WEDNESDAY, APRIL 29, 2009

SESSION 1: ADVANCES IN GEOMORPHIC RECLAMATION

Chairperson: Roger Calhoun, Office of Surface Mining, Charleston, West Virginia

A Geomorphologist's Perspective on Stream Restoration in Mined Land

Dr. J. Steven Kite, *West Virginia University, Morgantown, West Virginia*

The combative debate over stream restoration practices has taken place outside of coal-mined watersheds. As in the case in many urban watersheds, "allowing nature to take its course" is not an environmentally viable option for most mined-lands streams. Watershed impacts are so great and constraints so pervasive as to demand aggressive intervention.

Mined lands present both a challenge and an opportunity to the science and practice of stream restoration. The cumulative landscape impacts of surface coal mining are phenomenal. The volume of overburden and coal exhumed in Appalachian Basin surface mining each year roughly equals the 1.01 cubic km of volcanic ash generated by the 1980 Mt. St. Helens eruption. Coal mining in the Powder River Basin removes comparable volumes of rock. Denudation can be six or seven orders of magnitude faster than prehistoric rates determined by cosmogenic dating, yet mining practices are driven by cost efficiency and well-intentioned, short-sighted regulations, not by insights into long-term stability of a sediment legacy that will last for hundreds of millennia.

The greatest disturbance occurs in area mining, including the southern Appalachian practice of mountain-top mining and valley filling. Mountain-top relief can be reduced by up to 100 m, while valley fills may exceed 200 m. Filled valleys may be as high as 3rd order, as defined by geomorphological criteria, and well-integrated, runoff-dominated stream networks give way to subsurface flow through deep fills. Results of "nature's experiments" on how valley fills hold up under > 100 mm (>4 inch), 24 hour rainfall have been disappointing, especially fills built from shale and siltstone parent material.

Contour mining also greatly alters hydrology, sediment transport, and stream ecology. Post SMCRA (1977) reclamation has not eliminated negative impacts; approximate original contour (AOC) reclamation does not yield natural streams. Post-reclamation drainage networks may be poorly integrated, with disconnected sediment transport and ecological functions. Neither AOC reclamation nor remediation of abandoned pre-SMCRA mines prove stable under intense rainfall. In fact, AOC mining in the steep Southern Appalachian Coal Fields would present unacceptable deadly debris-flow and hyper-concentrated flood risks to downstream communities.

The best interest of streams would be served if we move past the debate over mountain-top mining *vs*. AOC reclamation, and rebuilt the practice of surface-mine reclamation from the ground up. A watershed-based perspective is essential for reclamation to yield functioning streams, but reach-based practices, including in-stream structures, will be invaluable. Maintaining stream flow across permeable fills may be impractical, but drainage practices can be revised to allow better sediment and organic matter transport. GPS-based mining should allow creation of "designer" mined-land topographies that are more geomorphologically functional, while minimizing overburden hauling distances and costs of production.

Science Basis for Reclamation of Low-Order Streams

Dr. Peter R. Wilcock, *Geography and Environmental Engineering**,** Johns Hopkins University, Baltimore, Maryland*

Most stream channel design is based on analogy. A template is sought in a nearby or idealized channel that the designer judges to be suitable. The science basis for such an approach is weak. There is little definitive guidance for the choice of template, nor does it provide a basis for linking cause and effect in a logically complete and testable framework. In the uncommon event that a stream has experienced only a local disturbance (typically livestock grazing or forest road construction), a template argument may be plausible, but cannot be shown to be correct. A scientific approach to stream design must explicitly incorporate the essential drivers including: the supply of water; sediment; nutrients; and organisms in a predictive, testable framework linking: drivers; objectives; design; and predicted outcomes. The tools available for an explicit, predictive design process have advanced in recent years, particularly in linking water and sediment supply to the physical performance of the channel. Yet, particular challenges remain. Forecasts of sediment supply remain difficult, time consuming, and highly uncertain. Improved guidance for selecting a design discharge awaits explicit connections between the physical and ecological components of the project. Uncertainty is rarely accounted for in channel design. The largest unmet challenge in stream restoration design is predicting ecosystem structure and function from stream hydrology and geomorphology. Trends and constraints are emerging, but predictions of ecosystem response to design choices are generally not possible. Stream design in mine reclamation has some parallels to restoration following a local disturbance such as grazing: in either case, putting the stream back the way it was is a plausible if unsubstantiated hypothesis. However, *de novo* construction of a reclaimed stream faces extra challenges: which elements must be replicated and how does one know if the list is sufficiently complete? If a pre-disturbance or undisturbed template is used to replicate the gross appearance of the stream, what assurance is there that the biogeochemical and ecological functions and populations will be restored? Of particular concern in a reconstructed valley bottom would be the interaction between surface and subsurface flow in the maintenance of stream temperature and water quality. Development of a science-based restoration practice will require close collaboration through which research results find their way into practice and practice helps define the most pressing research priorities.

