S. HRG. 111–1197

THE IMPACTS OF MOUNTAINTOP REMOVAL COAL MINING ON WATER QUALITY IN APPALACHIA

HEARING

BEFORE THE

SUBCOMMITTEE ON WATER AND WILDLIFE

OF THE

COMMITTEE ON
ENVIRONMENT AND PUBLIC WORKS
UNITED STATES SENATE

ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

JUNE 25, 2009

Printed for the use of the Committee on Environment and Public Works

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ONE HUNDRED ELEVENTH CONGRESS
FIRST SESSION

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THE IMPACTS OF MOUNTAINTOP REMOVAL COAL MINING ON WATER QUALITY IN APPALACHIA

THURSDAY, JUNE 25, 2009

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
SUBCOMMITTEE ON WATER AND WILDLIFE,
Washington, DC.

The subcommittee met, pursuant to notice, at 3:30 p.m. in room 406, Dirksen Senate Office Building, Hon. Benjamin Cardin (chairman of the subcommittee) presiding.

Present: Senators Cardin, Alexander, and Inhofe.

OPENING STATEMENT OF HON. BENJAMIN L. CARDIN, U.S. SENATOR FROM THE STATE OF MARYLAND

Senator CARDIN. Thank you, Senator Inhofe, and the Ranking Member of our Subcommittee, Senator Crapo, for helping to arrange for today's hearing.

This is the first hearing that we have had in the Senate in 7 years on mountaintop recoveries. So, I think it is an important hearing and I want to thank the leadership for moving forward.

I also want to thank Senator Alexander for his help in arranging today's hearing.

Let me make a couple of opening comments. First, I think is one that is pretty obvious. Coal is important to America. It is an important mineral that we have, and I think this Committee recognized its importance last year in the Lieberman-Warner Bill that we worked and marked up, providing for coal as a part of our energy solution and investing a significant amount of resources into clean burning coal.

The bill that may be on the House floor tomorrow that deals with global climate change invests a great deal of resources in coal, recognizing its importance as an energy source to America.

This hearing is to explore one method that is used in coal mining in the United States and to look at its environmental and health risks. We are talking about the impact of mountaintop removal coal mining on water quality. That is the responsibility of this Committee.

Now, we have had similar concerns about water quality in other types of industries from manufacturing and industrial and agriculture, and I think it is very important that this Committee look at the mining practices of mountaintop removal and its impact on our water quality in America.

There will be future opportunities to look at specific bills, including a specific bill that Senator Alexander and I have co-sponsored.

Mountaintop removal has grown in the Appalachia. It is one method. It is primarily limited to Eastern Kentucky and Southern West Virginia. We have many environmental concerns concerning coal slurry impoundment, which is used in mountaintop removal, but coal slurry impoundments are used in other types of activities in addition to just mountaintop removal.

Mountaintop removal involves the complete deforestation of a mountaintop. The mountaintop is then systematically removed, moving down the mountain. The overburden is then dumped into the valley. The impact of this type of activity is dramatic. It is dramatic in regards to issues concerning runoff. Runoff gets filtered in a mountain through its vegetation and through its natural contour. When that is removed, the types of pollution that are not filtered are much more dramatic as a result of runoff issues.

We have found the disappearance of valley streams. Over 1,700 miles of stream channels have been adversely impacted by mountaintop removal. Valley streams are critically important to the downstream water quality. We have found that, as a result of mountaintop removal, that we have toxic contaminants in our water supply. There is a public health concern. We find a much higher incidence of kidney disease, chronic airway obstruction, pulmonary disease and hypertension, just to mention a few, in those communities that are impacted by mountaintop removal.

And there is the issue about the natural beauty of our Country being permanently changed as a result of mountaintop removal. It adversely affects the economies of the region as far as tourism, property values and alternative uses that could produce economic activities in these areas, including one in energy dealing with wind energy.

I am very pleased that we have two panels of experts, one from the EPA, the other a group of individuals who are experts in this area, to help this Committee understand the impact on our water supply caused by mountaintop removal.

I am very pleased to recognize Senator Alexander, who has been a real leader on this issue, and a member of our Committee.

[The prepared statement of Senator Cardin follows:]

STATEMENT OF HON. BENJAMIN L. CARDIN, U.S. SENATOR FROM THE STATE OF MARYLAND

I want to thank our panels of witnesses for coming before the Water and Wildlife Subcommittee today to discuss mountaintop removal coal mining.

It has been more than 7 years since this Committee last examined the practice, and in that time mountaintop removal operations have grown across Appalachia. Our hearing will examine the impacts of mountaintop removal on water quality and how it affects the quality of life for the thousands of residents living in the Appalachian coalfields.

So there is no confusion about the subject of today's hearing, let me be clear:

(1) Not all coal extraction operations in the Eastern U.S., or even in all of Appalachia, use mountaintop removal techniques to mine coal.

Mountaintop removal/valley fill operations are largely limited to Eastern Kentucky and Southern West Virginia because

- of the depth of the coal seams beneath the surface,
- the topography of the region and
- the combination of Federal, State and local regulations that permit the practice.

Coal extraction operations in the Western United States do not employ mountaintop removal techniques because coal in the west is typically located near the surface.

(2) There are many adverse impacts associated with coal slurry impoundments beyond their use on mountaintop removal sites. The Committee is concerned with these issues but they will not be the focus of this hearing.

Mountaintop removal coal mining starts with the complete deforestation and removal of all ground level vegetation and topsoil from the top of the mountain. Using heavy explosives and excavation equipment, the mountaintop is systematically and evenly removed in sections going down the mountain. As the mountain gets shorter, the adjacent valley is buried under the "overburden," the combination of topsoil and rock displaced by explosives and excavation equipment.[1]

Mountaintop removal coal operations have led to burial or adverse impacts on more than 1,700 miles of stream channels.[2] The disappearance of these valley streams is a great concern of mine not only because the material used to replace the valleys is loaded with toxic contaminants like lead, arsenic, mercury and selenium, but also because these valley fills quite literally remove ephemeral and headwater streams from the landscape.

These streams are characterized by scientists as "where rivers are born" and are vitally important to the health of downstream water quality.[3]

Numerous studies have shown that when impacts to the natural landscape of a watershed exceed 10 percent, water quality and the biodiversity of aquatic life in all waters of the watershed decline.[4] In Southern West Virginia there are watersheds with more than 25 percent of the land impacted by surface mines operations.

What's more, the permitting process for these operations have not been taking into account the cumulative effect of an entire surface mine operation on downstream water quality.

What will start as a relatively small operation can expand upwards to 10,000 acres over a 7- to 12-year span.[5]

The vegetation and natural contour of the landscape absorb and slow the flow of stormwater through the watershed. Studies have shown that all attempts at remediation and stream construction on reclaimed mine sites have had zero success in replicating natural hydrological features.[6] These remedial streams also contribute to the persistent drainage of contaminants from the former mine.

When coal is referred to as an inexpensive source of energy there are many costs associated with the resource that are not taken into account, not the least of which is the cost to downstream communities.

Coalfield residents are saddled with declining property values, spoiled well water and soaring insurance rates as mining operations creep closer to their property.

Several medical studies focused in the region show higher incidence of kidney disease, chronic obstructed pulmonary disease and hypertension among coalfield residents.[7]

There is a more environmentally and economically sustainable path Appalachia can take. Many counties in Appalachia are seeing economic gains in tourism and outdoor recreation activities that are only viable when Appalachia's unique natural features are protected.

The potential for wind energy development along the mountain ridges of Appalachia would provide infinite economic and energy potential for the region.[8] Like tourism, the viability for wind energy development is dependent on the preservation of the region's mountains and valleys.

There is no denying coal's significance to the culture and economy of Appalachia. However, mountaintop coal mining is a long term assault on Appalachia's environ-

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[1] Source: EPA Region 3 Power Point presentation on the mountaintop removal process.

[2] Office of Surface Mining.

[3] Meyer, Judy—Where Rivers are Born: The Scientific Imperative for Defending Small Streams and Wetlands (2003).

[4] Yuan L.L. & Nortno S.S.—Comparing responses of macroinvertebrate metrics to increasing stress (2003). Allan J.D.—Landscapes and riverscapes: the influence of land use on stream ecosystems (2004). Morgan, R.P. & Cushman, S.F.—Urbanization effects on stream fish assemblages in Maryland (2005).

[5] Hobert 21 mine in Boone County, WV—10,000 acre footprint.

[6] Bernhardt E.S., et al.—Restoration of U.S. Rivers: a national synthesis (2005). Palmer M.A., et al.—Standards for ecologically successful river restoration (2005).

[7] Hendryx, M., et al.—Hospitalization Patterns Associated with Appalachian Coal Mining (2007). Ezzati M., et al.—The Reversal of Fortunes: Trends in County Mortality and Cross-Country Mortality Disparities in the United States (2008). West Virginians for Affordable Health Care—Early Deaths: West Virginians have some of the Shortest Life Expectancies in the United States (2009).

[8] Department of Energy. American Wind Energy Association.

ment, economy and culture. It needs to stop, and I hope that today's hearing will start us on that path.

Before I turn to my Ranking Member, I will note that I intend to hold another hearing on this subject this fall. It will be a legislative hearing on the Cardin-Alexander bill, S. 696, the Appalachia Restoration Act. This is not the last word, nor will it be, until these practices of mountaintop mining and associated valley fills are permanently outlawed.

OPENING STATEMENT OF HON. LAMAR ALEXANDER, U.S. SENATOR FROM THE STATE OF TENNESSEE

Senator ALEXANDER. Thank you, Mr. Chairman. And I want to thank our Ranking Member for letting me have his seat for a little while.

I am glad to be here, Mr. Chairman. I am the Ranking Member of the Interior Appropriations Subcommittee which is about to have its appropriations bill heard upstairs, or downstairs, whichever it is. So, I may have to step out for 10 minutes. But I will be back. And I have looked forward to this.

I want to thank Senator Cardin for his leadership. I want to thank the witnesses for coming today, especially Paul Sloan, representing Governor Bredesen of our State of Tennessee with whom I have talked and who has a strong interest in the Cumberland Plateau area of our State and in protecting it and in protecting our ridgetops and our mountaintops, both for the natural beauty that we enjoy as Tennesseans and for the fact they attract a lot of visitors who kindly leave a lot of their dollars in our State.

As Senator Cardin said, coal is an essential part of our energy future and I would to ask, Mr. Chairman, if I could have included in the record my article in the Chattanooga Times Free Press from March 15th of this year, talking about the importance of coal and why we need it.

Senator CARDIN. Without objection.

[The referenced article follows:]

Publication: Chattanooga Times Free Press;**Date:**Mar 15, 2009;**Section:**Perspective;**Page Number:**56

COMMENTARY

Burning question

Renewables cannot satisfy energy needs in near future

Lamar Alexander U.S. senator, Tennessee

The Tennessee Valley Authority says it may cost $800 million to clean up the coal ash spill at its Kingston power plant. Burning coal to make electricity is a major reason East Tennessee has unhealthful air. And coal-fired power plants produce 40 percent of the carbon that America contributes to climate change.

So why burn coal?

In his inaugural address, President Barack Obama said, "We will harness the sun and the winds and the soil to fuel our cars and run our factories." Such renewable power will make a contribution, but here are several reasons why we will be using coal — cleaner coal — to make electricity for the foreseeable future.

First, we need a lot of electricity and we have plenty of coal. The United States uses 25 percent of all the world's electricity, and coal produces half of what we use. (It produces 60 percent of what we use in the TVA region). " Renewable energy" from wind, solar and geothermal sources produces 3 percent. According to TVA, an independent study estimates that if we put giant wind turbines on the maximum number of ridges in the TVA region, it would still produce only about 3 percent of the electricity customers need.

Second, the United States is the Saudi Arabia of coal. We don't have to import it from unfriendly nations that might hold us hostage.

Third, electricity from coal is much cheaper than energy from the wind and sun. That matters, for example, to the 10 percent of Nashville Electric Service customers who said in December they could not afford to pay their electric bills even with TVA's relatively low rates. It matters to Volkswagen and its suppliers when they decide whether to put jobs in Chattanooga — or in some other state, or overseas.

Fourth, coal is reliable. Coal plants can operate almost all the time. On the other hand, the wind blows only when it wants to — about one-third of the time nationally, and less in the TVA region.

Fifth, it takes large amounts of low-cost, reliable electricity to produce renewable energy of the kind we hope we can rely on more in the future. For example, the new billion-dollar plant making solar power materials in Clarksville — like the new solar plant announced recently for Bradley County — needs 120 megawatts to operate. This is one-fourth the production of a typical coal plant.

Finally, we already know how to burn coal cleanly — with the exception of carbon. TVA has done a good job of getting rid of nitrogen pollutants but is just getting started on sulfur and mercury. There is a proven technique to recapture carbon and store carbon underground, but that is not yet, and may never be, a commercially viable method for most coal plants.

Nevertheless, the National Resources Defense Council, a leading environmental group, supports coal plants if carbon is recaptured because coal burned cleanly will help the United States and other countries move more rapidly to deal with climate change.

Former Vice President Al Gore says recapturing carbon from coal plants is "too imaginary to make a difference." I disagree. I believe we are more likely to recapture carbon from coal burning than we are to operate our huge economy on the wind, sun and heat from the Earth.

So how do we act boldly to increase energy independence, provide more jobs and deal with climate change?

Full speed ahead on conservation and efficiency. TVA customers lead the country in using the most electricity per capita, which means we waste a lot.

Build more nuclear power, which today produces 70 percent of all U.S. carbon-free electricity.

Convert half our cars and trucks to electric power over 20 years. This will reduce carbon and cut by one-third the billions of dollars we send overseas to buy foreign oil. We can do this without building one new power plant if we plug in at night when demand is low.

Find more natural gas and oil. New supplies of natural gas will keep manufacturing jobs from going overseas and will keep residential heating and cooling prices affordable. Even if we electrify half of our vehicles, we should be using our own oil for the other half instead of sending billions overseas.

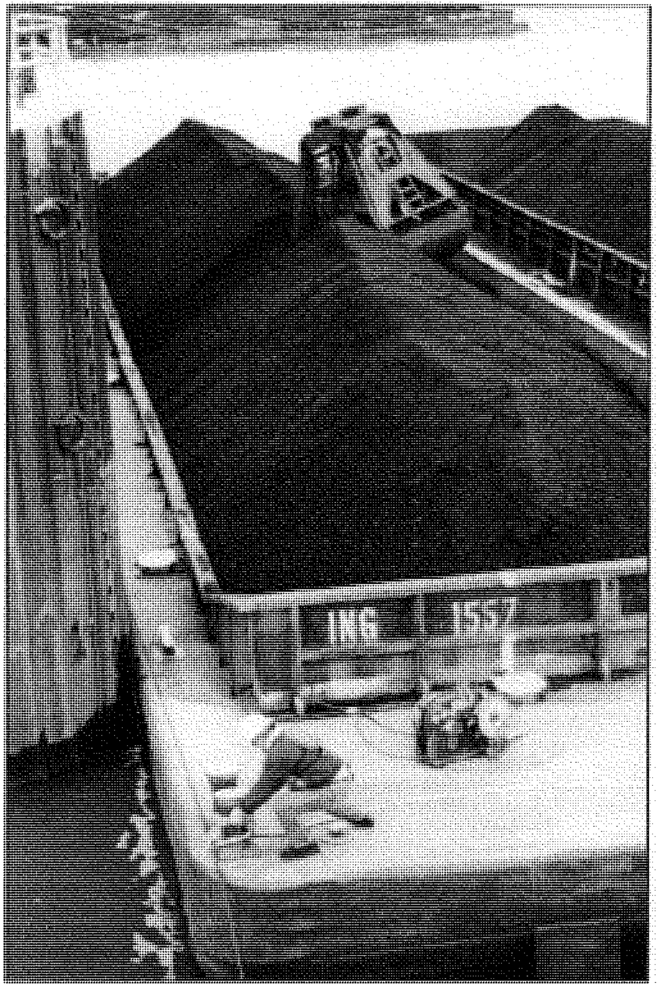
Put pollution-control equipment on all coal plants.

Double federal spending for energy research and development in order to launch four "mini Manhattan projects" to figure out how to recapture carbon from coal burning, make solar power cost-competitive with coal, reprocess waste from nuclear plants so it can be more easily stored, and make advanced biofuels from crops we do not eat.

Put carbon caps on coalfired power plants and fuel. Capping power-plant smokestacks and vehicle tailpipes (and giving all revenue gained from this back to those who pay higher energy prices) will limit 70 percent of carbon emissions, avoid capping or limiting small business and manufacturing, and cost much less than an economy-wide "cap and trade" program.

This agenda is comparable to President John F. Kennedy's challenge that we land a man on the moon in 10 years: It's one we can accomplish. On the other hand, an agenda that relies mostly on renewable energy anytime soon, as President Obama proposes, would be as unrealistic as it would have been for President Kennedy to propose that we land a man on Mars in 10 years.

Lamar Alexander is Tennessee's senior U.S. senator. He is chairman of the Senate Republican Conference, co-chairman of the TVA Congressional Caucus and a member of the Environment and Public Works Committee. He can be contacted via his Senate Web site at http://alexander.senate.gov. His Chattanooga office number is 423-752-5337.



Staff Photo by Angela Lewis Barges are secured in place to be unloaded on the Tennessee River at Widows Creek Fossil Plant near Stevenson, Ala.

Senator ALEXANDER. Coal is an essential part of our energy future. But it is not necessary to destroy our mountaintops in order to have enough coal. That is why I joined with Senator Cardin to make a simple amendment to the Clean Water Act that would end the practice of dumping coal mining waste into streams.

Millions of tourists spend tens of millions of dollars in Tennessee every year to enjoy the natural beauty of our mountains, a beauty that is for me, and I believe for most Tennesseans, something that makes us especially proud to live in our State.

I may come at this a little differently than some people. Saving our mountaintops is important to me, whether we are talking about cleaning up air pollution, whether we talking about stopping the practice of putting 50-story wind turbines on top of our scenic Appalachian mountaintops, or whether we are talking about stopping the practice of blowing off the tops of the mountains and dumping the excess waste into our streams.

People come to Tennessee, and to other parts of Appalachia, to see the natural beauty, not to see smoggy air, massive ridgetop towers or excess waste piled into streams. That is why I have introduced legislation with Senator Carper of Delaware, for example, that would stiffen the requirements for emissions of nitrogen, sulfur and mercury from coal plants.

And as Ranking Member of the Interior Appropriations Subcommittee, Senator Feinstein and I are talking with Secretary Salazar about an energy sprawl and making sure we find appropriate places for the large-scale new renewable energy projects that are coming on board in our Country, for example, that we put large wind turbines in the middle of Lake Michigan instead of along the coast and that we do not put them along scenic ridgetops between Georgia and Maine.

The kind of mountaintop removal that we are talking about today, as far as I am aware, does not exist today in coal mining practice in Tennessee. It once did. But I would like to make sure that it does not start up again.

The legislation that Senator Cardin and I have introduced and which will be considered in due time, does not ban surface mining as it is presently practiced in Tennessee, but it does help make sure that the beauty of our mountains and our streams are protected for those of us who live there and for our visitors.

The United States produces 50 percent of our electricity from coal. It will continue to need that coal in the future. It is a primary source of energy. We need a lot of electricity and we have a lot of coal. We do not want to import our energy from overseas. Electricity from coal is cheaper, for example, that from wind and solar, and we know how to burn it cleanly, if we would only do it, accept for carbon.

I have called for a mini-Manhattan Project to find ways to capture carbon from coal plants and I have urged Secretary Chu to reserve, if he can, a Nobel Prize in Science for the scientist who discovers a way to capture carbon from existing coal plants.

So, I look forward to learning today more about the effect of mountaintop removal in our entire Country, and the effect that it might have in Tennessee if it were to be restarted.

I thank Senator Cardin for his leadership on the issue and for chairing this hearing.

Senator CARDIN. Thank you, Senator Alexander.

Without objection, Senator Boxer's, the Chairman of the full Committee, opening statement will be included in the record.

[The prepared statement of Senator Boxer follows:]

STATEMENT OF HON. BARBARA BOXER, U.S. SENATOR FROM THE STATE OF CALIFORNIA

Senator Cardin, I would first like to thank you for holding this hearing and for your leadership on oversight of mountaintop mining. This is an important issue.

I also know you are working with Senator Alexander on legislation to stop the pollution and harm caused by this destructive practice, and I want to commend both of you for your efforts.

This hearing will explore the impacts of mountaintop mining on our water quality and the health and prosperity of Appalachian communities. It is critical that we better understand what impacts these practices have and whether our nation's laws are doing their job at protecting the environment and the citizens' health.

Mountaintop mining is one of the most destructive mining practices used today. It involves literally cutting the tops off of mountains and dumping the excess rock and soil into headwater streams that are critical for flood control, water quality, and the health of some of the nation's most precious ecosystems.

Mountaintop mining operations have already filled or impacted more than 1,200 miles of Appalachian streams. And the mining waste associated with these sites can include a host of chemicals, including selenium, arsenic, lead, chromium and mercury that can leach into streams and rivers, severely degrading water quality.

As we will hear from witnesses today, this practice has devastated the environment and harmed communities by displacing residents and ruining the natural resources on which they depend.

In light of all of the impacts, I believe we have to take a hard look at why such a destructive practice is allowed to continue.

Senator Cardin, I want to thank you again for holding this hearing, and I look forward to working with you to continue oversight of mountaintop mining and to ensure we are protecting our environment and the health of families and children.

Senator CARDIN. I am now pleased to recognize the Ranking Republican on the full Environment and Public Works Committee, Senator Inhofe.

OPENING STATEMENT OF HON. JAMES M. INHOFE, U.S. SENATOR FROM THE STATE OF OKLAHOMA

Senator INHOFE. Thank you, Mr. Chairman.

I would like to be able to stay for this whole hearing. I cannot do it because, as I think you know, we are still marking up the Defense Authorization Bill and I am the second Ranking Member on that. But I thank you for having this.

I want to welcome Randy Huffman, the Cabinet Secretary from West Virginia's Department of Environmental Protection. I am anxious to read his statement and to hear what position they are coming from.

Let me being by saying that I am concerned by the in-fighting among Democrats when it comes to coal. As an example, just look at the Memorandum of Understanding on mountaintop mining between the EPA, the Army Corps of Engineers and the Department of the Interior.

Now, some such as myself, are concerned. The MOU could mean economic hardship for Appalachia. But, consider the views of some of the radical global warming activists, such as NASA scientist and Obama supporter James Hansen.

He recently criticized President Obama for the MOU. And here's what he said. He said, Mr. Chairman, the Obama administration is being forced into a political compromise. It has sacrificed a strong position on mountaintop removal in order to ensure the support of coal State legislators for a climate bill. Coal is the lynch pin in mitigating global warming and it is senseless to allow cheap mountaintop removal of coal while the Administration is simultaneously seeking policies to boost renewable energy.

And, quoting on further, this is from the Los Angeles Times talking about this conversation, although the environmentalists had expected a new Administration to put the brakes on mountaintop removal, Representative Rahall and other mining advocates have pointed out that Obama did not promise to end mountaintop mining and was more open to it than his Republican opponent, Arizona Senator John McCain. This was during the Presidential election.

A review of Obama's campaign statement, according to the Los Angeles Times, shows that Obama had expressed concern about the practice without promising to end it.

So we have a lot of lawmakers that the Los Angeles Times refers to who, and this is a quote also from the Times, it says the mountaintop mining is politically sensitive because environmentalists were an active force behind Obama's election and the President's standing is tenuous among Democratic voters in coal States.

Moreover, the Times writes, Obama needs support from local lawmakers for an energy agenda that would further regulate home State industries, but halting the mountaintop mining could eliminate jobs and put upward pressures on the energy crisis. I think we all ought to understand this.

So, there is a lot of conflict here, a lot of in-fighting, and there is a lot of Beltway fighting on this, so I think that it is very appropriate that you have the Committee hearing.

I know that the Ranking Member of your Subcommittee, Senator Crapo, will be here shortly and I will have to go back to Arms Services.

Thank you, very much, Mr. Chairman.

[The prepared statement of Senator Inhofe follows:]

STATEMENT OF HON. JAMES M. INHOFE, U.S. SENATOR FROM THE STATE OF OKLAHOMA

I would like to thank Subcommittee Chairman Cardin and Ranking Member Crapo for holding today's hearing on the impacts of mountaintop mining on surface and groundwater resources and other indirect impacts in Appalachia.

I also want to welcome Randy Huffman, Cabinet Secretary for West Virginia's Department of Environmental Protection, as well as the other witnesses testifying today. I look forward to your testimony. And it's great that so many residents from West Virginia traveled to see this hearing in person. Whatever side of the issue they're on, it's good to see so many citizens engaged in the political process.

I want to emphasize today the importance of maintaining and protecting America's natural resources. Federal clean water laws should be followed and enforced for the citizens of this Nation, especially those in Appalachia. This is a fundamental value we all share. Yet it is not the only value to be considered: ensuring the economic viability of Appalachia, and the families who live there, is equally important. I believe these two values are complementary. Put another way, environmental protection can coexist with job creation and economic prosperity for families.

I'm not sure this view is acceptable among environmental activists. For them, coal is evil and must be banned, no matter the cost to families in Appalachia and states that depend on it for jobs, for schools, and for energy security.

I should also note that I'm somewhat concerned by the infighting among Democrats when it comes to coal. As an example, just look at the Memorandum of Understanding on mountaintop mining between the EPA, the Army Corps of Engineers, and the Department of the Interior. Now some, such as myself, are concerned the MOU could mean economic hardship for Appalachia. But consider the views of radical global warming activists, such as NASA scientist and Obama supporter James Hansen. Hansen recently criticized President Obama for the MOU. Here's what he said:

"The Obama administration is being forced into a political compromise. It has sacrificed a strong position on mountaintop removal in order to ensure the support of coal-state legislators for a climate bill . . . Coal is the linchpin in mitigating global warming, and it's senseless to allow cheap mountaintop-removal coal while the administration is simultaneously seeking policies to boost renewable energy."

Mountaintop mining has also provoked serious battles within the Obama administration. Consider this: the LA Times recently reported on a "shouting match in which top officials from two government agencies were heard pounding their fists on the table . . ."

But that's not all. Let me quote again from the LA Times story:

"Although environmentalists had expected the new administration to put the brakes on mountaintop removal, [Rep. Nick] Rahall [D-W.Va.] and other mining advocates have pointed out that Obama did not promise to end [mountaintop mining] and was more open to it than his Republican opponent, Arizona Sen. John McCain."

A review of Obama's campaign statements, according to the LA Times, shows that Obama had "expressed concern about the practice without promising to end it."

This gets even more interesting. The Times notes that mountaintop mining "is politically sensitive because environmentalists were an active force behind Obama's election, and the president's standing is tenuous among Democratic voters in coal states." Moreover, the Times writes, "Obama needs support from local lawmakers for an energy agenda that would further regulate home-state industries, but halting mountaintop mining could eliminate jobs and put upward pressure on energy prices in a time of economic hardship."

So, it seems the Administration and its supporters in the environmental community can't make up their minds about coal and mountaintop mining. It's not hard to understand why. Those "local lawmakers" the LA Times refers to, who are concerned about the future of their communities, are Democrats. Coming from Oklahoma, I would say that Democrats in my home State and in places like West Virginia tend to see coal and energy differently than, say, Speaker Pelosi, Henry Waxman, or the Obama administration. They tend have practical, rather than ideological, views about coal and energy.

As they see it, coal provides jobs and secures livelihoods for families. Coal also is a source of reliable, affordable electricity that powers the economies of West Virginia, Ohio, and much of the Nation. Banning coal or sharply curtailing its use makes no sense to people who rely on it every day of their lives. They can't understand why Democrats in Washington and their friends in the environmental movement think coal is the root of all evil. When they see the likes of the Waxman-Markey global warming bill, which would destroy thousands of well-paying jobs for hard-working people, or comments from the Secretary of Energy that "coal is my worst nightmare," or from Vice President Biden, who vowed on the campaign trail that there would be "no coal plants here in America," they scratch their heads and wonder whether such opinions are grounded in reality.

As the Democratic leaders in Washington are preparing for the debate tomorrow on the disastrous Waxman-Markey bill, and as they continue to fight over whether coal should be banned, diminished, or remain central to the Nation's energy policy, the 77,000 hard-working people in Appalachia who work in the mining industry are wondering whether they have job security.

My sincere hope is that the Democrats here in Washington can stop arguing about coal and listen to local officials from the heartland. Those officials—again, many of them Democrats—do not want to abandon the Clean Water Act and the protections it provides to the families who live, work, and play in their communities. They want clean water and they should get it. But at the same time, they want the recognition that their economic livelihoods matter just the same, both for their communities and for the Nation.

Senator CARDIN. Thank you. And we all cooperated on scheduling this hearing. It was difficult to find a time because of the recess, so we know that people will be coming in and out. We may also be interrupted by a vote on the floor. So, it is going to be a challenge and we are going to do the best we can to get in everyone's testimony.

We are going to start with John "Randy" Pomponio, the Director, Environmental Assessment and Innovation Division. The EAID is a multi-disciplinary organization with a broad range of regulatory and non-regulatory environmental responsibility. The division also has the leadership responsibility for environmental planning and analysis on environmental data for a better understanding of the conditions and trends within the Mountaintop Removal Valley Fill Initiative.

Mr. Pomponio has worked on mountaintop mining permitting issues for EPA for more than a decade.

It is a pleasure to have you with us today. Thank you very much.

STATEMENT OF JOHN "RANDY" POMPONIO, DIRECTOR, ENVIRONMENTAL ASSESSMENT AND INNOVATION DIVISION, U.S. ENVIRONMENTAL PROTECTION AGENCY MID-ATLANTIC REGION

Mr. POMPONIO. Good afternoon, Mr. Chairman and members of the Subcommittee.

I am Randy Pomponio, Director of the Environmental Assessment and Innovation Division in EPA's Philadelphia Office.

Thank you for the opportunity to address the Subcommittee on EPA's efforts to protect and restore water quality and water resources affected by the surface mining of coal, including mountaintop removal and valley fill activities.

EPA plans to more fully use its authorities under the Clean Water Act and the National Environmental Policy Act to address impacts of this type of mining activity on the aquatic and associated forest resources.

Let me explain why we are so concerned about the issues surrounding ongoing mountaintop mining and similar surface mining activities that involve valley fills.

First, the Clean Water Act sets out goals to restore and maintain the chemical, physical and biological integrity of our Nation's waters, so that they can protect human health and values and support the protection and propagation of fish, shellfish and wildlife, as well as recreation in and on the water.

Second, the streams of central and southern Appalachia and the forests that play an integral role in the function and quality of those streams are very important assets and must themselves be protected to achieve the goals of the Clean Water Act.

In my written testimony, I quote from a 2003 paper entitled Where Rivers Are Born, The Scientific Imperative for Defending Small Streams and Wetlands. That paper was written by 11 of the Country's most recognized aquatic experts. They say in their paper that the goal of protecting water quality, plant and animal habitat, navigable waterways and downstream resources is not achievable without the careful protection of headwater streams.

Third, despite the best efforts of State, local and Federal agencies, too many small streams and wetlands of central and southern Appalachia are being buried and polluted. We must do a better job of reducing or eliminating site-specific and cumulative impacts associated with these mining activities.

And, finally, while we continue to be guided by regulatory authorities, I believe we are now at a point where science and policy are beginning to converge to reduce the ecological impacts of surface mining practices such as valley fills.

The EPA is excited to work with other Federal agencies as announced in our joint June 11th Memorandum of Understanding to strengthen the regulation and review of these mining activities.

I would like to share a few facts and then move on to answer any questions you may have.

Valley fills associated with surface coal mining bury streams and degrade water quality. Over the years, State and Federal agencies have worked hard to address water quality impacts associated with valley fills. However, between 1992 and 2002, more than 1,200 miles of Appalachian streams have been filled at an average rate of 120 miles per year.

Recent studies show that coal mining can result in long-lasting impairments to aquatic biota in remaining streams below current and past mines. An EPA scientific study published in July 2008 shows that more than 63 percent of the streams sampled below mountaintop coal mining operations exhibit such impairments. In some large watersheds, such as the Coal River in West Virginia, more than half of the streams are impaired.

Concentrations of selenium, a heavy metal naturally found in rock, can also be elevated in streams draining valley fills. Deformities in fish have been observed downstream of coal mining operations where selenium is a known pollutant.

Dissolved and particulate organic carbon fuels the food web of headwater streams and this nutrient energy cascades downstream. Mining operations and associated valley fills essentially rob downstream aquatic communities of this energy source.

Valley fills associated with surface coal mining can destroy forest, habitat and other important ecosystems. The southern Appalachians are among the richest ecosystems in the United States. They represent a bounty of timber, wildlife and recreational assets that deserve worldwide recognition. Forests of this area have been described as the largest remaining contiguous temperate deciduous forest in the world. One area of roughly 13,000 square miles centered in western Virginia contains 144 imperiled species.

EPA's 2002 Landscape-Scale Cumulative Impact Study modeled terrestrial impacts based on surface permit data. That study basically suggested that, over a 22-year period, nearly 1,189 square miles of forest could be removed and cleared. The loss of that forest would conservatively equate to the loss of 1.7 million tons per year of carbon dioxide sequestration, the equivalent carbon dioxide that would be emitted from 300,000 cars.

Additionally, forests dampen flooding potential and act as natural nutrient sinks. One study estimates that forest cover of 1,189 square miles provides approximately $138 million per year in nutrient-cycling and waste treatment services.

Valley fills and associated coal mining should be addressed on a cumulative watershed basis. Cumulative impacts are among the most critical aspects of regulating and assessing impacts of future mines. Rapid cumulative degradation of streams and loss of forest habitat may render some watersheds, and indeed entire eco-regions, unable to supply those services.

So, thank you, Mr. Chairman, for giving me the opportunity to testify today. EPA understands the importance of domestic coal energy to our energy independence goals and to our Nation's economy. We want to ensure that this valuable resource is extracted in the least intrusive manner to the environment.

Thank you.

[The prepared statement of Mr. Pomponio follows:]

TESTIMONY OF
JOHN "RANDY" POMPONIO
DIRECTOR, ENVIRONMENTAL ASSESSMENT AND INNOVATION DIVISION
U.S. ENVIRONMENTAL PROTECTION AGENCY MID-ATLANTIC REGION
BEFORE THE
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
SUBCOMMITTEE ON WATER AND WILDLIFE
U.S. SENATE

JUNE 25, 2009

Mr. Chairman and Members of the Subcommittee, I am John "Randy" Pomponio, Director of the Environmental Assessment and Innovation Division at the United States Environmental Protection Agency (EPA) Mid-Atlantic Region in Philadelphia, Pennsylvania. Thank you for the opportunity to address the Subcommittee on EPA's efforts to protect and restore the water quality and water resources affected by the surface mining of coal, including mountaintop removal and valley fill activities. EPA plans to more fully use its authorities under the Clean Water Act and the National Environmental Policy Act (NEPA), to address the impacts of this type of mining activity on the aquatic and forest systems that provide invaluable ecosystem services to Appalachia and to the waters people use for drinking and fishing.

Our discussion here today provides us with the opportunity to talk about what we at EPA have learned from past experience. Over the past three decades, EPA, our state partners and other concerned stakeholders have begun to make a positive impact on the legacies of abandoned mine lands and acid mine drainage. Over $8 billion has been paid by coal companies into the Abandoned Mine Lands Fund, managed by the Department of the Interior's Office of Surface Mining. These funds are being spent to address environmental degradation and public health risks caused by past mining practices.[1] The Office of Surface Mining regulates this industry. EPA has an oversight role for water quality under the Clean Water Act. The Army Corps of Engineers regulates discharges of fill material into waters associated with these activities. The improved use of our authorities for regulating current surface coal mines through transparent and science-driven processes can help us avoid similar consequences from current and future mining activities. EPA is excited to work with other Federal agencies, as announced in our joint June 11 Memorandum of Understanding, to strengthen the regulation and review of these mining activities.

Surface Coal Mining in Central Appalachia

According to information submitted to the Department of Energy by coal companies, surface mining accounted for 40 to 45 percent of coal production in Central Appalachia during 2007. [2] Surface mining from the Central Appalachia Region produced approximately 10 percent of the nation's coal in 2007. [3] Surface coal mining, including mountaintop removal, in the steep-slope terrain of Appalachia very often employs valley-fill techniques as a means to dispose of the overburden (excess material) generated during mining activities. Such valley fills are constructed by placing overburden in existing stream valleys, which directly buries some stream segments and can have substantial downstream environmental impacts. The environmental impacts of the mine footprints and these valley fills are of the utmost concern to EPA.

Valley fills associated with surface coal mining buries streams and degrades water quality.

Over the years, the state and federal agencies have worked hard to address water quality impacts associated with valley fills. However, between 1992 and 2002, more than 1,200 miles of Appalachian streams have been filled at an average rate of 120 miles per year by ongoing surface mining practices. [4] Recent studies of streams below current and past mines have shown that coal mining can result in long-lasting impairments to aquatic biota. These impairments, recently better described as part of a more complete body of scientific studies, were not necessarily considered when undertaking prior permit evaluations under the Clean Water Act Section 404 program. An EPA scientific study released in July 2008 shows that more than 63 percent of the streams sampled below mountaintop coal mining operations exhibit such impairments. [5] In some large watersheds, such as the Coal River in West Virginia, more than half of the streams are impaired.

It is critically important that EPA re-invigorate its oversight and review role for the delegated 401 and 402 programs and address these important water quality issues before section 404 permit decisions are made.

Valley fills associated with surface coal mining increase the total loading of trace metals and toxic salts (sulfates, magnesium, bicarbonate, and additively--total dissolved solids) to downstream aquatic communities. These dissolved ions are not readily sequestered by the surrounding geology and may ultimately emanate from the fills for decades. [5] Certain macroinvertebrates are highly sensitive and thus disappear from the streams draining from the valley fills. This impairs the use of the streams and ultimately leads to listing of these streams as "impaired water bodies" in EPA's water quality reports required under Section 305 (b) of the Clean Water Act.

