Aquatic Ecosystem Enhancement at Mountaintop Mining Sites

About the Mountaintop Mining/Valley Fill Environmental Impact Statement
The U.S. Environmental Protection Agency (EPA), U.S. Army Corps of Engineers (Corps), U.S. Office of Surface Mining (OSM), and U.S. Fish and Wildlife Service (FWS), in cooperation with the State of West Virginia, are preparing an Environmental Impact Statement (EIS) on a proposal to consider developing agency policies, guidance, and coordinated agency decision making processes to minimize, to the maximum extent practicable, the adverse environmental effects to waters of the United States and to fish and wildlife resources from mountain top mining operations, and to environmental resources that could be affected by the size and location of fill material in valley fill sites. The draft EIS will be released for public comment during the summer of 2000. The final EIS is slated for completion by January 2001.

Early in 1998, the four Federal agencies now involved in the EIS formed a work group and agreed on a series of priority areas where more information and analysis would assist them in regulating the effects of valley fills associated with mining operations. Study plans were adopted and funded for undertaking valley fill inventories in West Virginia, Kentucky, and Virginia; for assessing the stability of valley fills; and for assessing the potential for downstream flooding from these mining operations. The agencies also placed priority on studying the impacts of valley fills on aquatic habitat; on surveying and evaluating mitigation practices being employed in West Virginia and neighboring Appalachian Coalfield States; and on evaluating how to better coordinate the Federal regulatory programs. These studies were underway or in the planning stages when the Bragg v. Roberston settlement agreement was reached.

With the decision to prepare an EIS, the agencies brought the coordination of these technical studies under the scope of the EIS, and broadened state participation. The expanded network of agencies has now examined the studies initiated in 1998 and has modified those study plans to make them more useful for the EIS. Additional work plans responding specifically to the EIS mandate have also been drafted.

Team leaders have been selected among the participating agencies for each of the technical study areas, which are listed below. The team leaders worked with a team representative of the expertise of each agency to develop a work plan. The work plans reflect what the agencies believe should be studied, and are subject to revision as work progresses and new insights are gained.

EIS Technical Study Areas:

- Future Mining
- Fill Stability
- Mining and Reclamation Technology
- Flooding Potential
- Fill Hydrology

- Streams
- Fisheries
- Wetlands
- Aquatic Ecosystem Enhancement
- Terrestrial Ecology
- Soil Quality and Forest Productivity
- Socioeconomic Issues
- Mine Dust and Blasting Fumes
- Landscape Ecology/Cumulative Effects

Prelude to the Symposium

The Team Leader for Aquatic Ecosystem Enhancement submitted a work plan for this technical study area to the EIS Steering Committee in July 1999. The work plan, which is available from the EPA Region III internet site containing information related to the EIS (http://www.epa.gov/region3/mtntop/index.htm), identified the goals of the EIS related to Aquatic Ecosystem Enhancement:

- Assess mining and reclamation practices to show how mining operations might be carried out in a way that minimizes adverse impacts to streams and other environmental resources and to local communities. Clarify economic and technical constraints and benefits.
- Help citizens clarify choices by showing whether there are affordable ways to enhance existing mining, reclamation, mitigation processes and or procedures.
- Identify data needed to improve environmental evaluation and design of mining projects to protect the environment.

The Aquatic Ecosystem Enhancement work plan was designed to augment the activities of the Streams and Fisheries Survey work plans and build upon the symposium held under the Mining and Reclamation Technology work plan in June 1999. The work plan included components to evaluate current stream practices and to evaluate opportunities for aquatic ecosystem enhancement using existing information, field monitoring, surveys, and expert reviews. The work plan proposed a workshop (subsequently changed to a symposium) of experts in ecology and stream restoration to review the current practices at specific sites selected by the mining companies and to outline the factors that would contribute to successful stream restoration and aquatic ecosystem enhancement.

An Aquatic Ecosystem Enhancement planning meeting was held September 15, 1999 to outline plans for the symposium on stream restoration and reclamation practices being used at valley fills and mountaintop mines. A panel of experts was selected to tour several mine sites to evaluate the restoration and reclamation practices being used at those sites. The National Mine Land Reclamation Center in cooperation with the West Virginia Mining and Reclamation Association and the West Virginia Coal Association recommended four sites to be visited by the panel of experts and serve as representative samples of current practices. The site visits occurred during the period December 7-8, 1999 at Elk Run Mine of Massey Coal; Samples Mine of Catenary Coal; Rollem Fork Mine of Pen Coal; and Hobet 21 Mine of Hobet Mining a subsidiary of Arch Coal.

The symposium followed on January 12, 2000 to offer a forum for presentation of the views and recommendations of the panel of experts for aquatic ecosystem enhancement at mountaintop mining sites. The symposium also offered an opportunity for public input, primarily from the mining and reclamation industry, on the barriers (regulatory, financial, or technical) to enhanced reclamation. The symposium was held open to the public, with no registration fee, at the Holiday Inn, Charleston House, in Charleston, West Virginia.

Symposium Attendees
A total of 162 persons registered their names and affiliations to attend the symposium. A complete listing of the registered attendees is included in this proceedings.

The largest group registered included 98 representatives of the coal mining industry along with their suppliers and consultants. The next largest group included 43 members of the government and regulatory community representing the following federal and state agencies; U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, U.S. Office of Surface Mining, U.S. Geological Survey, West Virginia Division of Environmental Protection, West Virginia Division of Natural Resources, Virginia Department of Mines, Minerals, and Energy, Kentucky Division of Water, and the Kentucky Department of Fish and Wildlife Resources.

There was a notably low turnout from the environmental advocacy community and the general public. However, considering the scientific and technical nature of the program, this was not considered to be detrimental to achieving the symposium objectives. The discussion that transpired between the panel of experts on aquatic ecosystems, the mining industry, and the regulatory community yielded numerous potential enhancements to aquatic resources at mining sites and the barriers to their implementation that will require further evaluation as part of the EIS process.

Panelist and Key Person Biographies

Paul F. Ziemkiewicz

Paul Ziemkiewicz is a native of Pittsburgh, PA. He received BS and MS degrees from Utah State University in biology and range ecology, respectively. He then received a Ph.D. from the University of British Columbia in Forest Ecology.

After graduating from UBC in 1978, he joined the Alberta Government's Department of Energy. There he directed its reclamation research program in coal and oil sand mining. He also served on Alberta's regulatory review committee and served as the research manager of the Province's coal research program. In 1988, he came to West Virginia University to serve as the Director of the National Mine Land Reclamation Center and the West Virginia Water Resources Research Institute.

He presently serves on a number of federal, state and industry advisory panels on environmental remediation. Dr. Ziemkiewicz has over 70 publications on the topics of mine land reclamation, acid mine drainage, and coal ash application in mines.

J. Bruce Wallace

J. Bruce Wallace received his BS from Clemson University, and MS and Ph.D. from Virginia Tech. He is currently Professor of Entomology and Ecology, University of Georgia in Athens, Georgia, where he teaches courses in stream ecology, aquatic entomology, and immature insects. He has served as major professor of some 38 graduate students at the University of Georgia. Dr. Wallace is author, or co-author, of some 150 scientific papers, including book chapters, concerned with various aspects of stream ecology or aquatic entomology.

Much of his research during the past 25 years has been conducted on southern Appalachian streams at the Coweeta Hydrologic Laboratory (U.S. Forest Service) in western North Carolina and supported primarily by the National Science Foundation. His primary research areas include: linkages between streams and terrestrial ecosystems; role of aquatic invertebrates in stream processes; effects of disturbance and recovery of streams from disturbance; secondary production and aquatic food webs and energy flow; and, organic matter dynamics in headwater streams.

Dr. Wallace is a past president (1991-1992) of the North American Benthological Society. He was the recipient of the 1999 Award of Excellence in Benthic Science from the North American Benthological Society.

D. Courtney Black

D. Courtney Black is the Program Manager for the National Mine Land Reclamation Center at West Virginia University. Mr. Black is a scientist with 6 years of research and project management experience. His primary focus has been in the fields of coal combustion product utilization and field scale acid mine drainage treatment. Mr. Black also serves as the Director of West Virginia University's National Environmental Education and Training Center. NEETC's primary focus is to ensure that health and safety concerns are incorporated into new environmental remediation technologies.

Peter Lawson

A native of County Durham, England, Peter Lawson received his undergraduate degree in Mining Engineering in 1978 from New Mexico Tech. In 1986, while maintaining full time employment in the mining industry, he received his MBA from Ashland University, Ohio. Mr. Lawson has more than 20 years of industry experience, the majority of which has been in surface coal mining in Appalachia. During his career he has worked on projects in western Canada, Russia and Mongolia, as well as having performed work in virtually every major coal-producing basin in the United States. Arch Coal, Inc. has employed Mr. Lawson for 5 years where he is currently President and General Manager of Catenary Coal Company. Catenary Coal Company has received numerous awards for the Samples Mine in Kanawha County where the company's achievements and approach to reclamation have been recognized at both state and national levels. Catenary Coal Company is twice winner of the David C. Callaghan Award, winner of the IMCC National Reclamation Award, and winner of the West Virginia Ducks Unlimited Wetlands Award.

John S.L. Morgan

John S.L. Morgan is an environmental mining consultant with extensive experience in both surface and underground mining for the extraction of metalliferous ores, coal and industrial minerals. He has a specific emphasis on the environmental effects of mining and mine reclamation. He also provides detailed technical expertise in the analysis of mine subsidence prediction and mitigation, acid mine drainage and mine planning.