Hydrological Functioning of Surface-Mined Watersheds in Western Maryland: Restoration or Reclamation?

Dr. Keith N. Eshleman *and Brian C. McCormick, M.Sc., P.E., Appalachian Laboratory, University of Maryland Center for Environmental Science, Frostburg, Maryland*

The Surface Mining Control and Reclamation Act (SMCRA) of 1977 (Public Law 95-87) requires that lands surface-mined for coal must be re-graded to approximate original contours, re-vegetated, and reclaimed in a way that minimizes the disturbance to the prevailing hydrologic balance at the mine site and to associated offsite areas. Despite the passage of more than 30 years since SMCRA was signed into law, relatively few experimental studies have quantified the extent to which the hydrologic balance and functioning of mined sites and downstream systems are affected by surface mining and reclamation. Currently, engineers employ mathematical models that prescribe the runoff response of mined lands in designing and sizing hydraulic conveyances, erosion and sediment control devices, and storm water management structures in an effort to meet these statutory requirements. Yet it is uncertain whether these relatively simple models accurately predict the actual hydrologic response of lands once mining and reclamation have been completed. Our research addresses the following five questions:

- *What changes in the hydrologic balance of mined lands (and the watersheds within which they are located) can be identified and attributed to surface mining?*
- *Is normal hydrological functioning of these lands typically restored by current reclamation practices?*
- *How well does the SCS-CN method accurately predict the storm runoff responses of lands that have been mined and reclaimed?*
- *Is the SCS-CN method biased in any way?*
- *How might we improve land reclamation practices in a way that would reduce disturbances to the hydrologic balance both on-site and to the watershed within which the mining has occurred?*

We address these questions using experimental data (i.e., rainfall and runoff) collected as part of a comparative hydrological investigation of a group of four small sub-watersheds located within the Georges Creek watershed in Allegany County, Maryland. Three of the experimental subwatersheds were at least partially mined and reclaimed, while one of the watersheds is un-mined and covered with natural forest. Our analysis focuses specifically on: (1) quantifying and understanding the stormflow responses of the mined and un-mined sub-watersheds to rainfall; and (2) determining the extent to which the widely-used SCS-CN method (originally developed by USDA for use in agricultural watersheds) adequately predicts the storm flow responses of mined lands in western Maryland. In addition, we also describe the results of some statistical analyses of flooding responses in the Georges Creek watershed and our efforts to detect temporal trends and a relationship to historical surface mining at the larger river basin scale.

Disturbed Land Reclamation Using Geomorphic Techniques: McKinleyCoal Mine, New Mexico, Mining Area 12C

*Richard Spotts, P.E., Water and Earth Technologies, Inc. (WET); Marie Shepherd, P.E., Chevron Mining Inc.; **Melissa Robson**, E.I., & Ryan Wade, E.I., (WET) Fort Collins, Colorado; and Wayne Erickson, CPESC, Habitat Management, Inc.*

The disturbance footprint typical of a surface coal mine consists of large piles of overburden spoiled in the process of coal removal. These spoil piles can be over 100 feet high and are typically comprised of uncompacted materials that can be easily moved and reshaped with heavy earthmoving equipment. Fluvial geomorphic post-mining topography ("PMT") designs must: (1) Aesthetically blend reclaimed surfaces into adjacent undisturbed lands; (2) Account for run-on from up-gradient watersheds; (3) Control reclamation costs by using available soil materials (optimize cut/fill balance); (4) Establish reconstructed soil depths adequate to support growth of desired vegetation communities; (5) Produce a stable landform; and (6) Reconstruct adequate drainage features.

Chevron Mining Inc.'s McKinley Mine is located about 27 miles west northwest of Gallup, New Mexico. Mining Area 12C presents unique PMT stability challenges that require the application of a geomorphic PMT design approach. This area is comprised of 20 acres of steeply sloping material with a southwest facing aspect. At McKinley Mine, steep southwest facing slopes pose unique challenges in reclamation, because vegetation density is typically low and root-mass establishes slowly, conditions that hinder slope stability. Other challenges specifically encountered in this area include: (1) the presence of an undisturbed rock outcrop at the lower end of the slope; (2) the operational need to limit bulldozer push distances under 200 feet; (3) the goal to obtain a cut-fill balance over the entire acreage and within individual sub-watersheds; and (4) the need to provide interim stability immediately after construction and prior to vegetation cover establishment.