Concentrations of selenium, a heavy metal naturally found in rock, can also be elevated in streams draining valley fills. Often these concentrations result in exceedances of State and Federal water quality standards for aquatic life. Deformities in fish have been observed in reservoirs downstream of coal mining operations where selenium is a known pollutant. In peer-reviewed scientific studies, high concentrations of selenium in fish tissue have been linked to physical deformities and reproductive failure. [6]

Dissolved and particulate organic carbon fuels the food web of headwater streams and this nutrient energy cascades downstream. Healthy forest soils and streamside vegetation supply food webs with this high-quality energy source that further delivers high-quality food to downstream communities of other consumers, such as fish and humans. Mining operations and associated valley fills essentially rob downstream aquatic communities of this energy source, damaging the food webs that serve to purify freshwater for aquatic life and human consumption.

Valley fills associated with surface coal mining can destroy forests, habitat, and other important ecosystems.

The southern Appalachians are among the richest ecosystems in the United States. They represent a bounty of timber, wildlife, and recreational assets that deserve their world-wide recognition. The forests of this area have been described as the largest remaining contiguous temperate deciduous forest in the world.[7] One area of roughly 13,000 square miles centered in western Virginia contains 144 imperiled species, many of which rely on the region's rivers and streams.[8] The southern Appalachians are legendary for their diversity of freshwater organisms such as fishes and mussels.

EPA's 2002 Landscape-Scale Cumulative Impact Study modeled terrestrial impacts based on past surface mine permit data. These data provide a retrospective examination of the impacts to forest that occurred over the 11-year period from 1992 to 2002. The Study estimates that 595 square miles (380,547 acres) of the forest environment (vegetation and soils) in the study area will be cleared due surface coal mining during this 11-year period. This represents 3.4 percent of the forest area that existed in 1992.[9] Based on a 2003 analysis, the impacts to forest and forest soils have subsequently been projected over the next 10 years. For the entire 22-year period from 1992 to 2013, the estimated forest clearing in the study area would be 1,189 square miles (761,000 acres) or 6.8 percent of the forest that existed in 1992.[9] Should these forest not be restored, invaluable water quality and ecological services will be lost.

Forest losses of this magnitude, although largely temporary, are not inconsequential. In addition to the popularly appreciated wildlife, recreational, and timber resources associated with forests systems, many ecological services can be attributed to forest systems. We are just beginning to understand and assign value to these ecological services. For example, forests are known to be natural areas of carbon sequestration. The loss of 1,189 square miles of forest would conservatively equate to the loss of 1.7M tons of carbon dioxide sequestration potential per year or the equivalent of taking 300,000 cars off the road.[10] Additionally, forests dampen flooding potential and act as natural nutrient sinks. One study estimates that forest cover of 1,189 square miles provide approximately $138 million in nutrient-cycling and waste treatment services.[11]

Valley fills associated with surface coal mining should be assessed on a cumulative and watershed basis.

The most critical aspect of regulating and assessing the impacts of future mines is effectively addressing the issue of cumulative impacts. The rapid cumulative degradation of streams and loss of forest habitat may render some watersheds—and indeed entire eco-regions-- unable to supply the ecological services that we as a society value and rely upon. These situations should be discovered and addressed through watershed and landscape analyses not currently performed in the region. Collaborative efforts such as the Clinch/Powell Memorandum of Understanding between EPA's Mid-Atlantic and Southeast Regions, the Commonwealth of Virginia, and the State of Tennessee, and supported by OSM, attempt to address important broad-scale watershed issues. The Mid-Atlantic Highlands Action Program is another collaborative initiative designed to protect and restore ecological services while providing green jobs. The program has been endorsed by the Governors of Virginia, West Virginia, Pennsylvania, and Maryland and could be retooled and chartered to manage the environmental and economic issues facing this part of Appalachia.

Building on these existing programs, Federal agencies are also looking to help provide clean energy jobs and to target economic recovery activities in Appalachia in order to help diversify and strengthen the Appalachian regional economy. As part of the agencies' recent Memorandum of Understanding, EPA and other Federal agencies – coordinating with the Council on

Environmental Quality – will be working with appropriate regional, state, and local entities to help stimulate clean energy and green jobs development. This initiative will encourage better coordination among existing Federal economic recovery efforts in Appalachia.

The mining industry employs many best management practices in Appalachia to minimize impacts to waters of the United States. These practices must be expanded, improved, and enforced. Most are generally designed to control water quality and quantity through the design and location of sediment control structures, timely backfilling, grading and re-vegetation of the operation areas, and stabilization of fill material to minimize earth disturbances.

EPA welcomes the opportunity to work with the coal mining industry to find additional best management practices and best available technologies to further minimize the environmental impacts associated with Appalachian surface mining. Examples include such methods as further backstacking overburden and waste material onto the mine site or adjacent sites and going beyond AOC/AOC+ requirements where appropriate from a mining safety and land stability standpoint. Expanding on the special handling requirements under SMCRA, to include additional water quality protective measures should also be explored. These include isolating materials that produce total dissolved solids and component ions; leaving some streams undisturbed to provide a source of clean water to downstream waters; and, where necessary, installing appropriate water treatment facilities. We will be working with the Department of the Interior and the Corps of Engineers to ensure these best management practices are employed in mining permit applications and evaluated in the course of the agencies' permit reviews.

Mitigation practices employ a variety of methods including enhancement, restoration and creation of streams and wetlands to compensate for the unavoidable impacts to waters of the United States. In the aquatic environment, mitigation should compensate for the physical, chemical, and biological functions, of the steams and/or wetlands being impacted. Often the mitigation required is based on linear footage of stream channel or wetland acreage proposed to be impacted. The applicant will propose to work downstream of the mine site to repair slumping banks; to reconnect a stream to its floodplain; and/or, create or enhance riparian buffer zones.

In the context of surface coal mining, mitigation generally has focused on the physical function of the stream. Mitigation goals should be to match the lost flow regime (frequency, duration and seasonality of flow annually); provide the same structural habitat (riffle pool, shading, etc.); meet the same water chemistry characteristics (hardness, pH, conductance); and, support the same biologic communities (macroinvertebrates, fish, etc.) within the watershed where the proposed impact is occurring. Before the end of 2009, EPA and the Corps will be evaluating the agencies' existing mitigation guidance to better incorporate these considerations within mitigation projects proposed for Appalachian surface coal mines.

EPA's Role in Surface Coal Mining

EPA's responsibilities to address surface coal mining activities under the Clean Water Act, the Clean Air Act and NEPA will be discussed here. The Clean Water Act Section 404 program is jointly implemented by the U.S. Army Corps of Engineers and the EPA. The Clean Water Act Section 404 responsibilities for the EPA Mid-Atlantic Region lie within my organization, the

Environmental Assessment and Innovation Division. EPA's role in the 404 process includes developing, with the Corps of Engineers, the substantive environmental criteria used in evaluating a permit application, known as the 404(b)(1) Guidelines, and reviewing and commenting upon permit applications. In addition, Section 404(c) of the Clean Water Act gives EPA the authority to prohibit the discharge of dredged or fill material at specified locations. This authority is sometimes referred to as a "veto."

The Section 404(b)(1) Guidelines lay out a three-step sequencing process to protect waters of the United States. Through an alternatives analysis and management practices, a project should first avoid impacts to "waters of the United States to the extent practicable." The project should then minimize unavoidable impacts if practicable, and ultimately provide compensation for unavoidable impacts to waters of the United States. The Section 404(b)(1) Guidelines also provide that no discharge of dredged or fill material shall be permitted if it causes or contributes to a violation of any applicable State water quality standards, or if it will cause or contribute to a significant degradation of waters of the United States, individually or collectively. The Corps defers to the Clean Water Act 401 certification process to determine compliance with water quality standards and takes into account compensatory mitigation in determining whether there is significant degradation.

In addition, EPA has authorities under the National Pollutant Discharge Elimination System (NPDES) pursuant to Section 402 of the Clean Water Act for other types of discharges from surface mining operations. Discharge ponds collect stormwater that comes in contact with overburden, exposed coal, and other materials at the mining sites, and water from buried streams that filters through the fill. Most states have been authorized to issue permits for such discharges under the NPDES program, but EPA retains authority to review and, if necessary, object to draft permits and to enforce violations.

EPA also has a role through NEPA. Since the Clean Water Act Section 404 process results in a Federal permit authorizing the placement of fill material into waters of the United States, that permit constitutes a Federal action requiring compliance with the procedures established by NEPA. Pursuant to Section 309 of the Clean Air Act and NEPA, EPA has a responsibility to review and comment on the environmental impacts of proposed Federal actions. The Corps is the lead agency under NEPA for Section 404 Clean Water Act permits.

The design, interpretation, and enforcement of our current tools at all levels of government can be improved to better achieve environmental and public health goals.

"The goal of protecting water quality, plant and animal habitat, navigable waterways, and other downstream resources is not achievable without the careful protection of headwater streams." [12] Today, both the Surface Mining Control and Reclamation Act (SMCRA) and the Clean Water Act serve to regulate surface coal mining in Appalachia. Despite these regulatory reviews and the addition of measures in permits to minimize environmental impacts from surface coal mining, many unintended and well-documented environmental consequences continue to occur from mining operations with valid permits.

EPA and Federal agencies have announced coordinated steps to help eliminate or minimize the environmental consequences described above.

EPA will be taking several steps before the end of the year to improve its oversight of mountaintop mining activities as part of an interagency Memorandum of Understanding announced on June 11. EPA, the Corps of Engineers, and the Department of the Interior will be taking a series of both short- and longer terms actions under the CWA and SMCRA to improve the regulation of these mining practices under existing statutory authorities. I would like to summarize a few of these actions in which EPA will play a significant role.

As part of this MOU, EPA and the Corps of Engineers will be developing new guidance specific to Appalachian surface coal mining on applying the 404(b)(1) Guidelines to pending permit applications. Work on these guidelines and on enhanced mitigation guidance will be coordinated with the U.S. Fish and Wildlife Service. EPA will also be looking to improve oversight over state NPDES permits and water quality certifications issued for discharges from valley fills and will be assisting states in their ongoing management of these CWA programs.

We look forward to working with the Corps of Engineers to incorporate these considerations within permit reviews to minimize adverse environmental consequences and more fully exercise our Clean Water Act and NEPA responsibilities.

Thank you, Mr. Chairman for giving me the opportunity to testify today. EPA understands the importance of domestic coal to our energy independence goals and to our nation's economy. We want to ensure that this valuable resource is extracted in the least intrusive manner to the environment. We look forward to working with you and your subcommittee to make a positive impact on this important issue.

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Senator CARDIN. Well, again, thank you very much for your testimony and thank you very much for your work.

I want to start with science, if I might, for a moment. President Obama has issued an Executive Order concerning trying to base our decisions on good science. What we are trying to find out is what good science tells us. Then, we obviously have to make the policy judgments. But if it not based upon good science, then everything else sort of falls by the wayside.

You have made some conclusions as to some of the environmental risks associated with mountaintop removal. I want to know how confident you are in the science basis of the public health risk and the environmental risk.

Mr. POMPONIO. I want to give you a bit of a perspective. I am a Senior Manager with our Region 3 EPA Office, and, as such, I have a number of folks who work for me, some of whom apply their skills in the regulatory environment and the Section 404 Program that assists in regulating mountaintop mining and valley fill. And some of them work in the field to collect environmental data, water quality data, and aquatic impact data, to set the science, to set the stage for the science, and inform us of what is going on.

I am very confident in the science that we have in Region 3 and across the country that discusses the impacts of valley fill activities on streams in central and southern Appalachia. There are a couple of reasons for that. The headwaters stream citation that I quoted in my prepared remarks strongly states that you cannot achieve the goals of the Clean Water Act without protecting headwater streams, Eleven scientists commented on that issue, and they cited 235 references when they did so. It is common knowledge that these systems, even these small systems, are necessary networks that provide ecological benefits, water quality control, flood control and those types of things downstream.

So, as we look at valley fill activities over the years, we examined a lot of referenced information and a lot of studies that had been done in the past by recognized scientists. As we evolved in our position on mountaintop mining, we began to notice that, one of the things that we really needed to do, is put the period on the end of whether or not EPA's perspective was represented by those studies.

Many of you may have heard of the Pond-Passmore Study. We had our own people go out into the field over a period of a number of years and check downstream water quality impacts below valley fill operations. And what Pond and Passmore found, and published in a peer reviewed journal, was that using the West Virginia method of demonstrating downstream aquatic impacts to insects, which is a fairly typical method used by States and the Federal Government, 63 percent of the time downstream of those valley fills water quality impacts to the aquatic insects were recognized to a point where we perceived that the narrative water quality criteria of the State would have been exceeded.

A different method that Pond and Passmore and others are looking at, the GLIMPSS method, improves the accuracy of such measures. With the GLIMPSS method 93 percent of streams downstream of those valley fills were impacted.

So, we are very confident in our information. Having said that, we have talked to the State of West Virginia's Deputy Director, Randy Hoffman, a colleague of mine, about concerns he has with our interpretation of the Science. We have asked the scientific community within EPA to once again review the information that we have collected to make sure that it is accurate and of high quality.

Senator CARDIN. Thank you for that answer. We will include, without objection, the report that you are referring to, Downstream effects of mountaintop coal mining: comparing biological conditions using family- and genus-level macroinvertebrate bioassessment tools. We will include that in the record of the Committee.

[The referenced document follows:]

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Downstream effects of mountaintop coal mining: comparing biological conditions using family- and genus-level macroinvertebrate bioassessment tools

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Abstract. Surface coal mining with valley fills has impaired the aquatic life in numerous streams in the Central Appalachian Mountains. We characterized macroinvertebrate communities from riffles in 37 small West Virginia streams (10 unmined and 27 mined sites with valley fills) sampled in the spring index period (March–May) and compared the assessment results using family- and genus-level taxonomic data. Specific conductance was used to categorize levels of mining disturbance in mined watersheds as low (<500 μS/cm), medium (500–1000 μS/cm), or high (>1000 μS/cm). Four lines of evidence indicate that mining activities impair biological condition of streams: shift in species assemblages, loss of Ephemeroptera taxa, changes in individual metrics and indices, and differences in water chemistry. Results were consistent whether family- or genus-level data were used. In both family- and genus-level nonmetric multidimensional scaling (NMS) ordinations, mined sites were significantly separated from unmined sites, indicating that shifts in community structure were caused by mining. Several Ephemeroptera genera (e.g., *Ephemerella*, *Epeorus*, *Drunella*) and their families (Ephemerellidae, Heptageniidae) were correlated most strongly with the primary NMS axis ($r > 0.59$ for these genera; $r > 0.78$ for these families). These same Ephemeroptera were absent and, thus, eliminated from most of the mined sites. Total Ephemeroptera richness and relative abundance both declined with increasing mining disturbance. Several other metrics, such as richness, composition, tolerance, and diversity, clearly discriminated unmined vs mined sites. Most family-level metrics performed well and approximated the strength of genus-based metrics. A genus-based multimetric index (MMI) rated more mined sites as impaired than did the family-based MMI. Water-quality variables related to mining were more strongly correlated to NMS axis-1 scores, metrics, and MMIs than were sedimentation and riparian habitat scores. Generally, the correlations between the genus-level MMI and water-quality variables were stronger than the correlations between the family-level MMI and those variables. Our results show that mining activity has had subtle to severe impacts on benthic macroinvertebrate communities and that the biological condition most strongly correlates with a gradient of ionic strength.

Key words: bioassessment, coal mining, macroinvertebrates, specific conductance, Ephemeroptera, multimetric index, taxonomic resolution.

Many studies have shown that coal mining activities negatively affect stream biota in nearly all parts of the globe (e.g., Lewis 1973a, b, Scullion and Edwards 1980, Winterbourn and McDiffett 1996, Garcia-Criado et al. 1999, Kennedy et al. 2003). Acidic coal mine drainage (pH < 6) and associated water-quality degradation have been studied the most extensively of all effects (e.g., Herlihy et al. 1990, Maltby and Booth 1991, Winterbourn and McDiffett 1996, Verb and Vis 2000, Cherry et al. 2001, DeNicola and Stapleton 2002, Freund and Petty 2007). In the northern Appalachians and Allegheny Plateau, certain coal strata have higher S content than other strata and tend to cause acidic mine drainage. Some coal mining activities routinely produce acidic mine drainage, but mountaintop mining (MTM) in the steep terrain of the Central Appalachian coalfields of Kentucky, Virginia, and West Virginia generally results in alkaline mine drainage

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(pH > 7). Calcareous strata and lower concentrations of S in the coal help to explain this alkaline mine drainage. Coal is made up primarily of organic elements (e.g., C, H) and inorganic elements (e.g., Al, Fe, Ca, Mg, Na, K, and S), and it contains trace elements (including As, Be, Cd, Co, Cr, Hg, Mn, Ni, Pb, Sb, and Se).

During MTM, several overburden layers of sedimentary rock are removed to access coal layers. Some of the mined rock is returned to the mountaintop and graded, but excess spoil typically is placed in valleys adjacent to the surface mine, resulting in valley fills (VFs) or hollow fills (detailed in Slonecker and Benger 2002). VFs permanently bury the ephemeral, intermittent, and perennial streams located adjacent to the mining operations. Land reclamation involves regrading and revegetation using grasses and other herbaceous plants that might be exotic (e.g., *Lespedeza cuneata*). Unlike clear-cut logging, colonization by native plants and trees is normally very slow because of heavy removal of topsoil and compaction of remaining soils on mine sites (Handel 2003). Biogeochemical properties of reclaimed mine soils can be radically different from forest soils, especially in terms of C and nutrient availability (Simmons et al. 2008). Across the MTM region as a whole, Wickham et al. (2007) found that interior forest loss from MTM was 1.75 to 5× greater than overall forest loss attributable to MTM and indicated that fragmentation of forests and introduction of edge forest can change the condition and ecological function of the remaining forest.

The direct impacts of MTM and associated fills on buried streams are undisputed (USEPA 2005). The streams buried by the overburden are permanently eliminated, and MTM and associated VFs have several indirect effects on downstream waters. Precipitation and groundwater in the mined watersheds percolate through the unconsolidated overburden on the mined sites and in the VFs and dissolve minerals until they discharge from the toe of the fills as surface water. The water quality downstream of the VFs can have elevated levels of SO_4, Ca, Mg, hardness, Fe, Mn, Se, alkalinity, K, acidity, and NO_3/NO_2 (Bryant et al. 2002). Sediment runoff is controlled through a series of sediment-control structures and ponds, but excess fine sediment might be increased in streams downstream of VFs (Wiley and Brogan 2003). Moreover, decreased evapotranspiration on the mined site and storage in the VFs can increase instream baseflows 6 to 7× downstream of VFs compared to unmined streams (Wiley et al. 2001), and peak flows might be higher (Wiley and Brogan 2003). These water-quality, hydrological, and physical habitat changes have the potential to negatively affect the instream aquatic life downstream of alkaline MTM and the associated VFs.

Contemporary MTM effects on downstream benthic macroinvertebrates have been reported in West Virginia and Kentucky (Green et al. 2000, Chambers and Messinger 2001, Howard et al. 2001, Pond 2004, Hartman et al. 2005, Merricks et al. 2007). Green et al. (2000) used family-level data because the state monitoring and assessments were done at the family level, and data comparability with state regulatory decisions was an important consideration. Green et al. (2000) also recognized that the family-level assessments might be conservative in that they might underestimate impairment caused by mining. Howard et al. (2001) and Pond (2004) identified consistent impairment of VF streams using genus-level data in Kentucky.

The West Virginia Department of Environmental Protection (WVDEP), the state agency charged with protecting the state's waters under the Clean Water Act (CWA), currently uses the family-level Stream Condition Index (WVSCI; Gerritsen et al. 2000) to conduct bioassessments and interpret the effect as biological impairment of aquatic life use. The state has listed many of the streams located downstream of mined areas and associated VFs as impaired on their CWA section 303(d) list of waters needing Total Maximum Daily Loads (TMDLs) (WVDEP 2007b). In many instances, the mining activity and associated VFs are the only sources of pollutants in the watershed.

Despite these studies, there have been different interpretations by regulators, the regulated community, and researchers about the severity and potential cumulative effects of MTM on resident aquatic life (USEPA 2005). Disagreement between regulators and the regulated community concerning the severity of impairment from mining and VFs might stem from differences in level of taxonomic identification, the different analyses and metrics used by various entities (e.g., regulators, regulated community, and researchers), and the ways in which these metrics are used by state agencies to interpret compliance with water-quality standards. In the Central Appalachians, both West Virginia and Virginia state agencies use family-level assessments to assess stream conditions and all related stressors. However, US Environmental Protection Agency (EPA) Region 3 and WVDEP have recently developed a genus-level mulitmetric index (MMI) called the Genus-Level Index of Most Probable Stream Status (GLIMPSS; Appendix 1), and WVDEP is using this MMI to do assessments. Recent studies on the benefits of finer taxonomic resolution indicate more accurate assessments when genus- or species-level data are used rather than family-level data (Guerold 2000, Hawkins et al. 2000, Lenat and Resh 2001, Arscott et al. 2006), but family-level assessments are also useful (Bowman and Bailey 1998, Bailey et al. 2001, Pond and McMurray 2002, Chessman et al. 2007), and the choice of which to use depends on the objectives of the assessments. Here, we compare family- and genus-level data using regulatory tools, such as WVSCI and GLIMPSS, and selected metrics that are commonly used by states and the regulated community to determine attainment of aquatic life uses for CWA programs. We examine the severity of impairment in waters downstream of VFs using genus-level data and offer further analyses of correlated stressors.

Methods

Site selection and study area

We sampled a total of 27 mined sites with VFs (mined) and 10 unmined sites in the region of MTM in the Central Appalachians (ecoregion 69; Woods et al. 1996) of West Virginia (Appendix 2). We selected sites to provide a range of mining intensity and water quality typical of MTM in this ecoregion. Locations of sample reaches in mined sites ranged from 0.15 km to 2.2 km downstream of the nearest mainstem or tributary VF (mean = 0.8 km). These data spanned collections taken in 1999/2000 ($n = 19$ sites) and 2006/2007 ($n = 18$ additional sites). We evaluated 6 sites (3 reclaimed mined and 3 unmined) for temporal changes over a 6- to 7-y recovery period (1999/2000–2006/2007). We did not combine data from the 2006/2007 revisit samples from these 6 sites with data from other sites in any statistical tests, but we did include the data in exploratory analyses.

The ecoregion is characterized by highly dissected terrain with similar forest types, geology, and climate. Bedrock geology is sedimentary and consists of interbedded sandstones, siltstones, shale, and coal. The dominant vegetation is mixed mesophytic forest (Braun 1950). Most unmined sites had minor anthropogenic influences (e.g., roads, gas wells, past channelization, timbering). Therefore, we considered them to be least disturbed (Stoddard et al. 2006) rather than pristine or minimally disturbed. Mined sites were located downstream of VFs in perennial reaches. Whereas some mined sites had limited mining disturbance prior to the MTM (e.g., contour mining with no VFs), many sites were relatively undisturbed prior to mining. Site watershed areas were relatively small and ranged from 0.5 to 15 km^2. Small streams in this ecoregion typically flow through constrained valleys with relatively high gradients and have boulder–cobble substrates (Woods et al. 1996). Reach slopes in this study ranged from 2 to 7% with an average of 3% (USEPA, unpublished data). Precipitation patterns are generally uniform throughout the study region; however, in summer 1999, this coalfield region reached extreme drought status. Rainfall was considered to be normal in our study area during 2006/2007 sampling (US Drought Monitor Archives 2008; http://drought.unl.edu/dm/archive).

Macroinvertebrate data

We collected macroinvertebrates from riffles using a 0.5-m-wide kicknet (595-μm mesh) in the spring index period (March–May 1999/2000 and 2006/2007). Briefly, we composited 4 targeted 0.25-m^2 kick samples to obtain a 1-m^2 sample from a 100-m reach at each site. In the laboratory, we randomly subsampled organisms in gridded pans to obtain 200 ± 20% individuals. We identified individuals to the genus level for most groups, except Turbellaria, Nematoda, Hydracarina, and Oligochaeta. In cases where the number of sorted organisms was far greater than the target, we subsampled all samples to 200 organisms using a Fortran® program (http://129.123.10.240/WMCPortal/modelSection.aspx?section=125&title=build&tabindex=-1; Western Center for Monitoring and Assessment of Freshwater Ecosystems, Utah State University, Logan, Utah). We sorted entire samples for some sites with low densities. For family-level analyses, we collapsed genera and summed them to family names in the database.

Environmental data

Bryant et al. (2002) reported monthly water samples at our mined and unmined sites collected in 1999/2000 ($n = 19$ sites), but we sampled only 1 of the 18 remaining sites for water chemistry in 2007. We used mean ($n = 13$ mo) chemical concentrations for the sites sampled in 1999/2000, whereas the sample collected in 2007 consisted of a representative grab sample taken at the time of macroinvertebrate sampling. Chemical variables included total metals, dissolved Fe and Mn, nutrients (NO_3, total P), total suspended solids, alkalinity, hardness, anions and cations, pH, and specific conductance. We recorded in situ physicochemical variables (pH, specific conductance, and temperature) at the time of benthic sampling at all 37 sites with a portable multiparameter sonde (Hydrolab Quanta; Hydrolab Corp., Austin, Texas). Sample collection, analytical methods, and results for water chemistry (1999/2000 data set) were reported in Bryant et al. (2002).

Percent mining in the catchment might serve as an appropriate indicator of mining disturbance, but we thought that our mining land-cover estimates were not sufficiently accurate for quantification (e.g., outdated imagery and inaccurate satellite interpretation). We offer these estimates in Appendix 2 for information purposes only. SO_4 concentration has been recommended as a way to estimate mining disturbance in some studies (Herlihy et al. 1990, Rikard and Kunkle 1990), but we lacked SO_4 data for nearly ½ of the sites. Therefore, we assigned sites to 4 categories of mining disturbance (unmined, low, medium, high) using specific conductance as the indicator based on the strong relationship between monthly SO_4 and specific conductance in the Bryant et al. (2002) data set ($R^2 = 0.94$, $p < 0.001$, $n = 511$). Many studies have shown that specific conductance is also a strong indicator of land disturbance, such as urbanization or agriculture (Herlihy et al. 1998, Dow and Zampella 2000, Paul and Meyer 2001, Black et al. 2004), but our sites included only upstream mining disturbances. We derived mining disturbance categories by splitting the range of mined-site conductivities into 3 categories (low: <500 µS/cm [$n = 7$], medium: 500-1000 µS/cm [$n = 8$], high: >1000 µS/cm [$n = 12$]). These categories were used primarily for graphical interpretations and to interpret taxonomic composition along a categorical gradient.

We scored physical habitat (0–20 points/metric; 0–200 points for total score) at all sites using the US EPA Rapid Bioassessment Protocol (RBP) (Barbour et al. 1999). We considered only the following RBP habitat metrics, embeddedness, sediment deposition, channel alteration, riparian zone width, and the total score, based on our knowledge of these metrics in relation to mined watersheds and their overall responsiveness in these small Central Appalachian streams.

Data analyses

We ordinated family- and genus-level community composition data across all sites with nonmetric multidimensional scaling (NMS; PC-ORD, version 4.25; MjM Software, Gleneden Beach, Oregon) using the Bray–Curtis similarity coefficient (Bray and Curtis 1957, McCune and Grace 2002) based on $\log_{10}(x + 1)$ abundances. We computed the data with 400 maximum iterations, 40 real runs, and 50 randomized runs. We grouped sites as unmined or mined with low, medium, or high disturbance. Taxa found at <5% (~2 sites) of all sites were removed prior to running NMS (as recommended by McCune and Grace 2002). The final matrices included 88 genera (of 162 total) and 44 families (of 48 total). We also tested for congruence in genus- and family-level community composition with Mantel's test using matrices calculated from Bray–Curtis similarity matrices (McCune and Grace 2002). The Mantel test compared the 37-site Bray–Curtis matrices between the family- and genus-level data sets by testing the significance of the correlation between matrices using 1000 Monte Carlo permutations (McCune and Grace 2002). We used the nonparametric multiresponse permutation procedure (MRPP) to determine if genus and family composition differed between disturbance categories (PC-ORD). Ranked Sorenson distances from the 37 sites were used to test the hypothesis of no difference between categories. MRPP produced an A-statistic, which compared observed vs expected within-site homogeneity based on the distance matrices (positive A-values indicate higher within-site homogeneity than expected by chance, i.e., differences in invertebrate composition between sites), and a p-value indicating statistical significance.

We compared several commonly used macroinvertebrate metric values between unmined and all mined sites and analyzed the influence of family- and genus-level determinations on these comparisons. Metrics included genus- and family-level total taxon richness, Ephemeroptera–Plecoptera–Trichoptera (EPT) richness, Ephemeroptera richness, Plecoptera richness, biotic index (BI), and Shannon diversity (H′). Some of these metrics are component metrics of the WVSCI and GLIMPSS and some of them are used commonly by other entities (e.g., researchers and the regulated community). The BI indicates the abundance-weighted tolerance value of the subsample and relies on tolerance values used by WVDEP that correspond to values reported in Hilsenhoff (1988), Lenat (1993), and Barbour et al. (1999). We used t-tests (after confirming that metric skew was $<\pm 1$) to detect differences between unmined and all mined sites with genus- and family-level metrics.

We calculated family-level (WVSCI; Gerritsen et al. 2000) and genus-level (GLIMPSS; Appendix 1) MMIs. These MMIs are used by WVDEP to assess condition and aquatic life-use attainment throughout the state. A comparison of the component metrics is shown in Appendix 1. Briefly, GLIMPSS is calibrated by region and season, whereas WVSCI is applied statewide within a broad single index period. Both MMIs were developed using similar methods, the same reference-site selection criteria, and 100-point best standard value (BSV) scoring procedures (Barbour et al. 1999). WVDEP has established an impairment threshold at the 5th percentile of WVDEP's reference distribution. Sites that score at or above this threshold are considered not impaired, whereas sites that score below the threshold are considered impaired. We used GLIMPSS scoring criteria for WVDEP's spring index period (March–May). For the GLIMPSS and WVSCI, scores <62 and <68, respectively, were rated impaired.

We also related ordination results (i.e., NMS axis-1 scores), biological metrics, and MMIs to chemical and habitat data using Spearman correlation coefficients. We correlated water-quality concentrations to individual metrics and MMIs in a separate analysis because the (nearly) full suite of chemical variables was available for only 20 of the 37 sites. Distance (km) downstream of VFs and the total count of fills upstream of the sampling reach were correlated to biological indicators, but only within the mined-site data set.

Results

Assemblage comparisons

NMS produced 2-dimensional ordinations with relatively high resemblance between family- and genus-level determinations (Fig. 1A, B). A 2-dimensional solution was found with satisfactory stress values of 15.7% for the genus ordination and 18.1% for the family ordination. NMS axis 1 represented the most variance in both taxonomic treatments (45% for genus, 67% for family). Both axes accounted for significantly more variance than would be expected by chance (Monte Carlo permutation test, $p = 0.02$, 50 permutations). In both genus- and family-level runs, mined sites were separated considerably from unmined sites in ordination space, which indicates that shifts in community structure were caused by mining intensity.

In general, low, medium, and high disturbance sites were similarly aligned along the primary axis in the 2 ordinations, but in a few instances, the mined-site cluster overlapped the unmined-site cluster (Fig. 1A, B). MRPP showed similar significant differences in genus- and family-level composition between all 4 disturbance categories (genus: $A = 0.38$, $p < 0.00001$; family: $A = 0.36$, $p < 0.00001$). McCune and Grace (2002) suggested that an A-value >0.3 indicates very high within-group homogeneity. For genus- and family-level taxonomy, within-group variability (distance) was lowest in unmined and low-disturbance sites and greatest in high-disturbance sites. Within the 3 mined categories, MRPP still showed significant differences in assemblage composition (genus: $A = 0.15$, $p = 0.0006$; family: $A = 0.21$, $p = 0.00003$) across disturbance categories. The Mantel test showed a strong positive correlation between family- and genus-level Bray–Curtis dissimilarity matrices and, thus, high overall similarity between family- and genus-level composition with respect to the sites (standardized Mantel statistic, $r = 0.82$, $p = 0.001$). Revisited sites (6–7-y period) shifted in ordination space (i.e., as indicated by vectors; Fig. 1A, B), but these pairs of sites generally plotted within their respective category domains.

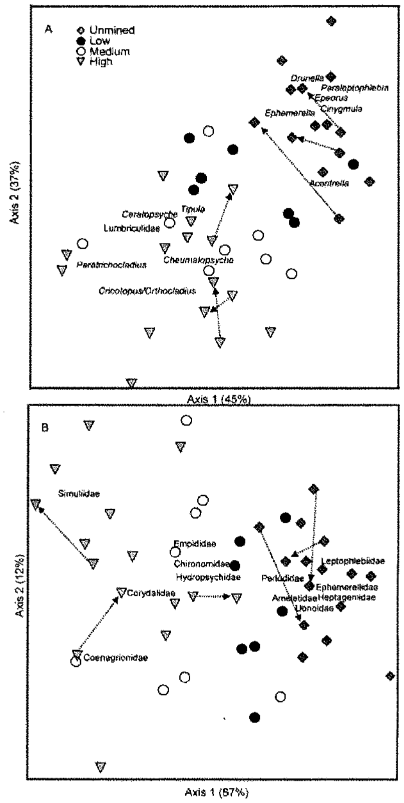

FIG. 1. Nonmetric multidimensional scaling ordination for genus (A) and family (B) determinations at sites categorized by mining disturbance (unmined, low, medium, high). Percent variance explained by each axis is in parentheses. Vectors represent temporal shift of community at 6 revisited sites from 1999/2000 samples to 2006/2007 samples. For clarity, only the 6 most strongly positively and negatively correlated taxa for axis 1 are shown.

TABLE 1. Mean metric values among unmined and mined sites. Statistical comparisons were based on Student's *t*-tests. EPT = Ephemeroptera, Plecoptera, Trichoptera.

Metric	Unmined	Mined	*t*	*p*
Total generic richness	31.9	21.7	−4.6	<0.001
Total family richness	19.9	11.7	−6.1	<0.001
EPT generic richness	17.9	8.9	−7.1	<0.001
EPT family richness	12.8	6.3	−5.9	<0.001
No. Ephemeroptera genera	8.2	2.1	−11.4	<0.001
No. Ephemeroptera families	4.7	1.6	−8.3	<0.001
No. Plecoptera genera	6.0	2.7	−5.3	<0.001
No. Plecoptera families	4.0	2.0	−4.2	<0.001
Genus Biotic Index	2.4	4.5	5.8	<0.001
Family Biotic Index	3.4	4.3	3.6	0.002
Genus Shannon *H′*	2.7	2.1	−3.7	0.002
Family Shannon *H′*	2.1	1.5	−3.9	0.001
% Orthocladiinae	5.1	22.1	4.8	<0.001
% Chironomidae	13.5	27.1	2.0	0.056
% Ephemeroptera	45.6	7.4	−6.4	<0.001
% Plecoptera	23.8	27.3	0.5	0.63
% EPT	77.9	51.1	−3.2	0.003

Simultaneous ordination of taxa and sites showed key genera and families typical of unmined and mined streams (Fig. 1A, B). In general, Ephemeroptera taxa were consistently weighted toward positive NMS axis-1 scores and unmined sites, whereas hydropsychid caddisflies, several Diptera, and oligochaetes were aligned with mined sites. Genera with the 5 highest correlations to NMS axis-1 scores included the caddisfly *Cheumatopsyche* ($r = -0.72$) and *Ceratopsyche* ($r = -0.62$), and the mayfly *Epeorus* ($r = 0.70$), *Ephemerella* ($r = 0.67$), and *Drunella* ($r = 0.59$). In the family ordination, families with the highest correlation to NMS axis-1 scores included the mayflies Ephemerellidae ($r = 0.89$), Heptageniidae ($r = 0.78$), Leptophlebiidae ($r = 0.67$), the caddisfly Uenoidae ($r = 0.68$), and the dipteran family Chironomidae ($r = -0.61$). The relative frequencies of EPT taxa among disturbance categories are reported in Appendix 3.

Metric comparisons

Nearly all metrics were able to detect mining influence, and *t*-statistics were generally stronger for genus-level metrics, but some family-level metrics performed as well as or better than genus-level metrics (e.g., total family richness, family Shannon *H′*; Table 1). Metric values for unmined sites were significantly different from metric values at mined sites ($p < 0.001$), except % Plecoptera ($p = 0.63$) and % Chironomidae ($p = 0.056$). Both genus and family Plecoptera richness metrics performed well (Table 1). Performance of the % Chironomidae metric ($t = 2.0$) was improved by identifying midges to the subfamily level (% Orthocladiinae, $t = 4.8$). Total and EPT richness declined similarly and consistently as disturbance category increased (Fig. 2A, B).

The greatest difference between family- and genus-level metrics occurred with the BI, an abundance-weighted pollution-tolerance metric. Low family BI values (i.e., representing the abundance of more sensitive taxa at unmined sites) were compressed within a narrow range and changed little between low-disturbance and unmined sites, whereas the more responsive genus BI decreased from >3 at low-disturbance sites to 0 at unmined sites to reflect the greater abundance of more sensitive genera present in the unmined sites (Fig. 3). A more consistent relationship between the genus- and family-level values of metrics was apparent at higher values of BI (>~3.5).

Family- and genus-level MMI comparisons

The GLIMPSS and WVSCI were strongly correlated ($r = 0.90$, $p < 0.0001$), and both MMIs generally agreed by assessing unmined sites as unimpaired and highly disturbed sites as impaired (Fig. 4). However, WVSCI appeared to underestimate impairment for some low- and medium-disturbance sites (Table 2).