Mr. Morgan founded Morgan Worldwide Mining Consultants, Inc. in 1995. Previously, he had established Morgan Mining & Environmental Consultants, Ltd. in 1990 with a staff of 18 people and built it into a $2 million per annum operation with 27 employees. The International Mining Consultants Group acquired the company in 1992. Mr. Morgan then served as the Executive Vice President of Weir International Mining Consultants until 1995 when he left to form Morgan Worldwide Mining Consultants, Inc.

Mr. Morgan has been the project manager for a number of mine technical reviews, for a significant number of subsidence investigations, and for environmental compliance and liability analysis reviews for both operating and abandoned mining operations. He is actively involved in projects in all regions of the United States, and has worked in Russia, Indonesia, Ukraine, Poland, Bulgaria, Peru, Argentina and Trinidad. During his career, Mr. Morgan has also worked in rock mechanics in South Africa, and as a planning engineer for open cast coal mining in Britain.

Horst J.Schor

Mr. Schor's educational background includes degrees in Civil Engineering and Geography and Graduate Course work in Environmental Studies.

His professional career spans more than 25 years during which he managed the development of large scale hillside planned communities in Southern California and other projects. Since 1991 he has been an independent consultant serving the private and public sectors on issues of land development, landform restoration and mining reclamation with particular emphasis on geomorphological restoration.

In recent years he has been a consultant to Syncrude Oil of Alberta, Canada re-designing large scale tailing deposits from tar sands excavations to give them natural landform characteristics. Mr. Schor has also been engaged by the State of Kentucky Environmental Protection Agency Water Quality Division, the State of Virginia Department of Minerals, Mines and Energy and the Navajo Nation Environmental Protection Agency to study coal mining reclamation practices in their respective states and make recommendations for improvements.

He is a regular guest lecturer at The University of Wisconsin College of Engineering and most recently was invited to speak at the University of Dresden, Germany.

Rocky Powell

Rocky Powell is the founder and principal of Clear Creeks Consulting, an environmental firm specializing in stream and watershed assessment, management, and restoration. Mr. Powell has over 25 years in the environmental field with experiences that include wildlife and fisheries research, water quality monitoring, natural resources protection, watershed management, stream assessment and restoration, and teaching. Providing environmental consulting services in Maryland, Virginia, West Virginia, North Carolina, Pennsylvania, New York, Vermont and Texas, Mr. Powell has: 1) conducted hundreds of geomorphic watershed and stream assessments; 2) developed watershed management plans; and 3) designed, permitted, provided construction supervision and post-construction monitoring for numerous wetland mitigation and stream restoration projects.

An instructor in the Johns Hopkins University School of Continuing Studies from 1992-1999, he taught graduate and undergraduate courses on stream ecology and stream related issues. He has presented numerous workshops and short courses on stream dynamics, stream protection, assessment, management, and restoration throughout the United States and Canada.

Randy Maggard

Randy Maggard is an Environmental Specialist and Surface Mine Engineer with Pen Coal Corporation. He has degrees in Chemistry and Civil Engineering and has been employed with Pen Coal for the last 14 years. He has been active in environmental affairs related to coal mining and is a member of the West Virginia Surface Mine Drainage Task Force. Pen Coal has received numerous reclamation awards for their operations in West Virginia and Kentucky. Pen Coal has been conducting extensive biological monitoring for the last five years on their Kiah Creek operation located in Wayne, Lincoln, and Mingo counties in southern West Virginia.

Steven N. Handel

Steven N. Handel is a restoration ecologist interested in the establishment of native communities on degraded lands. He serves as professor of ecology and evolution at Rutgers University in New Jersey, where he teaches and does research in the fields of plant ecology, plant-animal interactions, and restoration. Dr. Handel is Director of the new Center for Restoration Ecology at Rutgers. He also has been a biology professor and Director of the Botanical Garden at Yale University. He serves as an editor for the journal Restoration Ecology, and was elected chair of the Plant Ecology Section of the

Ecological Society of America. Trained at Cornell University, he and his students have done fieldwork throughout the east coast. As a consultant, he has advised on restoration design on degraded sites such as urban landfills, urban parks, sand mines, and national parks affected by invasive species.

Ben B. Faulkner

Ben B. Faulkner served as a surface mine reclamation inspector for the West Virginia Division of Natural Resources, dealing with inspection, enforcement, and permit review in many southern counties. He has served as an industry biologist and has coordinated reclamation and environmental affairs. He has been a research associate at West Virginia University in the fields of mine reclamation and mine drainage. As a private consultant, he has conducted training seminars for inspectors and operators in AMD prevention, and chemical and passive treatment.

As sole proprietor of Bratton Farm, he has provided professional consulting services to several international corporations and agencies. He has prepared surface mine, deep mine, and other permits and provided environmental management services including designing, installing, and monitoring numerous wetlands, anoxic limestone drains and other passive treatment systems for WVDEP, WVU, and industry. He has performed numerous benthic studies for industry and WVDEP. He serves as a special consultant to WVDEP for acid mine drainage issues.

Welcome and Introduction
Dr. Paul Ziemkiewicz

Dr. Ziemkiewicz, Director of the National Mine Land Reclamation Center and West Virginia Water Research Institute at West Virginia University, welcomed the attendees and explained the format of the symposium. He emphasized that the gathering was a technical symposium on improvements to current mining and reclamation techniques that will enhance the aquatic ecosystem. Furthermore, he made it clear this was not a forum to debate the practice of mountaintop mining.

He went on to describe two colossal coal refuse failures from mining history (Aberfan, Wales and Buffalo Creek, West Virginia) that resulted in many deaths and that led to most of the current regulations regarding the technical design of valley fills. These current regulations emphasize drainage through the fill materials and discourage standing water, such as ponds and streams, which affect the margin of safety for fills. Thus, he expressed the opinion that environmental considerations were not a major driver for the current regulations- safety was the paramount concern.

However, state-of-the-art in geotechnical engineering has advanced to the point that valley fills that include some streams and ponds in the final design could be safely considered, according to Dr. Ziemkiewicz. He introduced the symposium attendees to a group of distinguished experts who will suggest practices that may enhance the resulting aquatic ecosystem downstream from valley fills. He also noted that during the breakout sessions everyone would have an opportunity to identify barriers to implementing these enhanced practices.

Overview of First Order Watersheds
Dr. Bruce Wallace

Dr. Wallace provided a scientific view of the role of first order watersheds in the ecosystem and the impact of mountaintop mining with valley fills. Dr. Wallace highlighted data from ongoing experimental and descriptive studies of southern Appalachian watersheds and stream processes at the Coweeta Hydrologic Laboratory in western North Carolina where he has been working for 25 years. According to Dr. Wallace, the eighty kilometers of small headwater streams on this area owned by the U.S. Forest Service are much like the streams found in the central Appalachian region around mountaintop mining areas. He pointed out that organic material in these streams is the most important source of energy for downstream areas. He commented that nearly eighty percent of this energy comes from the detritus (decomposed organic material) from the surrounding forests.

Dr. Wallace noted that small streams in the ecosystem:

- Have maximum interface with the terrestrial environment with large inputs of organic matter from the surrounding landscape
- Serve as storage and retention sites for nutrients, organic matter and sediments
- Are sites for transformation of nutrients and organic matter to fine particulate and dissolved organic matter
- Are the main conduit for export of water, nutrients, and organic matter to downstream areas

He continued his presentation by noting that benthic organisms that shred course organic material and woody debris increase the rate of fine particulate and dissolved material that is exported downstream. He explained that leaves that enter the stream are first colonized by bacteria and fungi and then the invertebrates eat the microbially conditioned leaf material. Next he noted that these biota assimilate less than ten percent of the organic material they consume allowing the remainder to pass back into the stream. Thus, according to Dr. Wallace, the resulting fine and dissolved organic material is much more amenable to downstream transport with less than two percent of organic material continuing downstream as course particulate.

Diversity of detritus is essential to the production of organic material for release downstream, according to Dr. Wallace. He noted that different types of leaves decompose at different rates and tend to be in harmony with the different biota lifecycles in the nearby streams. One experiment that he participated in at Coweeta constructed a canopy over a segment of stream to preclude certain types of leaf material from the stream. He summarized the experimental conclusion that after six years with this cover in place, the Coweeta stream had the lowest secondary productivity of any stream recorded in the world, including many located in the Arctic tundra. Thus, according to Dr. Wallace, diverse detritus material is very important to the production of organic energy in the stream and this is one reason we should be considering a diverse array of detritus resources at a reclamation site and not just a single species of rapidly decomposing material.

Dr. Wallace further described experiments at Coweeta covering more than eleven years that have compared the rate of decomposition in treated streams [treated with insecticide], where there is less than a full complement of benthic invertebrates, to decomposition in untreated or natural streams. Based on the large quantity of data accumulated, he and others concluded that it took more than twice as long in the treated streams to decompose the same amount of organic material compared to the untreated streams. This led Dr. Wallace to the conclusion that reducing the number of invertebrates reduces the amount of decomposition and, as a result, the amount of fine particulate and dissolved organic material that is transported downstream. Furthermore, he noted that when the treatment was ended, there was rapid recolonization of invertebrates, which restored the downstream transport of organic material.

According to Dr. Wallace, measurements made at the Coweeta Laboratory over a period of fifteen years determined that the first and second order streams from this area provide more than fifty metric tons of fine particulate and dissolved organic material to the downstream reaches. Dr. Wallace noted that this amorphous detritus, as it is referred to in the downstream waters, is a major food source, especially for filter feeders, which eventually affects the entire food chain. He concluded his remarks on this experiment by stating that this organic material, which originated in the first and second order watersheds, represents more than eighty percent of the food supply for some downstream species.