A state-of-the-art fluvial geomorphic PMT design method to reclaim steep slopes is presented and contrasted with traditional draining terracing methods previously used at the mine. Potential construction and maintenance cost savings associated with this fluvial geomorphic PMT design method are identified.

Tools for Integrating Geomorphic Reclamation into Planning for Eastern Coal Surface Mines

Dr. Charles Yuill *and Michael Hasenmyer, Natural Resource Analysis Center, Environmental Design Visualization Group, West Virginia University, Morgantown*

Geomorphic reclamation concepts and methods have not had wide application to active coal surface mines in the eastern United States. However, such methods are now widely applied in the region for applications such as stream restoration, highway impacts reduction and mitigation, and abandoned mine reclamation. A variety of conditions account for this lack of application in active mining including: the steep slope topographic conditions of the Appalachians; typically utilized mining methods and equipment; post-mining reclamation land use objectives; and compliance with regulations that do no strongly encourage alternative reclamation methods. However, with careful integrated mining methods, reclamation, and post-reclamation land use planning, geomorphic reclamation methods can be effectively applied in eastern mining, particularly for mountaintop mining areas.

This paper addresses the integration of a variety of tools that are under development that were introduced two years ago at the previous Geomorphic Reclamation Meeting held in New Mexico. These tools and methods are being integrated into a potential framework for improved mining/reclamation/post-mining land use planning for mines in the Appalachian region. The tools include software for high-fidelity environmental visualization, landform shaping and evaluation that are integrated in a comprehensive GIS environment. The tools also include an involving framework for pre-mining and potential post-mining landform classification and analysis. The tools are being refined as a toolset for conducting applied mining/reclamation research and not necessarily as an off-the-shelf set of software and methods. Application to a couple of case study sites in the Central Appalachians will also be presented.

SESSION 2: GEOMORPHIC RECLAMATION IN APPALACHIA

Chairperson: ***Craig Walker****, Office of Surface Mining, Knoxville, Tennessee*

Challenges of Applying Geomorphic and Stream Reclamation Methodologies to Mountain-Top Mining and Excess Spoil Fill Construction in Steep-Slope Topography (e.g. Central Appalachia)

Peter Michael and ***Lois Uranowski****, Office of Surface Mining, Pittsburgh, Pennsylvania and* ***Mike Superfesky****, Office of Surface Mining, Morgantown, West Virginia*

Proponents of geomorphic mine land reclamation have criticized current reclamation practices in the coal fields of steep-sloped central Appalachia as being too narrowly focused on civil engineering principles. They have been criticized for being neglectful of the functional and aesthetic benefits of reclaiming mine sites in ways that mimic natural landforms and drainage patterns. These critics observe that current mining and reclamation practices are radically transforming the mountain-and-valley terrain into gigantic flat plateaus and, in so doing, disrupting the beauty and ecology of the natural landscape. Instead of designing and constructing linear or planar surfaces and unvarying slope gradients during the reclamation process, they recommend “landforming.” “Landforming” would provide for the adoption of curvilinear, compound slope forms that blend well with the surrounding physiography and represent the result of naturally stabilizing geomomorphic processes. The authors feel that the concept of geomorphic mine land reclamation is sound, however, its application to the central Appalachian coal fields faces significant--albeit not insurmountable--challenges. These challenges include: (1) existing reclamation-enforcement regulations that are focused on civil engineering principles and not explicitly supportive of geomorphic methodologies; (2) regulatory agencies’ current intent to limit the down-gradient reach of excess spoil fills in order to allay disruption or burial of natural streams; (3) actual or perceived increases in reclamation costs; and (4) the challenge of designing and constructing “natural” landforms that are mature and stable in an otherwise youthful, erosional landscape.

Can Appalachian Mine Reclamation be called Sustainable using Current Practices?

Nicholas Bugosh*, Carlson Software, Ft. Collins, Colorado*

Modern mining methods can drastically change landforms in the project area. Mine reclamation goals have advanced from merely smoothing the disturbed area and establishing a vegetative cover to the concept of “land use sustainability.” The land use sustainability concept recognizes the need to maintain *environmental* functions related to landforms when conducting *economic* development activities for the benefit of *future users* of the land.

Traditional reclamation grading methods, e.g., valley fills with terraces and down-drains, uniform, constant-gradient slopes, and linear “stream channels,” often do not address all the criteria that must be met for the environmental functions for the future users. Water quality standards, in-stream uses, vegetation diversity and other reclamation criteria may not be satisfied by traditional reclamation grading methods. For example, the Appalachian Regional Reforestation Initiative (ARRI) has identified that coal mine reclamation in the region ‘. . . *has* *not been accompanied by widespread replacement of forests disturbed by mining"* that may reduce the economic use of the land for future users.