Water chemistry, physical habitat, and biological relationships

Most of the chemical and physical variables differed significantly between unmined and mined sites (Mann–Whitney test, $p < 0.05$; Table 3). Mean elevation and watershed area did not differ significantly between mined and unmined sites. Mean water temperature did not differ significantly between mined and unmined sites ($p = 0.97$), even though many of the

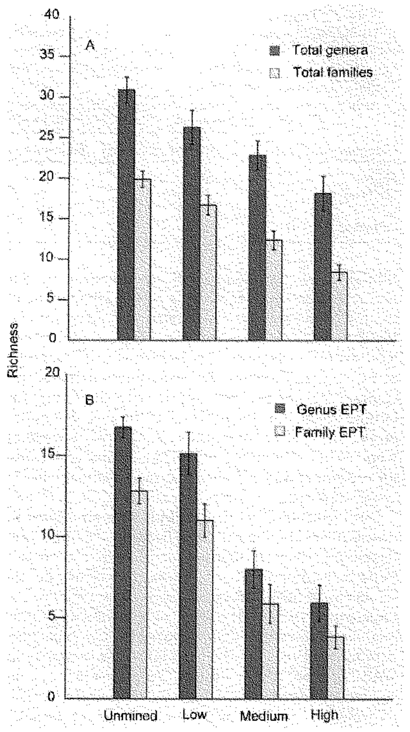

FIG. 2. Mean (±1 SE) total (A) and Ephemeroptera, Plecoptera, Trichoptera (EPT) (B) richness of genus- and family-level determinations across sites grouped by mining disturbance categories.

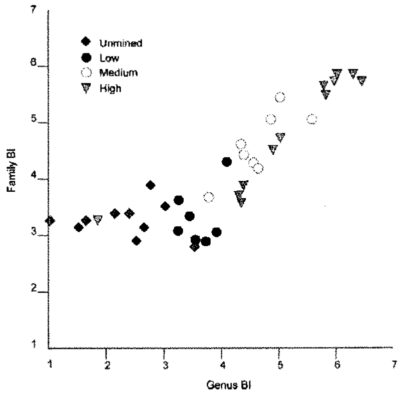

FIG. 3. Scatterplot for the relationship between genus and family biotic index (BI) values at sites categorized by mining disturbance.

mined sites were downstream of sediment-control ponds, which can become warm from insolation. Measures of ionic strength, including individual ions, were more affected by mining than were individual metals or habitat metrics. We did not encounter classic acidic mine drainage because all of our mined sites had relatively high HCO_3 alkalinity and circumneutral pH.

For the 20-site subset, water-quality variables and the total RBP habitat scores were relatively strongly correlated with many biological metrics and the MMIs (Table 4). Most biological metrics and the MMIs had substantially stronger correlations with specific conductance and individual ions than with the mining-related metals or individual habitat variables. NO_3-N was strongly correlated with many biological metrics, but total P was not detected at any site. The strongest relationships between biological variables and any metals were those between EPT and Ephemeroptera generic richness and Se ($r = -0.88$), and between % Chironomidae and dissolved Fe ($r = 0.61$).

For the complete 37-site data set and a smaller subset of environmental variables, the relationships between specific conductance and MMIs and NMS axis 1 were stronger than the relationships between pH, temperature, any of the individual habitat metrics, or the total RBP habitat score and MMIs or NMS axis-1 scores (Table 5). Percent Ephemeroptera showed a sharp nonlinear threshold response to specific conductance, whereby nearly all Ephemeroptera were eliminated from most medium- and high-disturbance sites (Fig. 5A, B). Percent Ephemeroptera was less strongly correlated with habitat-quality metrics than with specific conductance (see Table 4).

Temporal trends in condition

Minor shifts (i.e., vectors) in NMS ordination space (Fig. 1A, B) were observed for the 6 sites that were sampled in 1999/2000 and revisited in 2006/2007. After this 6- to 7-y period, both MMIs indicated that

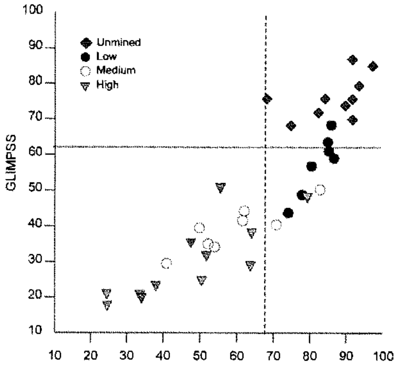

FIG. 4. Scatterplot for the relationship between Genus-Level Index of Most Probable Stream Status (GLIMPSS) and West Virginia Stream Condition Index (WVSCI) categorized by mining disturbance. Vertical and horizontal dashed lines represent impairment thresholds (68 for WVSCI; 62 for GLIMPSS) based on the 5th percentiles of West Virginia Department of Environmental Protection reference distributions.

the 3 mined sites remained impaired, and the sites showed variable signs of further degradation or slight improvement (Table 6). At Stanley Fork, MMIs, total taxon richness, EPT richness, and total RBP habitat score improved over time, but specific conductance increased substantially. MMIs at unmined sites were relatively stable or increased over time and indicated that unmined sites remained unimpaired. These sites were less variable than mined sites and had more consistent total taxon richness, EPT richness, and Ephemeroptera richness over time.

Discussion

The CWA directs states and tribes to designate beneficial uses for streams. Most waters in the US are designated for "aquatic life uses," which means the water must support fish, shellfish, insects, and other wildlife that inhabit the water. Water-quality standards, including numeric parameter-specific criteria and narrative criteria, are meant to protect those designated uses and specific aquatic life. Numeric water-quality criteria (e.g., Se, Fe, Al, pH, total suspended solids [TSS]) are sometimes exceeded in mined streams, but biological assessments (including MMIs) more commonly indicate impairment. For example, Ephemeroptera are a major component of the macroinvertebrate assemblage and often account for 25 to 50% of total macroinvertebrate abundance in least-disturbed Central Appalachian streams sampled in the spring. Therefore, Ephemeroptera richness and composition metrics are appropriate indicators for bioassessments in this region. Our finding that entire orders of benthic organisms (e.g., Ephemeroptera) were nearly eliminated in MTM streams is a cause for concern and is evidence that the aquatic life use is being impaired.

TABLE 2. Frequencies of assessment ratings of impaired and unimpaired based on genus- and family-level metrics for sites in 4 mining disturbance categories. GLIMPSS = Genus-Level Index of Most Probable Stream Status, WVSCI = West Virginia Stream Condition Index.

	GLIMPSS (genus level)		WVSCI (family level)	
Category	Impaired	Unimpaired	Impaired	Unimpaired
High	12	0	11	1
Medium	8	0	6	2
Low	5	2	0	7
Unmined	0	10	0	10

Our results indicate that MTM is strongly related to downstream biological impairment, whether raw taxonomic data, individual metrics that represent important components of the macroinvertebrate assemblage, or MMIs are considered. The severity of the impairment rises to the level of violation of water-quality standards (WQS) when states use biological data to interpret narrative standards. For example, in West Virginia, the narrative WQS reads, "... no significant adverse impact to the chemical, physical, hydrologic, or biological components of aquatic ecosystems shall be allowed" (WVDEP 2007a). Pertinent to ionic stress effects, Kentucky's narrative WQS states, "Total dissolved solids or specific conductance shall not be changed to the extent that the indigenous aquatic community is adversely affected" (KYDEP 2007). Both WVDEP and Kentucky Department of Environmental Protection (KYDEP) have used biological data to interpret its narrative WQS and then listed mining-impaired streams on their 303(d) lists. More research is necessary to determine whether MTM-impaired streams can be restored to full-attainment status through water-quality improvements (e.g., permits or TMDL implementation) and physical restoration. Family-level assessments might detect high and moderate mining impacts and potential recovery endpoints, but we think that genus-level assessments will be required for thorough stressor

TABLE 3. Chemical and habitat variables at mined and unmined sites. Chemical values are in mg/L unless otherwise specified; *p* values are associated with comparisons between mined and unmined sites done with Kruskal–Wallis 1-way analysis of variance using the Mann–Whitney *U*-statistic. Total P was not detected in any samples (0.05 mg/L detection limit). RBP = Rapid Bioassessment Protocol.

	Mined		Unmined		
Variable	*n*	Mean (range)	*n*	Mean (range)	*p*
Watershed area (km^2)	27	4.9 (0.5–15.9)	10	3.0 (0.8–7.0)	0.516
Elevation (m)	27	313.2 (230–500)	10	307 (259–421)	0.973
Temperature (°C)	27	11.7 (7.8–18.2)	10	12 (7.3–16.5)	0.682
pH (SU)	27	7.9 (6.3–8.9)	10	7.1 (6.1–8.3)	0.005
Specific conductance (μS/cm)	27	1023 (159–2540)	10	62 (34–133)	0.000
Embeddedness score	27	13.6 (3–18)	10	16.4 (12–19)	0.004
Sediment deposition score	27	13.4 (6–18)	10	14.8 (10–19)	0.229
Channel alteration score	27	14.7 (7–19)	10	16.8 (15–18)	0.011
Riparian zone width score	27	14.5 (7–20)	10	16.4 (9–20)	0.143
Total RBP habitat score	27	147.8 (126–171)	10	158.5 (141–168)	0.006
HCO_3	13	183 (10.7–501.8)	7	20.9 (6.1–35)	0.002
Al (μg/L)	13	96 (<50–272)	7	92.5 (<50–183)	0.380
Ba (μg/L)	13	41.1 (22–68)	7	39.6 (15–72)	0.692
Ca	13	137.5 (38–269)	7	7.5 (2.7–12)	0.000
Cl	13	4.6 (<2.5–11)	7	2.8 (<2.5–4)	0.022
Cu (μg/L)	13	2.6 (<2.5–3.4)	7	2.9 (<2.5–5)	0.496
Hardness	13	801.4 (225–1620)	7	42 (17–72)	0.000
Dissolved Fe (μg/L)	13	91.8 (<50–281)	7	74.3 (<50–185)	0.362
Total Fe (μg/L)	13	275.6 (66–650)	7	176 (65–471)	0.322
Pb (μg/L)	13	1.2 (<1–4)	7	1.2 (<1–2.1)	0.496
Mg	13	122.4 (28–248)	7	4.3 (2.3–7)	0.000
Dissolved Mn (μg/L)	13	113.4 (6.5–853)	7	20.9 (<5–55)	0.165
Total Mn (μg/L)	13	141.4 (9–904)	7	34.1 (<5–83)	0.143
Ni (μg/L)	13	14.2 (<10–59)	7	<10	0.287
NO_3-N	13	3.4 (0.8–16.5)	7	0.4 (0.1–0.9)	0.001
K	13	9.9 (3–19)	7	1.6 (1.3–2)	0.000
Se (μg/L)	13	10.6 (<1.5–36.8)	7	<1.5	0.001
Na	13	12.6 (2.6–39)	7	2.4 (0.7–5.5)	0.001
SO_4	13	695.5 (155–1520)	7	16 (11–21.6)	0.000
Zn (μg/L)	13	9.1 (<2.5–27)	7	10.2 (3.3–23.4)	0.322

identifications and to detect subtle improvements from stressor abatement activities.

Our results confirm that MTM impact to aquatic life is strongly correlated with ionic strength in the Central Appalachians, but habitat quality did explain some variance in MMIs and other metrics. All mined sites with specific conductance >500 μS/cm were rated as impaired with the genus MMI (GLIMPSS). Undisturbed streams in the Central Appalachians are naturally very dilute, with background conductivities generally <75 μS/cm. Downstream of MTM sites, specific conductance and component ions can be elevated 20 to 30× over the background levels observed at unmined sites (e.g., SO_4: 38×, Mg: 32×, HCO_3: 15×) (Bryant et al. 2002). Mount et al. (1997) recognized the toxicity of major ions and developed predictive models to assess the acute toxicity attributable to major ions using *Ceriodaphnia dubia*, *Daphnia magna*, and *Pimephales promelas*. They reported that the relative ion toxicity was $K > HCO_3 \approx Mg > Cl > SO_4$; this order was confirmed by Tietge et al. (1997), who used the models to quantify and predict the toxicity from major ions but also identified toxicity from other toxic compounds in some high-salinity waters. Our data showed that the toxic ions reported by Mount et al. (1997) had strong correlations with benthic macroinvertebrate metrics and MMIs (Table 4) but at concentration ranges much lower than those reported in Mount et al. (1997).

Merricks et al. (2007) reported sporadic acute toxicity to *C. dubia* and *D. magna* at sites draining VFs in West Virginia but did not conclude whether ions or metals were responsible. Soucek and Kennedy (2005) observed SO_4 toxicity to *Hyallela azteca* but at higher concentrations (>2000 mg/L in hard water) than were found in our study. Our mined sites averaged nearly 700 mg/L SO_4, whereas unmined sites averaged only 16 mg/L. A water-quality guideline of <100 mg/L SO_4 was recommended to protect freshwater organisms in British Columbia (Singleton

Table 4. Spearman correlation coefficients ($n = 20$) between genus and family metrics and multimetric indices (MMIs) in relation to environmental variables from the 20-site data subset. All chemical variables are total concentrations unless specified as dissolved. Units are as in Table 3. Biological metrics are abbreviated to order or family name. GLIMPSS = Genus-Level Index of Most Probable Stream Status, WVSCI = West Virginia Stream Condition Index, RBP = Rapid Bioassessment Protocol. Temperature, total P, Ba, Cu, total Fe, Ni, Pb, and Zn were not significantly correlated with metrics ($p > 0.05$). Coefficients in bold are statistically significant ($p < 0.05$).

Variable	GLIMPSS	WVSCI	Total generic richness	Total family richness	EPT generic richness	EPT family richness	No. Ephemeroptera genera	No. Ephemeroptera families	No. Plecoptera genera	No. Plecoptera families
pH	−0.30	−0.29	−0.12	−0.36	−0.23	−0.30	−0.35	−0.37	−0.01	0.02
Specific conductance	**−0.90**	**−0.80**	**−0.74**	**−0.89**	**−0.88**	**−0.88**	**−0.90**	**−0.90**	**−0.75**	**−0.73**
Embeddedness score	**0.61**	**0.57**	**0.67**	**0.64**	**0.69**	**0.72**	**0.52**	**0.50**	**0.61**	**0.60**
Sediment deposition score	**0.52**	**0.62**	0.40	**0.50**	**0.56**	**0.66**	0.44	**0.52**	**0.47**	**0.45**
Channel alteration score	**0.51**	**0.46**	**0.58**	**0.50**	**0.52**	**0.53**	0.34	0.34	**0.58**	**0.58**
Riparian width score	0.21	0.04	0.37	0.21	0.24	0.22	0.13	0.08	0.26	0.23
Total RBP habitat score	**0.76**	**0.74**	**0.76**	**0.75**	**0.78**	**0.83**	**0.64**	**0.66**	**0.76**	**0.72**
HCO_3	**−0.78**	**−0.72**	**−0.67**	**−0.77**	**−0.76**	**−0.75**	**−0.75**	**−0.77**	**−0.65**	**−0.62**
Al	0.28	0.38	0.24	0.43	0.35	**0.45**	0.29	0.24	0.11	0.12
Ca	**−0.89**	**−0.79**	**−0.75**	**−0.86**	**−0.88**	**−0.87**	**−0.88**	**−0.89**	**−0.81**	**−0.75**
Cl	**−0.54**	−0.40	**−0.52**	**−0.57**	**−0.53**	**−0.52**	**−0.53**	**−0.48**	**−0.52**	**−0.50**
Hardness	**−0.89**	**−0.79**	**−0.74**	**−0.85**	**−0.89**	**−0.87**	**−0.87**	**−0.88**	**−0.81**	**−0.78**
Dissolved Fe	−0.29	−0.41	−0.04	−0.28	−0.30	−0.39	−0.33	−0.42	−0.22	−0.23
Mg	**−0.88**	**−0.83**	**−0.71**	**−0.85**	**−0.89**	**−0.90**	**−0.87**	**−0.89**	**−0.81**	**−0.79**
Dissolved Mn	**−0.46**	**−0.45**	−0.17	−0.34	−0.39	−0.43	**−0.46**	**−0.53**	−0.32	−0.30
Total Mn	−0.36	−0.35	−0.04	−0.25	−0.28	−0.35	−0.37	**−0.47**	−0.21	−0.20
$NO_2 + NO_3$	**−0.86**	**−0.82**	**−0.68**	**−0.83**	**−0.83**	**−0.79**	**−0.89**	**−0.87**	**−0.79**	**−0.75**
K	**−0.92**	**−0.88**	**−0.75**	**−0.89**	**−0.88**	**−0.90**	**−0.88**	**−0.89**	**−0.77**	**−0.72**
Se	**−0.85**	**−0.78**	**−0.76**	**−0.82**	**−0.88**	**−0.84**	**−0.88**	**−0.87**	**−0.83**	**−0.80**
Na	**−0.67**	**−0.57**	**−0.57**	**−0.68**	**−0.57**	**−0.59**	**−0.60**	**−0.59**	**−0.48**	**−0.42**
SO_4	**−0.89**	**−0.79**	**−0.75**	**−0.88**	**−0.89**	**−0.88**	**−0.89**	**−0.87**	**−0.79**	**−0.69**

2000). We think that surrogate test organisms (e.g., daphnids, amphipods) are more tolerant of pollutants than are resident Appalachian biota and that toxicity results might not translate into protective criteria.

Elevated conductivity can be toxic through effects on osmoregulation (Wichard et al. 1973, McCulloch et al. 1993, Ziegler et al. 2007). Aquatic insects, such as Ephemeroptera, have relatively high cuticular permeability and regulate ion uptake and efflux using specialized external chloride cells on their gills and integument and internally via Malpighian tubules (Komnick 1977, Gaino and Rebora 2000). Large increases in certain ions can disrupt water balance and ion exchange processes and cause organism stress or death. Tests for conductivity toxicity for mayflies have produced varying results (Goetsch and Palmer 1997, Chadwick et al. 2002, Kennedy et al. 2003, Hassell et al. 2006), but we think that these studies used taxa that are more tolerant (i.e., *Hexagenia*, *Centroptilum*, *Cloeon*, *Isonychia*) than Central Appalachian mayflies (e.g., ephemerellids, heptageniids). Other unknown effects might include ionic stress on reproductive success.

Even at relatively low concentrations, increased conductivity can cause significantly higher drift rates in benthos (Wood and Dykes 2002), but some taxa are not affected (Blasius and Merritt 2002). It is plausible that sensitive taxa are absent from mined streams because of this drift, but increased drift does not explain how recolonization is hindered. Alternatively, elevated specific conductance might simply be an indicator of mining disturbance, and other mining-related variables (e.g., metal concentrations) might be causing or contributing to the impairment. Our bioassessment indicators were not strongly correlated with dissolved or total metals concentrations in the water column, but these results do not rule out possible exposure to metals via dietary uptake (Gerhardt 1992, Buchwalter and Luoma 2005, Cain et al. 2006, Buchwalter et al. 2007) or microhabitat smothering by metal hydroxide precipitate (Wellnitz et al. 1994, USEPA 2005).

TABLE 4. Extended.

Variable	Genus Biotic Index	Family Biotic Index	Shannon *H′* (genus)	Shannon *H′* (family)	% Ortho-cladiinae	% Chiro-nomidae	% Ephemer-optera	% Plecoptera	% EPT
pH	0.34	0.36	–0.12	–0.26	**0.53**	0.31	–0.35	–0.13	–0.32
Specific conductance	**0.83**	**0.68**	**–0.83**	**–0.83**	**0.48**	0.26	**–0.88**	–0.19	**–0.68**
Embeddedness score	**–0.53**	**–0.45**	**0.62**	**0.56**	–0.02	0.21	0.44	**0.45**	**0.47**
Sediment deposition score	**–0.60**	**–0.57**	**0.48**	**0.56**	–0.34	–0.23	**0.48**	**0.49**	**0.63**
Channel alteration score	**–0.46**	–0.32	**0.48**	0.36	–0.05	**0.24**	0.28	0.42	0.35
Riparian width score	–0.08	0.00	0.27	0.12	0.25	**0.55**	–0.05	0.10	–0.05
Total RBP habitat score	**–0.70**	**–0.57**	**0.72**	**0.71**	–0.21	–0.02	**0.58**	0.38	**0.60**
HCO_3	**0.81**	**0.70**	**–0.62**	**–0.73**	**0.54**	0.37	**–0.75**	–0.26	**–0.74**
Al	–0.24	–0.02	0.41	0.37	–0.24	–0.15	0.24	–0.08	0.17
Ca	**0.85**	**0.73**	–0.78	**–0.81**	**0.47**	0.26	**–0.88**	–0.28	**–0.74**
Cl	0.41	0.33	**–0.58**	–0.40	0.00	–0.16	**–0.46**	–0.10	–0.22
Hardness	**0.85**	**0.72**	**–0.77**	**–0.80**	**0.47**	0.26	**–0.90**	–0.26	**–0.73**
Dissolved Fe	0.41	0.34	–0.22	–0.43	**0.45**	**0.61**	**–0.51**	0.14	–0.40
Mg	**0.87**	**0.76**	**–0.74**	**–0.81**	**0.52**	0.32	**–0.92**	–0.32	**–0.77**
Dissolved Mn	**0.46**	0.44	–0.40	**–0.49**	0.42	0.35	**–0.52**	–0.07	–0.41
Total Mn	0.41	0.41	–0.30	–0.35	0.40	0.31	**–0.49**	–0.09	–0.36
$NO_2 + NO_3$	**0.85**	**0.82**	**–0.63**	**–0.73**	**0.60**	0.39	**–0.90**	**–0.44**	**–0.79**
K	**0.91**	**0.74**	**–0.78**	**–0.87**	**0.58**	0.40	**–0.90**	–0.27	**–0.80**
Se	**0.79**	**0.70**	**–0.68**	**–0.73**	0.44	0.32	**–0.86**	–0.28	**–0.72**
Na	**0.71**	**0.57**	–0.44	**–0.56**	**0.60**	0.32	**–0.58**	–0.20	**–0.60**
SO_4	**0.83**	**0.69**	**–0.79**	**–0.80**	**0.48**	0.26	**–0.88**	–0.25	**–0.71**

MMIs were correlated with Se, but Se is considered relatively nontoxic to invertebrates, and this element is a greater concern for bioaccumulation in vertebrates than it is for toxicity in invertebrates (Lemly 1999, Hamilton 2004). Ingersoll et al. (1990) reported chronic Se toxicity to *D. magna* at concentrations >10 to 100× higher than those found in our study, but Halter et al. (1980) reported chronic toxicity (14 d) in *H. azteca* at levels ~2× as high as our maximum concentration. A review by deBruyn and Chapman (2007) suggested that Se could cause sublethal effects to invertebrates at concentrations considered safe for fish and birds.

In cases where MTM activities resulted in smaller increases in ionic strength, we observed less-severe biological impairment. Within the mined site data set, we found no evidence that MMIs were significantly correlated with the number of VFs upstream or distance from the fill ($p > 0.05$), but these indicators appeared to be related to our inexact estimates of the amount of mining in the watershed. Aerial photos of these particular operations revealed that VFs were relatively small in size and intervening unmined tributaries probably offered some degree of dilution to our downstream sampling sites. For example, Dingess Camp had 1 small VF in its headwaters and 2 intervening unmined tributaries upstream of our sample reach. This site was rated unimpaired and had corresponding specific conductance of 423 µS/cm and total RBP habitat score of 160. However, medium- and high-specific-conductance sites contained either 1 large VF or multiple small VFs with no intervening unmined tributaries to provide dilution. This observation suggests that maintaining some unmined watersheds to provide adequate dilution immediately downstream of future MTM projects might be an effective way to protect downstream resources. These unmined watersheds also could act as refugia for maintenance of regional diversity and sources of recolonization for some species for reclaimed or restored reaches below VFs (e.g., Lowe et al. 2006). Future research should focus on the impairment mechanism and should include investigations of chronic effects on osmoreg-

Table 5. Spearman correlation coefficients of Genus-Level Index of Most Probable Stream Status (GLIMPSS) and West Virginia Stream Condition Index (WVSCI) and genus- and family-level nonmetric multidimensional scaling (NMS) axis scores vs a truncated list of environmental variables available for the entire 37-site data set. Values in bold are statistically significant ($p < 0.05$). RBP = Rapid Bioassessment Protocol.

			Genus		Family	
	GLIMPSS	WVSCI	NMS 1	NMS 2	NMS 1	NMS 2
Temperature (°C)	0.09	0.02	–0.14	**0.33**	–0.02	**0.41**
pH (SU)	**–0.44**	**–0.47**	**–0.47**	**–0.39**	**–0.47**	0.01
Specific conductance (µS/cm)	**–0.91**	**–0.80**	**–0.84**	**–0.72**	**–0.90**	0.16
Embeddedness score	0.23	0.22	0.22	0.04	0.15	0.04
Sediment deposition score	0.20	0.28	0.30	–0.07	0.20	**–0.33**
Channel alteration score	0.29	0.20	0.28	0.15	**0.33**	0.00
Riparian score	0.11	0.02	0.15	0.04	0.14	0.19
Total RBP habitat score	**0.38**	**0.43**	**0.45**	0.12	**0.38**	–0.16
Watershed area (km^2)	–0.19	–0.19	–0.22	–0.26	–0.25	**–0.37**
Elevation (m)	0.16	0.24	0.07	0.30	0.15	0.29

ulation from elevated specific conductance, catastrophic drift with no recolonization, chronic metal exposure via dietary uptake, and further study of the most vulnerable life stages. It is necessary to identify the specific parameters causing impairment to develop appropriate water-quality standards and control solutions.

Influence of MTM and taxonomic resolution on community composition

Unmined streams had assemblages (genus and family level) that differed markedly from assemblages in mined streams; ordinations showed strong shifts in taxonomic composition as indicated by the spread of sites categorized by mining disturbance. In general, Ephemeroptera genera and families were most indicative of unmined streams and contributed the most to separation of sites in ordination space. Mined sites also revealed signature communities dominated by facultative and tolerant taxa such as orthoclads, hydropsychids, oligochaetes, and other Diptera. In both mined and unmined streams, Plecoptera abundance often was dominated by the nemourid *Amphinemura*, a moderately facultative genus that is ubiquitous in small streams throughout the ecoregion.

Use of genus or family taxonomic determinations did not affect our multivariate ordination interpretations. Lenat and Resh (2001) indicated that family-level data approximate finer taxonomic data with multivariate statistics (Furse et al. 1984, Bowman and Bailey 1998); however, Hawkins et al. (2000) found that genus-level multivariate predictive models performed better than family-level models in California streams. Arscott et al. (2006) also showed that genus- and species-level ordinations distinguished urban and agricultural impacts to streams better than did family-level ordinations in the Hudson River Valley. We reason that genus- and family-level ordinations were relatively similar in our data set because many families collected had few genera at each site and because of spatial proximity and physical similarity of small study streams within the ecoregion and strong chemical stressor effects on mined communities.

Metric comparisons

Condition assessment of aquatic resources should rely on proven indicator metrics that are responsive to increasing stress (Karr and Chu 1999). In our analyses, genus-level metrics most accurately detected mining impacts based on *t*-tests, but family- and order-level metrics also were highly successful. The fact that most family- and order-level metrics could easily discriminate mining influences confirms that VF sites were considerably impacted and would certainly represent nonattainment of CWA designated use for aquatic life. The commonly used % EPT metric was less sensitive than other metrics because this metric was driven primarily by the presence of tolerant hydropsychid caddisflies or *Amphinemura* at mined sites. Total and EPT richness was greatly reduced below VFs (by 30–50% of values at unmined sites). In contrast, Merricks et al. (2007) did not find a significant decline in taxon richness below VFs. However, the single reference site used by Merricks et al. (2007) had values of specific conductance that were 4× higher than the average value at our unmined sites, indicating some disturbance at their reference site. Furthermore, the taxon richness value at their reference site was only ½ of the taxon richness we commonly observed.

Genus-level data offer better responsiveness than family- or order-level data because of the larger number of taxa identified and the more accurate tolerance values assigned to genera (Lenat and Resh 2001, Chessman et al. 2007). Differences in total taxon richness might be minimized because generic richness within individual invertebrate families (i.e., low genus:family ratios) seems to be lower in small Central Appalachian streams than in larger warm-water systems. Therefore, family-level taxon richness offers a close approximation to genus-level taxon richness in these small Appalachian systems. Exceptions to this are, for example, the families Chironomidae, Baetidae, Ephemerellidae, Heptageniidae, Hydropsychidae, Elmidae, and Perlodidae. Some of these same genus-rich families contain genera with a wide range of pollution-tolerance values (Blocksom and Winters 2006). This fact was evident in the comparison of genus- and family-level BI values. The family-level BI will be less sensitive than the genus-level BI if genera within a family have a broad range of tolerance values. Genus and family BIs were better correlated in the mid- and upper range of the BI scale than in the low range, a result that might reflect the narrower range of tolerance values in the more pollution-tolerant families normally found in mined streams. Ephemeroptera metrics performed similarly across taxonomic levels (i.e., genus, family, and order levels); populations were nearly eliminated below VFs in our study and others (Howard et al. 2001, Pond 2004, Hartman et al. 2005, Merricks et al. 2007). The only mayflies observed frequently at our low- to medium-disturbance sites were *Baetis* and *Plauditus*, 2 relatively facultative genera (Appendix 3).

MMI comparisons and impairment ratings

Nearly all of the mined sites were assessed as impaired based on GLIMPSS, whereas none of the unmined sites was assessed as impaired. Assessment ratings based on genus- and family-level MMIs were in agreement 81% of the time for sites in our data set. Genus-level GLIMPSS assessment ratings also agreed with family-level WVSCI assessment ratings ~80% of the time during development of GLIMPSS, which included all forms of impacts (not just mining; WVDEP, unpublished data; $n = 421$ for spring index period, ecoregions 67–69; Woods et al. 1996). However, 18% of the time, the WVSCI missed moderate impairment as rated by the GLIMPSS (73 of 421 sites). We think that this discrepancy represents a significant loss in assessment accuracy and supports the use of genus-level assessments in all state regulatory assessments of stream condition and related stressors. Several authors have acknowledged that family-level assessments (MMIs, multivariate predictive models, pollution-tolerance indices, or ordinations) can detect obvious impairment in relation to reference conditions (Bailey et al. 2001, Lenat and Resh 2001, Arscott et al. 2006, Chessman et al. 2007). WVSCI detected severe impacts but missed some low- to moderate-disturbance impacts that were detected by the GLIMPSS. The limitations of the WVSCI are that it does not use Ephemeroptera metrics, which were part of the GLIMPSS, and it does not account for spatial and temporal differences in benthic communities, whereas GLIMPSS is specifically calibrated to reference sites that have been seasonally and regionally partitioned. We did not attempt to modify the WVSCI to account for these issues because seasonal or regional adjustments were considered unnecessary in the development of WVSCI (Gerritsen et al. 2000).

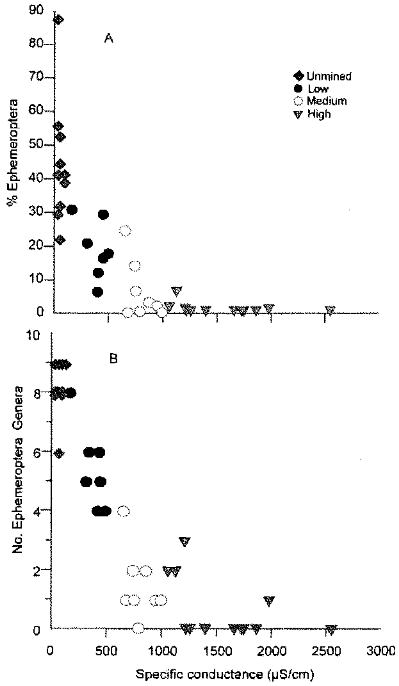

FIG. 5. Scatterplots for the relationship between % Ephemeroptera (A) and number of Ephemeroptera genera (B) and specific conductance at sites categorized by mining disturbance.

Table 6. Multimetric indices (MMIs), selected metric values, specific conductance, and total Rapid Bioassessment Protocol (RBP) habitat scores for 6 sites (3 reclaimed mined sites, 3 unmined sites) visited in 1999/2000 and revisited in 2006/2007. GLIMPSS = Genus-Level Index of Most Probable Stream Status, WVSCI = West Virginia Stream Condition Index, EPT = Ephemeroptera, Plecoptera, Trichoptera.

	Ballard (mined)		Stanley Fork (mined)		Sugartree (mined)		Rushpatch (unmined)		Spring (unmined)		White Oak (unmined)	
Stream	1999	2006	2000	2006	1999	2006	1999	2006	1999	2006	2000	2007
GLIMPSS	51	38	21	34	32	29	75	75	74	79	75	85
WVSCI	55	52	25	38	52	36	68	90	90	95	91	88
Total generic richness	33	20	14	28	22	20	42	40	33	37	32	30
EPT generic richness	12	9	2	6	4	4	17	19	17	21	17	20
Ephemeroptera generic richness	3	3	0	0	0	0	9	7	8	8	9	8
Specific conductance (μS/cm)	1201	1195	1387	2010	1854	1910	60	70	51	66	64	88
Total RBP habitat score	148	149	145	155	141	154	147	144	156	149	161	163

Water-chemistry, physical habitat, and biological relationships

Water quality structured benthic communities more than habitat quality. Our study and others (Chambers and Messinger 2001, Howard et al. 2001, Fulk et al. 2003, Pond 2004, Hartman et al. 2005, Merricks et al. 2007) suggest that specific conductance is the best predictor of the gradient of conditions found downstream of alkaline mine drainage and VF sites in the Central Appalachians. In previous studies, MMIs and Ephemeroptera metrics were strongly negatively correlated with instream specific conductance in West Virginia (Green et al. 2000, Chambers and Messinger 2001) and Kentucky (Howard et al. 2001, Pond 2004). Yuan and Norton (2003) found that Ephemeroptera richness was particularly sensitive to increasing specific conductance in the Mid-Atlantic Highlands. Black et al. (2004) reported that Ephemerellidae and Heptageniidae (the 2 primary mayfly families eradicated from our high-specific-conductance sites) had low specific-conductance optima in Pacific Northwest streams. In an analysis of West Virginia data, Fulk et al. (2003) confirmed that WVSCI scores were negatively correlated with individual and combined ion concentrations, but also with the concentrations of Be, Se, and Zn. Hartman et al. (2005) reported significantly lower densities of Ephemeroptera, Coleoptera, Odonata, noninsects, scrapers, and shredders ($p < 0.03$) in West Virginia VF streams compared to reference streams, but they also found that total abundance of all organisms was not substantially reduced in VF streams. Hartman et al. (2005) also reported that Ephemeroptera family richness was negatively related to specific conductance and that many of the richness metrics were negatively related to particular metals. Ephemeroptera are known to be sensitive to trace metals, especially in soft waters (Clements 2004), but we found that metal concentrations in the water column were not strongly correlated to Ephemeroptera (except Se) in our hard-water mined streams. Last, NO_3-N was significantly related to benthic metrics, but we did not visually observe excessive algal growth during the surveys. However, we cannot assume that diatom communities were not affected at these sites. Total P was probably limiting (it was below the 0.05 mg/L detection limit). Thus, most N probably was exported from the watershed and was autocorrelated with ionic strength.

Individual physical habitat variables and total RBP habitat score were more correlated with MMIs or individual metrics in the 20-site subset (Table 4) than in the full data set (Table 5). The discrepancy between habitat correlations in the 20-site subset vs the 37-site data sets probably arose because more mined sites had better habitat quality in the 37-site data set than in the 20-site subset. Howard et al. (2001) and Pond (2004) reported that habitat indicators (chiefly sedimentation and embeddedness) were strongly correlated with MMIs and particular metrics in Kentucky headwater streams. Surface mining can deliver excess sediment to watersheds (Starnes and Gasper 1995, Waters 1995, Chambers and Messinger 2001). We did not observe excessive sedimentation in our sampled reaches downstream of VF sediment-control ponds, but sediments might be transported and deposited farther downstream. Hartman et al. (2005) did not find significant differences in sedimentation below VFs after 5 to 20 y and speculated that after the initial pulse of sediments from mining operations, fine sediments might be sufficiently flushed from headwater reaches.

Observations on recovery

Our 3 revisits to sites downstream of reclaimed MTM and VFs revealed little sign of biological recovery (with MMIs or selected metrics) after 6 to 7 y, whereas communities within the 3 unmined catchments remained relatively stable. Habitat improvement was subtle at the downstream reaches of mined streams, but specific conductance remained very high, indicating that water chemistry is limiting recovery of these communities. Impacts to ecosystem structure and function (i.e., soil and water biogeochemistry, leaf decomposition, macroinvertebrates) remained after 15 y of recovery of a coal-mined watershed in Maryland (Simmons et al. 2008), and the oldest VF site in the data set given in Merricks et al. (2007) still had downstream specific conductance values >1200 µS/cm and no mayflies after 15 y. Further studies are needed to determine long-term recovery patterns of aquatic communities downstream of MTM and VFs.

Concluding Comments

We explored a causal link between MTM and biological degradation, and our data support the type of logical argument summarized by Beyers (1998) for establishing causal connections. Fore (2003) modified Beyers' 10 criteria and demonstrated causal links between human disturbance and biological condition in mid-Atlantic streams. The 10 criteria are: 1) strength, 2) consistency, 3) specificity, 4) temporality, 5) dose response, 6) plausibility, 7) experimental evidence, 8) analogy, 9) coherence, and 10) exposure. Eight of the 10 criteria were relevant for constructing a causal inference argument with our bioassessment data. We excluded specificity (because the bioassessment tools respond to many sources of degradation) and exposure (because we did not evaluate exposure indicators in affected organisms). Our data met 6 of the remaining 8 relevant criteria:

1. Ninety-three percent of the mined streams and none of the unmined streams were impaired using the preferred genus-level GLIMPSS, indicating the strength of the association.
2. The relationship between MTM and biological impairment has been confirmed by other investigators working in the Central Appalachians of West Virginia and Kentucky, indicating consistency.
3. Because our unmined sites were not impaired and were selected to be typical of least disturbed reference sites, these sites are representative of premining conditions in the watershed. We think it is reasonable to conclude that mining disturbance preceded the observed biological change (temporality).
4. Biological condition degraded in response to increasing mining disturbance, as measured by mining-related water-quality parameters, indicating dose response.
5. The premise that MTM causes downstream biological degradation is plausible given the wholesale landscape changes, hydrological alterations, and potential toxicants that are discharged. For example, elevated ionic strength can impair osmoregulation, which offers a plausible mechanism of impairment to macroinvertebrates.
6. Similar stressors cause similar effects to those found here (analogy). For example, diverse human activities (urbanization, oil- and gas-well drilling, road salting) that produce elevated ionic strength or landscape disturbance also are correlated with downstream impairment in empirical studies, and experimental toxicity testing has confirmed the toxicity of mining-related component ions.