Dr. Wallace explained that the measure of retention of organic material in watersheds is described by a term called "spiraling length, " which is the distance traveled by organic matter before its uptake by some organism and later reintroduction into the stream. He noted that this distance tends to be very short in headwaters, on the order of a meter, and very long downstream, usually several kilometers. Thus, Dr. Wallace concluded that organic material is retained for long periods of time in the first and second order watersheds where it is produced.

Temperature ranges for headwater streams throughout the seasons tends to be very important, stated Dr. Wallace. He explained that the growth of organisms is dependent on the cyclic temperature of the water, cueing many lifecycle events- pupation and mating, for example. Dr. Wallace highlighted the fact that the water coming from the toe of a valley fill tends to be at a mean annual temperature rather than at a seasonally appropriate temperature, which adversely affects the growth cycle of many stream organisms. Dr. Wallace expressed the opinion that leaving the ponds intact below the fill may help replicate the annual thermal variation further downstream. This idea will be explored further during the breakout sessions.

Dr. Wallace provided the following summary of the major roles of headwater streams in two categories, physical and biological:

Physical

- Headwater streams tend to moderate the hydrograph, or flow rate, downstream
- They serve as a major area of nutrient transformation and retention
- They provide a moderate thermal regime compared to downstream waters- cooler in summer and warmer in winter
- They provide for physical retention of organic material as observed by the short "spiraling length"

Biological

- Biota in headwater streams influence the storage, transportation, and export of organic matter
- Biota convert organic matter to fine particulate and dissolved organic matter
- They enhance downstream transport of organic matter
- They promote less accumulation of large and woody organic matter in headwater streams
- They enhance sediment transport downstream by breaking down the leaf material

- They also enhance nutrient uptake and transformation

Dr. Wallace made the additional point that small headwater streams in the Appalachians often harbor unique biota. According to Dr. Wallace, Morse et al. (1997) consider 19 species of mayflies, 7 species of dragonflies, 17 species of stoneflies, and 38 species of caddisflies to be vulnerable to extirpation at present in the southern Appalachians. He noted that many of the rare species are know from only one or two locations in springs, brooks or seepage areas. Furthermore, he stated, many small streams, seeps, springs, and brooks have not been fully explored. Dr. Wallace provided the following reference citations on this aspect of first order watersheds.

Morse, J. C., B. P. Stark, W. P. McCafferty, and K. J. Tennessen. 1997. Southern Appalachian and other southeastern streams at risk: implications for mayflies, dragonflies, stoneflies, and caddisflies. pp. 17-42, in: G. W. Benz, and D. E. Collins (eds.) Aquatic Fauna in Peril: The Southeastern Perspective. Special Publication 1, Southeastern Aquatic Research Institute, Lenz Design and Communications, Decatur, GA. 554 p.

Morse, J. C., B. P. Stark, and W. P. McCafferty. 1993. Southern Appalachian streams at risk: Implications for mayflies, stoneflies, caddisflies, and other aquatic biota. Aquatic Conservation: Marine and Freshwater Ecosystems 3:293-303.

Mine Site Visit Report

Courtney Black

Mr. Black summarized the tour taken by the experts to four mine sites on December 7-8, 1999. By way of introduction, Dr. Ziemkievicz made note that while we have many distinguished experts on these issues in West Virginia, introducing some outside experts may help us to generate some new ideas for consideration. Mr. Black organized the visits as a means of introducing the panel of experts to actual mountaintop mining and reclamation practices and the environmental conditions that result.

Mr. Black made note that the sites visited were:

- Elk Run Mine, operated by Massey Coal
- Samples Mine, operated by Catenary Coal Company
- Rollem Fork Mine, operated by Pen Coal
- Hobet Mining 21, operated by Hobet Mining, a subsidiary of Arch Coal

Mr. Black presented a number of photographs taken during the visit. His presentation is included with this proceedings. The images he presented from Elk Run depict several valley fills, sediment ponds at the toe of the fills, and downstream reaches. He noted there was evidence of water retention in the sediment ditches that could support aquatic resources. He commented that the experts had observed an experimental area where the backfill material was not heavily compacted to promote the growth of vegetation.

According to Mr. Black, Massey Coal also produced rolling landforms in the some of the fill areas that differed from the typical engineered fill site in slope gradient and benching.

Mr. Black commented that at the Samples Mine, the experts viewed an in-stream pond constructed by Catenary Coal Company. Several species of insects had been introduced into this pond to rebuild the ecosystem, according to Mr. Black. Mr. Lawson described this site in more detail during the next presentation.

Mr. Black stated that at the Rollem Fork Mine, being developed by Pen Coal, a large amount of toxic materials handling and encapsulation work was necessary based on the pre-mining conditions. He further noted that Pen Coal created a number of combination ditches for storm water and sediment control and that these are required to be removed within a specified time period after the site is closed to comply with existing regulations. During the site visit, the experts inquired if the ditches that contain developed wetland activity can be left intact after site closure. According to Mr. Black, the experts also observed several nontraditional landscape profiles. Mr. Black commented that at the Frank Branch portion of the mine site, several species of trees were observed including pines and Russian olives with evidence of natural succession underway.

Mr. Black described the Hobet 21 Mine site, a twenty-year old mining operation that offered views of more established reclamation sites. According to Mr. Black, one observation made by the experts was that there were too few species present. He noted that excavation by the large dragline coincidentally added some rolling landform profiles. As at the other sites, he commented that there was evidence of developing aquatic ecosystems that would have to be removed before release of the closure bond.

Catenary Coal's Success in Restoring Aquatic Habitat

Peter Lawson

Mr. Lawson began his presentation by noting the broad significance of the EIS and the potential impact on coal mining in West Virginia and throughout the country. Mr. Lawson spoke about four topics related to the Samples Mine operation; the scope and background of the Samples Mine, structures that are constructed as a condition of permits and two enhancement projects, the G-Ponds and the Abandoned Mine Land Mitigation Project.

Mr. Lawson began with the history of the site. He noted that the Samples Mine land was acquired by the company in 1989 and developed to the point of full production in 1995. In the year 2000, he expects to extract approximately 6.5 million tons of coal from the site and move about 95 million yards of overburden. According to Mr. Lawson, the site employs about 500 full-time employees and contractors.

He stated that all runoff from a mining site has to be diverted to runoff ponds that meet NPDES discharge permit conditions further downstream. He noted there are required structures that include both in-stream ponds and on-bench structures, including ditches and shallow ponds. According to Mr. Lawson, current law requires that these be designed to handle major storm events ranging from 10-year, 24-hour storms up to 100-year, 24-hours storms. At Samples Mine, he noted that Catenary Coal Company has completed construction of 23 in-stream ponds with 275 acre-feet of storage capacity at a cost of about $2.5 million dollars. He also commented that upstream ponds tend to accumulate any sediment from the mining operation and many of the downstream ponds are completely free of sediment and provide excellent aquatic habitat. They have also completed 4,300 linear feet of on-bench structures at the site. Mr. Lawson highlighted one in-stream pond that was built at the toe of a fill in a previously ephemeral or intermittent portion of the landscape that now provides perennial water flow. He noted that many of the on-bench structures also contain water year around and provide excellent habitat for vegetation, aquatic organisms, and water fowl.

The G-Ponds enhancement project, continued Mr. Lawson, is a combination of structures constructed in between two consecutive ridges to enhance the post-mining land use. He described the southern most ponds as shallow to attract wading birds and to give them refuge from the coyote, bobcat, and bear that have moved back into the area. The northern ponds, he explained, have deep pools to promote fish spawning and have floating nests for geese. These ponds are fed by both above ground and underground water sources according to Mr. Lawson. He noted that Catenary Coal used what they have termed “starter kits” of aquatic organisms including bass, bluegill, yellow perch, native minnows, crayfish, bull frog tadpoles, snails, clams, and water fleas. According to Mr. Lawson, they also added duck potatoes, water lilies, soft stem bull rush and cat tails along with red and silver maples, pin oak, and white pine. Mr. Lawson presented photographs showing the site being used last summer for an employee picnic when the ponds were stocked with sport fish.

Prior to acquisition of the land by Catenary Coal, continued Mr. Lawson, surface and underground mining had occurred on the site up until the mid 1970s and there were three large, abandoned refuse piles, covering about 155 acres and containing ten million yards of refuse, that needed to be reclaimed. Reclamation of these sites was beyond the scope of the original permits, according to Mr. Lawson, but offered an opportunity for mitigation of stream loss as a result of the Samples Mine valley fills. He also noted that reclamation provided immediate and long-term benefits to the community by improving the quality of water flowing into the Cabin Creek watershed. He explained that during heavy rains there was uncontrolled heavy flow and resulting black water in the adjacent stream and there were also large areas around the site producing acid-mine drainage. He stated that the site was graded and a large amount of cover material and topsoil was brought into the area taking care to protect the natural or volunteer vegetation that had developed over the years. He discussed the drainage channels that were installed to control the runoff and the wetland that was constructed to treat the acid-mine drainage with a series of four limestone cells, along with a relocated stream channel. He noted that vegetation was added to the wetland for biologic treatment and polishing cells were added to improve the quality of the water exiting the system.

As an introduction to the next portion of the symposium, Mr. Lawson highlighted a misperception that mountaintop mining operations using draglines leave large flat areas with monolithic structures uncharacteristic of the Appalachian region. At the Samples Mine, he pointed out, the dragline was used to move overburden from one area to another and lift the elevation of the material to an average of about 225 vertical feet of relief above the lowest coal seam being mined. This could not be economically accomplished by a truck and shovel operation at this site according to Mr. Lawson. Photographs presented by Mr. Lawson showed how this is being accomplished at the Samples Mine.