The deficiencies in meeting these environmental functions for future users can also have immediate and longer-term negative economic effects on the mine operations themselves. Inability to mitigate for these land use changes caused by the proposed reclamation landform can stop mining activity from proceeding or expanding at the permitting stage. The traditional grading methods produce landforms that are not in conformance with natural storm runoff and stream flow processes and therefore can add costs for "erosion control measures" like imported rip-rap rock, straw wattles, coir logs, interlocking concrete blocks, jute mats, hydro-mulch, and chemical soil amendments. Additional economic burdens are placed on mine operators when the landforms that are out of conformance with natural water flow processes, i.e. fluvial geomorphic principles, fail to resist erosion and require maintenance. If the failures and associated erosion problems are great enough, a mine operator's bond liability release can be postponed, adding more cost. The limitations of existing landform grading practices for meeting environmental and economic goals for future land users prohibit them from achieving sustainability.

A new, natural approach to landform grading called GeoFluv^{TM} offers a cost-effective alternative for sustainable mineral development that can satisfy the reclamation criteria. GeoFluv design offers the user flexibility to vary landform characteristics to meet reclamation use goals, including reforestation, while maintaining natural landform water runoff and soil erosion functions. The GeoFluv approach is the heart of the ***"Natural Regrade"*** computer software module that can help the user make the complex landform designs, in three dimensions, according to fluvial geomorphic principles. The computational speed of the computer makes it practical for the designer to evaluate alternate designs to minimize material movement and related construction costs. The GeoFluv method for designing landform grading offers operators a means to achieve true land use sustainability. This is because the GeoFluv approach addresses the *environmental* criteria, as well as providing *economic* benefits, with a landform that provides erosional stability into the *future* similar to that found in natural land.

Geomorphic Restoration of Coldwater Fork Following Oct. 2000 Slurry Spill

George Athanasakes P.E., *Stantec, Louisville, Kentucky*

A coal slurry release from the Big Branch Slurry Impoundment on October 11, 2000 resulted in the flow of millions of gallons of slurry into the Coldwater Fork and Wolf Creek watersheds. Clean up efforts along both streams included removal of slurry using excavators and the use of temporary dams and pumps. Efforts were made during excavation of the spill to maintain Coldwater Fork's pre-spill channel configuration, however, portions of the creek were realigned.

Since the slurry release, significant portions of Coldwater Fork have exhibited recovery on it's own including the reestablishment of pools and riffles, and gravel substrate. However, a series of head-cuts formed which threaten to destabilize the recovering portions of the creek and the excavation process resulted in a stream that was highly entrenched. In late 2003, a design was initiated to restore the damaged sections of Coldwater Fork.

In this presentation, an overview of the restoration of Coldwater Fork will be given, and the use of a reference reach to design the restored sections of Coldwater Fork will be discussed.

Modeling Sediment Loss on Geomorphic Graded Reforestation Lands in Kentucky

Dr. Richard Warner, *Dr. Carmen T. Agouridis and Dr. Chris D. Barton, University of Kentucky, Lexington, Kentucky*

The predicted stormwater and soil loss from two alternative head-of-hollow fill designs has been modeled to illustrate the efficacy of incorporating geomorphic design with reforestation. SEDCAD models were developed for the reclamation timeframe.

Standard head-of-hollow fill components encompass a structurally engineered, head-of-hollow fill with a rock French underdrain, contributing watersheds with parallel terraces and rock riprap down-drains, a slightly sloped crown, rock riprap channels located on both sides of the 2:1 (H:V) face with benches placed on a 50-ft vertical spacing that discharge to a sediment pond located down-gradient of the fill. Reclamation includes removal of the sediment pond with reconstruction of the stream from the toe of the fill to down-gradient of the sediment control pond and planting grasses for erosion control.

The alternative geomorphic design encompasses re-grading contributing watersheds and the crown of the fill such that runoff will flow to constructed ephemeral channels and to a created intermittent channel that is located to one-side of the head-of-hollow fill. Loose spoil is placed on contributing watersheds, the crown, face and benches of the head-of-hollow fill and high-value hardwood forest are re-established. A portion of the sediment pond is converted to a constructed wetland, to passively treat underdrain flow and an adjacent stream established to convey stormwater runoff from the intermittent stream.

Model results show that implementation of geomorphic grading with reforestation and establishment of ephemeral and intermittent streams reduces peak flow, increases base flow and reduces sediment concentration and sediment load below standard head-of-hollow fill reclamation levels.