We are currently conducting chronic toxicity testing experiments using surrogate organisms to provide experimental evidence that quantifies the toxicity of these mining effluents on downstream waters. These experiments will test the ambient downstream waters and synthesized waters that will mimic the ionic components of waters downstream of mines but will not contain any other potential toxicants (e.g., metals). The results of these experiments will help to provide more coherence between empirical and experimental evidence on the downstream chemical effects of MTM to aquatic life.

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APPENDIX 1. Additional information on development and application of the Genus-Level Index of Most Probable Stream Status (GLIMPSS).

The GLIMPSS was developed using best standard practices based on US Environmental Protection Agency (EPA) guidelines (Barbour et al. 1999) and Karr and Chu (1999) using >3000 statewide probabilistic and targeted sites (265 reference, 775 stressed) collected between 1998 and 2006. US EPA Region 3 and West Virginia Department of Environmental Protection (WVDEP) used widely recommended index calibration and validation techniques that included testing 36 different metrics for discrimination efficiency, redundancy, response to stressors, variability, and precision. Data were partitioned by bioregional (Allegheny Plateau, Central Appalachian–Ridge and Valley) and seasonal (winter, spring, summer) factors after examining nonmetric multidimensional scoring (NMS) ordinations and metric distributions. GLIMPSS metrics and scoring criteria were developed for 7 strata. For our study sites, we used metrics and final scoring criteria developed for the Mountain Spring stratum (i.e., spring index period/combined ecoregions 67 and 69). Table A1 compares the metrics used in the GLIMPSS to the family-level West Virginia Stream Condition Index (WVSCI).

TABLE A1. List of metrics used in the Genus-Level Index of Most Probable Stream Status (GLIMPSS) and the West Virginia Stream Condition Index (WVSCI). Metric scoring formulae indicate metric value (x) divided by the best standard value (BSV) that corresponds to the 5th or 95th percentile (depending on metric response direction) of West Virginia Department of Environmental Protection (WVDEP) data distribution for all sites in the spring index period, ecoregions 67/69 (for GLIMPSS), or within a broader March to October index period applied statewide (for WVSCI). The final GLIMPSS and WVSCI scores are calculated as the average metric score. Final GLIMPSS scores <62 were rated impaired; final WVSCI scores <68 were rated impaired. Intolerant richness is based on count of taxa with tolerance values <4. EPT = Ephemeroptera, Plecoptera, Trichoptera.

Metric	Scoring formula (value/BSV)100
GLIMPSS	
Total generic richness	$(x/41.5)100$
Intolerant richness	$(x/22.5)100$
Ephemeroptera generic richness	$(x/11)100$
Plecoptera generic richness	$(x/9)100$
Clinger generic richness	$(x/21.5)100$
Genus biotic index	$(10 - x)/(10 - 1.7)100$
% Ephemeroptera	$(x/53.5)100$
% Orthocladiinae	$(100 - x)/(100 - 0.7)100$
% 5 dominant genera	$(100 - x)/(100 - 47.2)100$
WVSCI	
Total family richness	$(x/22)100$
EPT family richness	$(x/13)100$
Family biotic index	$(10 - x)/(10 - 2.6)100$
% EPT	$(x/89.3)100$
% Chironomidae	$(100 - x)/(100 - 1.7)100$
% 2 dominant families	$(100 - x)/(100 - 37.3)100$

APPENDIX 2. General site information by mining disturbance category. Estimated percentage of the watershed mined, number of fills, and distance of site from nearest fill were determined using 1993 Landsat multiresolution land-cover data (for the 1999–2000 data set) and by digitized aerial photography with a 2006 mining permit boundary layer (2006–2007 data set). Distance to nearest fill (distance) is indicated as a mainstem (M) or tributary (T) fill. Mining activity was recorded as of the time of sampling. LF = left fork, UT = unnamed tributary, – = not applicable.

Site	Year	Watershed	Disturbance category	Watershed area (km^2)	Elevation (m)	% mining	No. of fills	Distance (km)	Mining activity
Rockhouse	1999	Coal	Medium	4.0	292.8	47	1	0.37 (M)	Inactive
Beech	1999	Coal	Medium	11.6	289.8	19	5	0.67 (T)	Inactive
LF Beech	2000	Coal	High	6.8	280.6	45	1	0.55 (T)	Active
Buffalo	1999	Coal	Medium	3.1	500.2	1	5	0.35 (T)	Inactive
Sandlick	2007	Coal	Low	11.4	245.4	9	2	0.96 (T)	Active
Laurel	2007	Coal	High	15.9	244.7	20	7	0.75 (T)	Active
Hughes	2000	Gauley	Medium	9.9	283.7	32	8	0.44 (T)	Inactive
Neff	1999	Gauley	Low	3.0	424.0	12	3	1.65 (T)	Inactive
Robinson	2007	Gauley	High	12.4	341.3	76	7	1.1 (T)	Active
Sugarcamp	2007	Gauley	Medium	5.2	328.2	31	2	2.2 (T)	Active
UT Twentymile1	2007	Gauley	High	0.8	331.1	85	1	0.51 (M)	Active
Boardtree	2007	Gauley	High	2.9	316.9	80	1	0.15 (M)	Active
Hardway	2007	Gauley	High	1.4	349.9	14	1	0.62 (M)	Active
Sugartree	1999	Guyandotte	High	1.9	256.2	50	2	0.08 (T)	Inactive
Stanley	2000	Guyandotte	High	4.5	250.1	65	6	0.32 (T)	Inactive
Ballard	1999	Guyandotte	High	6.2	260.8	17	8	0.93 (T)	Inactive
Cow	2000	Guyandotte	Low	1.3	439.2	1	1	1.02 (M)	Inactive
LF Cow	1999	Guyandotte	Low	3.2	353.8	13	2	0.61 (T)	Inactive
Hall	1999	Guyandotte	Medium	0.5	439.2	65	1	0.37 (M)	Inactive
Whitman	2007	Guyandotte	Low	2.8	324.9	41	1	1.2 (T)	Active
Ellis Camp	2007	Guyandotte	Low	1.0	274.3	49	1	0.99 (M)	Inactive
Winding Shoals	2007	Guyandotte	High	1.2	243.2	75	1	0.64 (M)	Inactive
Camp	2007	Guyandotte	Medium	1.5	335.8	35	2	0.85 (M)	Active
Righthand	2007	Guyandotte	Medium	12.4	230.1	17	6	0.89 (T)	Active
Slab	2007	Guyandotte	High	9.3	255.9	52	4	0.99 (T)	Active
Jims	2007	Tug Fork	High	1.3	250.2	57	1	0.60 (M)	Inactive
Dingess Camp	2007	Tug Fork	Low	2.1	280.4	16	1	1.8 (M)	Inactive
Oldhouse	1999	Coal	Unmined	1.8	317.2	–	–	–	Unmined
White Oak	2000	Coal	Unmined	2.7	350.8	–	–	–	Unmined
Trace	2007	Coal	Unmined	1.8	259.1	–	–	–	Unmined
Neil	1999	Gauley	Unmined	3.9	289.8	–	–	–	Unmined
Rader	2000	Gauley	Unmined	5.3	420.9	–	–	–	Unmined
Ash	2007	Gauley	Unmined	7.0	286.5	–	–	–	Unmined
UT Twentymile2	2007	Gauley	Unmined	0.8	279.8	–	–	–	Unmined
Spring	1999	Guyandotte	Unmined	1.4	274.5	–	–	–	Unmined
Rushpatch	1999	Guyandotte	Unmined	2.1	286.7	–	–	–	Unmined
Cabin	1999	Guyandotte	Unmined	4.7	265.4	–	–	–	Unmined

APPENDIX 3. Relative frequency (%) of Ephemeroptera, Plecoptera, and Trichoptera occurrences among mining disturbance categories. Note the strong dose response of many taxa along the mining disturbance gradient.

Order	Family	Genus	Unmined (n = 10)	Low (n = 7)	Medium (n = 8)	High (n = 12)
Ephemeroptera	Ameletidae	*Ameletus*	90	71	25	0
Ephemeroptera	Baetidae	*Acentrella*	60	43	25	8
Ephemeroptera	Baetidae	*Baetis*	70	71	63	17
Ephemeroptera	Baetidae	*Diphetor*	10	0	0	0
Ephemeroptera	Baetidae	*Plauditus*	10	43	13	25
Ephemeroptera	Ephemerellidae	*Drunella*	90	57	0	0
Ephemeroptera	Ephemerellidae	*Ephemerella*	100	86	25	8
Ephemeroptera	Ephemerellidae	*Eurylophella*	20	0	0	0
Ephemeroptera	Ephemeridae	*Ephemera*	20	0	0	0
Ephemeroptera	Heptageniidae	*Cinygmula*	80	43	0	0
Ephemeroptera	Heptageniidae	*Epeorus*	100	43	0	0
Ephemeroptera	Heptageniidae	*Stenacron*	30	0	0	0
Ephemeroptera	Heptageniidae	*Stenonema*	30	14	0	0
Ephemeroptera	Isonychiidae	*Isonychia*	0	14	0	0
Ephemeroptera	Leptophlebiidae	*Paraleptophlebia*	90	43	0	0
Plecoptera	Capniidae	Capniidae	10	0	0	0
Plecoptera	Chloroperlidae	*Alloperla*	0	14	0	0
Plecoptera	Chloroperlidae	*Haploperla*	30	14	25	0
Plecoptera	Chloroperlidae	*Sweltsa*	20	14	0	0
Plecoptera	Leuctridae	*Leuctra*	90	29	25	17
Plecoptera	Nemouridae	*Amphinemura*	100	100	88	75
Plecoptera	Nemouridae	*Ostrocerca*	10	0	0	0
Plecoptera	Nemouridae	*Prostoia*	10	43	13	0
Plecoptera	Peltoperlidae	*Peltoperla*	0	29	13	8
Plecoptera	Perlidae	*Acroneuria*	30	29	13	8
Plecoptera	Perlidae	*Eccoptura*	0	0	0	8
Plecoptera	Perlidae	*Hansonoperla*	10	0	0	0
Plecoptera	Perlodidae	*Clioperla*	0	0	0	8
Plecoptera	Perlodidae	*Diploperla*	0	14	13	8
Plecoptera	Perlodidae	*Isoperla*	20	29	25	25
Plecoptera	Perlodidae	*Malirekus*	10	0	0	0
Plecoptera	Perlodidae	*Remenus*	30	29	0	8
Plecoptera	Perlodidae	*Yugus*	60	14	0	0
Plecoptera	Pteronarcyidae	*Pteronarcys*	60	43	13	0
Plecoptera	Taeniopterygidae	*Taenionema*	0	14	0	0
Plecoptera	Taeniopterygidae	*Taeniopteryx*	10	0	13	0
Trichoptera	Glossosomatidae	*Agapetus*	10	0	0	0
Trichoptera	Glossosomatidae	*Glossosoma*	0	14	0	8
Trichoptera	Hydropsychidae	*Ceratopsyche*	10	43	38	50
Trichoptera	Hydropsychidae	*Cheumatopsyche*	0	86	88	92
Trichoptera	Hydropsychidae	*Diplectrona*	80	71	75	42
Trichoptera	Hydropsychidae	*Hydropsyche*	10	57	88	67
Trichoptera	Hydroptilidae	*Hydroptila*	10	0	0	8
Trichoptera	Hydroptilidae	*Ochrotrichia*	0	0	0	8
Trichoptera	Hydroptilidae	*Stactobiella*	0	0	13	0
Trichoptera	Lepidostomatidae	*Lepidostoma*	10	0	0	0
Trichoptera	Limnephilidae	*Pycnopsyche*	20	0	0	0
Trichoptera	Philopotamidae	*Chimarra*	0	29	13	33
Trichoptera	Philopotamidae	*Dolophilodes*	20	43	13	8
Trichoptera	Philopotamidae	*Wormaldia*	20	0	0	0
Trichoptera	Polycentropodidae	*Polycentropus*	30	29	13	8
Trichoptera	Psychomyiidae	*Lype*	10	0	0	0
Trichoptera	Rhyacophilidae	*Rhyacophila*	70	57	50	17
Trichoptera	Uenoidae	*Neophylax*	70	71	13	8

Senator CARDIN. I know that Secretary Huffman will be testifying later and he does call into question as to whether you have used broad-based scientific information or one study within the agency. I think you have already answered that. This is relying on broader scientific information than just one member of your staff.

Mr. POMPONIO. Yes, it is.

Senator CARDIN. Thank you. Let me talk about the cumulative effect, because I think that is an extremely important point. You look at one application, you say, gee, you know, it is only a few acres, it does not seem like it could have that much of a long-term impact on the environment.

But you talked in your statement about the cumulative effect that we now have. I think in one report it is 1,700, is it miles? I know it is a unit. I said in my opening statement, of streams that have been affected, we have found thousands of acres being affected and not just a few. Can you talk a little bit more about how you need to look at the cumulative impact that an application approval might mean, if we continue at the current pace, what impact this has on the environment?

Mr. POMPONIO. Yes. I am glad that you worded it that way. We need to look at the cumulative impact. I do not think that we have been doing a good job of doing that at all levels.

We need to look at cumulative impacts for several reasons. One is that there is an integral relationship between the forest and the streams in the area. When you lose forest, you lose a lot of the capacity of the streams to process and transfer the organic materials that feed the critters downstream. You lose the capacity of the forest to cool the streams. You lose transpiration through the leaves to help attenuate flooding problems and those sorts of things.

These little streams, which some people estimate represent 80 percent of the water resource in the entire Country, are like capillaries in your blood system. They are what travel through the landscape, capture the pollutants, and clean those pollutants, through the microorganisms in the streams themselves and through sediment filtration in the stream bottom. And we frankly do not know where the tipping point is in losing 1 stream, 5 streams, or even 18 streams in a particular watershed. So, our position is that we need to do a better job with that cumulative impact assessment.

In some of the watersheds in the region that I deal with, the footprint of the mining operations, mountaintop and other surface mining, encompass up to 20 to 30 percent of the watershed area. That, just to a lay person, would cause one to suggest that there needs to be some more rigorous opportunity to take a look at what that might mean. Downstream in the creek watershed I believe that upwards of half of the streams have been listed on the 303(d) list, which is a list of stream miles that do not necessarily meet water quality criteria and standards.

So, as we look at all of these mines and as we look at them one by one, we have to ask ourselves, in a particular watershed, can the watershed be resilient enough, and have a carrying capacity in terms of natural attenuation of problems, to accept that one mine? Or can it not accept that one mine? I do not believe we know the answers to those questions, and I think we need to do a better job.

Senator CARDIN. And let me ask you, last, on the issues of forest itself, you commented on the importance of the forest cover as it relates to the water quality and the environmental conditions generally. We know that on mountaintop removal, the forest is basically destroyed.

My question is, after you have done mountaintop removal, is there an adequate remedial program that can compensate for the loss of the forest that was there previous to the mountaintop removals or adequate ways that we can try to compensate for this?

Mr. POMPONIO. I think that is a two-part answer again. Practices in the past that involved compaction of the soil and the distribution of non-forest cover plants, did not necessary give one a lot of hope for a lot of quick or even mid-term forest recovery.

I do not quite know about the future. There are different operations now that are learning from the past. They are avoiding soil compaction and preserving topsoil, practices that were not common previously. I think it still has to be examined as to whether or not these methods will actually achieve reforestation.

Senator CARDIN. And I can appreciate that. I just raise an observation, and that is we do not know where technology will take us. I am sure there are going to be remedial efforts that will be effective in dealing with some of the damage that has caused.

We do know the value of forest. We do know the values of vegetation. Once that is destroyed, it puts you in a very difficult position to try to catch up. The remedial programs may help a little bit, but when you have eliminated that natural protection, for so many reasons to our environment, including our concerns about carbon emissions, it is difficult to see how you can have an effective policy.

And the last point on this is runoff. When you flatten the land, you certainly make the runoff issues much more complicated to try to deal with, with sediment, et cetera. And toxics. It makes it extremely challenging to figure out how the remedial programs could possibly compensate for the condition that was there before the removal.

Mr. POMPONIO. I agree with that.

Senator CARDIN. Well, let me thank you for your testimony. We appreciate it very much. As I said in the beginning, this will be a continuing effort of our Subcommittee and I think you have given us a good start to our work.

Thank you very much.

Mr. POMPONIO. You are welcome. Thank you.

Senator CARDIN. We are going to start with the second panel. I believe we will be interrupted during that period. I am looking in my BlackBerry and it looks like there are votes called at about 4:10 p.m. But why do we not get started with our second panel.

On our second panel, we have Paul Sloan, the Deputy Commissioner of the Tennessee Department of Environment and Conservation. Mr. Sloan oversees the Tennessee regulation of coal mining regulations. Tennessee prohibits the practice of valley fills and maintains a successful extraction industry. Mr. Sloan can also speak to the regulatory reforms on the coal industry that would require better environmental protection.

Randy Huffman is the Cabinet Secretary of the West Virginia Department of Environmental Protection. West Virginia's Department of Environmental Protection has oversight and regulatory authority of the valley fills associated with mountaintop mining sites in that State.

Maria Gunnoe is a community organizer of the Ohio Valley Environmental Valley Coalition. Mrs. Gunnoe is a property owner in Lindytown, West Virginia, whose land has been impacted by the nearby mountaintop removal operations. She just received a prestigious 2009 Goldman Environmental Prize for organizing work in the coal fields. This prize is given to one person per continent per year. She has been the subject of several documentaries and is a frequent speaker and advocate for coal field communities.

And Dr. Margaret Palmer, Laboratory Director, Chesapeake Biological Laboratory at the University of Maryland Center for Environmental Sciences. I am particularly pleased that Dr. Palmer has joined us. She is well respected in our State of Maryland. The broad objective of Dr. Palmer's research is to understand what controls streams, ecosystems, structures and functions. She specifically focuses on restoration ecology and how land use, hydrology and geopathology influence the health of running water ecosystems. Dr. Palmer is considered an international expert on freshwater systems.

And with that, we will start with Secretary Sloan.

STATEMENT OF PAUL L. SLOAN, DEPUTY COMMISSIONER, TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION

Mr. SLOAN. Chairman Cardin and Members of the Subcommittee, thank you for the opportunity you have given me to testify this afternoon. I am Paul Sloan, Deputy Commissioner of the Tennessee Department of Environment and Conservation.

Coal mining in Tennessee is best considered in the context of the rich cultural and natural heritage of the Cumberland Plateau, which is part of a 37 million eco-region stretching some 500 miles through six states, a region said to be the largest temperate hardwood plateau in the world.

In Tennessee, the plateau stretches from the Alabama border northeast to the Kentucky and Virginia borders. Its watersheds drain to the east and west, into the Tennessee River and the Cumberland River, and include significant portions of our 60,000 miles of rivers and streams in Tennessee. These two major watersheds contain some of the most biologically diverse freshwater streams found anywhere in the United States.

Roughly 600,000 acres of the plateau in Tennessee are public lands. Over 600 miles of State scenic highways thread this landscape, connecting more than 80 State and Federal parks, recreational, natural and wildlife management areas, as well as the Obed and National Wild and Scenic River and the Big South Fork National River and Recreation Area.

In short, the Cumberland Plateau is an invaluable resource, a gem for public recreation and ecological diversity.

Coal mining on the plateau has been conducted since the early 1800s. Much of the estimated 50,000 acres of pre-1977 unregulated mining has left a legacy of abandoned mine lands that pose ongoing health and safety risks as well as water pollution from sediment and acid mine drainage.

Approximately 3 million tons are mined per year in Tennessee, significantly less than our sister States, West Virginia, Alabama, Kentucky and Virginia, and well below our own peak of 11 million tons per year in the early 1970s.

For the past 25 years, mining oversight in Tennessee is under SMCRA and has been administered not by the State, but by OSM. The State implements the Federal Clean Water Act as well as the Tennessee Water Pollution Control Act, which provides that the waters of the State are a public trust, that the people of Tennessee have a right to unpolluted waters, and that the government has the obligation to protect that right.

In our implementation of the Federal and State mandates, Tennessee does not permit burial of streams for valley fills. There is neither sufficient social nor economic justification for such unalterable environmental and ecological insults. In Appalachia, mountaintop removal and water quality are incompatible.

Tennessee Governor Phil Bredesen recently signed into law a Responsible Mining Bill that codifies our requirement that all mining must maintain a 100 buffer foot on either side of all un-mined streams and prohibits mining of coal seems that have a high acid-bearing overburden, without demonstrated technology capable of properly handling such materials.

We very much support the purpose and intent of the Appalachian Restoration Act to prohibit filling streams with waste materials from coal mining and to bring nationwide consistency to this issue. We also support the intent of the Clean Water Restoration Act to bring consistency and clarity to what are Federal jurisdiction waters in the first place.

Responsible mining is possible in Appalachia. But only if the regulatory oversight and management are guided by the most current information available in order to consistently avoid unnecessary impacts. This is why Governor Bredesen has requested OSM to do an environmental impact statement in regard to Tennessee coal mining. The goal of this request is to have a rigorous, objective analysis of all impacts of coal mining on Tennessee's economy, as well as the environment.

For the same reason, we applaud the recent MOU among EPA, the Corps and Interior, calling for an interagency action plan to reduce unnecessary environmental impacts. In support of these efforts, we hope Interior's Fish and Wildlife Service will revisit the 1996 biological opinion on consultation under the Endangered Species Act, and that EPA will update its 1985 effluent guidelines for mining operations.

In closing, I want to restate my appreciation to the Subcommittee for taking up this issue. As stewards of the public trust, both Federal and State government have a high duty to resource protection in the mountains of Appalachia. So it is my hope that Appalachian mining practices will be limited to those known to be compatible with preserving the mountains and streams of this extraordinary area.

Thank you, sir.

[The prepared statement of Mr. Sloan follows:]

TESTIMONY OF
PAUL L. SLOAN
DEPUTY COMMISSIONER
TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION
BEFORE THE
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
SUBCOMMITTEE ON WATER AND WILDLIFE
U.S. SENATE

JUNE 25, 2009

Chairman Cardin, Ranking Member Crapo and members of the Subcommittee, thank you for inviting me to speak to you today on the subject of the impacts of mountaintop removal coal mining on water quality in Appalachia. I am Paul Sloan, Deputy Commissioner of the Tennessee Department of Environment and Conservation. I am Paul Sloan, Deputy Commissioner of the Tennessee Department of Environment and Conservation and Director of its Bureau of Environment.

I will address the topic by covering five areas:

- coal mining in Tennessee including the nature of the coal reserves and the methods of coal mining;
- the natural resources in the area in which our coal reserves are located;
- the potential pollutants and impacts of coal mining;
- some of the regulatory practices we have used in Tennessee to allow responsible mining of coal while protecting the environment; and
- our recommendations.

Coal mining in Tennessee

Historically, coal mining has occurred in 22 of Tennessee's 95 counties, on the Cumberland Plateau and the Cumberland Mountains. The area stretches from our

Alabama border to our Kentucky-Virginia border,. west of Chattanooga, and west and north of Knoxville.[1] Mining began in Tennessee in the early 1800's and gradually increased until eight million tons per year were mined during World War II. After hitting a high of 11 million tons per year in 1972, mining in recent years has been less than 3 million tons per year, significantly less than Kentucky, Virginia, and West Virginia. Coal mining now is mainly occurring in 4 Tennessee counties: Anderson, Scott, Campbell and Claiborne. One estimate of the recoverable coal reserves in Tennessee is 470 million tons.[2]

We recognize the importance of coal as an energy source. Approximately sixty percent of the electricity supplied to our region by TVA derives from coal. The coal industry provides well-paying jobs in some rural counties that are currently experiencing high rates of unemployment. Coal is mined both in surface and underground mines. Surface mine operations are of three types: area or pit mines, contour mining, in which coal is removed from the side of a mountain by making a bench cut following the contour around, and cross-ridge mining. Cross-ridge mining occurs at the top of a mountain, where the coal seam is accessed by removal of the mountain top. The rock and other material that is over the coal seam, or "overburden" is deposited as spoil material in fills on old mining benches and in head-of-hollow fills and used to return the top of the mountain to the approximate original contour after removal of the coal.

Since the mid-1980's, Tennessee has not administered the Surface Mining Control and Reclamation Act (SMCRA). Instead, the federal Office of Surface Mining (OSM) issues coal mining permits in Tennessee. The Department of Environment and Conservation (TDEC or the Department) does, however, administer the National Pollutant Discharge Elimination System (NPDES) program under the federal Clean Water Act. Therefore, under EPA oversight, we issue discharge permits to coal mining operations, as we do for all other industries as well as municipalities and others. The Department has 118 current NPDES permits for coal operations, including active and inactive sites. Of these, 34 are

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[1] The Energy Information Administration of the Department of Energy publishes coal profiles of the states. The Tennessee coal profile published in 1992 is attached.
[2] Two maps of the coal fields contrasting historic and recent mining are attached.

underground mines, 81 are surface mines, and 3 are surface and underground. The surface acreage affected by mining at both surface and underground mines is approximately 20,000 acres. Cross-ridge mining accounts for less than 500 acres.

As noted above, Tennessee now produces less coal from a smaller geographic area than was the case prior to the enactment of SMCRA in 1977. Pre-1977 unregulated mining has left Tennessee with a significant legacy of abandoned mine lands (AML). Fourteen thousand acres have been identified as impacted by pre-1977 mining and in need of reclamation. Of that, 4,400 acres have been successfully reclaimed, and 9,600 acres remain in need of reclamation. We appreciate the recent reauthorization of the AML program by Congress. Under it, we are scheduled to receive sufficient funds for the reclamation of the 1,900 acres that pose a health and safety risk (known as Priority 1 and 2 sites these are such things as landslides, pits and highwalls). We have not, however, identified a funding source for the remaining 7,700 acres that are causing environmental impacts (these are typically water pollution from high sediment or acid discharges).

The Natural Resources of the Cumberland Plateau and Cumberland Mountains

The area in which the coal reserves are located is a very special one. Some of the natural resources there are globally rare. The Cumberland Plateau is a relatively flat area approximately 1000 feet higher than the surrounding land and the river valleys that cut into it, with some mountains rising another 1000 feet. The Cumberland Mountains are an area in the northern part of the state, adjacent to the Plateau to the east where erosion over geologic time has resulted in mountains separated by river valleys. Since these two areas are some of the highest land in the east-central part of the state, they comprise the headwaters of many of our rivers, including the Sequatchie River, the Collins River, the New River and the Big South Fork of the Cumberland River (designated an Outstanding National Resource Water) and the Obed River (a National Wild and Scenic River) as well as the main stems of the Clinch and Powell Rivers after they have flowed into Tennessee from Virginia.

The U.S. Fish and Wildlife Service has listed as endangered species some of the fresh water mussels in the Big South Fork, the Clinch River and the Powell River. The Clinch and Powell may have more endangered mussel species than any other streams in North America, according to EPA and many other experts. Protecting the Clinch and Powell Rivers is the subject of an ongoing collaborative effort among EPA Region III, EPA Region IV, the Virginia Departments of Environmental Quality and Mines, Minerals and Energy and our Department, as well as scientists from other agencies and NGOs.[3]
The first sentence of the June 11 Memorandum of Understanding regarding surface mining among EPA, the Department of Interior and the U.S. Army Corps of Engineers states, "The mountains of Appalachia possess unique biological diversity, forests, and freshwater streams that historically have sustained rich and vibrant American communities." This is certainly true of the Cumberland Plateau and the Cumberland Mountains. The unique ecosystems of this area have made it a focus of The Nature Conservancy and the World Wildlife Fund.[4]

For context, coal mining in Tennessee must be considered within the rich cultural and natural heritage of the Cumberland Plateau where it is conducted. The greater Cumberland Plateau and Mountains region is a part of an eco-region that comprises 37 million acres, stretches approximately 500 miles through portions of 6 states (AL, GA, TN, KY, WV, and VA) – a region said to be the largest temperate hardwood plateau in the world and a valued habitat for declining neo-tropical migratory bird species such as the Cerulean Warbler.

Within our state, the Plateau stretches from the Alabama boarder northeast to our KY/VA boarders – its watersheds drain to the east and west into the Tennessee River and the Cumberland River and include a significant portion of the more than 60,000 miles of our rivers and streams. These two watersheds contain some of the most biologically diverse freshwater streams in the United States.

In Tennessee, approximately 600,000 acres of the Plateau are a part of a diverse portfolio of public lands. Over 600 miles of State Scenic Highways thread this landscape that includes 16 State Parks, 16 State Natural Areas, 8 State Forests, 31 State Wildlife

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[3] A copy of the MOU establishing the group is attached.
[4] See attached Fact Sheet about the Cumberland Plateau and Mountains for more detail.

Management Areas, 7 National Natural Landmarks, the Obed National Wild and Scenic River, and the Big South Fork National River and Recreational Area. These public lands include over 100 waterfalls (including Fall Creek Falls – the highest in eastern US) and the nation's highest concentration of natural arches – 107 identified on public lands). In short, it is an invaluable resource for public recreation and ecological diversity.

The federal and state owned lands in the region of current or recent coal mining include:

Cumberland Mountain State Park;
Fall Creek Falls State Park; Frozen Head State Park;
Justin P. Wilson / Cumberland Trail State Park;
Pickett State Park; Catoosa Wildlife Management Area
North Cumberland Wildlife Management Area
(with its Sundquist, Royal Blue, and New River Units)
Pickett State Forest

The Big South Fork National River and Recreation Area.

In 2007, the State of Tennessee under Governor Phil Bredesen's leadership, acting in concert with The Nature Conservancy and some private companies, made the largest purchase of public land in Tennessee since the Great Smoky Mountain National Park, in the North Cumberlands. This acquisition, valued at $135,000,000 (State's portion was $82 million) brought public conservation benefits to more than 127,000 additional acres in the northern Cumberland Plateau.

The potential pollutants and impacts of coal mining

Coal mining operations have the potential to cause pollution of streams through:

- discharging sediment, whether measured as suspended solids or settleable solids;
- discharging metals, including iron and manganese;
- discharging low pH or acidity;

- physical alterations, including burying streams with fill material, losing streams to the subsurface as a result of blasting, as well as other alterations of the bed or banks of streams; and
- alterations of flow regimes as a result of temporary or permanent changes to the watershed.

The first three are discharges of pollutants that are addressed by EPA's effluent guidelines promulgated for the coal mining industry at 40 CFR, Part 434. These guidelines form the basis for permit limitations in the NPDES permits we and other regulators issue to the coal industry. As mentioned more below, the requirements of these rules are largely unchanged since 1985 and are probably due for review.

The fourth category of impacts listed above is regulated under section 404 of the Clean Water Act as well as under SMCRA. In recent years, scientists have been documenting the fifth item above in various contexts, including coal mining. Streams are impacted by changes in land use in the watershed above them. Although there is growing scientific recognition of this fact, such actions are generally not regulated under the Clean Water Act (construction activity is an exception).

Tennessee's Regulatory Approach

Now I will turn to the regulatory system in Tennessee and to certain practices we have followed in regard to coal mining. In addition to the NPDES permits mentioned above, our Department issues permits under state law for activities that cause alterations of streams or wetlands.[5] We issue both individual and general permits for these activities.[6] When an individual permit is required by the Corps of Engineers under section 404, our permit is our certification under section 401. This system allows us to have enforcement authority distinct from that of the Corps for our permit/certification.

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[5] See T.C.A. §69-3-108

[6] See Rules at 1200-4-7 which are accessible at: http://state.tn.us/sos/rules/1200/1200-04/1200-04-07.pdf

For many years, the Department has declined to issue permits under state law for coal operators to mine through streams not impacted by previous mining or to bury streams under waste material, based on the concept that those discharges constitute impermissible pollution of the streams and there are reasonable alternatives available. Therefore, mountaintop removal mining is not practiced in Tennessee as it is in the other Appalachian states. We and OSM have issued permits for cross-ridge mining, as I have described. In the current legislative session, the Tennessee General Assembly enacted a bill proposed by the Governor (HB 2300, which became Public Chapter 289[7]) that codified these prohibitions in Tennessee's Water Quality Control Act. We understand the purpose and intent of the Appalachia Restoration Act (S. 696) is to prohibit filling streams with the waste materials from coal mining. This would be consistent with at least one part of our approach in Tennessee. We would applaud Congress bringing nationwide consistency to this area by enacting such legislation.

Because of our prohibition on mining through streams and burying streams under waste material, OSM's Tennessee office did not issue variances from the old stream buffer zone requirement in its rules prior to the December 2008 rule change. In this context, I would note that, although we applaud Secretary Salazar's move to do away with the 2008 revision to the stream buffer zone in the pending litigation, this is not enough. Under the old rule, it was the common practice both of OSM and the states that have primacy under SMCRA outside Tennessee to grant variances to the buffer zone requirement. This is why OSM was able to state in its rationale for the 2008 change that the new rule would not result in a significant increase in streams segments being buried.

Recommendations

In Tennessee, much of the current mining occurs in areas that are in or near the headwaters of streams. Having clarity as to what waters are protected by the Clean Water Act is critical in this regard. The Supreme Court decisions in the cases of *Rapanos v. U.S.*, 507 U.S. 715 (2006) and *Solid Waste Agency of Northern Cook County v. Army*

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[7] Copy attached.

Corps of Engineers, 531 U.S. 159 (2001) have brought much uncertainty to the application of the Clean Water Act to headwater streams and wetlands. We strongly support the Clean Water Restoration Act (S. 787) and its goal of restoring the approach used by EPA and the Corps of Engineers for many years prior to those decisions. Just as the circulatory systems in our bodies rely upon the healthy functioning of billions of capillaries, the nation's rivers and streams will not be healthy unless the headwaters are protected.

On September 24, 1996, the U.S. Fish &Wildlife Service issued a Biological Opinion under section 7 of the Endangered Species Act (ESA) in regard to coal mining. Rather than evaluate the impacts of a particular operation on a particular species, this opinion simply concluded all decisions of OSM and authorized states under SMCRA will be protective of any listed species. SMCRA is based on a balancing of environmental and economic factors in its effort to regulate coal mining while the ESA seeks to protect endangered species, such as the fresh water mussels in the Clinch and Powell Rivers. The opinion seems to assume that the purposes of the two acts are the same. It is my understanding that the opinion has also created some confusion about the level of deference FWS offices are to give to decisions based on SMCRA. For all of these reasons, the 1996 Biological Opinion should be reviewed and reconsidered.

In 2006, Governor Bredesen sent a letter to the former director of OSM requesting that they do a thorough study and an Environmental Impact Statement (EIS) in regard to the coal mining program in Tennessee.[8] The goal of this request was to have a rigorous, objective analysis of all of the impacts of coal mining on the environment as well as its contribution to the economy. Another economic issue that deserves study is whether the people of the Cumberland Plateau and Cumberland Mountains would be better served by the economic benefits of tourism than by those types of coal mining that put the critically important natural resources of the region at risk. As well as updating the EIS that was done when OSM took over the program, nearly 25 years ago, a new EIS could comprehensively evaluate all environmental impacts including those that are outside the

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[8] Copies of the Governor's letter and an accompanying letter from the Department are attached.

jurisdiction of the Department. The areas of needed study include fragmentation of terrestrial habitat, the cumulative impacts of many coal operations, and consideration of impacts on threatened and endangered species, including those that have been listed since the prior EIS. The changes in population and public land in the last 25 years should also be considered. We continue to hope that such a study will be made.

The adequacy of these effluent guidelines at 40 CFR Part 434, which are largely unchanged since they were adopted in 1985, is a subject which EPA should consider. One example is that these rules include a provision that the discharge does not have to meet the otherwise applicable standards in the event of an unusually heavy rain. This sort of exemption from requirements is not included in the more recently adopted requirements for discharges of storm water from construction sites. Also, much has been learned recently about other metals, including mercury and selenium. EPA should consider whether any coal related operations should have limits for other metals besides iron and manganese.

In closing, we want to urge this subcommittee and the entire U.S. Congress to take action that would bring national consistency to the area of protecting the waters of the United States while allowing responsible coal mining to occur. The intent and purpose of the Appalachia Restoration Act (S. 696), prohibiting valley fills, is one such step. Passing the Clean Water Restoration Act is also critical to protect headwater streams. A prohibition on burying streams would not protect headwater streams if it only applies to larger creeks and rivers, because of the restrictive definition resulting from those Supreme Court cases. We need to restore the protection of our primary water law, the Clean Water Act, to our precious Appalachian streams.

State Coal Profile: Tennessee

Coal is the leading mineral fuel produced in Tennessee. The coal output in 1992 accounted for about 10 percent of the total estimated value of all mineral commodities produced in the State.

Tennessee's coalfields, located in the eastern part of the State, are part of the Appalachian coal region. The coal-bearing area covers a northeasterly trending belt ranging from 50 to 70 miles in width. All the coal is bituminous in rank. Some of it can be converted into metallurgical coke, but none is currently produced for this purpose. Although about 12 coalbeds were mined in 1992, production was largely from the Sewanee, Beach Grove, and Jellico beds, which average 3 to 4 feet in thickness.

The first recorded use of coal in Tennessee was in 1814, when coal was mined by blacksmiths for forging iron near what is now Rockwood, in Roane County. Most of the early efforts to mine Tennessee coal commercially were unsuccessful because of transportation difficulties and lack of steady demand. The arrival of the railroads in the Tennessee coalfields provided a two-fold impetus to mine coal. In addition to transporting coal to distant markets, the railroads were also consumers of coal. Following the completion of the Tennessee Central Railway in the early 1900's, production rose almost steadily through World War I, reaching nearly 7 million short tons.