Mr. Lawson expressed the opinion, which he supported by several photographs, that the mining industry has become very good at the reclamation of sites in accordance with the approved post-mining land use, including fish and wildlife habitat.

Panelist Recommendations

The seven experts that toured the mining sites were each provided an opportunity to introduce their individual and collective perspectives on the subject of Aquatic Ecosystem Enhancement. These remarks are grouped into three areas (Landforms, Aquatic Resources, and Vegetation) with corresponding breakout sessions later in the symposium. Each topical area was followed by a brief question and answer session with remaining questions deferred to the breakout sessions.

Landform

Horst Schor and John Morgan

Comments by Mr. Schor

Mr. Schor described his interest as the changes in landform that take place when man makes use of the land for some purpose. Much of his work evolved as a response to urbanization on the west coast but his work has become of interest around the world as people deal with issues similar to mountaintop removal mining in Appalachia. The photographs he presented depict the radical alteration of the landscape with the resulting man-made landforms that coincidentally alter the hydrology into a sheet flow pattern. He noted that the progressive erosion of these man-made sites typically changes the site back toward a natural system of radial patterned swales. He suggested that reclamation of the site to natural landform analogs with vegetation concentrated in the swales is more visually appealing and more stable in the long-term. The concentration of moisture in the swales and focusing the development of vegetation in these areas promotes a more sustainable ecosystem, according to Mr. Schor.

Mr. Schor noted the distinction in the post-mining land forms at surface mines and at mountaintop mining operations. Surface mines, he observed, tended to retain much of their natural relief (elevation and contour) while there was a dramatic change to the relief at mountaintop mining sites. He noted that the reformed land shapes tend to promote sheet runoff across large areas channeled into streams without much transition from top to bottom. He also noted that Catenary Coal had succeeded in recreating a ridgeline in a man-made landform. The next step toward his concept of natural landform regrading, he explained, would be to also depress the valley fills recreating a natural runoff path. According to Mr. Schor, an example of this concept was designed into the Pine Creek Branch valley fill in Kentucky, which was permitted with a depressed valley fill design, but the fill has not yet been constructed.

Mr. Schor described a project he had recently completed for the Department of Power and Water, City of Los Angeles, which involved a half million-yard valley fill. In the photograph he presented, the main drainage path was a curvilinear pattern with radial drainage paths leading to it throughout the length of the run. The benefit of the project, according to Mr. Schor, was that the Corps and the FWS granted credit for wetland and riparian woodland habitat mitigation where the project had concentrated runoff in the swaled areas, thus avoiding the cost of going off-site to achieve mitigation. He noted that depressing the valley fill and raising the ridgelines would affect the areal size of the fill. However, he also noted that, based on the information he gathered during the tour, these valley fills only account for about thirty percent of the total backfill material handled at the sites. He expressed the opinion that it should not affect the cost of the operation substantially. Based on his experience with the Los Angeles project, Mr. Schor explained that depressing the valley and raising the ridgeline caused only a ten percent reduction in the holding capacity of the design fill.

Comments by Mr. Morgan

Mr. Morgan pointed out that what the industry has been asked to do [reclamation] it has learned to do very well. According to Mr. Morgan, the objective of the symposium was to explore where we might alter the objectives of the industry during reclamation to satisfy environmental concerns regarding the resulting aquatic ecosystem. With the current valley fill design, commented Mr. Morgan, we are removing streams and replacing them with upland habitats that have far less aquatic resources. Mr. Morgan explained that there is currently no water on the backfill for a number of reasons including:

- Greater permeability in the mine spoil leading to greater infiltration
- Nothing to retard the flow during storm events
- No defined horizons within the backfill like in the pre-mining configuration
- No aquicludes until you reach the outcrop of the lowest coal seam.

Mr. Morgan presented a diagram of a model surface mining operation and explained that the water in the fill area infiltrates into the backfill material until it reaches the pavement under the lowest coal seam. The outcrop of this flow is typically at the toe of the valley fill, explained Mr. Morgan. He continued on to note that some surface water is captured in the surface drainage ditches but it also tends to quickly infiltrate. According to Mr. Morgan, in fill areas there are very few surface flows except during storm events and there are very few ponds allowed to remain on the backfill area. He expressed the opinion that this is driven by the objectives of the Approximate Original Contour (AOC) Model, which minimizes the areal extent of a valley fill based on geo-technical considerations.

Mr. Morgan proposes an alternate geometry for the placement of spoil in the valley fill area that allows the subsurface flow over the pavement horizon to emerge onto a low point of the valley fill. Identifying where this will occur and intercepting this subsurface flow will provide perennial flow further up the mountain, according to Mr. Morgan. He noted that the experts saw an example at the Pen Coal operation in Wayne County of the increased perennial flow from ditches down dip of the valley fill. Mr. Morgan proposed constructing more of a side-fill in the valley fill area tilting the face to one side, rather than a horizontal surface, to intercept the subsurface flow at a reasonably low gradient creating a stable surface aquatic resource. The disadvantage of this configuration, according to Mr. Morgan, is that you will have a concentration of water flow on one side of the fill and there will be regulatory concerns as you try to meet the 2:1 slope and 50-foot separation of benches on a side fill. There will likely be additional costs to place the side fill material further up on the hill, he explained. Mr. Morgan proposed a change to the AOC Model to allow the operator the flexibility to vary from the strict geometric approach and introduce landforming as a means of improving the aquatic habit in reclamation areas. He introduced a comparative study of the current AOC model and the alternative side fill configuration, which uses a volumetric definition for AOC, for a site in eastern Kentucky that had not been mined. According to his model, the side hill fill model actually covered less area because the backfill material was placed further up on the mountain. He further depicted a third phase to the AOC process to optimize the extent of the fill somewhere between these two solutions to allow the operator the flexibility to introduce additional landforming.

Questions and Answers

Mr. Schor and Mr. Morgan then entertained questions from the audience:

Q: [to Mr. Schor] Are you aware that the design surface water flows for this region [Appalachia] are much greater than in southern California? Also, our fills have a much greater volume than the example you showed. How do you know that your concept will work in this region and the fill will not all erode away?

A: Mr. Schor explained that the half million cubic yard project [for the City of Los Angeles] was only one example but is comparable in size to some of the valley fills in this area. Also, he explained, the last project he worked on was over 22 million yards of soil. With respect to the water flow, Mr. Schor continued, the criteria is how the drainage is concentrated into the tributaries; the larger water flow of this area would necessitate smaller concentration areas like smaller valleys. The person asking the question followed up that based on his extensive experience he has noted many fills constructed to the current design standard that could not withstand the extreme water flows of this area and failed.

A: Rocky Powell added that in his presentation later he would draw a comparison between pre-mining morphology and post-mining conditions. Mr. Powell noted that in post-mining conditions the ecosystem is changed from forested watersheds to grasslands. Additionally, he explained, we have reduced the time of concentration by departing from natural landforms, which has the effect of increasing erosion. He noted that restoring the natural landform and restoring the vegetation will increase the storage in the channel and convey the water in a more controlled manner.

Q: [to Mr. Schor] What requirements that the mining industry is currently under would have to be changed for your concept to be implemented at large-scale surface mines?
A: Mr. Schor replied that the operator would have to have relief from current design requirements for surface slope and bench requirements. According to Mr. Schor, examples of this were observed at the Samples Mine where they had not only restored the ridgeline but also did not have any benches. Furthermore, he commented, the equipment operator at this site explained his technique for preventing erosion was to grade the surface in a way that prevents the concentration of too much surface water- exactly as his theory suggests. Mr. Schor noted that the equipment operator had coincidentally developed this technique from field observation.

Q: [to Mr. Schor] What proportion of fill material would require rehandling or special handling to accomplish your concept?
A: Mr. Schor explained that this would be up to the operator but could actually be less. In a project he worked on in Virginia, explained Mr. Schor, the operator left two or three planned fill areas open. He thought the alternative concept might require an average of about thirty percent change in the amount of material handled.

Q: [to Mr. Morgan] What changes would you make to the AOC Model to accomplish your modified valley fill proposal?
A: Mr. Morgan explained that AOC calculates excess spoil that would require placement in a valley fill. He commented that the amount of material that is placed back on bench should be maximized. The volume of material placed in the valley fill should be minimized, according to Mr. Morgan, and not be greater than that calculated by the AOC Model. Mr. Morgan expressed the opinion that the operator should have the flexibility to put material where it best supports his operation.

Q: [to Mr. Morgan] Assume the mine is designed to AOC. Then you depress the valley fills and raise the ridgelines to construct natural landforms. This appears to increase the length of the stream affected. Please comment.
A: Mr. Morgan responded that this would be true in many cases. However, he noted, the issue of covering up a stream is a value judgement that should consider the quality of the original stream length. He concluded that the potential benefit from increasing the length of stream affected compared to the benefit of the proposed reclamation project is an issue that should be considered during the EIS process.

Q: [to Mr. Morgan] The AOC optimization approach conveyed in the slides does not reflect many of the necessary working conditions of a mining operation.
A: Mr. Morgan responded that the initial and additional material must be placed on the mined area.

Q: [to Mr. Schor] Are there other landforms possible for valley fills? For example, how about a finger ridge?

A: Mr. Schor replied that there are a myriad of alternatives for natural landforms.