Stream Restoration on the Cumberland Plateau, Tennessee

Dennis Clark*, Office of Surface Mining, Knoxville, Tennessee and Tim Slone IRTEC*

This presentation discusses the ongoing project that involves the final reclamation of a surface coal mining and reclamation operation involving a dragline operation in Sequatchie County, Tennessee. The final pit was reclaimed by blasting the final highwall and utilizing the final dragline bench and spoil ridge to rough backfill and grade the site. A previously approved Aquatic Resource Alteration Permit (ARAP) was modified to make use of the final pit reclamation area as a stream restoration area. The original ARAP was for the restoration of a small intermittent and perennial stream that bisected the surface coal mine.

This presentation will address the history of the site leading up to the modified ARAP that improves aquatic habitat along with addition of riparian vegtation and the current progress of construction, including plans, problems and construction phases.

Case Study - Kentucky: Recreating a Headwater Stream on a Head of Hollow Fill

Dr. Christofer Barton *and* ***Carmen Agouridis****, University of Kentucky, Lexington, Kentucky*

Head-of-hollow fills or valley fills have gained national attention due to increasing environmental concerns, particularly with regards to headwater stream loss. Researchers at the University of Kentucky in conjunction with outside scientists and consultants in the fields of stream restoration, wetland restoration, and mine land reclamation have developed new design methodologies for creating a headwater stream system for a head-of-hollow fill in eastern Kentucky. The design incorporated aspects of the Forestry Reclamation Approach (FRA), which encourages a non-compacted spoil medium to promote tree growth, in an effort to address concerns related to water quantity and quality as well as habitat development. Major components of the design included: (1) modifications to the crown geometry; (2) compaction of the crown to control infiltration; (3) utilization of natural channel design techniques; (4) use of the FRA to promote tree growth; (5) creation of ephemeral channels and vernal ponds; and (6) implementation of a novel bioreactor-wetland treatment system to improve water quality. A total of approximately one-mile of streams and nearly an acre of vernal ponds were created in the fall and winter of 2008. Intensive on-going monitoring efforts are focused on assessing long-term hydrologic, water quality, and habitat changes.

Use of Natural Stream Channel Design Techniques in the Coal Fields of Virginia

Lance DeBord*, D.R. Allen and Associates, Abingdon, Virginia*

Prompted by changes in U.S. Army Corp of Engineers regulatory policy concerning the restoration of streams impacted by coal surface mining, D.R. Allen & Associates began using natural stream channel design techniques in Virginia’s coalfields in 2002. Since that time, over 10,000 linear feet of natural stream channel restorations have been implemented by our clients. Natural stream channel design criteria are based upon measured morphological relations associated with the bankfull stage for a specific stable stream type. Stream restoration sites are not only designed to pass bankfull flows but the sediment delivered to them from the upstream watershed. Constructing stream restorations based on a range of morphological variables from stable reference streams and considering both bankfull flow and sediment transport allows the practitioner to achieve a stable stream condition. Natural stream restorations reduce bank erosion and enhance habitat for aquatic organisms. Stream restorations designed and implemented in the coalfields of Virginia include headwater streams in drainages of around 0.5-3.0 square miles. Typical restoration sites include streams impacted by pre-SMCRA surface mining, streams previously mined and restored using traditional engineering methods, and recently removed sediment ponds located downstream of reclaimed surface mined areas. Restoration activities include construction of a proper dimension, pattern and profile, active floodplains (bankfull bench), in-stream grade control and habitat structures and bioengineering. Restoring streams impacted by surface and underground coal mining present unique challenges that must be addressed during the design process. Nevertheless, following the guiding principles of natural stream channel design appears to be a successful restoration technique for Virginia’s coalfields.

THURSDAY APRIL 30, 2009

SESSION 3: GEOMORPHIC RECLAMATION IN THE WEST

Chairperson: ***Mychal Yellowman****, Office of Surface Mining, Denver, Colorado*

Integrating Natural Form and Process with Drainage Reclamation in Montana

Tom Golnar, *Shannon Downey, and* ***Julian Calabrese,*** *Montana Department of Environmental Quality, Helena, Montana*

Reclamation of drainages at Montana coal mines has gone through changes in design and field reclamation approaches since the introduction of Montana's Surface and Underground Mining Reclamation Act (MSUMRA) in 1973. Montana regulations outline reclamation requirements for drainage basins, including valleys, channels, and floodplains. Drainage reclamation is further explained through a set of guidelines outlining practices and approaches for drainage basin and channel reclamation, approximate original contour and postmine topography.

Native creeks, coulees, and draws in the mine areas often form entrenched, erosionally dissected ephemeral drainage networks, with steep upland slopes and tributary basins below sandstone or clinker capped hills and ridges. While losses of premine topographic, geologic and vegetation character are unavoidable with surface mining, building a postmine landscape with similar drainage basin and channel morphology allows for better approximation of premine hydrologic processes.