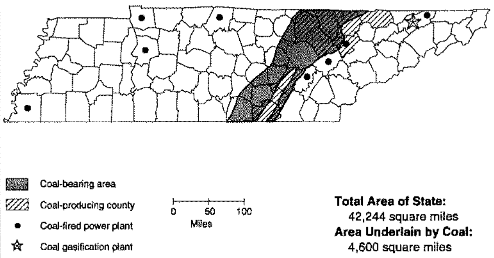
After a setback due partly to the Depression and the development of hydropower in the State, production expanded to about 8 million short tons during World War II. The postwar coal industry, however, experienced a loss of two of its major markets. Coal once widely used for space heating was replaced by oil and gas, and coal-fired locomotives were phased out by diesel-electric engines. These losses were later offset as coal demand increased when the Tennessee Valley Authority (TVA) constructed a series of coal-fired power plants in the State. As a result, coal output rose to a record 11 million short tons in 1972. Since then, however, Tennessee's coal production has been trending downward, as the output from surface mines has fallen due to the high cost of working thin, discontinuous coalbeds under thick overburden. The State's coal output dropped to 3 million short tons in 1992.

Underground mines have been the major source of coal production in Tennessee. Before 1938, all coal produced in the State was from underground mines. The output from surface mines gained importance after World War II. In 1992, the leading source of coal was the Underground No. 6 mine of Cross Mountain Coal, Inc., in Campbell County. Tennessee's leading coal-producing counties were Campbell and Sequatchie.

About two-thirds of the coal shipped from Tennessee's mines in 1992 was used to generate electricity, and the rest was mostly for other industrial use. Nearly 60 percent of the coal distributed remained in the State. Most of the shipments out of Tennessee went to Alabama, and a small amount was exported.

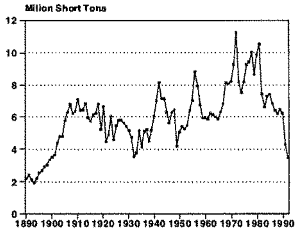
More than 80 percent of the 24 million short tons of coal consumed in Tennessee was used to generate electricity. About three-fourths of this coal was from Kentucky; Tennessee's mines supplied about 6 percent of the total. The largest coal-fired power plant in Tennessee is TVA's 2,494-megawatt Cumberland plant, in Stewart County. The leading coal consumer in the industrial sector was Tennessee Eastman Company, a unit of Eastman Chemicals Division of the Eastman Kodak Company, located in Kingsport. The company's coal gasification plant, in operation since 1983, is one of three commercial coal gasification plants in the United States. This coal gasification plant uses coal as a feedstock to manufacture acetic anhydride, used in the production of cellulose acetate for photographic film base.

Tennessee



Total Area of State:
42,244 square miles
Area Underlain by Coal:
4,600 square miles

Coal Production, 1890-1992



First Year of Documented Coal Production .... **1840 (558 short tons)**
Peak Year of Coal Production .... **1972 (11,260,000 short tons)**

Coal Reserves (Million Short Tons)

Type of Reserve	Underground	Surface	Total
Demonstrated Reserve Base: (January 1, 1992)	551	293	843
Estimated Recoverable Reserves: (January 1, 1992)			
Sulfur Content (pounds per million Btu)			
< 0.61 (low sulfur)	69	39	108
0.61-1.67 (medium sulfur)	173	118	291
> 1.67 (high sulfur)	60	41	101
Total	302	196	500
Estimated Recoverable Reserves at Active Mines, Year-End 1992	W	W	43

Production

Salient Data by Mine Typa	1980	1985	1990	1991	1992
Underground					
Quantity (thousand short tons)	4,750	5,204	4,526	3,060	2,039
Mines	54	70	61	50	37
Miners	2,076	1,871	1,319	988	599
Productivity (short tons per miner per hour)	1.21	1.50	1.68	1.72	1.81
Average Mine Price (dollars per short ton)	29.09	29.71	W	W	W
Surface					
Quantity (thousand short tons)	5,100	2,242	1,666	1,230	1,437
Mines	63	48	25	22	13
Miners	1,539	751	378	254	205
Productivity (short tons per miner per hour)	1.57	1.55	2.32	2.45	3.06
Average Mine Price (dollars per short ton)	25.92	25.78	W	W	W

Tennessee

Total					
Quantity (thousand short tons)	9,850	7,446	6,193	4,290	3,476
Mines	117	118	86	72	50
Miners	3,615	2,622	1,697	1,242	804
Productivity (short tons per miner per hour)	1.36	1.51	1.81	1.88	2.19
Average Mine Price (dollars per short ton)	27.54	28.54	27.96	26.74	27.11

Tennessee

Number of Mines by Production Range and Percent of Production, 1992

Mine Type	Production Range (thousand short tons)							
	1,000 and over		500 to 999		100 to 499		< 100	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Underground	0	0	1	37	4	29	32	34
Surface	0	0	0	0	5	85	8	15
All Mines	0	0	1	22	9	52	40	26

Coal Demand

Disposition	1980	1985	1990	1991	1992
Consumption (thousand short tons)					
Electric Utilities	21,679	20,853	20,814	19,216	20,263
Coke Plants	W	W	W	W	0
Other Industrial	W	W	3,779	3,702	3,682
Residential and Commercial	W	W	W	W	157
Total	24,496	25,105	24,878	23,107	24,102
Year-End Utility Stocks (thousand short tons)	9,200	3,846	3,596	3,148	3,016
Electricity Generation					
Total (million kilowatthours)	60,211	66,581	73,903	73,932	75,395
Coal (percent)	84	75	68	63	66
Nuclear (percent)	1	15	19	22	21
Other (percent)	15	10	13	15	13

Utility Coal Data, 1992

Average Quality and Average Delivered Cost	Produced in State	Receipts, All Sources
Heat Content (million Btu per short ton)	25.34	24.36
Sulfur Content (percent by weight)	1.39	2.02
Ash Content (percent by weight)	9.63	8.31
Pounds of Sulfur per million Btu	1.10	1.66
Dollars per million Btu	1.33	1.27
Dollars per short ton	33.63	31.01

Tennessee

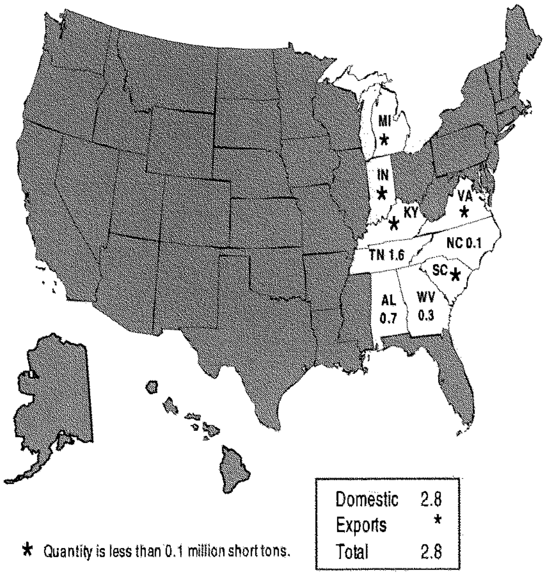
Estimated Total State Energy Consumption, 1991: 1,747 trillion Btu (**coal**, 566; **natural gas**, 235; **petroleum**, 567; **nuclear electric power**, 178; **hydroelectric power**, 109; **other**, 0; **net interstate flow of electricity and associated losses**, 93.

W = Withheld to avoid disclosure of individual company data.

Notes: **Data coverage—Production**: all mines. **Number of mines:** 1980, mines that produced 10,000 short tons or more; other years, all mines. **Number of miners and productivity**: mines that produced 10,000 or more short tons and preparation plants that had 5,000 or more employee hours. **Average mine price**: mines that produced 10,000 or more short tons. **Average quality and average delivered cost of utility coal**: power plants with a generator nameplate capacity of 50 megawatts or more. Totals may not equal sum of components because of independent rounding. Extent of coal-bearing areas and locations of coal-consuming plants shown on map are approximate; small coal deposits are not shown. Coal-producing counties shown on map exclude any county where all 1992 output was from mines producing less than 10,000 short tons. Coal receipts are based on distribution data and may not have actually been received during the year.

Sources: Energy Information Administration—*U.S. Coal Reserves: An Update by Heat and Sulfur Content*, February 1993; *Coal Production 1992* and prior issues; *Coal Data: A Reference; Quarterly Coal Report October-December 1992* and prior issues; *Electric Power Annual 1991* and prior issues; *Electric Power Monthly*, March 1993; *Cost and Quality of Fuels for Electric Power Plants 1992; Inventory of Power Plants in the United States 1992; State Energy Data Report 1991: Consumption Estimates*; Map of coal-bearing areas is based mainly on U.S. Geological Survey map, *Coalfields of the United States, 1960.* Data for historical graph 1890-1975, U.S. Department of the Interior, Geological Survey and Bureau of Mines (*Minerals Yearbook* and annual predecessor *Mineral Resources of the United States*); 1976 forward, Energy Information Administration, *Coal Production 1992* and prior issues.

Destination of Coal Produced in Tennessee, 1992
(Million Short Tons)



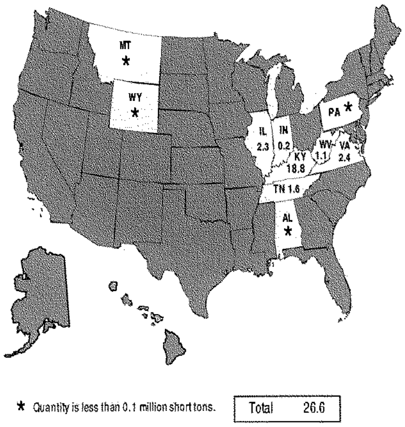
Domestic	2.8
Exports	*
Total	2.8

* Quantity is less than 0.1 million short tons.

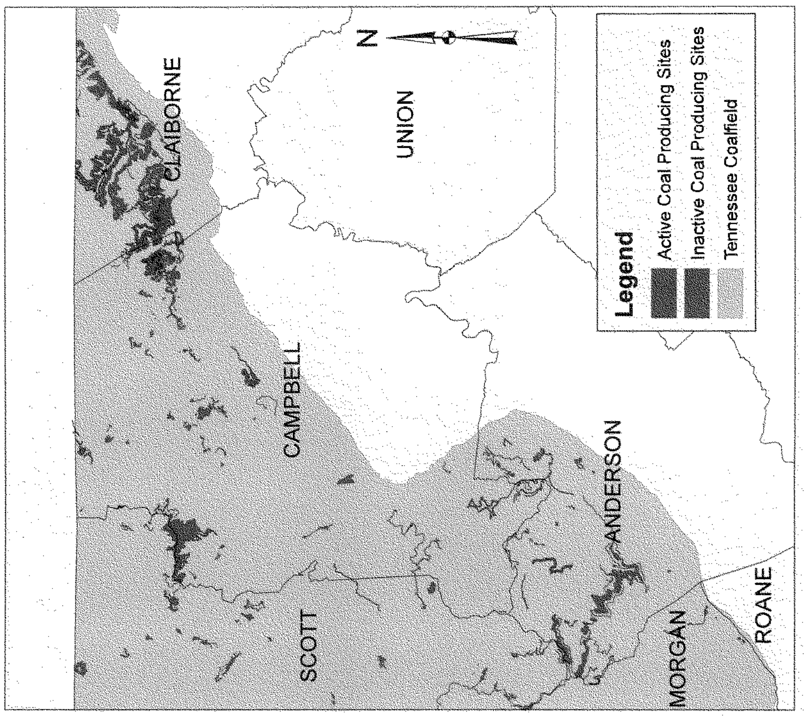
Transportation modes, domestic markets (percent): rail, 60; water, 24; truck, 14; unknown, 2.

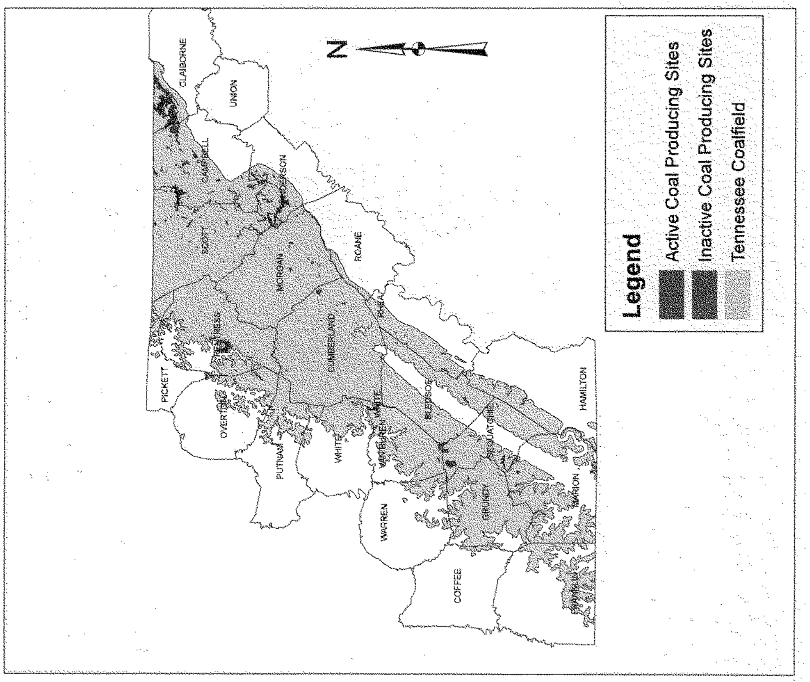
Note: Total may not equal sum of components because of independent rounding.
Source: Energy Information Administration, Form EIA-6, "Coal Distribution Report."

Origin of Coal Received in Tennessee, 1992
(Million Short Tons)



Note: Total may not equal sum of components because of independent rounding.
Source: Energy Information Administration, Form EIA-6, "Coal Distribution Report."


CLAIBORNE
UNION
CAMPBELL
ANDERSON
SCOTT
MORGAN
ROANE
N
Legend
Active Coal Producing Sites
Inactive Coal Producing Sites
Tennessee Coalfield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RHEA
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WHITE
VAN BUREN
BLEDSOE
SEQUATCHIE
HAMILTON
WARREN
GRUNDY
MARION
COFFEE
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N
Legend
Active Coal Producing Sites
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Tennessee Coalfield

MEMORANDUM OF UNDERSTANDING AMONG REGIONS III AND IV OF THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, THE TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION, THE VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY, AND THE VIRGINIA DEPARTMENT OF MINES, MINERALS, AND ENERGY CONCERNING THE CLINCH AND POWELL RIVERS

Introduction

This Memorandum of Understanding (MOU) in regard to the Clinch and Powell Rivers in Virginia and Tennessee is executed by Regions III and IV of the United States Environmental Protection Agency (EPA), the Tennessee Department of Environment and Conservation (TDEC), the Virginia Department of Environmental Quality (DEQ), and the Virginia Department of Mines, Minerals, and Energy (DMME), also known as the (Parties). It establishes a working group for coordinating the efforts of, and enhancing communication among, the signatories to protect and restore the Clinch and Powell Rivers. These five agencies have the responsibility for administering the Clean Water Act (the Act) and the corresponding state laws in Tennessee and Virginia. There are also many other governmental agencies and non-governmental environmental and conservation organizations that have demonstrated an interest in and commitment to these two rivers. It is the intent of the signatories to continue to work with such other organizations to accomplish common goals.

The Clinch and Powell Rivers originate in the mountainous terrain of southwestern Virginia and flow in a southwesterly direction into Tennessee eventually flowing into the Tennessee River. The watershed historically has contained one of the most diverse fish and mussel assemblages in North America. A number of studies have documented the decline in the mussel populations in the Clinch and Powell Rivers, both before and since the passage of the Act. Both rivers support populations of federally threatened and endangered fish species and segments of both rivers have been designated as critical habitat for certain endangered fish and mussel species. The rivers and their mussels and fish are impacted by a number of human activities in the watershed including coal mining and processing, agriculture, urbanization and the development of transportation corridors. As the government agencies charged with administering the Act, our agencies have a critical role in addressing these issues.

The tasks to be accomplished are both scientific and regulatory in nature. Further scientific research is required to determine the pollutants, disease and/or habitat destruction involved, the way in which they impact aquatic life, and the best methods of treatment or prevention. Regulatory decisions to be made under the Act include, among others, the status of the rivers under Section 303 of the Act, any necessary Total Maximum Daily Loads to be developed, appropriate permit conditions, and appropriate reclamation priorities. Through coordination and communication on all of these and other efforts regarding the rivers, the signatories can provide for more efficient use of resources, reduced costs, and reduced time required to take appropriate action to protect and preserve the rivers.

The Working Group

The signatories agree to establish a Working Group to coordinate actions of and facilitate communications among the signatories in regard to the Clinch and Powell Rivers. These shall include, but not be limited to:

(a) Discussing the need for, as well as coordinating and providing a focus for any further scientific research in regard to the causes of mussel population decline;
(b) Designating the watersheds as worthy of particular focus for attention and resources through such means as the Region III and Region IV approaches of "healthy waters" and "priority watersheds;"
(c) Maximizing to the extent possible the use of Abandoned Mine Land Funds for reclamation and restoration projects that significantly enhance water quality in the watersheds;
(d) Developing an integrated database of all point source, biological and non-point source, monitoring data covering both states;
(e) Developing specific action plans, as needed;
(f) Working together to implement follow-up actions suggested at the Abingdon Symposium held on September 5-7, 2007;
(g) Working toward developing potential new best management practices or other regulatory measures to control sources of pollutants;
(h) Working toward developing ways of incorporating information from studies on mussels by qualified experts into the assessment protocols of EPA and the states; and
(i) Identifying possible funding sources for all of the foregoing efforts.

The Working Group shall also coordinate efforts with the other governmental and non-governmental organizations actively involved in work to protect and restore the rivers.

General

This MOU is intended solely as a framework for the Working Group and does not create any rights, either substantive or procedural, enforceable by any party. This document does not, and is not intended to, impose any legally binding requirements on federal agencies, states, or the regulated public, and does not restrict the authority of the employees of the signatory agencies to exercise their discretion in each case to make regulatory decisions based on their judgment about the specific facts and application of relevant statutes and regulations. This MOU does not necessarily commit the Parties to this MOU to joint action on each of the enumerated items set out under the Working Group Section of this MOU.

Nothing in this MOU is intended to diminish, modify, or otherwise affect statutory or regulatory authorities of any of the signatory agencies, or relieve any party to this MOU of their obligations under federal or state law. All of the signatories will be given the opportunity to consult on and jointly issue any formal policy statements and work product arising from this MOU.

Nothing in this MOU will be construed as indicating a financial commitment by the EPA, TDEC, DEQ or DMME for the expenditure of funds except as authorized in specific appropriations and, as appropriate, through a validly issued contract, grant, or Interagency Agreement. Any agency may withdraw from the MOU at any time by providing written notice to the other agencies. In the event one agency terminates its participation, the MOU will remain in effect for the other agencies.

This MOU may be signed seriatim and will take effect on the date of the last signature and will continue in effect for 10 years, or unless earlier modified or revoked by agreement of all signatory agencies. Modifications to this MOU may only be made by mutual agreement of all the signatory agencies. Modifications to the MOU must be made in writing.

Donald S. Welsh, Regional Administrator Region III The U.S. Environmental Protection Agency	Date
J. I. Palmer, Jr., Regional Administrator Region IV The U.S. Environmental Protection Agency	12/14/07 Date
Paul L. Sloan, Deputy Commissioner Tennessee Department of Environment and Conservation	12-14-07 Date
David K. Paylor, Director Virginia Department of Environmental Quality	Date

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Donald S. Welsh
DEC 11 2007

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Tennessee Department of
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Virginia Department
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Tennessee Department of
Environment and Conservation

Date

David K. Paylor, Director
Virginia Department
of Environmental Quality

12/11/2007
Date

George P. Willis

1/07/07

George P. Willis, Director
Virginia Department
of Mines, Minerals, and Energy

Date

Facts about the Cumberland Plateau & Mountains

Size, Location, & Physiographic Assignment

- The Nature Conservancy groups the Cumberland Plateau & Mountains into a large ecoregion with the Southern Ridge & Valley province (i.e., the CSRV Ecoregion). *(note: This grouping was done because of close geologic affinity between the two areas. The Ridge & Valley is essentially a series of large, parallel gorges.)*
- The CSRV Ecoregion comprises almost 37 million acres and stretches app. 500 miles through portions of 6 states (Alabama, Georgia, Tennessee, Kentucky, Virginia, & West Virginia).
- Also known as the Appalachian Plateau by some physiographers, the greater Cumberland Plateau & Mountains region is the *largest temperate hardwood plateau in the world*.

Geologic History & Coal Formation

- The Cumberland Plateau formed geologically from the backwaters of a shallow, inland sea that filled over time from erosion of sediment from the Appalachian Mountains to the east.
- Carboniferous Age swamps developed as the inland delta receded and were buried over eons to form the vast coal deposits in the region today.
- Later continental collisions between North America and Africa caused uplifting of the Cumberland Plateau & Mountains to elevations above the adjoining ecoregions. Elevations range from approximately 1,000 feet to over 4,000 feet above sea level.
- Coal deposits, having formed later in the geologic history of the region, typically occur in the upper geologic layers of the region.

Biodiversity Significance

- The greater Cumberland Plateau region (i.e., CSRV Ecoregion) is one of the most biologically diverse areas in all of North America. This biodiversity is largely due to a complex interconnected ecological framework of forests, streams, and caves.
- An assessment by NatureServe found that the Cumberland Plateau region was among only 6 'hotspot' areas of critical biological significance in the country. *(source: Precious Heritage – the status of biodiversity in the United States, 2000.) (note: the CSRV was part of the larger Appalachian hotspot.)*
- Furthermore, a more recent internal assessment by The Nature Conservancy of known biodiversity in all ecoregions across the globe found the Cumberland Plateau ecoregion (i.e., CSRV Ecoregion) to rank 7th out of 88 temperate broadleaf forest ecoregions in the world.
- Compared to all ecoregions regardless of major habitat type (i.e., including tropical areas), the Cumberlands ranked in the top third for known biodiversity across the globe (249th out of 789 global ecoregions).
- Large portions of the headwaters of both the Tennessee and Cumberland river systems originate in the Cumberlands region. Collectively, the Tennessee and Cumberland Rivers are considered as to be the most biologically diverse freshwater region in the United States (primarily due to fish and mussels). *(source: The Nature Conservancy, Rivers of Life – critical watersheds for protecting freshwater biodiversity, 1998.)*

- Other broader assessments list the Cumberlands Ecoregion as a global center for freshwater aquatic biodiversity.
- The World Wildlife Fund designated the rivers of the Southeastern United States as one of only 200 large regions of biological significance based largely on the Tennessee-Cumberland drainages that largely originate in the Cumberlands. *(source: World Wildlife Fund, The Global 200 Ecoregions – a User's Guide, 2000.)*
- Due to the unique karst (i.e., limestone) topography of the Cumberland Plateau, the region contains one of the highest densities of caves in the country. These caves are also of global significance for the large number of rare, indigenous fauna. Many of the species in these caves occur in only one or two cave systems. *(source: Dr. Tom Barr.)*
- A recent series of cave surveys by The Nature Conservancy in Tennessee of 127 caves scattered over 20 counties of the Cumberland Plateau yielded 150 new occurrences of globally rare species and 48 previously undescribed species new to science. *(source: TNC- TN Chapter)*
- By conservative estimates, less than 5% of the cave systems in the Cumberlands region have been surveyed. *(source: TNC – TN Chapter)*
- As scientists continue to explore caves in the region, the connections between above-ground aquatic and terrestrial systems to subterranean systems are believed to be much more intricately linked.
- Coal mining (both historic and current) has been cited by numerous ecological plans to be a critical threat to fauna and flora in a large portion of the Cumberlands. *(sources: The Nature Conservancy – CSRV Ecoregional Plan and TWRA – Comprehensive Wildlife Conservation Strategy, a.k.a. TN State Wildlife Action Plan.)*
- The recently completed Tennessee Wildlife Action Plan, an assessment required by the U.S. Fish & Wildlife Service by each state wildlife management agency, cited over 90 animal species negatively affected by incompatible mining practices (primarily coal mining) from both current activities and ongoing consequences of historic mining. Approximately 10 of these species are of global significance in that they have very few remaining populations.
- The indirect effects of coal mining on habitat conversion and fragmentation of forests also affects a number of declining neo-tropical migratory bird species (e.g., Cerulean Warbler). *(source: Dr. Dave Buehler – Univ. of Tennessee)*

STATE OF TENNESSEE

PUBLIC CHAPTER NO. 289

HOUSE BILL NO. 2300

By Representatives Mike Turner, McCord, Hawk, Ferguson, Litz, Lollar, Fraley, Niceley, Borchert, Coley, Faulkner

Substituted for: Senate Bill No. 2321

By Senators Kyle, Southerland, Black, Ketron, Overbey, Faulk, Tracy, Yager, Watson, Marrero, Bunch, Ford

AN ACT to amend Tennessee Code Annotated, Title 69, Chapter 3, Part 1, relative to water quality.

BE IT ENACTED BY THE GENERAL ASSEMBLY OF THE STATE OF TENNESSEE:

SECTION 1. This act shall be known and may be cited as "The Responsible Mining Act of 2009".

SECTION 2. Tennessee Code Annotated, Section 69-3-108, is amended by adding the following language as a new subsection (f) and by redesignating the remaining subsections accordingly:

> (f) In regard to permits for activities related to the surface mining of coal:
>
> (1) No permit shall be issued that would allow removal of coal from the earth from its original location by surface mining methods or surface access points to underground mining within one hundred feet (100') of the ordinary high water mark of any stream or allow overburden or waste materials from removal of coal from the earth by surface mining of coal to be disposed of within one hundred feet (100') of the ordinary high water mark of a stream; provided, however, that a permit may be issued or renewed for stream crossings, including but not limited to rail crossings, utilities crossings, pipeline crossings, minor road crossings, for operations to improve the quality of stream segments previously disturbed by mining, and for activities related to and incidental to the removal of coal from its original location, such as transportation, storage, coal preparation and processing, loading and shipping operations within one hundred feet (100') of the ordinary high water mark of a stream if necessary due to site specific conditions that do not cause the loss of stream function and do not cause a discharge of pollutants in violation of water quality criteria. Nothing in this subdivision shall apply to placement of material from coal preparation and processing plants.
>
> (2) Without limiting the applicability of this section, if the commissioner determines that surface coal mining at a particular site will violate water quality standards because acid mine drainage from the site

will not be amenable to treatment with proven technology both during the permit period or subsequent to completion of mining activities, the permit shall be denied.

SECTION 3. This act shall take effect upon becoming a law, the public welfare requiring it.

PASSED: May 4, 2009

Kent Williams

KENT WILLIAMS, SPEAKER
HOUSE OF REPRESENTATIVES

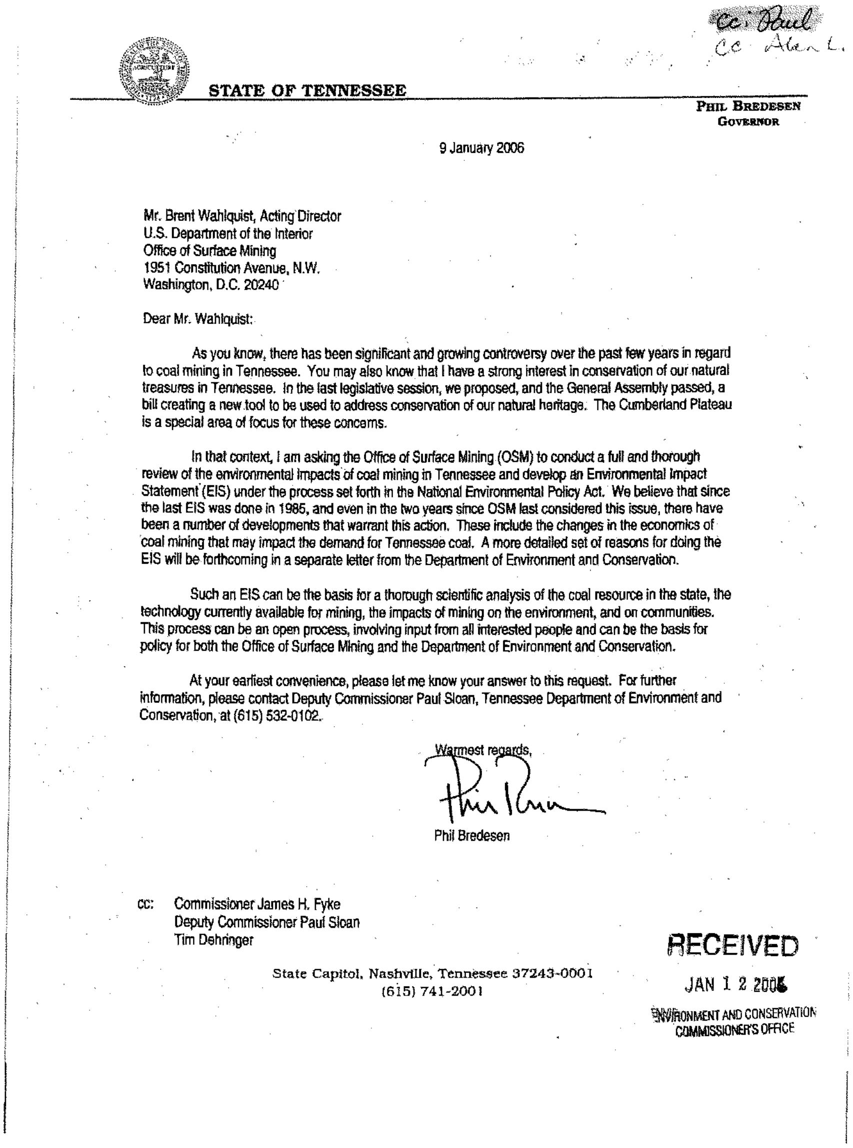
Ron Ramsey

RON RAMSEY
SPEAKER OF THE SENATE

APPROVED this 21st day of May 2009

Phil Bredesen

PHIL BREDESEN, GOVERNOR



cc: Paul
cc Alan L.

STATE OF TENNESSEE

PHIL BREDESEN
GOVERNOR

9 January 2006

Mr. Brent Wahlquist, Acting Director
U.S. Department of the Interior
Office of Surface Mining
1951 Constitution Avenue, N.W.
Washington, D.C. 20240

Dear Mr. Wahlquist:

As you know, there has been significant and growing controversy over the past few years in regard to coal mining in Tennessee. You may also know that I have a strong interest in conservation of our natural treasures in Tennessee. In the last legislative session, we proposed, and the General Assembly passed, a bill creating a new tool to be used to address conservation of our natural heritage. The Cumberland Plateau is a special area of focus for these concerns.

In that context, I am asking the Office of Surface Mining (OSM) to conduct a full and thorough review of the environmental impacts of coal mining in Tennessee and develop an Environmental Impact Statement (EIS) under the process set forth in the National Environmental Policy Act. We believe that since the last EIS was done in 1985, and even in the two years since OSM last considered this issue, there have been a number of developments that warrant this action. These include the changes in the economics of coal mining that may impact the demand for Tennessee coal. A more detailed set of reasons for doing the EIS will be forthcoming in a separate letter from the Department of Environment and Conservation.

Such an EIS can be the basis for a thorough scientific analysis of the coal resource in the state, the technology currently available for mining, the impacts of mining on the environment, and on communities. This process can be an open process, involving input from all interested people and can be the basis for policy for both the Office of Surface Mining and the Department of Environment and Conservation.

At your earliest convenience, please let me know your answer to this request. For further information, please contact Deputy Commissioner Paul Sloan, Tennessee Department of Environment and Conservation, at (615) 532-0102.

Warmest regards,

Phil Bredesen

cc: Commissioner James H. Fyke
Deputy Commissioner Paul Sloan
Tim Dehringer

RECEIVED
JAN 1 2 2006
ENVIRONMENT AND CONSERVATION
COMMISSIONER'S OFFICE

State Capitol, Nashville, Tennessee 37243-0001
(615) 741-2001

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
NASHVILLE, TENNESSEE 37243-0435

JAMES H. FYKE
COMMISSIONER

PHIL BREDESEN
GOVERNOR

January 12, 2006

Mr. Brent Wahlquist, Acting Director
Office of Surface Mining
1951 Constitution Avenue, N.W.
Washington, D.C. 20240

Dear Mr. Wahlquist:

You recently received a letter from Governor Bredesen requesting the Office of Surface Mining develop a new comprehensive Environmental Impact Statement (EIS) on Coal Mining in Tennessee. In addition to what he stated, please consider the following reasons OSM should grant this request.

We are aware that OSM has taken the position in court that the 1985 EIS meets legal requirements. We are not trying to dispute OSM's legal position. Our request is based on our view that environmental regulation should be based on best available scientific and technological resources and should be developed in a process that is open to the affected interest groups and the public. We expect you share that view.

The many events and changes that have occurred in the twenty years since the programmatic EIS was done mean that the 1985 EIS is now inadequate as a matter of policy to be the basis for good decision making. These changes include developments in the technology and methods used for mining, changes in marketplace conditions, new effluent standards developed by EPA, new information about threatened and endangered species, and the experience of both of our agencies in regulating mining since 1985.

TVA has, in the past, adopted the 1985 EIS for its NEPA compliance for coal mining. Although it has not been issued, we are aware that TVA has done a significant amount of work on it own EIS on the Koppers property. If TVA issues that EIS, it will no longer rely on the document. If OSM acts now it will be ahead of that development rather than behind.

Here are more reasons why OSM should develop a new EIS:

1. A number of Lands Unsuitable Petitions have been reviewed and restrictions placed on mining in certain locations since the EIS was written.

- Fall Creek Falls
- Rock Creek
- Little Yellow Creek
- Flat Fork

You also have another Lands Unsuitable Petition that has been filed regarding the New River watershed. As can be seen from some of the items below, we would like to incorporate some of the concerns raised by that petition into a more comprehensive analysis of impacts from mining throughout the state.

2. Sewanee coal seam surface mining has routinely created lasting problems with acid, metals, or other conditions resulting from the neutralization of acid. The failure of the toxic material handling plan at Skyline Coal and the problems encountered at Sequatchie Valley Coal and Cumberland Coal are examples. The treatment of some acid mine drainage has resulted in other water quality problems. The methods of treatment have not proven to be satisfactory. Contrary to findings of the EIS at paragraph 4.4.3.4.2., in these situations the treatment of AMD has not had a beneficial impact on the area.

3. Passive water treatment, although used extensively by the industry, is not addressed in the EIS.

4. The EIS should include considerable volume of more up to date water quality and stream biota information.

    - TVA has produced considerable data in their Koppers EIS efforts.
    - OSM's CHIA sampling has produced considerable data along with the trace metal monitoring required of operators for some time.
    - The Division of Water Pollution Control's Mining Section has collected considerable data and the general water quality assessment databases of the Division have a great deal of information.
    - More data needs to be collected and included.

    In addition to the increase in data, the quality of the data is better because of improved geological and water sampling techniques and analytical methods have been developed.

5. Enforcement activities of both OSM and the state of Tennessee involving coal mining are not included.

6. State of Tennessee now manages lands known as: Sundquist Wildlife Management Area, Royal Blue WMA, Cumberland Trail, Fork Mountain, Colditz Cove. Management measures to support the objectives of the state's management plans for these sites need to be included.

7. There is more information now about a number of threatened and endangered species and other species of concern than there was in 1985. No protection is proposed for the Blackside Dace in the EIS, nor does it mention critical habitat for the Indiana and Gray Bats. (Table 3-19). The Cerulean Warbler is not mentioned. (Table 3-20)

8. Mining technology-Augur mining (3.3.2.4) may have been improved by current highwall mining machines which retrieve coal from much farther into a coal horizon. This improvement in retrieval volume has also changed the amount and configuration of surface area needed for the newer mining machines.

9. Erosion and sediment control measures need for haul road control not discussed. (Erosion and Sediment Impacts (4.4.3.2)

10. Effluent Limitations – Standards have changes since the EIS was produced, Best Available Technology has changed to New Source Performance Standards. See A.3.1.

11. Many believe the change in air pollution standards for power generating facilities and other market conditions have created an increased demand for Tennessee coal. See the Tennessee Wildlife Federation Report on Mining.

12. A comprehensive inventory of abandoned mine land and lands where reclamation has not been effective including slides, post mining land use problems is needed to address cumulative impacts

I appreciate your consideration of this request and I am happy to be your point of contact if you have any questions as well as to be notified of your decision.

Sincerely,

Paul L. Sloan

Paul L. Sloan
Deputy Commissioner for Enviornment

PLS:AL:cm

cc: Governor Bredesen
Tim Dieringer, OSM

Answers by Paul Sloan to Questions from the Environment and Public Works Committee

Senator Barbara Boxer

Q. Mr. Sloan, during the Subcommittee hearing we heard testimony about how the West Virginia Department of Environmental Protection believes that they are adequately offsetting the adverse effects of mountaintop mining valley fills on water quality. Can you explain why the State of Tennessee believes that the mining through streams or burying steams with waste material, which are commonly associated with mountaintop removal mining, "constitute impermissible pollution of the streams and there are reasonable alternatives available" and why Tennessee does not permit these activities?

A. This year, the Tennessee General Assembly made these prohibitions explicit in the Tennessee Code by enacting Public Chapter 289 (copy attached). Although Tennessee, like West Virginia, allows for mitigation to offset the impacts of various activities on streams and wetlands, not every activity is entitled to a permit. Prior to this new statute, there were two sources in federal and state water pollution laws for the rationale for the language you quote. In the context of the federal Clean Water Act, these are known as the 404(b)(1) guidelines and anti-degradation. In plain language, these both require that an analysis of alternatives must show that there is not a reasonable alternative to accomplish the project. There are alternatives both to mining through streams not impacted by prior mining and the deposition of waste materials from surface mining in streams. In practice, coal mining operations in Tennessee have found such alternatives.