Aquatic Resources

Rocky Powell, Dr. Bruce Wallace, and Randy Maggard

Comments by Mr. Powell
Mr. Powell prepared a written report, which is included as an appendix to this proceedings, containing his observations and recommendations from the tour of the four mine sites and he highlighted the report for the audience. Then he focused his remarks on the subject of stream channel morphology as he had mentioned during the morning session of the symposium.

Mr. Powell used a series of eight criteria to compare pre-mining and post-mining conditions of the aquatic ecosystems at each mine site:

- Are the valley and watershed characteristics consistent with pre-mining conditions?
- Is the vegetative cover consistent with pre-mining conditions?
- Have the soil characteristics been modified?
- Has the hydrologic regime been modified?
- Has the sediment regime been modified?
- Is channel morphology consistent with a natural, stable channel form?
- Have the physiochemical properties of the streams been altered?
- Have the biotic communities, trophic structure, and energy sources of the stream ecosystems changed?

He acknowledged that he had to rely on his experience with other watersheds in the region to complete the assessment due to the lack of pre-mining conditions for the mine sites that were visited. His report provides a detailed presentation of the regional watershed characteristics that were used as a pre-mining baseline for the assessment.

Based on his analysis, Mr. Powell concluded that the streams and ponds he observed did not serve to mitigate (replace the structure and function of) the original first and second order watersheds. Mr. Powell noted that the focus of his comments will be on enhancement, or improvement to the existing practices of mining and reclamation, with respect to aquatic resources. He pointed out that, in his opinion, the mining operators are doing a very good job of complying with current regulations and in many cases go beyond the regulations.

Mr. Powell commented that in the pre-mining condition, storm flows are moderate, runoff is minimal, and base flow is fairly reliable. The exception, he noted, is in shale and sandstone areas where flow may discontinue, especially during the summer. First and second order streams have base flow cross-sections where this base flow is channeled according to Mr. Powell. He explained these streams also have a flood surface where storm flows are channeled after they exceed the base flow section. In the post-mining condition, he noted, the reconstructed streams have little or no base flow and are designed to carry only storm flow and with a lack of base flow, there is no area for aquatics to live. He pointed out that there was evidence in the field that, with time, many of these constructed ditches and channels are evolving into a series of steps and pools. He also noted that the shape of the constructed channels is trapezoidal and designed to carry all the flow in one channel which differs from a natural channel. Mr. Powell showed pictures of several constructed channels and the erosion problems they endure including head cuts that travel up channel and scour erosion that travels downstream.

From an aquatic standpoint, Mr. Powell reiterated that without base flow there is little hope of establishing aquatic life forms. The mining industry, according to Mr. Powell, has constructed many storm flow channels that are very effective at handling storm flows and reducing the sediment loading on downstream water resources but do not contain base flow to support aquatic life forms. Mr. Powell expressed confidence, based on what he observed during the site visits and other recent study, that the mining industry could be successful in constructing natural channels with base flow capable of supporting aquatic organisms. Mr. Powell presented a number of examples of natural stream systems with various overall gradients, both steep and shallow, and explained how each had its own aquatic ecosystem. He also emphasized reclamation to natural channel flow with visual examples from several of his reclamation projects.

Comments by Dr. Wallace

Dr. Wallace followed Mr. Powell and provided his observations from the mine site visits. He started off by noting that he only observed flowing water in two places at the four sites that were visited. He commented that, perhaps, it is unrealistic to try to recreate lotic habitats in these areas. While he supports protecting every stream that exists, he noted that we may need to look to other values in these mined areas. He expressed the opinion that the trade off is between wetlands and headwater streams- they both have value. Headwater streams are a major feature in Appalachia, according to Dr. Wallace, while ponds and wetlands are relatively rare in this region. Furthermore, according to Dr. Wallace, streams normally have maximum interface with the terrestrial environment acquiring energy resources from the adjacent watershed whereas in ponds and wetlands the primary forms of energy are algae or plant material that enter the detritus food web. Streams have important linkages to downstream areas whereas wetlands vary, according to Dr. Wallace. Wetlands observed during the mine site visits, he continued, were not linked to the downstream watersheds- again, not that they do not have value but they do not replace the pre-mining streams. However, he noted, the wetlands do tend to limit the effect of disturbances on the downstream watersheds. Also, Dr. Wallace continued, the biologic communities found in streams tend to be indicative of disturbance whereas in wetlands this is much less so. Therefore, he concluded, trying to replace the aquatic resource of original streams may not be possible and there is certainly a trade-off between a reconstructed stream and a wetland.

One way to look at this tradeoff, stated Dr. Wallace, is in terms of minimizing the effect of valley fills on downstream reaches. He noted that the problem with the temperature coming from the base of a fill is that it is somewhat like a spring- nearly constant annual temperature. With a pond, Dr. Wallace noted, you will have exceptionally warm water in the summer and cold water in the winter. He expressed the opinion that we could redesign our ponds with larger shallow areas and increased throughput for the overall pond. Increasing the shallow zone, according to Dr. Wallace, will increase the amount of aquatic macrophytes and the benefits derived from them and the increased amount of wetland may also address the water chemistry problem that he hypothesizes to exist downstream from the toe of the valley fill. Dr. Wallace also noted that a number the sites have long straight stretches of drainage ditch that could be improved by creating a more natural, meandering run as proposed by Mr. Powell.

Changing the design of these wetlands, commented Dr. Wallace, simply by increasing the diversity of vegetation could improve the contribution to the ecosystem, particularly groundwater recharge. Also, he noted, creating an anaerobic condition as exists in many wetlands is an important contribution to denitrification and to transformation of sulfates in mine drainage to an immobile form- two important contributions to the quality of groundwater.

Dr. Wallace provided the following tabulation of some relevant comparisons of small streams and ponds or wetlands.

Headwater Streams	**Ponds and Wetlands**
Major features of the Appalachian landscape	Present, but rare in Appalachian landscape
Maximum interface with terrestrial environment	Less interface with terrestrial environment
Energy resources from adjacent watersheds as leaves, detritus, etc.	Primarily autochthonous primary production from algae and aquatic plants
Important energy links to downstream areas. Creeks and rivers strongly connected into a system	Rather closed energy system with less linkage, if any, to other areas, or downstream
Disturbance in headwaters can influence downstream areas	Little effects of disturbance on other ecosystems
Important retention and transformation of nutrients and organic matter	Can be important sites of nutrient storage and uptake provided sufficient littoral zone with plants
Biological communities (at least animals) often indicative of disturbance	Biological communities not as indicative of disturbance

Comments by Mr. Maggard

Randy Maggard summarized his views as consistent with the views of Dr. Wallace; do we want to try to replace intermittent and perennial streams or should we proceed with the development of wetlands and ponds? Mr. Maggard noted that someone had made the comment to him that there are no aquatic resources on reclaimed mine sites- only mud holes. He commented in reply that, while they may start off as mud holes, they do not remain mud holes. Mr. Maggard presented several photographs of sediment pond projects developed by Pen Coal. He indicated that his company has performed a number of studies that substantiated the aquatic resources that are present in these habitats and that they are improving over time.

Mr. Maggard provided three of these studies to the other experts of the panel for there use during the mine site visits. The document citations are presented below and the documents are included as an appendix to this proceedings.

Maggard, Randall and Ed Kirk. "Downstream Impacts of Surface Mining and Valley Fill Construction." Paper presented at the 1999 Annual Meeting of the West Virginia Acid Mine Drainage Task Force. Morgantown, WV. April 13-14, 1999

"An Evaluation of the Aquatic Habitats Provided by Sediment Control Ponds and Other Aquatic Enhancement Structures Located on Mine Permitted Areas in Southern West Virginia." Conducted for Pen Coal Corporation; Kiah Creek Mine Office; P.O. Box 191; Dunlow, West Virginia 25511. Prepared by R.E.I. Consultants, Incorporated; Ed J. Kirk Aquatic Biologist; 225 Industrial Park Road; Beaver, West Virginia 25813. November 23, 1999.

"Benthic Macroinvertebrate Study of Honey Branch, Its Sediment Control Ponds, and Its Influence on the East Fork of Twelvepole Creek Conducted 10/08/99" Conducted for Pen Coal Corporation; Kiah Creek Mine Office; P.O. Box 191; Dunlow, West Virginia 25511. Prepared by R.E.I. Consultants, Incorporated; Ed J. Kirk Aquatic Biologist; 225 Industrial Park Road; Beaver, West Virginia 25813. November 24, 1999.

Questions and Answers

The conclusion of Mr. Maggard's presentation was followed by a period of questions and answers on the subject of Aquatic Resources. Only one question was asked during this session.

Q: [to John Morgan] Do you see any situation where you can add streams or wetlands higher up on the hills in these fill areas? Is basal flow rare or can it occur at any site? Do you think from the number of West Virginia mining sites you have seen that this [basal flow] is possible at most sites?

A: As mentioned earlier, responded Mr. Morgan, it will be difficult to create basal flow at an elevation any higher than the outcrop of the lowest seam being mined. He continued by noting that the features that Randy Maggard showed are on the down dip side of the mined area where basal flow will typically occur. On most mine sites you will have some area where basal flow can be captured according to Mr. Morgan.

Vegetation

Ben Faulkner and Dr. Steven Handel

Comments by Mr. Faulkner

Mr. Faulkner began his remarks by noting that the only water that is consistently available around these sites is from the sediment channels down gradient from the surface-mined area and from the ponds and sediment structures below the valley fill. He commented that the valley fill provides a desirable source of water with near constant temperature and with plenty of dissolved oxygen that is of interest to the aqua culture industry. Furthermore, he continued, it is important to recognize that during the drought last summer the only source of consistent water flow in first and second order streams was from these valley fills. Although fills may change the appearance of the stream, it creates a different, not necessarily a worse, aquatic habitat according to Mr. Faulkner. He expressed the opinion that we should encourage leaving ponds on and below fills and encourage diversification of vegetation in and around the water courses to provide the shade and detritus that Dr. Wallace has identified as important to the ecosystem.