As a channel develops, soil particles distribute in relation to floodplain hydraulic characteristics, creating channel and floodplain features such as alternating point bars which host microenvironments where mesic vegetation will dominate. Stream sections experiencing increased erosion or exposing less fertile subsoil or spoil, create microenvironments where shrubs and warm-season grasses will dominate. Thus, the combination of topographic diversity and geomorphic processes results in vegetative diversity with patterns similar to native landscapes.

The Application of Geomorphic Reclamation Methods in Wyoming

Marcello Calle *and Jonathan Stauffer****,*** *Wyoming Department of Environmental Quality, Cheyenne, Wyoming, and Scott Belden****,*** *Peabody Energy, North Antelope/Rochelle Mine, Gillette, Wyoming*

Disturbances associated with surface mining drastically alter the form and function of a landscape. The design and construction of a suitable postmine topography is essential to satisfying reclamation responsibilities including the maintenance of acceptable erosion and sediment control, establishment of appropriate fluvial hydrology and successful revegetation. Landforms develop in what researchers describe as dynamic equilibrium, constantly adjusting to acting forces such as concentrated precipitation runoff. Wyoming coal producing regions demonstrate an arid to semi arid climate; near-surface geology is tertiary coal with overlying sedimentary strata. Reclamation design challenges include creating a new landform that is regionally in context yet recognizes alterations in pre-existing controls such as geology, is economically realistic and observes regulatory policy.

Since its initiation, the Wyoming coal regulatory program has required the application of fundamental fluvial and geomorphic principles to reclaim surface coal mines. Historically, an inventory and comparison of pre mine and post mine basin morphometry has served as the dominant tool in evaluating proposed reclamation landforms. Published regional studies have also provided significant guidance regarding observed geomorphic and fluvial relationships in Wyoming and their application to reclaimed mine surfaces.

Wyoming continues to encourage progressive reclamation strategies that integrate geomorphology into the design of post mining landscapes. Developing software has recently provided calculating power to create terrain models that incorporate geomorphic and fluvial design principles. Recently, the Wyoming Abandoned Mine Land Program has been applying this developing technology to coal and uranium mine reclamation projects in Wyoming. Predicted benefits include less follow up maintenance and enhanced topographic variability that effectively controls run off, captures moisture and promotes vegetation and habitat diversity.

Geomorphic Reclamation in New Mexico: A Regulator's Perspective

Dave Clark, *New Mexico Mining and Minerals Division, Santa Fe, New Mexico*

Each of New Mexico's active coal mines has reclamation challenges that are being successfully resolved through the application of geomorphic grading methods. At the La Plata Mine, steeply dipping, multiple coal seams were mined by open pit methods. It was recognized that the structurally-controlled trellis drainage pattern that existed pre-mine would have to be replaced with a dendritic drainage pattern on reclamation where the overburden had been pulverized. At the San Juan Mine, the soils and overburden material are of poor quality, and it is not uncommon for the mine to receive less than 6 inches of precipitation per year. Without irrigation, the San Juan Mine can expect successful revegetation establishment in only 1 of 5 years. Revegetation on uniformly flat or gently sloping regraded areas sometimes failed to persist after it had been established with irrigation. MMD had therefore been encouraging topographic diversity on reclamation to improve water harvesting and reduce the percent of south aspect slopes. At the McKinley Mine, sodic spoil material is prone to differential settling and the creation of piping features in areas where runoff ponds, which may lead to down-slope instability. In each of these scenarios, the approximation of natural drainage patterns on the reclamation has reduced erosion and sedimentation by creating shorter slopes with correct profiles, and by improving conditions for revegetation establishment.

Geomorphic Reclamation at BHP Billiton New Mexico Coal – Successes, Challenges and Future