Senator Benjamin L. Cardin

Q. Tennessee has successful mining operations throughout the Eastern portion of the state. You say you have done so without permitting Valley Fills. Have mining interests within your state taken issue with your Agency's policies on Valley Fills?

A. There have not been legal challenges to Tennessee's requirements for protecting streams and the coal industry did not lobby against the codification of the requirements by Public Chapter 289.

Q. The rules on "Fill Material" are obviously written in a way that permits Valley Fills to accompany surface mining activities. You've indicated the importance of coal to the Eastern Tennessee economy. What was the process that led to the determination in TN to not permit Valley Fills? Has your state's ability to mine coal been hindered at all by the prevention of valley fills?

A. As noted above, state and federal law require that we protect waters. Filling streams with overburden material is simply incompatible with that objective and the specific regulatory requirements. It is well-demonstrated that overburden can be managed without placing it in waters. We are not aware that these legal requirements are more of a limiting factor on mining in Tennessee than are natural factors such as the thickness of coal seams.

Q. Some would argue that Cross Ridge mines are effectively MTR projects. You do after all excavate the Mountain from the top down. Can you please explain to me the difference between what you permit mining operations to do in TN and the differences, in terms of impacts to water quality and the environment, between Cross Ridge mining and Mountaintop Removal Mining as it occurs in other states in Appalachia?

A. The distinction is how overburden is managed. We allow surface mining operations to remove overburden to access coal so long as it is placed where it does not harm waters. When OSM or an authorized state issues a permit for mountaintop removal mining which will result in the final contour being a level or gently rolling plateau, the operation is exempted from the normal requirement to reclaim the mine site to the approximate original contour of the mountain before mining. See 30 C.F.R. §716.3. Because we do not allow burial of streams, OSM does not issue such permits in Tennessee. Also, to allow the valley fill associated with mountaintop removal, OSM also has to authorize the fill within the 200 foot stream buffer zone under 30 C.F.R. §816.57. OSM does not issue such authorizations in Tennessee. There is no question that disposal of mining overburden in Appalachian streams has long-term negative impacts on those streams that are buried.

Senator James M. Inhofe

Q. Aren't many, if not most of the current coal mining sites in Tennessee re-mining operations that are reclaiming old abandoned coal mines to modern environmental standards?

A. Yes, many are. One of the most common examples is the reclaiming of old benches left on the sides of mountains by prior contour mining. The benches are one of the places used for the deposition of the overburden material instead of deposition in streams.

Q. If so, then shouldn't we be encouraging such operations, since they can dramatically improve long term acid mine drainage from pre-law sites and actually improve water quality?

A. We do encourage ongoing mining operations to reclaim old mine sites. In the example given above, the use of the airspace above the old bench is one of the reasons cross ridge mining is feasible. Since the overburden material expands when it is removed, there is a need for more disposal space than that at the top of the mountain.

We also authorize mining through stream segments that are still showing impacts of prior mining if they can be improved. However, at least in Tennessee, very little of the ongoing mining is correcting acid mine drainage problems. This is for at least two reasons: (1) correcting such problems is very expensive; and (2) no current mining is being permitted in coal seams with associated acidic overburden. In Tennessee, both we and OSM are unaware of any technology capable of preventing future acid mine drainage problems.

Q. In your testimony you call for a study of mining, but hasn't the federal government already completed a comprehensive programmatic EIS just a few years ago, examining all aspects of MTM?

A. Without getting into the merits of the programmatic EIS on mountaintop removal mining, that is a different subject than the one we want OSM to address. We want a study on all the impacts of coal mining in Tennessee. Since mountaintop removal mining does not occur in Tennessee, we would not expect that issue to be addressed in the study. It is true also that OSM did an EIS when it took over the program in the mid 1980s. However, that study did not address all of the concerns that exist today. I have attached a letter I sent to OSM when this request was first made that sets out a long list of the concerns that were not addressed and should be.

Senator CARDIN. Thank you very much for your testimony.
Secretary Huffman.

STATEMENT OF RANDY HUFFMAN, CABINET SECRETARY, WEST VIRGINIA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Secretary HUFFMAN. Thank you, Mr. Chairman. Good afternoon. I want to thank you for the opportunity to be here today to represent West Virginia's concerns in this dialog over mountaintop mining.

Senator CARDIN. Would you just turn your microphone on, if you have not?

Secretary HUFFMAN. I apologize. It says it is on. Yes.

Senator CARDIN. Good.

Secretary HUFFMAN. Again, thank you for the opportunity to be here today to represent West Virginia's concerns in this dialog over mountaintop mining and its impact on water quality.

As you know, West Virginia is at the center of the debate, from both a regulatory perspective and a geographical perspective, since the majority of the Appalachian Highlands where mountaintop mining is practiced are located in West Virginia.

It is important that we first, though, frame the discussion in proper context. Mountaintop mining is one of many surface mining methods recognized and regulated by the Surface Mining Act. And, as the State's top environmental regulator, it is not something that I come here today with the intention of promoting for or speaking against.

What must be understood is that the connection between protecting water quality and the practice of mountaintop mining, is not a unique one. Nor is the assumption by many that valley fills are only associated with mountaintop mining.

In fact, the debate cannot be limited to surface coal mining alone. Hard rock surface mining, other development activities, and any other activity that removes vegetation and breaks rock can be subject to the same types of concerns and issues.

There are may surface mines that are not mountaintop removal by definition which require valley fills. And in fact, in West Virginia, 90 percent of all surface mining activity contains at least one fill. And, as you know, 40 percent of our State's coal production comes from surface mining.

Also, the Clean Water Act and West Virginia's Water Enforcement Program require the same levels of protection for all mining activity, regardless of whether it is mountaintop mining by definition.

While West Virginia is concerned about losing the opportunities associated with mountaintop mining for future economic development, our greatest concerns are the uncertain regulatory climate EPA has created and the unintended consequences of their recent actions that have the potential to significantly limit all types of mining.

I believe it is important to understand West Virginia's role in enforcing the Clean Water Act. While West Virginia is concerned about the economic impacts that would accompany any policy change that reduces coal production, my agency's role is, and hence our primary objective in this discussion is, the protection of our water resources.

The Clean Water Act clearly allows EPA to delegate portions of the act to the States and we believe that was Congress' intent as they recognize the States as being better positioned to regulate than the Federal Government.

The DEP in West Virginia has a very effective and progressive regulatory program. We have been regulating mining-related impacts to surface and groundwater since we received primacy over SMCRA from the Office of Surface Mining in 1981. Our program has evolved a great deal since then and continues to grow and change as research and technology help us learn more about health and environmental impacts from our industrial processes.

Concurrently with the primacy of SMRCA, we have delegated authority from EPA to oversee the Clean Water Act, section 402, permitting program, and section 401, which is the certification of Federal permits. In fact, before one certification authority, which is the EPA's current challenge to West Virginia's program, is not delegated by EPA but is delegated to the States by Congress through the Clean Water Act itself.

West Virginia received awards in 2005 and 2007 from the EPA for "outstanding performance in implementing their NPDES program." EPA's recent inquiry scrutiny over the Army Corps of Engineers' authority to issue valley fill permits is intended to be a way to curb mountaintop mining. EPA has clearly stated this on numerous occasions.

The problem is, in so doing, the EPA's selected venue has been to attack West Virginia's 401 certification program. In short, EPA is not claiming that West Virginia is failing to enforce Federal law. They are wrongly claiming that West Virginia is failing to enforce its own rules, which have gone through proper rulemaking channels and which, ironically, EPA has approved as being protective.

Further, this position by EPA is new. It evolved out of Region 3 in Philadelphia since January in the absence of a Regional Administrator appointed by President Obama.

Even as coal's future is being debated, West Virginia is positioning itself to continue to be an energy producing State. In just the past month, Governor Joe Manchin has signed into law three pieces of legislation that do just that: one requiring coal burning power plants to diversify their energy portfolio to include alternative and renewable energy; the second creates a regulatory framework for establishing a permitting program for carbon capture and sequestration; and the third, turning reclaimed surface mine lands into a resource that can be used in a post-mining economy.

I will close with a comment about the latter. West Virginia and our Nation needs job and we need coal. Nothing in the debate over surface mining is going to change that in the short term. But in the long term, as we mine and use a nonrenewable resource, and as we develop alternative energy sources, the people that live in the steep, narrow terrain of southern West Virginia need the opportunities created by surface mining.

And as the State's regulatory agency, the DEP in West Virginia needs consistency and clarity from EPA in order to be effective regulators. And right now, we do not have that.

Thank you, Mr. Chairman.

[The prepared statement of Secretary Huffman follows:]

Name:	**Randy Huffman**
Title:	**Cabinet Secretary**
Organization:	**West Virginia Department of Environmental Protection**
Committee:	**Senate Committee on Environment and Public Works, Subcommittee on Water and Wildlife**
Hearing:	**The Impacts of Mountaintop Removal Coal Mining on Water Quality in Appalachia**

The State of West Virginia appreciates the opportunity to be a part of the dialogue regarding mountaintop mining and its impact on water quality. Because West Virginia is home to the majority of the Appalachian highlands where mountaintop mining is practiced, the State is at the center of the debate from both a regulatory and geographical perspective.

It is important that the discussion is framed in the proper context. Mountaintop mining is one of many surface mining methods recognized and regulated by the Surface Mining Control and Reclamation Act. What must be understood is that the connection between protecting water quality and the practice of mountaintop mining is not a unique one. Nor is the assumption by many that valley fills, which have been the focal point of attention in recent months, are only associated with mountaintop mining. In fact, the debate cannot be limited to surface coal mining. Mining through streams, hard rock surface mining and development activities could warrant the same scrutiny that is being given to the use of valley fills. There are many surface mines requiring valley fills that are not mountaintop removal mines by definition. Also, the Clean Water Act and West Virginia's Water enforcement program require the same levels of protection for all mining activity.

Coal production is the leading revenue generator for West Virginia, and many in the State are concerned about losing the opportunities for future economic development associated with mountaintop mining. The greater concern for the Department of Environmental Protection, however, as protector of the State's water resources, is the unintended consequences of the Environmental Protection Agency's recent actions that have the potential to significantly limit all types of mining.

West Virginia Water Regulatory Program

The Surface Mine Control and Reclamation Act (SMCRA) was enacted by Congress in 1977 to provide a comprehensive program to regulate surface coal mining and reclamation operations including mountain top mining and associated valley fills. The West Virginia Surface Coal Mining Reclamation Act (WVSCMRA) and its implementation was designed and approved to be as stringent and effective as the Federal program, which regulates coal mining under the SMCRA. In 1981, WV was approved as the primary regulating authority of coal mining activities under SMCRA.

In 1982, WV was authorized by United States Environmental Protection Agency to be the primary regulatory authority under the National Pollution Discharge Elimination System program. The West Virginia Department of Environmental Protection was designated as the certifying authority under 401 of the CWA as to whether a proposed Federal undertaking will comply with State water quality standards.

Things have changed a great deal, particularly in the last 10 years, with regard to the scope and scale of surface mining in West Virginia. Surface mining operations have shrunk, for example there were seven draglines in 1998 compared to only three today.

The environmental programs that apply to mining have matured considerably, and the US Army Corps of Engineers and the State of West Virginia have done everything that EPA has requested:

-West Virginia developed, at EPA's urging, an Approximate Original Contour policy under SMCRA that is an engineering formula used to verify valley fills are as small as physically possible. EPA's approval of the AOC policy as optimization of fill space was sent in a formal letter to both the Corps and WVDEP.

-The EPA was concerned that mining permits were being approved by the Corps through nationwide or general section 404 permits. The mining industry in West Virginia responded and made the transition to the Individual Permit process under section 404 while other states and regions continued to use the nationwide permit process that required less review and environmental analysis.

-West Virginia has gone above and beyond the EPA's recommended water quality parameters for coal mining by assigning water-quality-based effluent limitations for mining operations that broaden the parameters for which mining operations receive assigned permit limits. Other states continue to use tech based limits that assign permit standards for pH, iron, manganese and Total Suspended Solids. West Virginia permits have limits for these parameters and a host of others such as aluminum.

-West Virginia developed an anti-degradation program that considers the ability of the receiving stream to assimilate discharges of parameters that was approved by EPA and increased the detail and complexity of the Cumulative Hydrologic Impact Assessment (CHIA) required by the 1977 Surface Mining Act.

-For the past several years the State has required every permit to include a Surface Water Runoff Analysis which is an engineered formula that assures no flooding potential from proposed mining operations. Additionally, West Virginia modified its valley fill construction rules to further assure no flooding potential in times of short, intense runoff from flash storms and thunderstorms.

-The State has participated in a multi-agency effort to establish on-site mitigation and stream reconstruction and replacement in the restored mining area to mimic the functions of headwater streams. These practices were specifically sustained by the 4th United States Circuit Court of Appeals.

During the development of the Mountain Top Mining/Valley Fill (MTM/VF) Environmental Impact Study nearly a decade ago, there were permitting protocol agreements entered into by the

Corps, the EPA and the WVDEP that outlined what needed to be included in all the regulatory applications to allow for the issuance of the various permits required. These agreed upon requirements were intended to minimize the effects of MTM/VF on water quality and the environment as a whole. The approach also makes the review of permits more consistent and provides a stable playing field for the applicant.

The WVDEP has followed the agreed upon approach. It assigns water-quality-based effluent limitations in its NPDES permits in accordance with all applicable state requirements: the West Virginia Water Pollution Control Act, W.Va. Code §§ 22-11-1 through 22-11-29; the Coal National Pollution Discharge Elimination System Rule, 47 CSR 30; Water Quality Standards Rule, 47 CSR 2; and, the Antidegradation Implementation Rule, 60 CSR 5, all of which have been approved by the EPA. In addition to complying with all applicable State requirements, the effluent limitations in the WVDEP's NPDES permits also comply with all applicable Total Maximum Daily Loads.

Lack of Distinction Between Mining Types

Mountaintop mining currently is one of the recognized mining methods in the law for extracting coal, and is regulated by the State of West Virginia under the Surface Mining Reclamation Act and the Clean Water Act.

As mentioned, West Virginia has authority under the Clean Water Act, Section 401 to issue certifications ensuring that the project will comply with State water quality standards. It is this certification that the U.S. Army Corps of Engineers uses to determine whether a 404 permit allowing the construction of a valley fill will be issued.

Valley fills are not unique to mountaintop mining, but are, in fact, a necessary part of many mining practices – including those for hard rock, other minerals, ores, refuse fills and deep mines.

West Virginia Concerns Regarding Recent EPA Actions

The consequences of the EPA's recent position moves West Virginia and the nation toward the elimination of valley fills. In fact, EPA's position cannot be limited only to mining related fills. If these impacts are real, they are real for all earth moving activities and would impact highway construction and other development activities.

With the exception of mitigation, there has been no change in the law since the Clinton administration to justify the sharp change in direction that the EPA has taken. The only new development that appears to have precipitated the EPA to change its position on valley fills is the publication of a study conducted by the EPA's Region 3 freshwater biology group in 2008 (Pond, et al., 2008). The WVDEP does not believe that this study justifies the sweeping change in regulatory approach the EPA is making.

Based on the Pond study, the EPA contends that water quality is not being protected downstream of the fills proposed by mining companies. In West Virginia, downstream water quality is principally regulated through the NPDES permit issued by the WVDEP, which believes that the NPDES permits it issues for these types of mining operations fully comply with all requirements, and the recently published Pond study does not change this belief. In fact, when WVDEP is satisfied that the proposed activity is protective, it issues a certification under section 401 of the CWA, over which it has authority.

The EPA contends that these mines will violate one of the State's narrative water quality criteria. This water quality standard prohibits a "significant adverse impact to the . . . biologic component[] of aquatic ecosystems." The Pond study concludes that this standard has been violated downstream from valley fills associated with mining operations, based on its application of two biologic assessment tools, the West Virginia Stream Condition Index (WVSCI) and the draft Genus Level Index of Most Probable Stream Status (GLIMPSS), to samples of benthic macroinvertebrate life taken from these streams.

A first observation about this study is that West Virginia does not use the draft GLIMPSS in its assessment of the biologic health of State streams. Various activities will need to be accomplished before GLIMPSS is finalized and put into regulatory use. Those activities include scientific peer review, allowing opportunity for public comment and the establishment of implementation thresholds. Second, WVDEP uses the WVSCI to assess biological integrity under the narrative water quality criterion. This practice has been utilized since 2002 with EPA approval. These tools are just that, tools. They are not stand alone determinants of compliance with the narrative criterion. Any application of these assessment tools in determining compliance with the narrative criterion must faithfully apply the language of the standard itself, which prohibits significant adverse impacts on the biologic component of the aquatic ecosystem. In that regard, the WVDEP considers streams with WVSCI scores less than 60.6 as biologically impaired.

Without evidence of any significant impact on the rest of the ecosystem beyond the diminished numbers of certain genus of mayflies, the State cannot say that there has been a violation of its narrative standard.

Alternatives/Avoidance/Minimization

Beyond the water quality issues, the EPA also questions whether the extent of the fills, as proposed, have been sufficiently avoided and minimized. The agency is questioning whether application of the Approximate Original Contour formulae would result in less aerial extent of fill. Nine years ago, the EPA agreed that it would accept the application of the AOC and AOC + formulae as determinative of whether the extent of fill proposed in connection with a surface mine site has been sufficiently avoided and minimized. Leaving a flat area on the mountain top to accommodate emergency flood relief housing on the Highland project and construction of the King Coal Highway on the Consol of Kentucky and Frasure Creek projects will not cause the extent of the fill to be larger than it would be if these sites were restored to their approximate original contour. The toes of the proposed fills for these projects would not be moved upstream if they were reclaimed to AOC because the AOC formula was used to establish the location of the toes of these fills. The volume of spoil material that would have been used in reclamation to approximate original contour (rebuilding the ridgelines that are present in the pre-mining topography) will be spread out over the extent of the fill and backfill areas to provide a sufficient footprint of flat land for the proposed emergency flood relief housing and highway portions of these projects. As a result of spreading this material out instead of using it to rebuild the ridgeline, the elevation of the top of the fill will be higher than the target fill elevation dictated by the AOC formula. Despite that AOC is not being restored on the Highland, Consol of Kentucky and Frasure Creek projects, the extent of the fill is no greater than if these projects were reclaimed to AOC.

The approach EPA has taken in its objection letters indicate that EPA is hostile to post-mining land uses that call for something other than a return of mined land to its approximate original contour (AOC). This approach is contrary to the intent of Congress regarding development of mined lands expressed by its adoption of the federal surface mining act. The Report of the House of Representatives' Committee on Interior and Insular Affairs, H.R. 95-218, which accompanied and recommended adoption of the bill that became the Surface Mining Control and Reclamation Act of 1977, said:

[S]urface mining also presents possible land planning benefits as such mining involves the opportunity to reshape the land surface to a form and condition more suitable to man's uses. In such instances, the overburden and spoil become a resource to achieve desired configurations rather than a waste material to be disposed of or handled by the most economic means. The performance standards recognize that return to approximate premining conditions may not always be the most desirable goal of reclamation and thus appropriate exceptions to the general requirements are provided.

H.R. 95-218, p. 94. This committee report also went on to state:

[I]t may not always be best to return mountain lands to their approximate original contour. In various areas such as the mountainous Appalachian coalfields, there is a paucity of flood free, relatively flat developable land. Thus some surface mining operations offer the opportunity for creating a resource which otherwise might not be available or might be prohibitively expensive.

The mining application process and environmental standards allow the regrading and spoil placement requirements for mountaintop mining in order to achieve post mining land uses including industrial, commercial, agricultural, residential, or public facility (including recreational facilities) development.

H.R. 95-218, p. 124. To take advantage of the opportunity to create flat, developable lands in Appalachia presented by surface coal mining operations, Congress specifically provided for variances from the AOC requirement in 30 U.S.C. § 1265(c) so industrial, commercial, agricultural, residential or public facilities, including recreational facilities could be created. This opportunity is very important in the southern West Virginia coal mining region where no flat land exists. To assure that these opportunities are not lost, this year, the State has adopted legislation that requires a mine's post-mining land use to comport with county master land use plans that are developed by local economic development officials and approved by the State's

Office of Coalfield Community Development. These master land use plans target lands which are proximal to transportation or other infrastructure for development, so these areas of the State, which historically have had little economic activity other than coal mining, can develop sustainable post-coal economies. EPA's objection to land uses which would allow for development of mined lands is contrary to the expressed intention of both the Congress and the West Virginia Legislature.

Problems

The recent increased scrutiny by the EPA over the Corps of Engineers authority to issue valley fill permits is intended to be a way to curb mountaintop mining. The EPA has clearly stated this on numerous occasions. The agency's selected venue has been to attack West Virginia's 401 certification program, by claiming the state is failing to enforce its own rules, which have gone through proper rule making channels and have been approved by the EPA as being protective. This position by the EPA has evolved out of Region 3 in Philadelphia since January in the absence of a Regional Administrator appointed by President Obama.

Impact on West Virginia's Economy

West Virginia participated in a multimillion-dollar, multi-agency Environmental Impact Study that included studies on the ability to extract coal in Central Appalachia without fills. This study predicted a 90 percent reduction in recoverable coal reserves at the 11 mining sites examined. Most notable was the fact that one of the mines was a large underground mining complex with a refuse fill, which also requires a section 404 permit. All of the coal at the underground mining complex was deemed unmineable because of the inability to construct a refuse fill.

Without valley fills, the effect on coal production in Appalachia would be felt in the world's energy markets. The elimination of valley fills would effectively bring coal production to a point that it would be difficult to sustain energy production and the impact to the State's economy would be staggering.

Valley fills are a key component of post-mine-land-use development and any move toward elimination of valley fills would jeopardize the future opportunity to develop land for a meaningful purpose after mining. This would directly affect the post-mine-land-use legislation signed into law last week by Governor Joe Manchin, and could stifle economic development on former mine sites in communities throughout Appalachia.

Impact on Energy Production

In West Virginia, nearly 100 percent of the State's energy needs are supplied by coal-fired power plants. Nearly 50 percent of the nation's energy needs are supplied in the same manner.

It is one of few energy sources that can support the nation's current electrical power grid configuration. While nearly everyone agrees that moving to a more diversified energy portfolio is eminent, today coal remains a key component to gaining energy independence.

Even as coal's future is being debated, West Virginia is positioning itself to continue to be an energy producing state. In the past month, Governor Manchin has signed into law three pieces of legislation to accomplish just that.

One piece of legislation requires coal burning power plants to diversify their energy portfolios to include alternative and renewable energy. A second creates a regulatory framework for permitting carbon capture and sequestration and the third transforms reclaimed surface-mined lands into a resource to be used in a post-mining economy.

West Virginia and the nation need jobs and coal. Nothing in the debate over mountaintop mining is going to change that in the short term. But, in the long term, as we mine and use a nonrenewable resource and as we develop alternative energy sources, the people that live in the steep, hostile terrain of southern West Virginia need a future, too. The opportunities created by surface mining will be gone if not taken advantage of now. We must have a base upon which to build our future and surface mining provides a key piece that base.

Environment and Public works Committee Hearing
June 25, 2009
Follow-Up Answers to Questions for Written Submission

Questions from:

Senator Barbara Boxer

1. Mr. Huffman, during the Subcommittee hearing we heard testimony about how mountaintop removal coal mining is severely degrading stream water quality in Appalachia.

In the 32 years since the passage of the federal surface mining act and in the 37 years since the passage of the federal Clean Water Act, water quality in West Virginia has greatly improved.

How is the West Virginia Department of Environmental Protection considering the cumulative impacts of mountaintop removal coal mining when making permitting decisions for these mine operations?

Have you determined whether the projects that your agency has permitted are having a cumulative impact on water quality?

There are two principal ways that cumulative impacts are considered.
Before any surface mining permit is issued, a hydro-geologist working for my agency prepares a cumulative hydrologic impact assessment (CHIA) based upon chemical analysis of geologic core samples from the area to be mined, baseline water quality data, the applicant's proposed hydrologic reclamation plan and the determination of probable hydrologic consequences provided by a hydrologic consultant for the permit applicant. The CHIA analyzes site-specific and cumulative impacts on surface and groundwater, and determines whether the proposed mining operation meets the most basic hydrologic protection standard in state and federal surface mining law: whether the operation has been designed to prevent material damage to the hydrologic balance outside the permit area. To assure that the operation functions as designed, surface and groundwater monitoring plans are required as permit conditions.

Where cumulative impacts on a stream, whether caused by mining or other some source, cause it to be in violation of the state's water quality standards, my agency includes the

stream on the list of impaired streams it compiles pursuant to section 303(d) of the federal Clean Water Act. This results in the preparation of a Total Maximum Daily Load (TMDL) for the stream to attempt to deal with the cumulative impacts which are causing the impairment. Both the 303(d) list and the TMDL are approved by USEPA. Where a mining operation proposes discharges into a stream for which a TMDL has been prepared, my agency incorporates the requirements of the TMDL into the NPDES permit for that mining operation.

Senator Benjamin L. Cardin

1. Your testimony focuses a great deal on West Virginia's water quality standards.

What has your agency done to ensure compliance with the selenium water quality standard downstream from surface mines?

Proposed mining operations are required to core-drill the area to be mined and test each rock layer for selenium (as well as other acid- or toxic-producing potential). Rock layers with the potential to cause an exceedence of the selenium standard are targeted for special handling. Special handling requires the material to be kept out of any fill and isolated in the backfill area, above the pit floor, where it is covered with the most impervious material available, then compacted. This encapsulation cell is then covered with other backfill material in the reclamation process. The goal of special handling is to keep this material out of the course of drainage so the selenium cannot leach out. The same approach has been used successfully for many years in handling acid bearing materials to avoid the formation of acid mine drainage. Mine operators that have followed their handling plans have been successful in preventing selenium pollution.

Operations that had begun before the potential for selenium pollution from coal mining was known are currently testing a variety of different measures for control of selenium in their discharges.

Aren't you preparing to give coal companies another three years to come into compliance?

This year, the West Virginia legislature adopted a bill that permits, but does not require my agency to extend compliance schedules for attainment of compliance with selenium standards to July 1, 2012. The law that otherwise governs the granting or extending of compliance schedules under the State's Water Pollution Control Act was not changed. No such extensions have been granted.

2. You testified that EPA's position on valley fills "cannot be limited only to mining related fills" but would also affect construction activities.

The position USEPA has recently adopted on water quality issues downstream from mining operations deals with total dissolved solids concentrations or conductivity levels (which is used as a surrogate for measurement of total dissolved solids) and the purported effect of elevated levels of dissolved solids or conductivity on populations of certain genera of mayflies. Dissolved solids result from unweathered rock being exposed, for the first time, to weathering, allowing minerals to leach into streams

nearby. This problem exists in the case of any unweathered rock that is brought to the surface, whether it be through mining or through construction.

Didn't the Clean Water Act rules previously distinguish between "fill" for constructive purposes and waste disposal?

Before 1977, the regulations of both USEPA and the Army Corps of Engineers defined "fill material" as "any pollutant used to create fill in the traditional sense of replacing an aquatic area with dry land or changing the bottom elevation of a water body for any purpose". This definition does not make the distinction posed in the question.

In 1977, the Corps amended its regulations to add a "primary purpose" test that excluded material placed to dispose of waste from the definition. While this rule was in effect, some groups contended in litigation that fills constructed of excess spoil from mining operations were barred by this primary purpose test. Notwithstanding this contention, the Corps continued to approve such fills under section 404 of the Clean Water Act while this rule was in effect.

In 2000, the USEPA and the Corps recognized that their different rules on the same subject resulted in some confusion for the regulated community and proposed to modify their fill definitions so they were the same. These rules were finalized in 2002. As finalized, the rules provide that fill material means "material placed in waters of the United States where the material has the effect of (i) replacing any portion of a water of the United States with dry land; or (ii) changing the bottom elevation of any portion of a water of the United States. These rules do not make the distinction posed in the question.

Isn't the purpose of the Clean Water Act to prevent the destruction of waters for the purposes of waste disposal?

Section 101 of the Clean Water Act lists the Act's goals and objectives. This purpose is not listed among them. Section 404 of the Clean Water Act allows the Corps to permit filling of waters. Fills placed for construction purposes are comprised of rock and dirt. Fills that are placed to facilitate coal mining are also comprised of dirt and rock. The type of material used as fill in either case is the same. In the mining scenario, though, there are additional environmental protections not present in the construction scenario. As described above, under the surface mining scenario the rock is drilled and analyzed to identify rock layers that are potentially toxic or acid producing. These rock layers are excluded from the fill and targeted for special handling so as to prevent them from causing water pollution.

3. We heard from the EPA witness and again from Dr. Palmer that there is a strong and growing body of science indicating both the importance of protecting headwater regions and on the adverse water quality impacts of streams below valley fills.

Are you familiar with the seven pages of studies that Dr. Palmer cites in the White Paper she co-authored with Dr. Emily Bernhardt of Duke?

Are you familiar with the dozen studies that Mr. Pomponio cited in his written testimony?

First, we would like to say that we are familiar with the references cited by Mr. Pomponio. In fact, most of these publications were available for consideration for the Programmatic EIS on Mountaintop Mining developed by USEPA et. al. in 2003. Three of the studies cited are simply statistics on coal production and associated fees paid by the industry. The "new" science is primarily limited to the 2008 Pond / Passmore publication in JNABS. WVDEP is very familiar with this study and will be working with USEPA to further understand the findings of the paper and hold discussions on how future regulatory efforts may be adjusted.

With respect to the 126 publications cited in Dr. Palmer's 'White Paper', I can honestly state that neither I nor my staff have reviewed each and every publication cited in this un-reviewed and relatively new document. With that said and similar to my comments on Mr. Pomponio's references, much of this information was available for consideration for the 2003 Draft Programmatic EIS on Mountaintop Mining. However, the references also include articles or papers that have little or nothing to do with the issue at hand (e.g., *Exotic riparian vegetation lowers fungal diversity but not leaf decomposition in Portuguese streams* and another on the origin of lunglessness in Plethodon salamanders).

Dr. Palmer's paper does cite new and relevant information about ecosystem impacts and restoration. Consistent with my responsibility to keep abreast of the best available science for protecting West Virginia's waters, WVDEP staff will be reviewing in detail the relevant studies cited.

Do you believe that it is your job as the top environmental official in West Virginia to be familiar with the best available science on issues relating to the protection of West Virginia's waters?

Yes. My agency is using the best available science to protect against flooding caused by mining operations, to promote restoration of native hardwood forests on mine sites and investigate claims that well water supplies have been contaminated, diminished or interrupted by mining. In these cases, the science has been thoroughly developed and incorporated into the regulatory program through the legislative, rulemaking and policy-making processes – and in some cases – litigation processes. These processes

provide for transparency in the incorporation of sound science into sound regulatory approaches. The science can be vetted in the public's eye and any stakeholders may have their perspectives considered. Science should not be rushed from the latest research paper and adopted as regulatory policy without this transparency in the process.

4. On a West Virginia Public Radio Program earlier this year, you said, "*Mainly what we're concerned about as regulators is the ability to develop land after mining. You need valley fills if you're going to have a viable post mining economy. You need flat land. And in order to have flat land, you need to have valley fills, and one of our biggest concerns is that EPA is wanting to reduce the size and number of valley fills in Appalachia.*"

Is it your agency's mission to level sites for development projects or is it—as the name suggests—to protect the environment?

If one were to listen to the entire interview I conducted on Public Radio to which you refer, it should be obvious the context of that interview was related to the recent failure of USEPA to continue following established procedures for making permitting decisions regarding valley fills and not a general statement about the mission of WVDEP. My comments over West Virginia's concern about not being able to ever create valley fills again was specific to USEPA's policy change which would effectively eliminate West Virginia's ability to create land for a post mining economy for which the Surface Mining Act clearly provides. So, in the narrow scope of the issue about which I was being interviewed, that was and remains "one of our biggest concerns." The mission statement of the agency is "Promoting a Healthy Environment" and we take that mission very seriously.

How many valley fills are there in West Virginia? (The EIS—now 10 years old—said there are 5858 valley fills in WV and KY in the study area, so there are at least that many in the region.)

In Table III.K-1 of the EIS, which was published in 2005, 6,697 valley fills were identified in the four state study area of Tennessee, Virginia, Kentucky and West Virginia, with 1,147 of those fills identified as being permitted in West Virginia. The data was gathered from permits issued from 1985 until 2001. On Page III.K-31, the EIS estimated that 75 percent of these were already or may have been constructed. Currently, there are 1,579 fills permitted in West Virginia. The difference between this number and the number in the EIS is the inclusion of fills permitted prior to 1985 and after 2001.

How many of these have been developed for transportation or industrial uses? (VA tech professor estimates less than 1%.)

This question appears to assume that the only reasons fills are permitted is for transportation and industrial post mining land uses, which require a variance from the requirement of surface mining law to restore the approximate original contour (AOC)

of the land. This is incorrect. Nearly all mining activity in the steep slope terrain of the southern West Virginia coalfields generates more spoil material than can be used in reclamation of the mined area. This is because the loosening of rock and earthen material in the mining process causes this material to occupy a much greater volume than it did in place where it had been compacted by millions of years of the effects of gravity and weathering. This excess spoil must be placed somewhere outside the mine area. Excess spoil disposal is required for all surface mines in this area, even those that are restored to AOC. For example, since 2003, 129 permits have been approved, out of which only seven were granted mountaintop or steep-slope variances from AOC requirements. Yet, more than 90 percent of surface mines require fills for excess spoil disposal.

Even among mining operations that have received approval of a variance from the AOC requirement for commercial, industrial, residential, transportation or other development as a post mining land use, the development is generally planned for the mined out area, not the filled area. So, it is not surprising that the professor of whom you speak estimated that a very low number of fills have been developed.

As for development of mine sites, this opportunity is very important in the southern West Virginia coal mining region where no flat land exists. To assure that these opportunities are not lost, this year, the state has adopted legislation that requires a mine's post-mining land use to comport with county master land use plans that are developed by local economic development officials and approved by the State's Office of Coalfield Community Development. These master land use plans target lands that are proximal to transportation or other infrastructure for development, so these areas of the state, which historically have had little economic activity other than coal mining, can develop sustainable post-coal economies.

According to the 2003 Draft Programmatic Environmental Impact Statement that WVDEP participated in preparing, mountaintop mining had already resulted in the loss of 1,189 square miles of forests. That's almost as big as the entire state of Rhode Island. Do you have any data suggesting that the state has businesses ready to come in and develop 1,200 square miles?

The EIS's estimate of 1,189 square miles included parts of four states. The estimate for West Virginia was 173,174 acres or 271 square miles. That number was derived from the number of acres permitted in the ten years prior to the EIS study. The number was then doubled to reach an estimate for ten years after the study.

It is inaccurate to characterize this permitted area as "lost" forests. To do so requires one to assume that there will be no reclamation of mined lands, in violation of state and federal

surface mining laws. Every bit of the area permitted will be reclaimed in compliance with the revegetation requirements of the law.

Early in this decade, the office of Surface Mining Reclamation and Enforcement (OSMRE) initiated its Appalachian Regional Reforestation Initiative with a goal of restoring native hardwood forests on mined lands in the region. Research previously conducted by leading universities in the region as well as research sponsored by OSMRE was used to develop the Forestry Reclamation Approach (FRA). West Virginia has been a leader in applying the FRA. In 2008, the FRA was applied to 85 percent of all area permitted for mining in West Virginia. For each of the previous five years, the percentage of acres permitted for reclamation using the FRA was approximately the same. While all of the acres to be mined will be reclaimed, a very high percentage will be reclaimed to native hardwood forests using the best available science.

Does the state of WV really believe that mountaintop removal is an issue of "jobs versus mayflies" as you have stated?

I have never made this statement.

5. At a Surface Mine board Hearing on June 9, 2009 regarding a permit for a mine near the Gauley River National Recreation Area, opponents of the mine argued the permit should not be renewed because the company was in ongoing violation of its NPDES permit. In response, WVDEP's lawyer argued that, if that were the rule, it would shut down all mining and that no permits would be renewed. This implies that no coal company in the state is in compliance with its permit. Yet in your testimony you indicate that mining companies are generally in compliance with NPDES permit.

These positions seem inconsistent. Can you explain? Are coal companies in West Virginia in compliance with their NPDES requirements?

I believe the compliance rate is good. For the first quarter of 2009, there were 2,143 exceedences of applicable NPDES effluent limits by mining operations in West Virginia. This is out of approximately 172,800 data points that were reported, which when using the formula below equates to a violation percentage of 1.24 percent, or a compliance rate of 98.76 percent.

(This percentage was determined from and an average of 5,760 outlets reporting flow per month times two types of limits [a monthly average limit, plus a daily maximum limit for each month] times three months times five parameters = 172,800. This equates to (2,143 divided by 172,800 times 100%.)

Does your department have a policy about issuing NPDES permits to firms that are in on-going non-compliance?

The WVDEP does not issue NPDES permits to people who are unable to demonstrate that they are capable of complying. Where a permit has been issued and the permittee fails to comply, the agency takes enforcement action.

6. You list a number of ways you believe the WV DEP's water programs with respect to mining are superior to other states' programs.

How many of those improvements are the result of litigation, from community groups or others?

Some of these improvements have come as the result of litigation. In each case, though, the changes that have come through litigation have also passed through legislative, rulemaking, or policy-making processes, which have provided transparency and considered stakeholder input.

Senator James M. Inhofe

1. Can you explain in detail how West Virginia's economy depends in large part on mountaintop mining?

See answer to question #2.

2. Can you describe the economic impacts that the administration's proposed MOU will have on West Virginia's budget?

Mountaintop mining is only one type of surface mining. As I have previously stated, valley fills are not specific to mountaintop mining, but are a necessary component of all types of surface mining. While the stated purpose by USEPA underlying the debate is to look specifically at mountaintop mining, the primary impact being discussed as the means for being able to curb, control or eliminate it is valley fills. So, I must answer this question in relation to how the loss of valley fills will impact West Virginia's economy.