Mr. Faulkner described several practical and regulatory considerations for revegetation in and around drainage structures and watercourses.

1. Engineering considerations for hydrologic appurtenances.
    - safety considerations
    - erosion considerations
    - terrestrial and aquatic habitat enhancement
    - final reclamation considerations
2. Tree and shrub species for forestry and wildlife planting plans.
    - water availability and management
3. Natural succession on surface mines.
    - alien species vs. natives
4. Logistics and economics of revegetation and reforestation.

He noted that safety is of paramount consideration in surface mine development and reclamation. Mr. Faulkner commented that engineering watercourses for direction and retention of seepage and surface runoff must safely pass design storms. Furthermore, he continued, any efforts toward enhancement of the aquatic habitat provided by these structures must not compromise the safety or sediment control objectives of the structure.

Encouraging wildlife and aquatic life in watercourses and structures is generally of no negative influence on mining operations, according to Mr. Faulkner, with the exception of muskrats or beavers which may compromise the principal spillway elevation or interfere with bank stability. Seldom, he noted, can unreinforced grass covers be used in diversion ditches on steep slopes. Mr. Faulkner stated that where velocities exceed the maximum allowable for vegetative cover (3 fps), rock rip rap is used. He further stated that there is no comparison of cost, and slopes are kept as flat as possible to permit the lower velocities and cheaper grass banks whenever possible to control erosion. He identified two concerns in planting additional stems of shrubs or trees around sediment or drainage structures. First, the root system of woody vegetation, if planted in proximity to pipe conduits, will grow along those conduits compromising the integrity of the pipe and the compacted fill around it. Second, any plantings where water is impounded against compacted fill must be planned with this in mind.

Another concern in aquatic habitat enhancement, according to Mr. Faulkner, is that although the “long range” view is sought when selecting vegetation, one must realize that the long range (seral succession climax) of standing water in the Appalachian geology and geography associated with West Virginia is a grassy meadow and then a climax hardwood forest. Furthermore, he noted, there is no naturally occurring lentic community in the state with the exception of a one acre pond in the eastern panhandle. According to Mr. Faulkner, the future of all pools of standing water in the state (from man-induced activities, beaver dams, or inadvertent activity such as railroad or highway fills) is to be filled with sediment and become a meadow and then grow into a forest. He commented that established lentic aquatic habitat is present only for a limited time. Furthermore, he continued, there will always be a lotic community, but it will also change as the site ages. Additionally, he noted, increasing the number of woody stems around a lentic water body will accelerate the desiccation of the pool during periods of drought as the trees mature and their need for water increases. According to Mr. Faulkner, this will accelerate the natural succession of the water body to a meadow and eventual hardwood forest, actually reducing the number of years of lentic habitat and strongly influencing the remaining lotic habitat.

Mr. Faulkner commented that the lotic aquatic habitat on mountain-top mining sites is quite limited and that spoil swell necessitates steep slopes and watercourses or gentle watercourses over valley fill crests or backfill. This material, he commented, is so porous that it usually holds water only in response to significant precipitation events. The only location water can be found with some continuity is in down-dip sediment structures along the outcrop (sediment channels) or at the toe of the valley fills according to Mr. Faulkner. Generally, he noted, the only dependable lotic water is from the toe of the fill to the sediment pond, and this is generally a short distance. However, he continued, both these locations provide some dependable aquatic habitat which may be enhanced through land use and focused vegetation efforts.

During the drought in West Virginia this summer, the only first order watersheds with flow contained proven springs or valley fills according to Mr. Faulkner. The fills through their porous nature, he commented capture all seepage and runoff within the watershed and slowly release the water over a several month period, flattening out the wide runoff flows seen in an undisturbed or disturbed watershed. Generally, Mr. Faulkner commented, valley fill flows (at the toe) are oxygenated with reduced amounts of sediment and a constant temperature. He expressed the opinion that this constant, moderate temperature (generally about 55° F) is ideal for fish aqua culture. Substantial interest, according to Mr. Faulkner, has been raised about this resource in the state in the last few years including an extensive study and investment by the West Virginia Department of Agriculture and U.S. Department of Agriculture. Mr. Faulkner expressed the opinion that water quality at mines in West Virginia is generally of good quality, with only five percent of all NPDES sites requiring even occasional water quality attention.

The lentic habitat in shallow sediment ponds and channels can be made to be more beneficial for aquatic life with the planting of shrubs and trees to add detritus according to Mr. Faulkner. This coarse particulate organic matter, he noted, will be available to the shredder macroinvertebrates that will export fine particulate organic material downstream to the valley fill sediment ponds and receiving streams.

Mr. Faulkner stated that economics is of particular concern at drainage structures. Only a handful of hydrophilic woody stems are available from the state nursery according to Mr. Faulkner. He continued that the state nursery makes these plants available a full order of magnitude cheaper than commercial nurseries. He commented that state nurseries should be encouraged to provide additional viable species at a reasonable price. He also noted that substantial work was done on tree species, soil building and vegetation through the U.S. Department of Agriculture in the 1960's and 1970's and this material is available to the mine operator.

The sediment channels and valley fill ponds represent the best available aquatic habitat on surface mines, according to Mr. Faulkner, but they are often removed within a few years at the landowners request because of liability concerns. He stated that this complicated question will require a collective agreement between operator, regulator, and landowner.

In summary, Mr. Faulkner noted that fills on surface mines offer some significant benefits:

- a constant, moderate temperature and oxygenation which is optimum for aquatic life.
- Fills "meter out" water during drought.
- Fills provide "different" aquatic habitat (lentic) which is rare in mountains of West Virginia compared to plenteous lotic habitat.

He concluded that during reclamation we should encourage:

- Leaving ponds on and below fills.
- Planting diverse vegetation in/around watercourses to provide shade and detritus.

Comments by Dr. Handel

Dr. Steven Handel, a professor of ecology and evolution at Rutgers University, focused his presentation on the issue of landscape links and the potential of using natural landscape processes and links to restore and enhance wetland environments. Using the example of an oak woodland in West Virginia, Dr. Handel discussed the links between the first order streams and the surrounding terrestrial habitat. What can we do, he asked, in areas where there is sufficient base flow to support a first order stream to make them function in a manner similar to some of these natural streams? He added the question , how can we build on the natural ecological processes to rebuild self-sustaining natural landscapes at a minimum cost?

The difference between restoration ecology and landscaping is one of process and change according to Dr. Handel. He noted that for an ecologist the design has a wildlife value with a minimum amount of subsequent human involvement while a landscaper creates a human-dominated landscape with plants available from the commercial nursery. What the restoration ecologist plants to begin the process may all be gone in a few years according to Dr. Handel. He added that success is achieved when the original plants are replaced in natural succession by other self-sustaining native plants.

Dr. Handel highlighted that the value of small first order streams is enormous as has been pointed out today by others. He emphasized that his interest in these streams is based on their benefit to the surrounding wildlife. He noted that small ponds and flowing water attract wildlife to the area. While displaying photographs of a mine reclamation project and the rip rap lined drainage channels, he emphasized the opportunity to improve the surrounding ecosystem by encouraging the growth of vegetation. He rhetorically posed the question, how can we do this on very large sites that are engineered with large areas of grass and small clusters of trees? He responded that a concept that should be of interest to this audience is the idea of designing the site restoration to attract birds-natural landscapers. That design, he noted, includes perching, foraging, and nesting areas, and areas where they can find protection from their enemies.

He explained that his recent studies have considered the idea of encouraging natural succession by creating "islands" that attract natural seed dispersers (birds). Out west, he noted, people have experimented with the idea of transplanting an area of natural vegetation in a chunk on reclaimed mine sites. The experiment, he explained, included establishing twenty of these "islands" with traps under the trees to find out what types of seeds were being introduced into the area and are they appropriate natural succession plants. He continued to explain that samples taken during the first four months of the study collected approximately 14,000 seeds in a 65 square meter area including 26 native plant species that were not planted on the reclaimed site. This, he concluded, showed that this link in nature could be quickly established by providing a target for the birds to perch on and some remnant of the native vegetation in the surrounding area to provide the seeds. Of importance to this audience, he noted, is to know that the small pockets of native vegetation that are left intact at a site become a critical source of seeds to stimulate the subsequent natural succession during the reclamation process.

Seeds are only one part of reestablishing plant demography according to Dr. Handel. The quality of soil and the ground cover placed at the site are also important, he added, to the development of seedlings and eventual self-sustaining growth. He noted that there is general agreement that it is important to limit the amount of compaction of the top layers of soil at the site. He expressed the opinion that we must also modify the amount and type of ground cover that we place to control erosion, which is as important for proper development of the ecosystem as it is for the safety of the site. Deep rooted ground covers bind the soils and make space for the small seedlings of woody plants, he explained. He noted that this was discussed at the industry meeting last spring (1999) in Kentucky with the conclusion that operators must be trained to tread lightly on the land and to modify the types of ground cover used.

Dr. Handel also noted that diversity of vegetation is essential. He commented that the panel of experts observed many examples of wetlands on mine sites that are heavily populated with cattails. However, commented Dr. Handel, there was not sufficient diversity of vegetation. He continued to explain that what is missing are the blueberry, elderberry, willows and other shrubs and herbs that are typical of watercourses in the southeast where there is sun and adequate water. To get those back, he noted, we will have to jumpstart the process ourselves. He concluded with the comment that having only one species of plant is insufficient to promote natural succession because it will not attract a variety of birds.

