more trees - and not just more trees, but more viable and valuable trees.”

“Over the last 50 years of surface mining in Appalachia, the vast majority of mined land was originally forest,” said Brent Wahlquist, director of OSM’s Appalachian Regional Office. “It is our hope that through this initiative, perhaps 50 or 100 years from now it will be forest again, and be virtually indistinguishable from the rest of the landscape” (Picture 2).

Reforestation of coal-mined lands has the potential to provide many environmental and economic benefits. Environmental benefits include diversity of plant species, natural succession of native forest plants, enhanced wildlife habitat, soil and water conservation, improvement of overall water quality, and carbon sequestration. Economic benefits are also made possible by reforestation. They include increased timber value; landowner tax reductions; enhanced recreational opportunities; jobs for the local economy; and local tax revenue.

Reforestation provides an environmentally and economically viable post-mining land use option for both the landowner and the mining company.

A core group of the ARRI began meeting in May to address ways to increase the planting of more high-value Appalachian hardwood trees on active and abandoned coal mines through the use of Forestry Reclamation Approach (FRA) technology. This reclamation
technology will provide for the sound restoration of healthy productive forest on mined lands in the Appalachian region.

The Forestry Reclamation Approach steps are:

- Create a suitable rooting medium for good tree growth that is no less than four feet deep and comprised of topsoil, weathered sandstone, or the best available material.
- Loosely grade the topsoil or topsoil substitute to create a non-compact ed growth medium.
- Plant native and non-competitive ground covers.
- Plant two types of trees; early succession species that provide for wildlife enhancement and soil stabilization, and commercially valuable crop trees.
- Use proper tree planting techniques.

These forestry reclamation steps are based in academic research and practical experience, including that done initially by Dr. Clark Ashby, formally of Southern Illinois University and Willis Vogel, formerly of the U.S. Forest Service. Currently research is ongoing at the Starfire Reforestation Project through the University of Kentucky under the direction of Dr. Donald Graves (Picture 3), at the Powell River Project in Virginia led by Dr. James Burger of Virginia Tech, and at West Virginia University by Dr. Jeff Skousen.

Individuals who signed the agreement for their organizations were:

Brent Walquist, OSM Appalachian Region
Reed E. Detring, National Park Service
D. Michael Baines, USDA Forest Service
Lee Barclay, U.S. Fish and Wildlife Service
David Ledfox, Rocky Mountain Elk Foundation

For more information on the Appalachian Reforestation Initiative, please see our Web site at http://arri.osmre.gov.

Or contact: Patrick Angel, Office of Surface Mining (606) 878-6440
VISIT THE ASMR WEB SITE!
http://ces.ca.uky.edu/asmr
New Membership Application Form 2006

❑ Dr.  ❑ Prof.  ❑ Mr.  ❑ Miss  ❑ Ms  ❑ Mrs.

Name: _________________________________________________________________________________________________

Job Title: _______________________________________________________________________________________________

Company, University, Agency, etc.: _______________________________________________________________________

Preferred Address:
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

Second Address (optional):
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

E-mail address: _________________________________________________________________________________________

Business Phone: (______) ______________________ Home Phone (optional): (______) ______________________

Business Fax: (______) ______________________ Mobile Phone (optional): (______) ______________________

Technical Div. 1st choice 1 ___________________________ Technical Div. 2nd choice ___________________________

Technical Div. 3rd choice __________________________

Professional Certification 2 1st __________________________

Professional Certification 3 2nd __________________________

Professional Certification 4 3rd __________________________

Were you referred 5 by a current ASMR Member? If yes, enter their name here. ________________________________

Footnotes
1 Choices include Ecology, Forestry and Wildlife, Geotechnical Engineering, International Tailings Reclamation, Land Use Planning and Design, Soil and Overburden and Water Management.

2 Include states certified if appropriate.

3 Include states certified if appropriate.

4 Include states certified if appropriate.

5 This person will receive credit for the membership contest.
2005 Subscriptions Available to Members at No Charge in Addition to our Magazine – Reclamation Matters. Also one copy of the CD of Proceedings from the past meetings is complementary, choose one of the following:

- 1990
- 1994
- 1996
- 1997
- 2002
- 2003
- 2004
- 2005

**You must check the appropriate boxes to keep receiving these publications:**
- Inside Coal (Quarterly, So. Illinois University)
- FIPR newsletter (Florida Inst. Phosphate Res.)