Daphne Place, *BHP-Billiton New Mexico Coal, Farmington, New Mexico*

BHP Billiton operates three coal mines in northwest New Mexico: (1) La Plata Mine, a truck shovel operation that completed reclamation at the end of 2008; (2) San Juan Mine, a surface dragline operation that transitioned to an underground operation in 2002; and (3) Navajo Mine, a multiple dragline operation located on the Navajo Reservation. BHP Billiton first applied fluvial geomorphology principles to part of an out of pit spoil pile at La Plata Mine in 2002. Successful application of these principles led the way for the remainder of La Plata Mine to be reclaimed using the GeoFluv™ approach. We also found opportunities to construct geomorphic based land forms as San Juan Mine was transitioning from traditional engineered reclamation (i.e., gradient terraces) to fluvial geomorphic based reclamation. As a result, San Juan Mine earned the Office of Surface Mining's 2004 National Reclamation Award and 2004 Best of the Best award for reclamation of a final dragline pit area in the South Lease Extension, know as Cottonwood. This reclamation demonstrated the successful implementation of both steep and flat slope geomorphic reclamation. Navajo Mine has begun evaluating opportunities to integrate fluvial geomorphology into its reclamation and recently completed construction of a GeoFluv™ based design. Our transition from traditional to geomorphic reclamation, although successful, includes many challenges. Expanding the skills set of our professional staff to include fluvial geomorphology and our operators and foremen to understand the construction of such land forms has been and continues to be an area of continual development. The future of geomorphic reclamation at BHP Billiton's New Mexico coal operations is bright. We continue to improve our design and construction skills to achieve successful, sustainable reclamation and to identify opportunities to implement our geomorphic reclamation strategies. We also look forward to monitoring the performance of our geomorphic reclamation areas to quantify its success through maintenance cost reductions, improved bond release timing, and revegetation success.

Session 4: GEOMORPHIC RECLAMATION IN THE MIDWEST

*Chairperson: **Bryce West**, Peabody Energy, Evansville, Indiana*

Anthropo-Geomorphology of Streams, Wetlands and Landscapes of the Illinois Basin, and Restoration Techniques

***Tim Sandefur,** Wetland Services, Inc., Corydon, Kentucky*

The purpose of this presentation is to: (1) illustrate anthropogenic impacts and current geomorphic conditions of Streams and Wetlands in the Illinois Basin; (2) demonstrate data collection techniques and interpretation methodologies; and (3) apply those results to successful restoration strategies.

Modification of the vegetation, hydrology and topography of the Illinois Basin since European settlement has been extensive. The relatively flat topography from glacial, alluvial and eolian deposition readily facilitated conversion of the region to modern land uses. These conversions generally include agriculture, river navigation, flood control, mining and urban.

Large-scale delineation and assessment requires the use of advanced methods and technology to effectively gather, organize, and process large data sets. Microsoft Access databases were used to record, interpret, quantify and correlate existing conditions.

The extent of conversion impacts, whether direct or indirect, is virtually all-inclusive, and leaves very little if any true reference area for use in restoration design. The advanced science and nature of wetland restoration can be used to target specific wetland types and functions without the use of traditional reference data.

Stream restoration however, does require reference data in the form of a regional curve along with various other Rosgen-based measurements. With the exception of several non-representative landforms, very few reference areas still exist for use in stream restoration design. As such, it has become necessary to base stream design on a combination of both regional reference data and reference data from other applicable eco-regions.

These data were considered and combined with a basic set of target parameters to produce a stream design process that is both replicable and modifiable to be site specific or updated as necessary. The long-term goal of this stream restoration process is the development of a free-form channel in dynamic equilibrium and with the ability to provide natural and sustainable stream function.

Current Stream Mitigation Requirements & Results

***Mike Ricketts,** US Army Corps of Engineers, Newburgh, Indiana*

The US Army Corps of Engineers is responsible for administering the permitting program for Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. Part of this responsibility includes working with Coal Operators to delineate "jurisdictional waters of the US," develop permitting standards, mitigation plans, and success standards. Jurisdictional waters of the US include wetlands and perennial, intermittent, and ephemeral streams as identified in the 2007 Rapanos Supreme Court decision. Natural Stream reclamation is a relatively new and developing science in the Midwest. Geomorphic reclamation techniques appear to have the potential to be a significant step forward in the process of returning mined lands to a more natural condition. Geomorphic grading could provide additional opportunity for successful natural stream restoration.

This presentation will provide a brief explanation of the 404 and 10 programs. Also a description of Rosgen methods to capture physical characteristics of streams as well as an overview of the evolving stream mitigation and restoration requirements of the Louisville District will be presented. In addition, the current techniques which appear to be headed for success and those which appear headed for failure will be discussed and illustrated.