Dr. Handel identified the presence of wild bees, which are essential to setting seeds and cultivating plants, as another consideration to enhance the natural succession process. There are over 8,000 species of wild bees in North America according to Dr. Handel. He explained that bees nest in soft ground or hollow trees and eat nectar and that simple modifications to encourage the habitat development of bees are necessary including the addition of flowering groundcover since grasses are all wind pollinated. Dr. Handel also noted that microbial processes in the soil are essential to the development of plant roots. He continued to explain that there are businesses that sell small packets of innoculum but we do not necessarily have to buy them. Sometimes, he noted, the necessary microbes will move back in by themselves if we have remnant forest areas near the mine site. Dr. Handel commented that studies have shown that in newly disturbed areas the amount of fungi on plant roots dissipated rapidly with the distance into the distressed area from the edge of site. He explained that this can cause the stressed nature of the woody plants and the inability of these plants to sustain growth. Dr. Handel noted that if we can hold, stockpile, and respread the original topsoil, we can retain these microbial populations and accelerate their reestablishment across the site.

Dr. Handel described an experiment that measured the ability of native plant species to grow on sites reclaimed with typical mixtures of rough grasses (fescue and Timothy). He explained that of more than 8,000 native plant species seeds only 130 seedlings were able to establish themselves in the soil and native grass mixture of a reclaimed site. The only species that were successful, he noted, were chokeberries, hackberries, dogwoods, spicebush, white oak, and sumac. He concluded that the typical mixture of rough grasses challenged the development of native species. Additionally, he noted that this further emphasized the interrelation of all the aspects of reclamation (seeds, groundcover, bees, “islands”, water) and how they affect the resulting ecosystem.

Dr. Handel described the reclamation project at the Powell River site where the compaction had been carefully controlled and the topsoil stockpiled and remixed. He commented that this provided a good example of the more advanced reclamation techniques that lead to greater value for the landowner. He noted that increasing the value to the landowner for subsequent land use creates an important economic incentive that could translate into lower lease rates to the coal operator. He also pointed out a typical rip rap drainage channel and expressed concern that it is so commonly used throughout the region. According to Dr. Handel, there are situations where more suitable techniques may be used with little or no increased cost that would enhance the value of the water structure. He presented photographs of several alternative bioengineering projects that would replace rip rap. One example project, he noted, used organic fabric that will remain in place for several years until the plant growth is sufficiently established to protect the drainage channel from erosion. This particular example, according to Dr. Handel, had sustained two fifty-year floods in sequential years with no observable damage to the channel. Dr. Handel also commented that nursery stock may not have adequate biodiversity to develop a self-sustaining community. Accordingly, he concluded that we need a mixture of genotypes and these need to be reflected in our regulations.

He concluded his presentation by listing several environmental enhancement considerations to the hydraulic engineering that goes into a reclamation project:

- Create situations where restoration leads to reproduction
- Assembly of new communities
- Enhance invasibility by inviting natural dispersers
- Establish successional processes
- Meta-populations; linkages to the remnant forests that surround the site such as islands
- Buffer natural populations by having more plants in riparian zones
- Ecological processes
- Habitat links
- Cost effective management and monitoring

Dr. Handel commented that drainage channels and sediment ponds solve the engineering problems but they only create plumbing devices. He expressed the opinion that we would like to add to the hydraulic engineering concerns by introducing living restoration ecology solutions. Then together, he concluded, we can create a habitat that can begin to restore the ecological services we all depend on.

Questions and Answers

Dr. Ziemkiewicz expressed his observation that some of the recommendations appeared to be contradictory. For example, he continued, topsoil recovery preserves nutrients and, to some extent, the microbial population. He noted that many topsoils contain significant clay and spreading them on the surface can lead to significant compaction. He opened the question and answer session by raising the first question.

Q: [To the panel] Which is more important, the microbial population or the need for loose compaction? How many cases where topsoil is stockpiled do we see native plant populations subsequently emerge?

A: Mr. Faulkner explained that there is very little topsoil to begin with in so many areas and it is difficult to collect because of the roots and rocks. Furthermore, he noted that the desirable qualities of topsoil do not store well. He expressed the opinion that when topsoils are removed and subsequently remixed with spoil material very little of the microbial population will remain to support the desirable species.

C: Mr. Faulkner commented regarding Dr. Handel's point about bee populations. Mr. Faulkner explained that while there are many grasses on these reclaimed sites, we also have many plants that encourage pollinators such as trefoil and crown vetch. While many people dislike these ground covers, exclaimed Mr. Faulkner, they do have flowers for much of the growing season.

C: Dr. Handel responded to Mr. Faulkner with agreement that these flowering species are an enhancement. Dr. Handel also followed up on Mr. Faulkner's comments regarding topsoil by noting that topsoil is only a thin veneer above sandstone in mountain forests. Yet, he noted, these areas support huge forests suggesting that you do not need much topsoil. The issue is soil quality and not quantity according to Dr. Handel. Microbes are essential, he exclaimed, and studies have shown that you can create very healthy soils with only a small amount of topsoil mixed with crushed, weathered brown sandstone. Limiting the focus to the riparian zone, he continued, topsoil material would have to be introduced and minimizing the amount of compaction is critical. At one site, he observed, tilling the soil only six inches caused a dramatic increase in plant growth. On the point of stockpiling topsoil, Dr. Handel agreed that this can lead to anoxic conditions that damage the microbes. He concluded on this point by noting that some special handling is required to maximize the ecological value of the subsequent use of these topsoils.

C: Mr. Powell commented on the cost of restoration. He noted that there are many opportunities for stream restoration or creation of new streams. Creation of new streams at mountaintop mining sites, he stated, should not cause additional expense, it is a matter of changing the way the fill material is laid down. He also pointed out the difference of the higher gradient systems and that they require somewhat different techniques to control the energy of the stream compared to the bioengineering projects presented by Dr. Handel. In both cases, Mr. Powell concluded, the establishment of vegetation is essential to the long-term stability of the system.

Q: Mr. Morgan asked Mr. Powell for his opinion regarding sediment ponds and the value of multiple spillways, primary and emergency.
A: Mr. Powell explained that there may be benefit from changing some of the larger sediment ponds to shallow marshes with multiple channels to restore some lengths of channel.

C: Dr. Handel commented that it would be beneficial if we could find some way to increase the complexity or diversity of the streams. He added that this might include adding boulders, logs, snags, and channeling diversity that would have significant benefit to the development of the ecosystem and cost very little.

Q: [To the panel] What is the value of organic debris that is now lost during the process of creating a valley fill? According to the person asking the question, some in the Division of Natural Resources have felt the real loss is not so much the stream or the landform but the loss of the topsoil and the organic debris that has built up over time in the coves and valleys. He continued by noting that the DNR is looking at the possibility of collecting the material from one valley area and using that in the restoration of adjacent areas.
A: Dr. Handel commented that this debris should be mixed into the topsoil of adjacent areas and not burned. He explained that by placing the organic material back into the ground, it will rot and support the development of insects and other essential species. He expressed the opinion that it loses all its value when it is burned. Using this debris to restore a site, he continued, would be an enhancement that could be offset by a cleverly applied tax break and make improvements to having only hundreds of acres of grasslands. He stated that he has observed many sites reclaimed to grasslands when that is not typical of this region. Dr. Handel expressed the opinion that sites need to be set up to eventually return to a more natural ecosystem with much greater long-term economic value.
C: Mr. Maggard responded to Dr. Handel's closing remark with his observation that some landowners prefer the grassland because it offers more opportunity for near term economic potential.

Breakout Sessions

The symposium participants each selected to attend one of three concurrent breakout sessions to follow up on the conclusions and recommendations of the experts. These sessions were facilitated by representatives of the Department of Energy who are otherwise uninvolved with the development of the EIS. The focus of each session was to review the key conclusions and recommendations of each expert and to identify the associated benefits and potential barriers (regulatory, technical, liability, or cost) to implementing them. The experts were present in their respective breakout sessions and the Aquatic Ecosystem Enhancement Team Leader placed knowledgeable representatives of the regulatory community, particularly WVDEP and OSM, in each session. The summary presented by each facilitator to the reconvened symposium is presented below.

Aquatic Resources

Dr. Jan Wachter (National Energy Technology Laboratory), the Aquatic Resources Breakout Facilitator, presented the consensus recommendations from his breakout group to the reassembled Symposium. He noted that almost uniformly, the barriers were regulatory in nature and there were few concerns about technical, cost, or liability issues with these recommendations. Two of the recommendations developed in this breakout session were included with other breakout reports for consistency of subject matter.

1. *Make extensive use of existing sedimentation ponds and sedimentation ditches to create fisheries and wetlands thereby enhancing aquatic ecosystems on reclaimed mining sites.*

Benefits: The feasibility has been demonstrated. No major additional costs are incurred issues.

Barriers: Current regulations provide little or no consideration for aquatic ecosystem enhancement in ponds and wetlands. They are viewed primarily as a means of sediment control. Regulatory connotations inhibit long-term use. Landowners will retain long-term liability for the ponds and wetlands. Design standards for ponds and wetlands are not habitat related but are driven by storm water transport criteria. Need to have flexibility in regulations to encourage designs that consider base flow and bank full loading. In summary, there are very few incentives to develop standing water on the site, primarily due to geotechnical safety issues in SMCRA.

2. *Take advantage in the design of the valley fill for the generation and maintenance of base flow to create perennial aquatic habitat*

Benefits: Development of base flow is critical to the development and enhancement of the aquatic ecosystem. It is difficult not to have base flow (e.g., chimney drain effect) directed to the center of the hollow.