<table>
<thead>
<tr>
<th>Membership Class</th>
<th>Advanced Payment</th>
<th>Lifetime Membership</th>
<th>No. Years</th>
<th>Total Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annual Dues</td>
<td>Per Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regular</td>
<td>$50</td>
<td>$50</td>
<td>$500</td>
<td></td>
</tr>
<tr>
<td>Sustaining Member</td>
<td>$100</td>
<td>$100</td>
<td>$1,000</td>
<td></td>
</tr>
<tr>
<td>Corporate Member</td>
<td>$100</td>
<td>$100</td>
<td>$1,000</td>
<td></td>
</tr>
<tr>
<td>Full-time Student</td>
<td>$10</td>
<td>$10</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Part-time Student</td>
<td>$25</td>
<td>$25</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

Memorial Scholarship Donation (Tax deductible receipt will be mailed to you)

*With a donation > $25, a CD of Stu Bengson slides will be sent in appreciation of your gift.*

**Membership Dues**

**Other Publications**

<table>
<thead>
<tr>
<th>Publication</th>
<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecological Restoration – Individual (Includes online access)</td>
<td>$43</td>
<td></td>
</tr>
<tr>
<td>Foreign Individual (Surface) (Includes online access)</td>
<td>$53</td>
<td></td>
</tr>
<tr>
<td>(Air Mail) (Includes online access)</td>
<td>$78</td>
<td></td>
</tr>
<tr>
<td>Intern. J. of Surface Mining &amp; Reclamation (16 more pages in 2004)</td>
<td>$123</td>
<td></td>
</tr>
<tr>
<td>Land and Water – USA</td>
<td>$15</td>
<td></td>
</tr>
<tr>
<td>Foreign</td>
<td>$27</td>
<td></td>
</tr>
<tr>
<td>Northwest Mining Association Bulletin</td>
<td>$10</td>
<td></td>
</tr>
<tr>
<td>Mine Water &amp; the Environment (4 issues/year + Membership in IMWA) Subscriptions end March 31</td>
<td>$40</td>
<td></td>
</tr>
</tbody>
</table>

**Subscription Total**

<table>
<thead>
<tr>
<th>Item</th>
<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASMR hats with logo white mesh $15, solid tan</td>
<td>$16</td>
<td></td>
</tr>
<tr>
<td>ASMR shirts M, L, and XL $25 &amp; XXL and XXXL</td>
<td>$30</td>
<td></td>
</tr>
</tbody>
</table>

**Add $5.00 if payment by credit card**

**Grand Total (Dues, Subscriptions, etc.)**

- MasterCard
- Visa

Card Number (   -   -   -   )  Expiration Date (   /   )

Name as appears on card (Please print) _________________________________ Signature _____________________________

Make checks payable to: **American Society of Mining and Reclamation or ASMR in U.S. Dollars.**

Send to

**American Society of Mining & Reclamation**

3134 Montavesta Road, Lexington, KY 40502-3548

For questions, call (859) 351-9032 or email asmr@insightbb.com
Index to Advertisers

Applied Polymer Systems, Inc. ............... IBC
Aquafix Systems Inc. ................................ 7
Arkansas Valley Seed Solutions .................... 17
BKS Environmental .................................. 17
Bowser-Morner ....................................... 36
Brockton Equipment Spilldam Inc. ............... IBC
Burns & McDonnell ................................ 24
California Straw Works .............................. 13
Caudhill Seed Co. ..................................... IBC
CRC & Associates .................................... 20
Earth Saver ............................................. IFC
Environmentally Innovative Solutions, LLC .......... OBC
Ernst Conservation Seeds ........................... 5
Foam Concepts ....................................... 20
Marshall Miller & Associates ...................... 36
Nedia Enterprises, Inc ............................... IFC
Peabody Energy ....................................... IFC
Rain For Rent ......................................... 21
Rocky Mountain Bio Products .................... 13
Skelly and Loy, Inc. ................................... 24
SuperTree Seedlings .................................. 15
Wind River Seed ...................................... 36

For advertising opportunities, call (866) 953-2189
The Floc Log is one of the most innovative approaches for using polymer-coagulant blends in water applications. The Floc Log eliminates the need for machinery or other electrical devices needed for pumping or mixing when using liquid materials to treat turbid water.

* NPDES Phase 2 certified
* Outperforms PAM or chitosan.
* Reduces turbidity, metals and TMDLs.
* Non-toxic (48, 96 and 168 hr acute and chronic toxicity data available on each product.)

For free soil and water sampling, please call 678-494-5998. Visit our website and case histories at www.siltstop.com

Floc Log®

Floc Log is a registered trademark of Applied Polymer Systems, Inc.
EIS consists of several member companies that offer complete “turn-key” environmental services to private industry, government agencies, and non-profit organizations. We can guide your project from its inception to completion.

EIS specializes in resolving mine drainage issues including: permitting, design and construction of active and passive treatment systems, developing highly diverse wetlands for mitigation and wildlife habitat, establishing post-mining trust funds, and the operation, maintenance, and retrofitting of existing treatment systems.

Performance guarantees are available dependent upon monitoring and site data.

Let our experienced professionals find the right solution for your water quality issues.

For more information, visit us on the web at www.eisadvantage.com.

The EIS Advantage:
- Turn-Key Capability
- Assessment
- Design
- Permitting
- Construction
- Monitoring & Retrofitting
- Performance Guarantees
- Patent Pending Methods
- Public Relations

200 Neville Road
Pittsburgh, PA 15225
Phone: (724) 458-6167
Fax: (412) 777-6684
Email: info@eisadvantage.com

Member Companies
Aquascape
BioMost
Dolence Consulting
Quality Aggregates
Stream Restoration
Dave Jessloski, Director
Tim Danelly, COO
Robert C. Dolence, CEO
Jeff Ankrom, Vice President
Margaret Dunn, PG, President