Forty percent of West Virginia's coal production comes from surface mining activities and much of the underground production depends on this surface production in order to achieve a marketable and more environmentally friendly product which is created through a blending process. It is likely that the loss the US Army Corps of Engineers ability to permit valley fills would eliminate most surface production and subsequently impact the quality of the underground production to a point that overall coal production in West Virginia would be severely hampered. Eight of the twelve counties that account for the most surface mine production in West Virginia actually produce more than 50 percent of their total coal production from surface mining.

According to West Virginia's Department of Tax and Revenue, the total estimated value of coal production in West Virginia in 2007 was $6.76 billion. Severance taxes in 2007 were $418 million and severance taxes from surface mining alone was $167 million. In addition to the 6,000-plus surface mining jobs, these severance taxes pay into the general revenue fund and make up a large portion of the total revenue used by these counties for schools and other government services.

3. Mountaintop mining is an issue that environmental groups consistently rally against. However, they only seem to tell one side of the story. Please explain about the process behind and the results of reclamation in West Virginia. How are these former mine sites used today?

All surface mining must be reclaimed in accordance with the law as established by SMCRA. More than 80 percent of all surface mining today is reclaimed using the Forestry Reclamation Approach, which is designed to re-establish the native hardwood forests. This reclamation approach leaves the soil very loose for good root attachment, reduces the velocity of runoff, and recharges the groundwater tables much more effectively than the traditional compaction and revegetation methods of the 80's and 90's. We are very confident that time will prove this to be the best way to reclaim surface mined lands.

As for the remainder, there have been numerous success stories for legitimate economic value on previously mined land. Attached is a list of many of those projects. We acknowledge that not all reclaimed mine land is suitable for contribution to a post mining economy, which is why Governor Manchin sought and the Legislature passed Senate Bill 1011 this past legislative session, which calls for detailed planning and coordination between landowners, coal operators, and local planning and development authorities to come together to establish the future needs of local communities as they prepare for a post mining economy.

4. One of the witnesses on the second panel, Maria Gunnoe, has written statements, posted by anti-mining websites, claiming that West Virginia Department of Environmental Protection is, "not there for the citizens, they're there for the coal companies..." She also said that, "In some cases they even lie to the citizens in order to continue the work on the mountaintop removal site."

Do your agency and its employees perform their jobs in a professional manner? Is there mission to serve to citizens of West Virginia? Do they fulfill that mission?

Absolutely. The staff of WVDEP is committed to protecting people and their communities from the adverse impacts of coal mining. There are always issues that need to be addressed and our staff responds to those issues in a timely manner with concern and compassion. Often the result of a citizen's complaint will be violations and fines for unlawful events that have taken place.

She also stated that "everyone downstream from where that mountaintop removal site is gets flooded and their wells are contaminated. My well is contaminated. Can't drink my water. I buy on average about $250 worth of water a month."

i. Based on your knowledge of the site involved, are all of the wells downstream from the mining operation contaminated, including Ms. Gunnoe's? If so, is your agency enforcing the requirements of SMCRA, requiring protection of the hydrologic balance?

The WVDEP does not have any objective basis to believe that wells downstream from this mining operation are contaminated. If the wells downstream from mining near Ms. Gunnoe's residence are alleged to be contaminated from mining, no one has made these allegations to the WVDEP. There is a formal process for investigating citizen complaints of violations including well water contamination caused by a mining operation, which includes providing the citizen with the results of the investigation and whether enforcement action was taken. The citizen has a right to appeal if the agency fails to take appropriate action in response to a citizen's complaint. Ms. Gunnoe is well acquainted with this process. The agency has investigated 22 citizen's complaints concerning the operation that is upstream from Ms. Gunnoe, including 11 such complaints from Ms. Gunnoe (Ms. Gunnoe has made citizen's complaints concerning

other mining operations as well.) None of these 22 complaints alleged that groundwater or water well had been contaminated. The majority of the complaints concerned blasting.

The WVDEP does enforce the requirements of the state SMCRA program concerning protection of the hydrologic balance, including the requirement that a mine operator replace the water supply of a resident that has been contaminated, diminished or interrupted. The procedure in the case of a complaint of well contamination is for an inspector to investigate, with assistance from an agency hydro-geologist. Where well water loss or contamination is found to have been caused by a mining operation, the agency's policy is to require the operation to supply drinking water to the residence within twenty four hours, temporary water replacement capable of serving the whole house within seventy two hours, and begin whatever construction (connection to public water supply, replacement well, etc.) is necessary to provide a permanent water supply replacement within 30 days. In the past ten years, the WVDEP has investigated more than 1,200 claims of well water impacts from mining operations and ordered replacement of water supplies where appropriate after analysis of the facts and application of principles of hydro-geologic science.

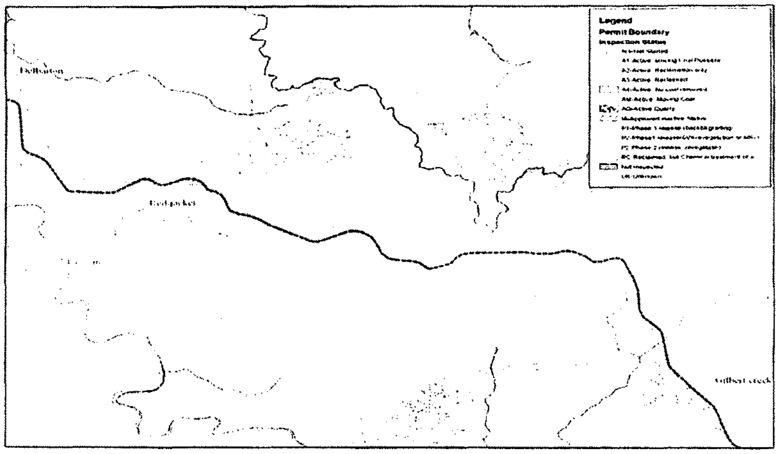
The provisions of federal rules under SMCRA that provide protection for flooding only have a general requirement that mine operators "provide protection against flooding and resultant damage to life and property". The West Virginia regulations go well beyond federal requirements by mandating that each surface mine applicant conduct a detailed Surface Water Runoff Assessment (SWROA). A permit will not be issued for a proposed surface mining operation unless the SWROA shows that there will be no increase in peak runoff into area streams during storm events. Even though this requirement was not in place when the mining operation on the mountains above Ms. Gunnoe's residence was permitted, the WVDEP required a SWROA to be conducted when this requirement was added to the state program. One of the evaluation points for evaluating peak runoff in the SWROA conducted for this operation happens to be in the creek in front of Ms. Gunnoe's house. The analysis used three scenarios – before, during and after mining – to determine peak runoff from the upland area. The analysis found that peak runoff during and after mining was less than it found in the before mining scenario.

Examples of Development on Mined Lands

- King Coal Highway ** (See Attached)
- King Coal Highway/Coalfields Expressway and Industrial Park (McDowell County)
- Robert C. Byrd High School (Harrison County)
- Mount View High School (McDowell County)
- Several Shopping Malls – Morgantown, Grandview, Logan, Clarksburg, Beckley
- Columbia Wood Products (Nicholas County)
- Wood Products (Mingo county)
- Twisted Gun Golf Course (Mingo County)
- Pete Dye Golf Course (Harrison County)
- Southwest Regional Jail (Logan County)
- Logan Airport (Logan County)
- Mt. Olive Correctional Facility (Fayette County)
- Hatfield and McCoy Trail (Logan County)
- Chief Logan's Conference Center (Logan County)
- Federal Prison (McDowell County)
- Cabela's (Wheeling)
- Aqua Culture- raising Fish (Mingo County)
- New Hope Village - homes for 70 families (McDowell County)
- Anker Sports Complex (Monongalia County)
- Beckley Soccer Complex (Raleigh County)
- FBI Complex – (Harrison County)
- Proposed High School in Mingo County along King Coal Highway
- Proposed Airport in Mingo County along King Coal Highway
- Knight of Columbus Community Park (Tucker County)
- Davis Cemetery (Tucker County)
- Morgantown Hall (Monongalia County)

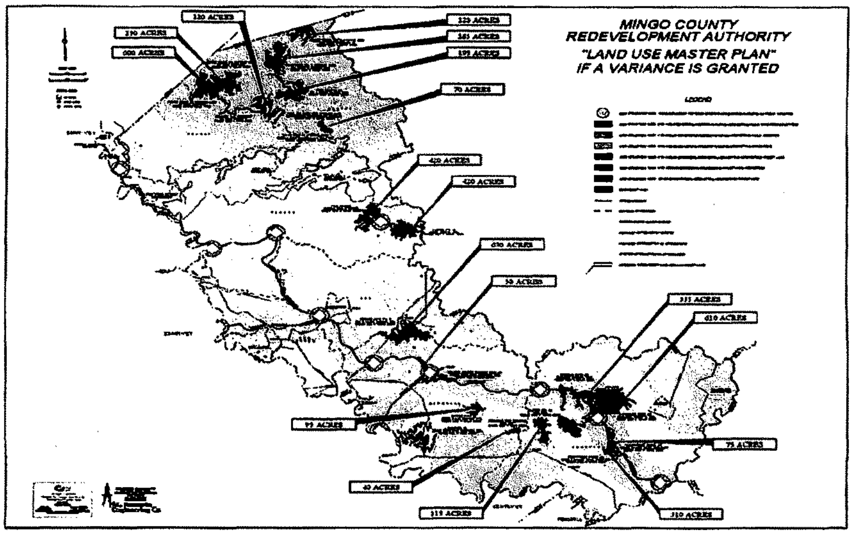
- Hilltop Hunting Preserve (Boone County)
- Beckley YMCA Soccer Complex (Raleigh County)
- Mountain Greeneries (Fayette County)
- Earl Ray Tomplin Industrial Park (Logan County)
- Animal Shelter (Hancock County)
- Proposed Motor Sports Park (Mingo County)
- A T Massey Regional Office Complex (Boone County)
- Malan Park Sport Complex for Handicap (Monongalia County)
- Monongalia School Bus Terminal (Monongalia County)
- Twin Hollow Campground (Mingo County)
- Bearwallow Trail Head (Logan County)
- Rockhouse Trail Head (Logan County)
- Pinnacle Rock Trail Head (Wyoming County)
- Public Fishing Area – Rockhouse Lake (Boone County)
- Numerous Windmill s on the Allegany front (Grant County)

King Coal Highway with Permits



Mingo County Land Use Master Plan

Adopted November 28, 2001



Senator CARDIN. Thank you very much for your testimony. I appreciate it very much.

Maria Gunnoe. First of all, congratulations on the award that you received. That is quite an accomplishment.

Ms. GUNNOE. Thank you, thank you very much.

STATEMENT OF MARIA GUNNOE, ORGANIZER, OHIO VALLEY ENVIRONMENTAL COALITION

Ms. GUNNOE. My name is Maria Gunnoe. I am from southern West Virginia, Boone County. Boone County is the No. 1 coal producing county in West Virginia, next to McDowell County, and they are both equally impoverished.

Energy that is produced from mountaintop removal coal mining is, basically it is bringing temporary jobs. This is temporary energy. And the destruction is permanent. We get what is left.

I hear a lot of professionals, if you will, defending mountaintop removal mining in the name of economic development and that is, quite honestly, not true. There is no economic development desired if people do not live there. If people cannot live in these areas, there is no need for shopping malls. There is no need for infrastructure if people cannot live there.

Basically, what goes on where we live at, there is a massive amount of blasting that goes on around our homes. And this blasting, of course it is unnerving to the people that have to live in those conditions, and I am one of those people. What it does to our air quality is horrible. Myself and my children actually suffer from the causes of the blasting at this mine site.

My home is located here. This is the top of my house. Our property, we have acreage, a lot of acreage, that covers this area here. This is the mine site behind my home. This here is the valley fill. There are two ponds at the toe of this valley fill. These ponds are to settle out the coal mines that wash through this massive operation. And in 2003, these ponds failed and when they failed, they devastated my home. It literally washed away about five acres of my land, turned it into a landslide and washed it away.

At that point, I began organizing in the communities that I live in. This is the people that I live around, the people that I grew up with. This is a common impact. When you have a valley fill, what you have is not only polluted water, but you have a mountaintop removal site that is allowing this water to run freely, there is nothing slowing it down, into this valley fill, which has two ponds that sit at the bottom of it, and it causes catastrophic flooding. This is not only me. This is on people throughout the area I live in.

The blasting is one nightmare. But the water pollution is horrible. We can live without energy in West Virginia. But we absolutely cannot live without good, healthy, clean water.

One of the things that I feel compelled to address is jobs. In 1950, we had 150,000 coal mining jobs in the State of West Virginia alone. Today, we have less than 15,000 coal mining jobs. Now, you will hear a lot of difference in those numbers. But, honestly, I am talking about coal miners. I am not talking about the people who work in the office. I am not talking about the people that work in the janitorial departments. I am talking about the coal miners, the people that actually mine coal. There are less than 15,000. I have heard 12,000.

But this is not about jobs. The mountaintop removal absolutely is not about jobs. Mountaintop removal is a human rights issue. Myself and my children have a right, as United States citizens, to clean water. And that right is being taken away from us in the State of West Virginia.

And there is no replacing that. You cannot replace my water. You can give me city water access, but you cannot replace the springs and the streams and the well water that has sustained our lives for hundreds of years. There is no replacing that. There is no reclaiming the land that has been destroyed. It will never be again what it once was.

We need to decide, as a Country, is it really, can we really keep doing this? Can we really keep flattening mountains to produce energy? I say no. Because there are only so many mountains and we will run out. We will run out of coal. The USGS suggests that we have 20 years of mineable coal left. We need to start making a plan right away so that we do not leave our children in area of devastation: no water, no energy and no plan. We need to think about what we are doing to our children.

[The prepared statement of Ms. Gunnoe follows:]

Maria Gunnoe
Coal field Resident and Organizer in the affected communities for the Ohio Valley Environmental Coalition. www.ohvec.org
The Senate Committee on Environment and Public Works, Subcommittee on Water and Wildlife
"The Impacts of Mountaintop Removal Coal Mining on Water Quality in Appalachia."
THURSDAY, JUNE 25, 2009
3:30 p.m.
Room 406 of the Dirksen Senate Office Building

My name is Maria Gunnoe. I am 40 years old and I am a life long resident of Boone County in southern West Virginia. My family history there goes back to the 1700's. I know the areas and the people that are being impacted by mountaintop removal very well simply because this is the homeland where generations of our ancestors before me have raised their families and lived their lives. Most of these families have depended on underground coal mining to make a living but we as a culture of people have depended on these mountains to take care of our families. We are gatherers, hunters, gardeners, fishermen, active and retired miners, loving community members, we are stewards of this land and we are now organizers. We are working to protect and preserve the communities, culture and people that we love and hold dear to our hearts

Water Quality Impacts

There is a relatively new method of mining now happening in the coal fields of Appalachia called mountaintop removal coal mining. This method of mining is where the coal companies use nearly 4 million pounds of blasting material a day *(in WValone)* to blast the coal out of the mountains. Then everything other than the coal *(including trees and topsoil)* is used to create valley fills in our headwater streams. The artificial streams running off these sites are toxic with selenium.

The energy is temporary energy. You only burn coal one time. The destruction of the land, air, communities and people is permanent. There have been 500 mountains leveled for their coal and energy in the name of homeland security. These 500 mountains were surrounded by communities who depended on the mountain's resources and water for their very existence. There have now been more than 2000 miles of streams buried by valley fills. People depended on these streams as much as any animals. The cumulative impact of the permits that are being allowed in some incidents are further depopulating and destroying communities and people. The regulatory agencies turn a blind eye to this pollution by continuing to allow the companies to buy more time to come in compliance with the existing laws. Without enforcement these laws are only words on paper.

Local communities truly do not have a voice in the process of these permits. The DEP will set up what is called an informal conference to inform citizens of what the DEP and coal companies are planning to do and to give community members a chance to comment. These comments are recorded and we are told that they become a part of the permit record. In these hearings the citizens often beg the regulatory agencies to not allow these permits but commonly they approve every permit applied for. The people who live in these communities do not want mountaintop removal mining. Especially near their homes and communities simply because it is destroying everything they and their families before them have worked for.

In the 8 years of the Bush Administration the laws and courts were aligned to destroy any protection that we had for these beautiful and unique places and their people. The clean water act lost its meaning when the Bush Administration changed one word of this law – the definition of fill material. Another important rule, --the buffer zone rule- that protected our streams was done away with on the eve of Christmas 2008. With this rule change the Bush Administration opened us as residents up to nothing but destruction.

There are health impacts too. A study by Dr Michael Hendryx at West Virginia University has proven that there is reason to be concerned about the pollution that the people throughout the coalfields are being exposed to. This study has not been taken seriously by our state leaders or our state regulatory agencies as a matter of fact it has been ignored. Portions of this study were based on the community of Twilight near where I live. Twilight Surface Mines surrounds the small communities of Lindytown and Twilight and the people who live there either put up with the impacts or leave.

The blasting has been horrible and the community's members concerns are not being heard. There is near 4 million pounds of blasting material used each day in WV alone. At one point the department of defense and Department of Environmental Protection allowed the coal company to dispose of old munitions from war *{called tetryl its used as an igniter}* on the mine site behind my home. It was too dangerous to use in war so they thought they would dispose of it in our community over our people's heads.

We have for many generations depended on the water from these mountains. Now this water is being polluted forever. In the case of Big Branch Creek where I live it is now polluted with toxic level of selenium. This is also present in my well water. This was quietly done by the coal company and the regulatory agency permitted it. The entire aquifer of where I live is now pollution spill way. The loss of timber from our hollow alone will be felt for thousands of years to come. There is no way that the reclaimed land can grow the hardwood forest that the natural land does. This land is dead. It's impossible to grow a healthy forest on dead polluted land. Reclamation is a pretty word but on the ground it has been proven to be impossible.

Culture

My family before me settled these mountains through the forced removal of the Cherokee known as the trail of tears and most of my neighbors have a similar story. My grand father told me the story his mother told him of the men in the family dressing as women to allow the women and children to escape this forced removal. The women and children then followed the rivers to their headwaters and settled the area where I now live. Throughout the past 250 years our families have built these places through determination and love for the place itself. The mountains here sustained our families by supplying us with an abundance of food and fresh clean water in our wells, springs and streams. Southern West Virginians are fortunate enough to live in the second most bio-diverse region on this planet. This is richness beyond wealth. As residents we recognize our most valuable resources as being our land, water and people not the coal that lies beneath it all. Our people were here before the coal was discovered. Why should we have to leave now in the name of coal?

Some of our current resident's ancestors were awarded their land for military service to this country. Now this very land being destroyed and the residents don't have the rights to protect it. Appalachians are the history of this country. We have given all to build the infrastructure that supports this American dream that we all share. We help to supply 48% of this country's energy and the cost of this is never truly calculated. I have heard coal referred to as a cheap and clean energy. This ignores the facts. The facts are that the true cost of coal fired energy has never been calculated. We must consider the cost of coal from the cradle to the grave. We must consider the cost of mountaintop removal coal mining not only the aquatic life and the wildlife where this coal is being extracted but on the human lives of everywhere it touches.

I have to ask what about the homeland security of the folks that are being forced to sell out to the coal companies in Lindytown W.V? The people who proudly built this community are being told that they are in the way of coal production and that they must leave their homes of many generations. The coal company engineers strategically buy out homes and family heir owned land to depopulate communities by making life unbearable. Their air land and water are being destroyed by mountaintop removal there is no way people can continue to live here and be healthy. They are being forced to leave home places of many generations to save their lives. This alone is personally and emotionally devastating. The boom of "Big Bertha" -- a dragline -- swings over the community of Lindytown. Blasting is frequent and terrifying for residents that are holding out not wanting to sell.

This same "clean coal" that forced an elder woman out of her home who happened to die of a heart attack while she packed her belongings for the first time in 72 years. She too was in the way of production. The people in Lindytown were only free to leave. Why is it as homeland security increases here in DC ours only gets less and less likely to even exist?

In our mountains we have many mountain cemeteries that date back to the beginning of civilization here. We are grounded like our ancestors before us. These cemeteries are awarded no protection by our regulatory agencies or law enforcement. We as citizens are expected to register and account for these cemeteries in order to protect them from mining activity and most of the time the coal companies won't allow us into our family cemeteries to do this work. They stop us from visiting our dead by locking us out of our ancestral land in these mountains. I know of many grave yards that were in our mountains that no longer exist. The areas where they were are now gone.

The people here belong no where but here. These folks will thrive in their own environment but taken away from here they will perish as they are not where they belong. The culture of people in West Virginia is a culture of survivalist not environmentalist. We have survived here throughout times of extreme poverty during the rise and fall of the coal markets. We have always had the land to sustain our lives. Now the very reasou for our existence as a culture of mountain people is being annihilated for its coal.

Jobs

Boone County falls second in poverty only to McDowell County, WV another leading coal producing county. This is still the most impoverished area in the US today. If mountaintop removal was about jobs and prosperity where is it? In the 1960's we had 125,000 direct coal mining jobs in the coal industry in WV, but now we have less than 12,000. Ask yourselves is this really about jobs or profit and exploitation? These jobs are temporary jobs at best. The operation behind my home started in 2000. It is now closed down. These good paying jobs only lasted long enough for the employees to get in debt.

I have watched as coal companies have destroyed one of the most beautiful places in this country by mountaintop removal coal mining. The people who live in these areas are often retired or active UMWA underground miners and their families. The people who work in mountaintop removal most often do not live in the environment that their jobs create. The companies are out of state coal companies and the workers are out of area workers. The companies commonly do not hire local people.

The coal companies will tell all that will listen that they are doing this for future economic development of an impoverished region. They will say that we don't have any flat land for development. They will tell you that we need this flat land and that our mountains are useless land in their natural state. I have even heard them say that the mountains are in the way of development. There will be no future here for anyone with mountaintop removal. I cannot believe that we as a nation are depending on continuing to blow up mountains to supply energy in this country when the energy we need in this country rises with the sun everyday and blows in each churn of the wind. The ridges of southern WV are wind viable ridges until they are blown up. We cannot continue to allow this to be called clean coal.

Stop Mountaintop Mining

In my own mind I know that mountaintop removal coal mining will stop. According to USGS we are running out of mineable coal and we are quickly running out of mountains in Southern, WV. Global warming is very real. We are all just pawns on this chess board called earth. I hope that we can stop mountaintop removal and coals global attack soon enough to preserve some of what is left of one of the most beautiful and ecologically diverse places in this country. The rolling hills of Appalachia are becoming the flat plateaus of the West as I speak.

We have the opportunity to stop the annihilation of mountains and people by mountaintop removal and to change the history of energy in this country. We are at a cross roads. We must put all special interest aside and follow what we know to be best for all of our future generations. Stop the attack on Appalachia's water supply and the people it sustains.

Thank you again to Senator Cardin and Senator Alexander for standing up for what any fellow human knows to be the right thing.

I would like to extend my tremendous appreciation to Senator Cardin and Senator Alexander for introducing Senate Bill 696 the Appalachian Restoration Act. This Bill if passed could turn back some of the Bush administration changes that is currently allowing coal companies to destroy valuable headwater streams and all that is connected to them. The residents I work with in the Boone County coal fields send their support for this bill as it is in some cases the only hope we have of remaining in our ancestral homes and in our ancestral homelands.

I leave you with photos and a recent article about flooding in the coalfields caused by run off from flattened mountains.

This is what inspired me to get involved in stopping mountaintop removal. There are other organizers just like me being created everyday by this industry. We have no choice but to oppose the practice of filling headwater streams, we live here!

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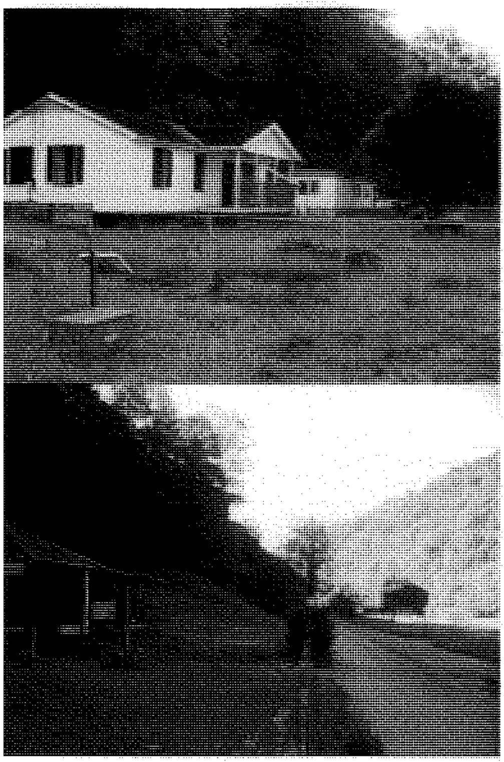
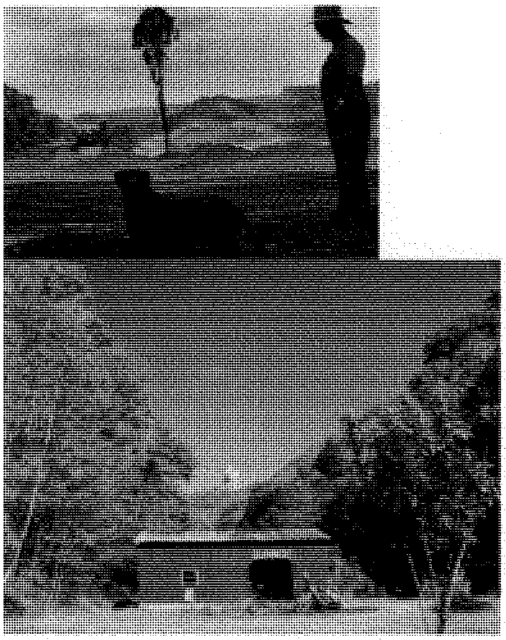
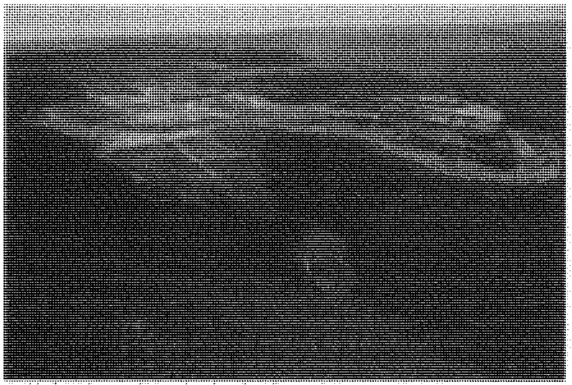
Below are supporting documents to be submitted with the testimony of Maria Gunnoe.





What about our homeland security? Are the people in Boone County, WV a part of this cost of coal conversations?



Is this the "clean coal" I am hearing about?

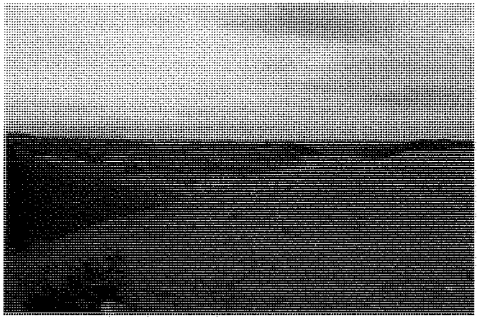


photo by Maria Gunnoe

We cannot rebuild mountains no more than we can un pollute water.

photo by Maria Gunnoe

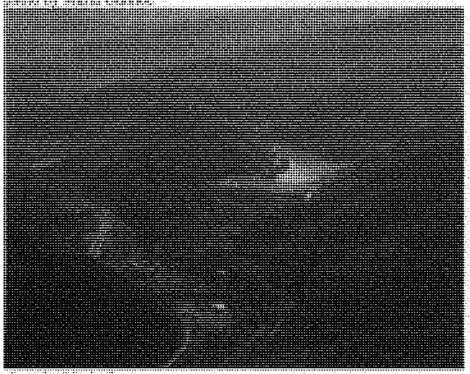


photo by Maria Gunnoe

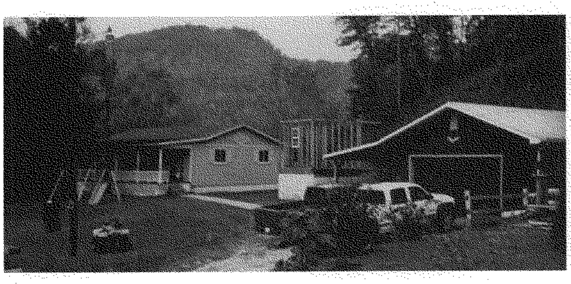
Marsh Fork Elementary School in Sundial, WV. www.penniesofpromise.org

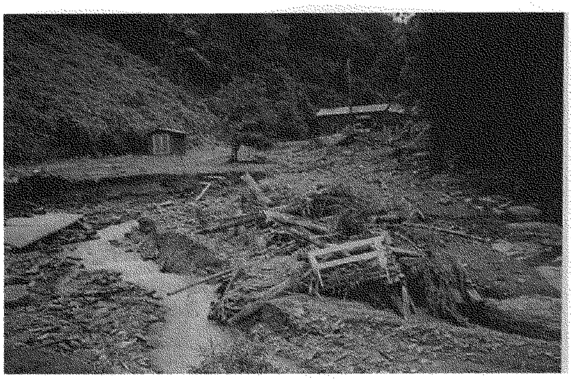
I live at the mouth of the hollow in the bottom center of this photo by Antrim Caskey.
[PC1]

Comment [PC1]: here

Maria Gunnoe's home at the mouth of the hollow at the bottom center of the photo by Antrim Caskey.

Maria Gunnoe's home before and after flooding from 2003.





More recent flooding from Ky and WV. Mountaintop removal has been proven to exacerbate and even cause flooding.

The Logan Banner

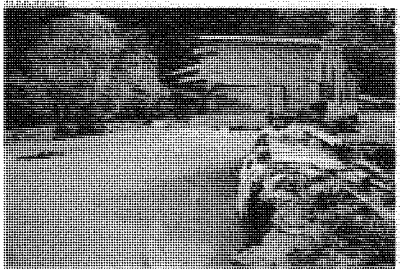
Devastation

by MICHAEL BROWNING, Managing Editor

05.10.09 - 11:[illegible] am

Much of Mingo County was hit by severe flash flooding late Friday night and early Saturday morning. Reports said up to four inches of rain poured down on the Varney, Red Jacket, Gilbert, Delbarton and Man areas. Eddie Fields' home at Pie was destroyed by the raging waters. Photo/Michael Browning

slideshow

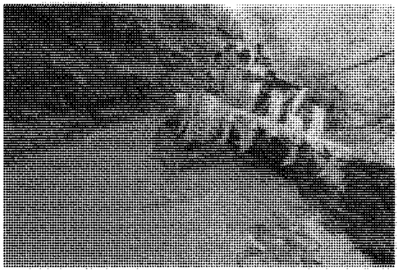


A double-wide mobile home at [illegible] was cut in half by the rushing current and the ground underneath the trailer was washed away. Photo/Michael Browning

slideshow

The [illegible] family cemetery at Pie was covered with mud and debris. Photo/Michael Browning

slideshow



The mud boils under a dozer clearing the highway at Gilbert Creek. Photo/Michael Browning

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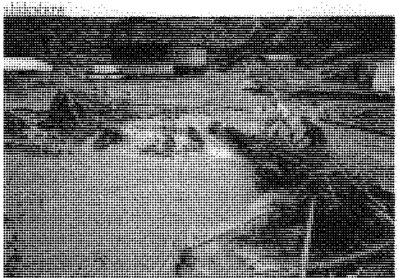
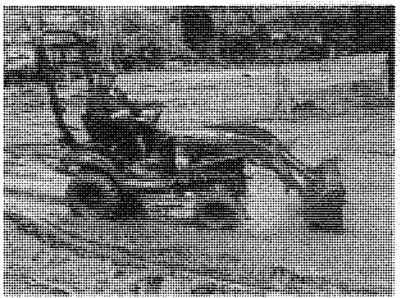


Barbara Frank and Ralph Manuel of Fairway clear debris from the bridge leading to Ralph Manuel's home after flooding submerged it. Photo/Michael Browning

slideshow



[illegible] Photo/Michael Browning

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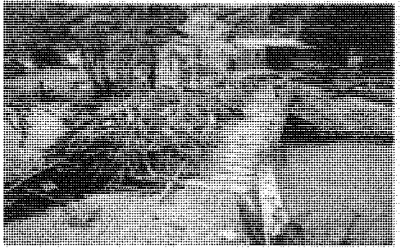
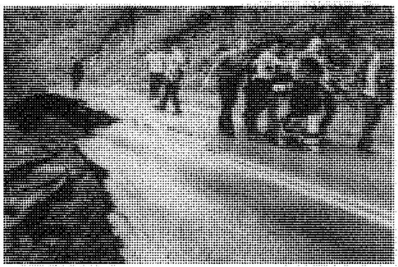


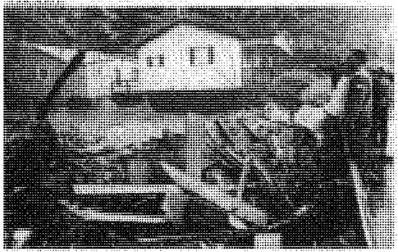
[illegible] *Photo/Michael Browning*

slideshow



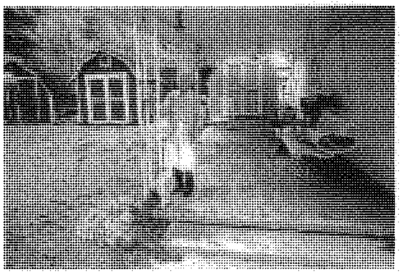
A Cloverdale-area firefighter is rushed down a broken section of State Route 22 to an awaiting ambulance by emergency crews. The firefighter was suffering from a heart attack, according to reports.

slideshow



Bobby Jarrell, Amanda Brooks, Cassie Duncan and Andy French watch flood waters push debris under a bridge at Lincoln City.

slideshow



[illegible] Clark of Musick Bottom stands on her porch after floods washed through her house. Clark is 93 years old and was staying with relatives when the flooding occurred. Her house had several inches of water inside, the underpinning was destroyed and her fence flattened by the rushing current.

slideshow

VARNEY — A flash flood washed through much of Mingo County and the Man area, Friday night and early Saturday morning, causing mass destruction and at least two injuries.

One death reportedly resulted from the flooding. According to reports to The Logan Banner, a Gilbert-area firefighter died after suffering a heart attack while providing aid in the flooded areas. The Logan Banner was unable to confirm the reported death at press time Saturday night.

At least two injuries were reported Saturday morning after a house reportedly collapsed in the Gilbert area. Those were also unconfirmed late Saturday night.

Around 1 a.m., Saturday morning, flood waters were rising in the Varney area of Mingo County and a rush of water coming out of a hillside at Pie shoved tombstones off their graves at the Marcum family cemetery.

Residents in the flood areas began moving cars to higher ground and packing clothes and other items as they headed for safety.

By 5:30 a.m., roads were blocked in the Belo, Delbarton, Taylorville, Red Jacket, Pie, Musick and Horsepen areas. In Gilbert, several sections of Browning Fork were washed away. Gilbert Creek suffered heavy damage to the road and several homes.

Residents of Bruno and Greenville and other areas near Man were evacuated from their homes and told to seek higher ground.

State Route 8! 0 from Man to Gilbert and U.S. Route 52 going out of Gilbert were both blocked by debris and flood waters covering the highway.

State Route 65 from Belo into Delbarton was blocked in several places by swift-running waters. State Route 49 from Williamson to Matewan was blocked by rock slides and debris in the road.

U.S. Army Sgt. Eric Parsley, who came home from Fort Knox to visit his mother for Mother's Day, made it all the way from Kentucky to Williamson, but had to turn around and got back due to the blocked roads leading to his mother's home at Sprigg.

At Hardy in Pike County, Ky., Corridor G was under water at the Velocity Market grocery store. Belfry High School near Hardy was being used as a shelter. Several fire departments were also in use as shelters.

At Lincoln City in Delbarton, families watched from their upstairs windows as Pigeon Creek ran like a river around their homes. Burch High School was surrounded by water and some of the rooms at Gilbert High School were flooded. The Mingo County Career Center at Delbarton also appeared to have suffered some flooding.

The Gilbert High School baseball field was destroyed, as was the Little League field sitting nearby.

Man High School's prom, scheduled for Saturday night at the Larry Joe Harless Center in Gilbert, was postponed to next weekend.

In the Gilbert area, Arville Cline and his wife, Georgetta, watched as the hillside slid down and moved their home several feet off its foundation. Arville Cline, the pastor of Sharon Heights Assembly church, said he and his wife made it safely out of their home.

"We've lost 15 feet of the church parking lot," Cline said. "We had a slide on our home and it shoved our home off its foundation and buckled the roof and the floor. Plus, there's a potent! ial slide behind our office. We left our home at 3:30 a.m. and spent the rest of the morning in the church sanctuary as we watched the water take its toll."

At Varney, 93-year-old Garnette Clark fought back tears as she assessed the damage to her home of several decades. Clark's house at Musick Bottom had several inches of water inside and thick mud blanketing her front yard, something that had never happened in past floods — even in 1977.

"Oh, isn't this awful," Clark said as she looked at her home that had been badly damaged by the raging waters of Pigeon Creek.

Chris Beckwhit, a Man resident and the post master at the Delbarton Post Office, was out early trying to figure out how he was going to get the post office open since his three employees were all trapped at Varney.

Ralph Maynard of the Elk Creek area said he marked w! here water had been on his home during the 2004 flood and Saturday mor ning the water was five inches above that mark.

"This one is worse than the 2004 flood," Maynard said.

Greg Dixon and Vickie Bailey walked over the rubble and mud that had covered the Marcum cemetery. He said the water rushed out of the top of the mountain.

"This has to be caused by strip mining," Dixon, who takes care of the cemetery, said as he searched for missing tombstones. "All this came from the top of the mountain."

Just down the hill from where Dixon and Bailey found one of the lost tombstones rests the grave of Taylorville businessman Wirt Marcum, whose tombstone was half covered, but was one of the few to survive the torrent.