Barriers: Engineering driven regulations oppose and are frequently counterproductive to aquatic ecosystem enhancement (e.g., engineering stability goals versus aquatic enhancement goals). No incentives are given to the operator for designing stream channels and other aquatic habitat into the valley fill structure to establish base flow.

3. *Create incentives (or remove disincentives) for companies to voluntarily manage wetlands at reclamation sites.*

Benefits: Provides incentives to the operator and landowner to develop and maintain aquatic habitat.

Barriers: Regulation reform is needed with "hold harmless" consideration with respect to wetlands and other aquatic habitat, especially related to the landowner's liability if he should need to remove or fill in the wetlands.

4. *Modify overburden disposal and valley fill practices to minimize the impact on primary and secondary streams.*

Benefit: Minimizes the impact on natural streams.

Barrier: Deferred discussion of barriers to Landform breakout due to time constraints.

5. *Restore existing stream channels and flood plains where opportunities exist.*

Benefit: Minimizes the impact on natural streams.

Barrier: Also deferred discussion of barriers to Landform breakout due to time constraints.

Vegetation

Dr. Heino Beckert (National Energy Technology Laboratory), the Vegetation Breakout Facilitator, presented the following summary to the reassembled symposium. His breakout group reached consensus on six key recommendations with the associated benefits and barriers. The seventh recommendation below was developed in the Aquatic Resources Breakout Session and moved to this list for consistency of subject matter.

1. Stockpile native topsoil for use in lining banks of streams, ponds, and wetlands; also provide pre-treatment of topsoils to increase soil aeration:

Benefits: Increase of moisture retention capability of soil, facilitate infiltration of water and plant seeds; increase likelihood of successful revegetation.

Barriers: Difficulties in obtaining enough suitable topsoil; storage of topsoil may decrease its fertility by leaching and loss of microbial content.

2. Avoid use of exotic invasive plants in revegetation efforts.

Benefits: Development and maintenance of native flora, which is best suited for providing appropriate habitat for native wildlife and for erosion control.

Barriers: None; but nurseries must be encouraged to make available appropriate native plant species; this may present difficulties and increase of overall revegetation costs.

3. Plant a mix of different genotypes.

Benefits: Provides for the appropriate genetic diversity, resulting in better resistance to pathogens and will ensure healthy habitat suitable for a variety of native fauna.

Barriers: Nurseries will market what they can sell; it may be difficult to obtain a healthy genetic mix of the appropriate species instead of clones of species selected for revegetating mine sites.

4. Plant a buffer zone around streams and ponds.

Benefits: Enhancement of aquatic communities; results in ecological advantages by providing appropriate habitat for littoral flora and fauna.

Barriers: Restriction of access for cleaning ponds of sediments; possible safety concerns with pipes being damaged by tree roots.

5. Use of bio-engineering materials for use in stream channels and banks.

Benefits: Prevents erosion, stabilizes banks, enhances seed development and speeds up the overall revegetation process.

Barriers: Suitable only in moderately flat terrain; must last at least five years while vegetation becomes properly established; may require engineering approval for installation.

6. Plant ground cover to attract and keep pollinating insects.

Benefits: Promotes reproduction of planted vegetation.

Barriers: Wildflower seeds are expensive; care must also be taken that these plants do not crowd out those species planted for the actual revegetation project.

7. (From Aquatic Resources Group) Modify soil characteristics in order to restore native species. Restore the innoculum to the topsoil and allocate topsoil for riparian and ridge zones- not necessarily the entire landscape.

Benefits: Encourages the restoration of native species and diversity to the reclaimed site and provides riparian and ridge buffer zones.

Barriers: This recommendation conflicts with current topsoil regulations such as the one that provides a requirement for pH maintenance. May be counter to the decreased use by regulators of the "fish and wildlife land-use option" for non-AOC sites. Cost and education of regulators and operators are also barriers.

Landform

Mr. Randy Moore (EG&G), the Landform Breakout Facilitator, presented the consensus of his breakout group to the reconvened symposium. This breakout group identified two summary recommendations. A third recommendation below was developed in the Aquatic Resources Breakout Session and moved to this list for consistency of subject matter:

1. *Promote natural landforms on backfill areas to create more natural drainage patterns.*

NOTE: For more discussion on natural landform regrading on reclaimed areas, see the earlier discussion by Mr. Horst Schor and the relevant supporting information in the appendix. "Natural landforms" for this region of Appalachia are NOT flat top fills with a terraced face. Fills and regraded mined lands would have rounded tops with fairly smooth hill side slopes and valleys with stream channels - similar to unmined areas nearby.

Benefits: Natural landforms promote establishment of more stable and productive aquatic ecosystems in the drainage system. In some cases, the reclaimed site aquatic resources may be of greater economic value than the existing resources that were impacted by earlier land use.

Barriers: The principal barrier is the current 100-foot buffer zone imposed by Judge Haden's ruling based on the Clean Water Act, which prohibits valley fills on existing natural streams even temporarily. Additionally, landform contouring on the valley fill can extend the footprint required for disposing of the excess spoil. Longer lengths of streams can be impacted than currently allowed by the AOC model.

2. *Capture flow from down dip side of the mine site and within the valley fill to create base flow within the valley fill.*

NOTE: Water percolates down through the rocks and soils which have been placed back on the floor of the mined area. The floor of the mine is usually an aquatard which redirects the groundwater to the down dip side where it emerges as a "spring." If these "springs" are covered by valley fills in the reclamation process, they can be directed to *the toe of the fill through special channels built to carry the flow directly to the discharge point and minimize contact with fill material.*

Benefit: Capturing base flow from subsurface flow on the down dip side of the mine site provides an attractive opportunity to enhance the aquatic resources within the valley fill area.

Barrier: Capturing base flow at the outcrop of subsurface flow requires the movement of substantial spoil higher up on the backfill. Mr. Lawson demonstrated how this is possible with a dragline but could be costly at a truck and shovel operation. Any landforming to create natural relief or develop base flow, other than surface contouring, must occur during the initial movement of material while the large earthmoving equipment is still available or it may not be economically feasible. Additionally, the haul roads necessary to create the side fill will create additional compaction that is counterproductive to some post-mining land uses, such as commercial forestry.

3. (From Aquatic Resources Group) *Modify drainage systems to create stream and wetland areas on steeper regions.*

Benefit: Natural streams and wetlands in steeper regions is more characteristic of the Appalachia region. Note that there are not many wetlands in the Appalachian region that were not created by humans.

Barrier: The requirement to limit the total area of valley fills restricts the ability to construct more natural configurations. Aquatic ecosystem enhancement with natural channels may require the development of larger valley fills than allowed by the AOC model.

Symposium Conclusion

Dr. Ziemkiewicz expressed his appreciation to the group for their effort to develop the recommendations along with the benefits and barriers for further consideration during the EIS process. For his closing remarks, he provided his perspective on each of the three symposium focus areas, Vegetation, Aquatic Resources, and Landforms. He included a list of issues that must be developed further during the course of the EIS to be able to translate these recommendations into practice and such that the public will be able to understand their full benefit and costs.

On the topic of Vegetation he discussed the issues of soil reconstruction and plant community development. He noted that soil reconstruction is actually a very complicated issue; how to manage it, how to create soil, what criteria describes sufficient soil quality compared to overburden? How should reconstructed soil be handled? How long can they be stockpiled and still retain their beneficial qualities? Dr. Ziemkiewicz also discussed the issue of soil decompaction and the implications for compaction from using a dragline compared to a truck and shovel operation. He also noted the issues; is decompaction permanent? While it is necessary to reestablish vegetation, how effective is it over time? Dr. Ziemkiewicz commented that all of these questions and more will have to be addressed to communicate consistent criteria in advance to operators for the reclamation of a mine site.

Dr. Ziemkiewicz also discussed the complexity of plant community development. He asked the question, what kind of plant communities are needed at a reclamation site? Obviously, continued Dr. Ziemkiewicz, we need several different types including aquatic, riparian, and upland forests. He continued to question what species of plants should each type include? The regulation, according to Dr. Ziemkiewicz, must identify critical plant communities and essential native plant species. Another key issue he noted is that there is a need coordinate natural plant succession on mine sites while maintaining adequate erosion control because the operator cannot immediately plant oak trees or pine trees on a spoil area and hope to be successful. He concluded that we must have realistic expectations that consider natural succession to be able to coincidentally achieve erosion control while restoring natural ecosystems.

On the topic of Aquatic Resources, Dr. Ziemkiewicz asked the question, can streams be reestablished on mine spoil? From his experience, he commented, many operators have expended a lot of resources to try and place streams across spoil material without success. He continued that these reaches are difficult to maintain due to the high permeability of the mine spoil. According to Dr. Ziemkiewicz, operators and regulators have to consider the value of constructed wetlands compared to the value of the original ephemeral streams that may be covered in the process of valley fill. Furthermore, he questioned what is the comparative productivity of wetlands, ponds, and streams on mine sites? He commented that we may not be very close to getting the answers for this and other questions necessary to consider a regulatory basis for developing aquatic resources.

On the topic of Landforms he summarized the issue as the optimization of placement of fill material in a valley fill or by back hauling. Dr. Ziemkiewicz noted that we must be able to prescribe how to configure the landscape to meet all the competing criteria including aquatic ecosystem enhancement.

At the end of the EIS process, he concluded, we must be able to proclaim what we are trying to accomplish and the public must be able to understand the benefit to the aquatic ecosystem in comparison to other concerns.