From Rip Rap to Riffles: The Evolution of Stream Reclamation in the Indiana Coal Fields

Ramona Briggeman, *Indiana DNR, Division of Fish & Wildlife, Jasonville, Indiana*

Restoring drainages has been a requirement for coal mine reclamation since the Surface Mining Control and Reclamation Act (SMCRA) was signed into law on August 3, 1977. Indiana achieved primacy in 1982. In the beginning, in highly agricultural Indiana, the major focus when constructing drainages was soil stability and water conveyance. Stream banks were heavily armored with rip rap. Rip rap check dams were installed to slow water velocities and ensure no erosion of soil would occur. Although this appeared successful from an erosion control and water conveyance standpoint, the wildlife value of these drainages had been lost or severely degraded. With the maturation of the program, those wildlife related values are being given the same consideration as the others. Streams are being designed to mimic natural landforms. Structures are placed in the streams that not only slow water velocity but also increase wildlife habitat within the stream itself. Many benefits of this type of stream reclamation exist (increased wildlife habitat, less maintenance, aesthetics, better flood control, etc). However, many challenges also exist (land use restrictions, seemingly conflicting regulations, multi-agency jurisdiction, landowner concerns, the learning curve, etc). Mine reclamation is an opportunity to landscape on a massive scale. In regards to acres reclaimed, stream reclamation is only one small part of this process but can impact the success of the entire project. Geomorphic reclamation and natural stream design is a step in the right direction towards successful, sustainable reclamation.

Kentucky Perspective – Past & Current Practices, Benefits and Challenges

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This paper will analyze the past and current practices of mine site reclamation, as it relates to stream restoration, in the Western Kentucky Coal field. The paper will explore both the past and future programmatic compliance as well as the utilization of Geomorphic Principals to achieve natural stream channel design. In the past, it has been viewed by many that natural stream channel design techniques result in the design and construction of stream channels that: (1) increases reclamation costs; and (2) creates problematic compliance issues with the Kentucky Division of Mine Reclamation & Enforcement. This paper will discuss opportunities for programmatic compliance, cost effectiveness, and sustainable design.

Illinois Stream Restoration - Opportunities for Habitat Enhancement: Policy, Principles and Practices

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To facilitate large scale surface coal mining in southern Illinois during the late 1970's -1980's, temporary diversion and eventually relocation (restoration) of perennial streams was required at some surface mine sites. Illinois' first stream restorations incorporated geomorphologic and ecological principles in their designs and construction to enhance their function and value as lotic and riparian habitats. IDNR's Office of Mines and Minerals (OMM) - Land Reclamation Division required (Federal Surface Mining Control and Reclamation Act of 1977 (PL 95-87) pre-disturbance stream restoration designs and plans as well as post-disturbance monitoring of the physical, chemical, and biological components of the stream community. The OMM interdisciplinary Stream Restoration Committee reviewed plans and provided technical input to the industry to ensure compliance with regulations and maximization of habitat enhancement opportunities. The Cooperative Wildlife Research Laboratory of Southern Illinois University Carbondale (CWRL) initiated stream diversion / relocation research in the early 1980's to assess stream restoration practices. CWRL evaluated ~ 18 miles of diversions and restorations associated with the Arch, AMAX, CONSOL mining complex in Perry County. In addition to the comparative evaluations of stream diversions and restorations (Bonace 1983, Bush 1989), CWRL research staff conducted long-term (1986 - 1994) monitoring of Pipestone Creek associated with the AMAX Denmark Mine (now part of the ~16,000-acre IDNR Pyramid State Park complex).

These early investigations of southern Illinois stream relocations and restorations provide an extremely valuable database for evaluation of the long-term geomorphologic and biologic recovery processes in previously restored stream habitats. This presentation will highlight the extent and distribution, restoration practices, and biological performance of these stream restorations initiated more than 25 years ago. A reassessment of these stream reconstructions that have undergone 10-20+ years of geomorphological adjustment and biological recovery can provide valuable insight into future stream habitat restoration practices.

Industry Perspective— Past and Current Practices, Benefits and Challenges

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Geomorphic Reclamation can be explained as *the process of restoring the earth's shape or surface to a suitable condition or use*. In the context of surface coal mining, Geomorphic Reclamation can be narrowed to mean the process of restoring disrupted ground conditions and landscape to a suitable post-mining configuration and use. The importance of geomorphic reclamation is creating topography and slope configurations that remain stable. Stable slopes follow natural hillside geometry more so than conventional grading designs and recreate natural drainage patterns rather than straight convex terraced slopes. Natural landform grading techniques and natural drainage development, if designed properly, yield a post-mining landscape that resists surface erosion and mass wasting and increases the opportunity for more diverse vegetation.

If geomorphic land grading is preferred for successful surface mine reclamation, why haven't more operators and regulators considered the long-term environmental and aesthetic benefits of artificial reshaping and restoration of natural topography? This presentation will explore that question by identifying the evolutions of: (1) regulations promulgated under the Surface Mining Control and Reclamation Act (SMCRA) and Sections 401 and 404 of the Clean Water Act (CWA); (2) conventional mining and reclamation practices; and (3) methods of restoring jurisdictional waters, i.e. wetlands and streams. The goal of this overview is to better understand the benefits and challenges of geomorphic reclamation at Midwest surface coal mining operations.