U.S. Route 52 in front of the cemetery was covered with several feet of mud. A path was cleared for one lane of traffic to travel between the mounds of muck.

At Varney, R! alph Manuel and his brother, Frank, stood atop a badly damaged bridge and tried to dislodge trees and garbage trapped underneath that was causing water to flood Ralph Manuel's yard.

At Gilbert High School, a U.S. Army helicopter landed with a crew from the National Guard out of Parkersburg. Sgt. Alex Huffman said the flooded area is definitely a disaster area.

"It's the worst disaster I've ever seen and I was down at (Hurricane) Katrina and what I've seen in some of these small communities was worse than Katrina," Sgt. Huffman said.

Longtime Delbarton resident Bobby Robertson stood on the bridge at Lincoln City and watched as flood waters rose around houses. The bridge was halfway under wa! ter and popping from all the debris crashing underneath. Rick Hatfield , a Varney native, was also at the bridge watching the flooding and said he had tried to get home to his wife and children, but couldn't. He said his wife had to evacuate their home and took their young baby with her.

Amanda Brooks and Cassie Dotson watched with friends as Pigeon Creek overflowed its banks. The two Varney natives braved the high waters to get to Delbarton to check on friends who were flooded. They watched as debris crashed into the bridge at Lincoln City.

At Pie, Eddie Fields' home cracked in the middle after flood waters washed the foundation away from one end of his home and broke a room away from the house.

Curtis Marcum's home at Lincoln City had nearly four feet of water in the downstairs section. He said! he'd never seen destruction like that in his life.

"My heat pump is completely underwater and I've lost stuff I wouldn't take anything for," Marcum said.

Carl Thompson of Taylorville kept close watch as flood waters rose throughout the night and saw a neighbor's trailer wash into a tree in his yard. A building in Thompson's yard was rushed downstream by the current and he was trapped after his bridge went with it.

"I sat out on the porch and watched it come up," Thompson said. "Me and my wife thought we'd leave out the back way, but everything out back was under water. I watched my building float off and my neighbor's trailer move over. It was scary. Once it started raising it came fast. It completely covered my fence and you couldn't see the bridges."

The number of bridges destroyed by the flash flooding was in the double digits along Pigeon Creek, Island Creek and Gilbert Creek.

Several community centers were being used to give flood relief. The American Red Cross was already in Mingo County by 5 p.m. Saturday and the National Guard was assessing the damage so troops could move in to help with the cleanup.

"This is devastating," Commissioner Baisden said as he looked over at Chafin Funeral Home in Delbarton that was surrounded by water early Saturday morning. "We encourage everyone to help their neighbors."

Gov. Joe Manchin was reportedly going to tour the Mingo County area this morning. A report said he planned to tour the Gilbert and Matewan areas.

Mingo County Commissioner David Baisden was out early Saturday morning, as was Mingo! County Sheriff Lonnie Hannah. Baisden said "this is Mother Nature's wrath poured out upon us. I encourage those who pray to pray."

Several Department of Highways crews were dispatched throughout the two-county area to work on roads that were blocked or broken. Appalachian Power had crews out working to restore power to numerous communities. Tree-trimming companies had workers out cutting trees in Mingo County.

Senator CARDIN. Well, thank you very much for your testimony. You really do put a face on the issue. A lot of time we hear about the people who are affected, and I think your personal story is very compelling and I thank you very much for that.

Dr. Palmer, with your permission, I think we are going to take about a 10-minute recess and we will be back.

The Subcommittee will reconvene in about 8 to 10 minutes. There is a vote currently pending on the floor of the U.S. Senate and I will return as soon as I can cast my vote.

Thank you.

[Recess.]

Senator CARDIN. I apologize for the interruption, but we had a vote on the Senate floor. I think we will be OK and I will be to complete the hearing.

Dr. Palmer. I look forward to your testimony.

STATEMENT OF MARGARET A. PALMER, Ph.D., LABORATORY DIRECTOR, CHESAPEAKE BIOLOGICAL LABORATORY, UNIVERSITY OF MARYLAND

Ms. PALMER. Thank you. Good afternoon. I am very happy to be here.

I have been researching streams and watersheds for more than 25 years and, while I am a professor at the University of Maryland, I also have a home in West Virginia and my family is from the Appalachian regions of North Carolina. So this is close to my heart.

There is irrefutable scientific evidence that the environmental impacts of mountaintop removal are substantial and they are permanent. Related to this, I want to make three points today.

First, as you have heard, many beautiful headwater streams such as the one in this photograph are destroyed when they are buried by fills. Headwater streams are exponentially more important than their size would suggest. In watersheds, they function very much like the smallest branches in our lungs that deliver oxygen that nourishes our entire body. Without them we would slowly suffocate.

As headwaters are lost, the cumulative impacts are significant. The larger streams and rivers below become unable to support life.

The second point I want to make is related to the pollution that results from the process of mountaintop removal. Chemicals that leach from the valley fills are a result of exposure of mine rocks to air and water, and this results in the movement of elevated levels of sulfate, aluminum, selenium and many ions into the water that permeates the watershed downstream.

There is a very large body of science documenting this and, in fact, Mr. Huffman's agency, the West Virginia DEP, has a very long list of mine-impacted streams on the 303(d) list. And this listing is influenced by contaminants that are in the water, not influenced by those in the stream sediments where they actually are largely stored. And, also, the stream sediments are where the fish feed and, of course, when we walk in streams, we are walking where these contaminants are stored.

These contaminants move. They extend great distances downstream with toxic effects on organisms. The levels of selenium that occur in these systems can cause things like huge curvatures of the spine in fish, two eyes on one side of the head; there is no question that these levels of contaminants are a problem. Unfortunately, they also persist for a very long time even after the mines are not active.

Now, let us talk about Mayflies for a few minutes. We have been hearing a lot of people saying, well, is it about bugs? Is it about bugs versus people? Well, absolutely not. It is about what the loss of Mayflies represents.

We use rats to test for effects of toxic materials on humans. Well, guess what? For aquatic streams, for streams and rivers, we use bugs, small bugs that live in the streams. Their loss tells us something is wrong with the streams below valley fills. And I can tell you that you would not find a single, credible scientist that would refute this fact. I certainly would not allow my children to wade and play in streams that have these levels of contaminants.

The third point I want to make is related to, is there evidence that mitigation is actually working? And I am very sorry to say that, unfortunately, there is not evidence of that. Attempts to create streams to replace lost ones have been made by trying to make ditches with similar structural features to real streams. But there are no measurements demonstrating that they function like real streams.

Just as an aside, in scientific jargon, structures are how things look and functions are how they work.

Digging a ditch, adding rocks and diverting water to it does not make a living functional stream. No direct measurement of how streams function have been provided for streams that are created, or ones that are restored, in some cases for full mitigation credit after mining.

Now, just to drive this point home, it is easy to understand the difference between structure and function when you think about routine health measurements. For example, my husband is a really good-looking guy. He is 6 foot 2 inches, he weighs about 185 pounds which are his “structural features.” But guess what? He has really high blood pressure. He is at a high risk of heart disease. Can you imagine a doctor giving him a clean bill of health without taking some measurements of how his systems are functioning? His blood pressure, his heart rate, his metabolism of glucose, et cetera.

So, from a scientific point of view, it is equally unacceptable to say a stream is healthy ecologically just because there are rocks in it and there is water in it.

In summary, Mr. Chairman and fellow Senators, mountaintop mining first causes permanent environmental impacts. Second, networks of streams that are not directly touched by the mining activities are biologically impaired because the water quality impacts permeate downstream great distances. Third, there is no evidence whatsoever that mitigation is replacing what is lost. Measurements of ecological functions are not even being done.

Thank you.

[The prepared statement of Ms. Palmer follows:]

Testimony of
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To: Subcommittee on Water and Wildlife
Committee on Environment and Public Works
United States Senate
Hearing on:
The Impacts of Mountaintop Removal Coal Mining on Water Quality in Appalachia

Submitted June 22, 2009

Good afternoon Chairman Cardin and members of the Committee. I am Margaret Palmer and I thank you for inviting me to discuss scientific evidence of the environmental impacts of surrounding mountaintop removal coal mining, and the likelihood these can be mitigated using current restoration practices.

By way of background: I am an environmental scientist with expertise on stream ecosystems and restoration ecology. I have been conducting research and publishing books and articles for more than 25 years, have served as a scientific advisor for the National Science Foundation, the National Center for Ecological Analysis & Synthesis, the National Center for Earth Surface Dynamics, as well as both international and regional scientific programs. While I am a Professor at the University of Maryland and spend most of my time in that great state, I also have a home in West Virginia. My ties to the Appalachian mountains go way back since my family is from western North Carolina, where I spent much of my childhood.

Everything I am presenting today is based on current science from published peer-reviewed scientific literature. I have provided, along with this statement, a paper by myself and Professor E.S. Bernhardt from Duke University that not only includes more detail, than what is in this testimony but provides the citations to the scientific literature upon which my comments are based. My comments fall into two main categories:

Part I - Environmental Impacts on Natural Resources
- I.1. Magnitude and irreversibility of impacts;
- I.2. Consequences of losing headwater streams;
- I.3. Significance of cumulative impacts:
- I.4. Extent of downstream water quality impacts

Part II: Scientific Feasibility of Mitigation
- II.1 Methods used to assess impacts and calculate required mitigation actions:
- II.2 Types of mitigation proposed

Summary and Closing

Part I. Environmental Impacts on Natural Resources

I.1. Magnitude and irreversibility of environmental impacts

The impacts of mountaintop removal with valley fills (MTVF) are immense and irreversible, and there are no scientifically credible plans for mitigating these impacts. The process involves complete deforestation of a mountain summit, followed by blasting it with explosives to remove hundreds of meters of the mountain that cover the coal seam. The rocks and other 'overburden' are then pushed into valleys surrounding the site where they fill small streams. The valley fill which now sits on top of once forested streams is graded into a series of 'stair steps'; water that was once absorbed by the mountain soils and associated vegetation, now runs rapidly into the fill and exits at its base into larger streams.

The removal of vegetation from mined watersheds, and the alteration of valley contours on mined sites fundamentally alters the patterns of water flow through impacted valleys and changes how water is delivered to streams that are below the valley fill. It is important to understand that how water reaches a stream, and what that water has encountered as it moved toward the stream determine the quality of that water. Before they are destroyed by mountaintop mining, the steep, small streams receive most of their water from belowground (i.e., as groundwater) unless there has just been a heavy rain. This water arrives at the stream after infiltrating the ground around lush vegetation, soaking into the soil, and then moving laterally toward the stream (Fig. 1). As it moves through the soil, the water is purified and simultaneously enriched with nutrients that are necessary for the stream food web. Mining however removes hundreds of feet of soil, rock, and dead and living plant material. Even if the surface soils are stored and returned to the summit, the paths along which groundwater previously flowed to streams have been obliterated – the summit and its organic-rich layers of soils which harbor ecologically important communities of bacteria, fungi, and burrowing insects are no longer intact stratigraphically. In fact, water reaching the streams that are left at the bottom of valley fills comes from the fill itself which, as I describe later, is so polluted that entire groups of organisms can no longer live in it.

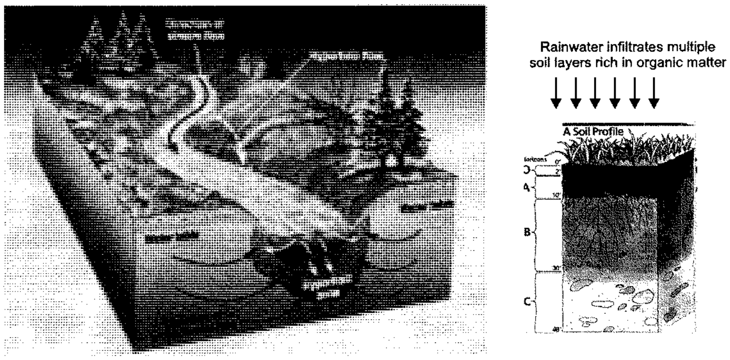


Fig. 1 Groundwater moves into healthy streams after passing through vegetation and rich soil layers.

There are now a number of peer-reviewed scientific studies documenting the fact that the hydrologic "regime" (source, timing, and amount of water flow) below mined sites is fundamentally altered. Since the flow regime is one of the key variables determining what types of fish, insects, and other aquatic organisms can live in a stream, even if the water coming out of valley fills could be purified before entering streams, the biological community will never be the same. Further, wildlife that were residents of the mined site are displaced or die and biota in the stream that was buried are killed.

I.2. Consequences of losing headwater streams

The streams that are buried by the valley fill are called headwater streams – they are those regions "where rivers are born" because their flow and associated biota, sediment, and dissolved constituents feed downstream waters – without headwaters, larger streams and rivers below lose the nourishment and source of clean water that fuels them.

Fig. 2 West Virginia streams.

In their healthy state, many headwater streams have visible surface flow only part of the year, but ecological processes important to the entire watershed occur within them year-round; when surface water is not visible, many of the biota including salamanders, insects and crustaceans reside below the streambed surface or in small pools under rocks that retain water. In fact, headwater streams are among the most diverse streams in the world in part because they can harbor some species that are unique (*i.e.*, the only place in a river network these species occur is in the headwaters). Headwaters also provide a refuge from predators and changes in temperature for some species, and are important spawning and nursery grounds for some others.

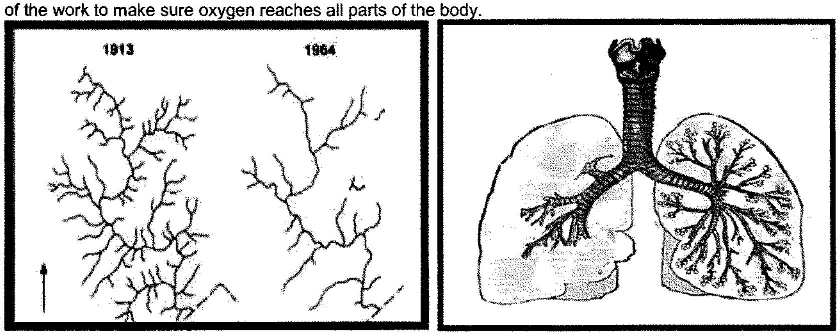
In addition to being biodiversity hotspots, there is abundant scientific evidence that headwater streams play roles disproportionate to their size in watersheds. They are critical to nutrient cycling, water purification, and organic matter processing that fuel downstream food webs. The small ephemeral and intermittent streams within the river networks are conduits that transport water, sediments and dissolved materials from mountain tops to large river ecosystems. Shallow headwater streams have high contact between water and sediments, and thus exceptionally high rates of nutrient and organic matter storage and processing. The biological communities in headwater streams import hard-to-digest plant material from forest products (leaves and sticks) and convert that material into high-quality fats and proteins (insects and salamanders) that are exported to downstream food webs.

I.3. Significance of cumulative impacts

It might seem intuitive to assume that because headwater streams are small, with only a few are filled each time a new mine is dug, that the overall impacts are not that significant. This is not the case. First, because the ecological importance of headwater streams is disproportionate to their size, they are critical to the health of watersheds. Second, it is important to understand that in the central Appalachian Plateau, the most significant changes in land use and land cover are related to surface mining of bituminous coal. This change is the single largest driver of land use change in this region today. To give you an example: in the Laurel Creek watershed in West Virginia more than 25% of the watershed by area is covered by surface mine permits, and 37% of the headwater streams (by length) intersect mines or valley fills. When you think about the fact that many counties across the U.S. are trying to limit land use change for development to 10 – 12% because water quality is so degraded beyond that point, it is hard to imagine those numbers for Laurel Creek – particularly because mountain top mining is far more destructive to the landscape than a new home or even a cluster of homes.

A useful way to think about the loss of headwater channels is to consider how analogous they are to the small passageways in the human lung. The capillaries accomplish most of the important work in exchanging gases between the respiratory and circulatory system; without them you would die. Indeed, when a person gets emphysema (like my mother), they begin to lose use of the small passageways and slowly suffocate. Small intermittent and ephemeral headwater channels function similarly in watersheds – they do much of the processing of source materials for delivery to sustain downstream ecosystems and ensure productive rivers. Remove too many of them and the system slowly dies (Fig. 3).

Fig 3. Watersheds have complex stream networks – the smallest branches called headwaters are responsible for a disproportionate amount of stream functions carrying nutrients and organic matter to larger streams and rivers. Similarly the capillaries surrounding the smallest branches of the lungs (alveoli) do most of the work to make sure oxygen reaches all parts of the body.



I.4. Extent of downstream water quality impacts

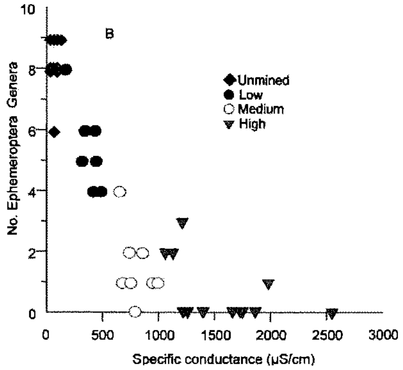
The fragmentation and exposure of mined rock to air and water results in high rates of rock weathering, which leads to increased concentrations of a number of chemical constituents in the stream water below fills. Some of these cause acute toxicity in aquatic life, but many of them cause chronic low level stress to organisms. The chronic stress from many chemicals adds up to serious problems for organisms. The high level of impairment found in streams below mining valley fills is because the additive impact of all this stress is simply too much for many species. Thus, it is the cumulative impact of elevated concentrations of multiple stressors that leads to biological impairment in these streams. By analogy, consider a person that smokes just a few cigarettes a day but is 75 pounds overweight and has very low level diabetes --- none of the stressors alone necessarily lead to death but together, the levels of physiological stress on this person are extreme and will shorten their lifespan.

Elevated conductivity from pollution by numerous ions. Water feeding larger streams emerges from the base of the valley fill and has elevated concentrations of sulfate, bicarbonate, calcium and magnesium ions, as well as often including elevated concentrations of multiple trace metals (aluminum, manganese, selenium) that are potent pollutants. The combined toxicity of multiple constituents leads to a loss of sensitive aquatic organisms even though downstream habitats are intact.

The exposure of coal seams during coal mining provides many opportunities for the leaching of sulfate (SO_4^{2-}) into surface waters. Mining-impacted streams in WV often have 30-40 fold increases in SO_4^{2-} concentrations (Brooks et al. 2002; Pond et al. 2008) with 13 streams in the 2009 WVDEP database having SO_4^- concentrations higher than found in seawater (>2717 mg L^{-1}). Studies have shown that sulfate concentrations continue to increase even after mining ceases. The relationship between mining activities and high sulfate concentrations is so well established that the 2008 WVDEP West Virginia Integrated Water Quality Monitoring and Assessment Report suggested that SO_4^{2-} concentrations >50 mg L^{-1} could be used as an indicator of mining activity. *Why is this a problem?* Elevated sulfate concentrations stimulate stream bacteria to produce sulfide that is directly toxic to plants and many organisms. High sulfate concentrations also interfere with nutrient cycling in streams.

Other ions that enter the streams below valley fills, including magnesium, calcium, and bicarbonate, lead to very elevated levels of suspended solids and conductivity; as noted earlier, trace elements like aluminum and selenium are also elevated and the latter is so serious that I devote an entire section to it.

The cumulative, or additive effect, of all the constituents leads to biological impairment in waters below valley fills. A group of insects well known to those who love to fly fish are the mayflies – they are considered good indicators of water quality because they are not very tolerant to pollution. The number of species of mayflies you find in streams declines as mayflies you find in streams declines as pollution increases. Since conductivity is a good indicator of water pollution below valley fills, many studies have examined mayfly diversity and abundance in valley fill streams (Fig. 4). Typical conductivity levels in West Virginia streams range from 13 – 253 µS/cm while valley fill streams can reach >2500. Recent studies by Hartman et al. (2005) and Pond et al. (2008) compared water quality between paired reference and valley fill impacted streams and found that specific conductivity in the filled sites was at least twice as high as in the reference streams.



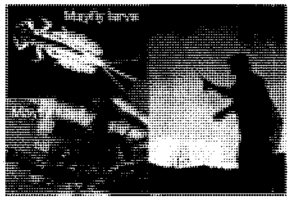


Figure 4. Number of sensitive insect (mayflies) groups (genera) as a function of stream conductivity in West Virginia streams with different levels of mining impact. Mayflies are widely recognized by the scientific and management community as indicators of water quality. From Pond et al. (2008). "Downstream effects of mountain top coal mining." Journal of the N. American Benthol. Society. 27:717-737.

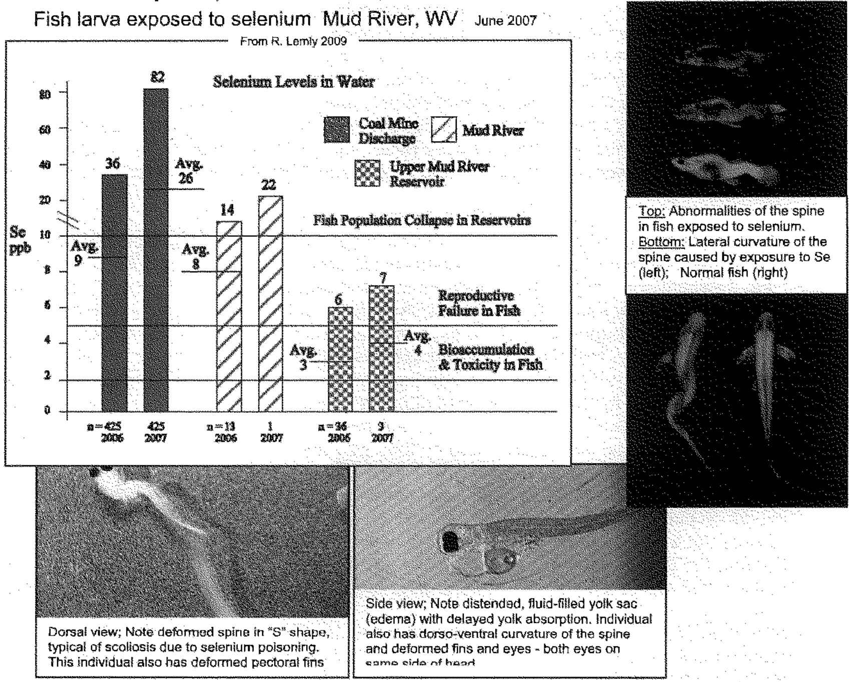
The finding that entire groups of insects – and not just mayflies -- are nearly eliminated in MTM streams is not a good finding for West Virginia water ways, particularly because the poor water quality with high conductivity and high sulfates can persist long after mining activities cease. The West Virginia Department of Environmental Protection has found that 86% of the mountain streams in their database with conductivity > 500 µS/cm were scored as impaired using the genera based GLIMPSS index.

<u>Selenium (Se) and water quality</u>. The water quality of streams below mountaintop removal mining sites is a serious issue, because when Se enters the aquatic food web it can reach levels that are toxic to fish and wildlife, such as birds. Selenium occurs naturally in coal. It is leached out from coal and overburden that fills valleys when they are exposed to air and water. Professor Dennis Lemly of Wake Forest University, who is a world expert on selenium and its ecological impacts, has completed numerous studies and a white paper he wrote on the topic was submitted as part of this hearing. I refer you to this paper for details, but describe the seriousness of the issue very briefly here. Because selenium can be bioaccumulated in the tissue of organisms, even small quantities in the water can lead to major problems for organisms: as you move up the food chain, Se is concentrated more and more and can cause severe abnormalities, death, or reproductive failure (Fig. 5).

We know that this is a major problem in Appalachian streams impacted by mountaintop mining, because a major environmental impact study was completed in 2005 by four federal agencies and the West Virginia DEP (EPA 2005). Over 1200 stream segments were examined, finding that the valley fills used for waste disposal are a primary source of selenium contamination. Because of the size and placement of these fills, selenium leaching and associated pollution of downstream aquatic habitats, left untreated, will continue in perpetuity. Further, Dr. Lemly's studies since this EIS have shown that effluent from a mountaintop removal operation in West Virginia had as much as 82 ug/L selenium –

an amount that is over fifteen times the threshold for toxic bioaccumulation. Thus, selenium is a real and immediate risk for wildlife.

Figure 5. Selenium in discharge from a mountaintop removal coal mining operation in West Virginia polluted downstream receiving waters to levels that far exceed toxic thresholds for fish (from Lemly 2008). The maximum concentration (82 ug/L) is over fifteen times the threshold for toxic bioaccumulation. Selenium causes fish deformity and reproductive failure.



Top: Abnormalities of the spine in fish exposed to selenium. Bottom: Lateral curvature of the spine caused by exposure to Se (left); Normal fish (right)

Dorsal view; Note deformed spine in "S" shape, typical of scoliosis due to selenium poisoning. This individual also has deformed pectoral fins

Side view; Note distended, fluid-filled yolk sac (edema) with delayed yolk absorption. Individual also has dorso-ventral curvature of the spine and deformed fins and eyes - both eyes on same side of head

Part II. Scientific Feasibility of Mitigation

II.1 Methods used to assess impacts and calculate required mitigation actions

In order to obtain a permit, companies proposing a new mine site must thoroughly evaluate the existing water resources, estimate the impacts quantitatively, and propose actions to mitigate for these impacts. Streams and impacts to them can be characterized in two ways: structurally and functionally. The distinction between the two characterizations is key to serious scientific concerns about current and past comprehensive mitigation plans, as well as, impact assessment requirements by the U.S. Army Corps of Engineers.

Structural measures evaluate the ecological state at a point in time while functional attributes describe how the system is performing over time. Examples of ecological structure include channel shape, habitat features, and the number of species found in one sampling trip. Functional measures describe ecological processes and rates such as the input of organic matter over time, the rate of growth of organisms, or the nutrient cycling capacity. Both types of measures are important, yet mitigation plans do not directly measure ecosystem function; instead, almost all plans are based on a single "snapshot" measure of structural traits like channel shape, water depth, and number of insects. Functional measures represent system performance; not measuring them to evaluate the health of a stream that is to be destroyed (and thus has to be mitigated for) would be like our doctor only measuring our height and weight and never taking our blood pressure or heart rate.

Those performing assessments of sites to be mined or receive permit applications have argued that measuring ecological functions is too hard, yet aquatic ecologists do it all the time. I even employ high school students to assist with this work, and we do it on many streams using a very small annual research budget. In fact, the second edition a text book is now out with a chapter devoted to each method and there are many examples in the literature of streams that have been assessed using this method. The reason that scientists are concerned about the inadequate assessments that are being completed on these sites, is that the roles these small streams play in nature is vastly underestimated without these measures. Healthy streams are living, functional systems not simple channels that can be described based on their size and shape.

Because ecologically valuable headwater streams will be permanently destroyed, all mitigation plans should address the ability of enhanced or restored streams elsewhere to replace the functions performed by the lost headwater streams, yet this is not done. Further, the Clean Water Act stipulates that all natural resource and ecological functions that are lost must be replaced. Thus, a clear emphasis has been placed on functionality.

Mitigation projects are typically monitored for 5 to 10 years after completion. The required monitoring suffers from the same short falls – failure to measure stream functions. In addition, while the burial of streams is permanent many stream enhancement projects will be of short duration. Thus, monitoring of 5-10 years will miss the temporal differences between impacts and the mitigation intended to offset them.

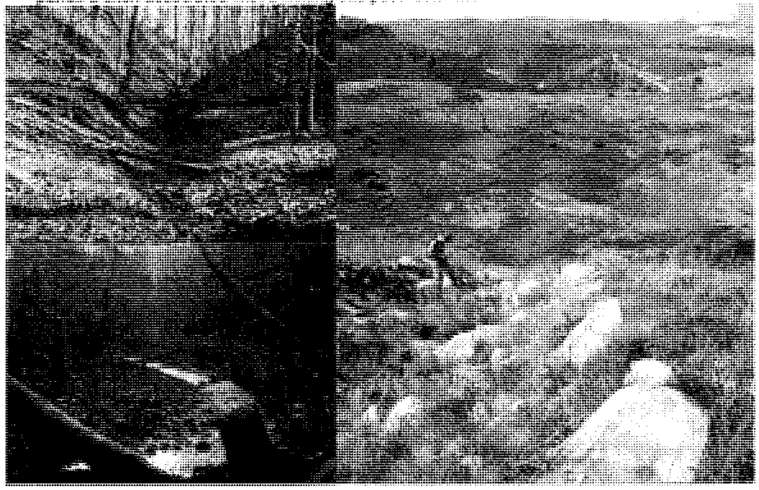
11.2 Types of mitigation proposed

Permits to fill "waters of the U.S." may be granted by the U.S. Army Corps of Engineers based on 'rendering the impacts non-significant', because mitigation actions are proposed to replace lost aquatic resources and ecological functions. Proposals for compensatory mitigation to replace losses when headwater streams are buried by the mining activities may occur through a variety of actions, but generally fall into two categories: stream creation and stream restoration or enhancement.

Stream creation. This is a process where attempts are made to create a stream by excavating a ditch and placing structures like boulders and rocks into the channel. These are meant to replace the headwater streams that are buried by mining overburden. These creation attempts are often undertaken on or near a valley fill and they usually rely on the fill or mined area for their waters source.

Even if a channel can be constructed to convey water below a valley fill, they will not have the energetic base, thermal or flow regimes to support the native aquatic community. The energetic basis of the stream food web of mountainous Appalachian streams is leaf litter from the surrounding trees. For most of the year, bacteria, fungi and aquatic insects consume the leaves and wood that fall or are washed into the stream from the surrounding forest. Constructed streams on or below valley fills are in high light environments, with early vegetation consisting primarily of short-stature grasses. With abundant light, algal production is likely to be high, and with the open canopy, temperatures may reach levels that native fauna can not acclimate to. Thus, while an un-impacted mountain stream ecosystem in the Appalachian region is fueled by leaf litter from the surrounding forest, the created streams will be fueled by algal production. Without a forest canopy, water temperatures in the constructed streams will be significantly hotter in summer and significantly colder in winter than in the forested streams.

Fig. 6: left panels: an intermittent headwater streams during dry periods and after rains; right panel: a ditch associated with a mining site post reclamation.



The process of attempting to create a stream in association with a mountaintop coal mine typically involves: re-grading mined land and digging a channel with a particular shape, width, and depth that is selected from a stream channel classification system originally developed in the western U.S. This shape is not necessarily even similar to what existed prior to the mining activities; more importantly, what surrounds a new ditch and how water reaches the ditch bear no resemblance to intact headwater streams in the Appalachians. Due to the mountaintop removal and valley fill activities, all of the natural water flow paths, the landscape topography, the vegetative inputs to streams, the riparian soil and the streambed biogeochemistry are different or totally absent.

There is not a single case in which a channel built in this manner has resulted in a healthy stream with the biota and functions of un-impacted headwater streams. No study has ever produced any evidence that created streams at these sites have hydrological and ecological dynamics that are similar to the high gradient headwater streams they are meant to replace. Stream creation is simply outside the current scope of accepted science. Ditches may be built to convey water but streams are living systems – far more than rock lined ditches. Creating ecologically healthy streams in places where the natural groundwater and surface water flow paths are so altered, and the landscape and vegetation so impacted, has not ever been accomplished - yet permits are being given for this activity. Stream "creation" is certainly not considered a form of ecological restoration. Stream restoration varies along a continuum from simple projects like planting riparian trees along streams, to re-shaping channels and even sometimes re-routing a section of a channel. But that is very different from trying to make a fully-functioning, living stream some place that it did not previously occur.

Stream restoration. Restoration or enhancement of degraded streams in areas adjacent or contiguous to the mining site typically involves stabilizing a streambank, re-shaping a channel, or replanting riparian vegetation. Enhancement and restoration actions are typically applied to perennial streams, even if the streams that are lost due to mining are ephemeral or intermittent.

Proposals to mitigate by restoring or enhancing degraded perennial streams off-site can not mitigate for the loss of ephemeral and intermittent streams. The unique biota, distinctive high gradient profiles, and irregular flows of these small streams generate ecological conditions that can only be found on the very steep sides of intact mountain summits. In particular, the intermittent nature of flow contributes to the evolution of diversity, the support of unique species, and heightened rates of particular biogeochemical processes with watershed wide consequences.

Summary and Closing

In conclusion, Mr. Chairman and fellow Senators, mountaintop removal mining with valley fills causes permanent environmental impacts. The mountain summits that are removed to reach the coal may not have the same shape or height they previously did, the streams that are buried when rocks and dirt are dumped over the side of the mountain into the valleys below are gone forever, and there is no evidence to date that mitigation actions can compensate for the lost natural resources and ecological functions of the headwater streams that are destroyed. Further, the water quality impacts from the mining and valley fills permeate downstream such that many streams not directly touched by the mining activities are biologically impaired. Selenium levels measured in streams below valley fills are as high at levels known to cause major deformities, toxicity, or reproductive failure in fish. Conductivity levels in some streams below valley fills are like seawater. Fish in rivers and reservoirs below fills have deformities and reproductive failures due to selenium exposure. Scientific studies in well respected journals document these impacts, and there is not a single study in the peer-reviewed literature providing evidence that streams created for mitigation replace the functions and structures of natural headwater streams.

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Mountaintop Mining Valley Fills and Aquatic Ecosystems: A Scientific Primer on Impacts and Mitigation Approaches

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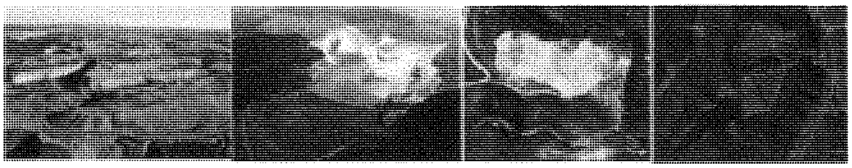

To protect your rivers, protect your mountains. --Emperor Yu of China, 1600 B.C.E.

EXECUTIVE SUMMARY

Mountaintop mining and valley fill (MTVF) operations have both local and regional effects on aquatic ecosystems. The effects are described in brief here along with key points (bullets) from scientific studies published in peer-reviewed journals.

I. Watershed and Stream Alteration by Mountain Top Mining

The topography and the hydrology of mountain top mined watersheds are radically altered – valley contours are flattened and precipitation is routed through rock lined ditches on the surface or percolates through fill material. Even after reclamation, the vegetation is dramatically different. The alteration in topography persists forever and it will take centuries to reestablish the soils and forests that were historically present. The impacts of mountain top mining are more severe than other land use changes within these watersheds (e.g. clear cutting, residential development) because they are immense in scale and lead to irreversible alterations of watersheds. In fact, a 1999 study singles out mountaintop mining and valley fills in West Virginia and adjacent states as the greatest contributor to earth moving activity in the United States[1].

- The Office of Surface Mining reports that as of 2004 more than 1.1 million acres of land in northern and central Appalachia were undergoing active mining operations.[2] In 2009, the dominant driver of land cover land use change in this region remains surface mining and reclamation.[3]
- Numerous studies show that when impacts to watersheds exceed about 10% by area, biodiversity and water quality in their streams decline[4] yet some watersheds in West Virginia have more than 25% of their area covered by surface mine permits.

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[1] Hooke 1999
[2] Loveland et al. 2003
[3] Townsend et al. 2009
[4] Yaun and Norton 2003; Allan 2004; Morgan and Cushman 2005

II. Structure and Function of Headwater Streams

Small streams like those buried by valley fills are biological hotspots: The Mountaintop Mining Environmental Impact Statement found that in 2002 more than 1200 miles of stream channels had already been buried by valley fills or directly harmed by mining. Later studies by the Office of Surface Mining found that from October of 2001 to June of 2005, mining permits impacted yet another 535 miles of streams nationwide and approximately 2/3 of those impacts were from valley fills. Some watersheds have been particularly hard hit by mining activities. For example, in the Laurel Creek of the Big Coal River in WV, 28% of the *total* stream length have been buried beneath valley fills or impacted by surface mines. Loss of this magnitude mean some downstream reaches may be permanently impaired. In addition to the localized destruction of individual stream reaches, many thousands of miles of downstream reaches have been impacted by the resulting sediment and chemical pollutants that are transmitted throughout the river network.

This represents not only a significant loss of a treasured natural resource but loss of ecosystems that are critical to the provision of water that is clean and abundant in supply to the larger downstream streams and rivers. The headwater streams of the southern Appalachians are also a biodiversity hotspot, supporting hundreds of species (some unique to these smallest of streams) that require stream habitat for all or part of their life cycle. The organisms living within headwater streams are well adapted to habitats with large fluctuations in flow and populations persist through occasional droughts and floods within stream sediments and isolated pool habitats. Despite their resilience to fluctuating flows, these organisms are not adapted to the dramatic changes in water chemistry that result from valley fills. In particular, the diverse historic assemblages of salamanders and mayflies are lost from polluted streams.

- Loss of headwater streams impacts hydrologic processes, chemistry, and stream biota in downstream waters.[5]
- Stream structure and function are both impacted by mountain top mining. Structural attributes include biodiversity, habitat, and channel properties while functional attributes include all those ecological and hydrogeomorphic processes that support healthy headwater streams.[6]
- Headwater streams support unique and ecologically important species including insects, fish, and salamanders.[7]
- Ephemeral and intermittent streams support diverse plants and animals and contribute to critical biogeochemical processes. Many ephemeral and stream organisms live in the streambed substrate and thus even when surface water is not running many species depend on these small streams.[8]

Ecosystem Functions within the River Continuum: In addition to serving as habitat or feeding-ground for a unique and diverse assemblage of organisms including salamanders, insects, fish and larger wildlife, the ephemeral and intermittent streams within the river network are conduits that transport water, sediments and dissolved materials from mountain tops to large river ecosystems. Shallow headwater streams have high contact between water and sediments and thus very high rates of nutrient and organic matter storage and processing. The biological communities in headwater streams import low-quality lignin and cellulose forest products (leaves and sticks) and convert that material into high-quality fats and proteins (insects and fish) that are exported to riparian and downstream food webs.

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[5] Wipfli et al. 2007
[6] Hauer and Lamberti 2006; Fischenich 2006; Palmer and Richardson 2008
[7] Meyer et al. 2007
[8] Stout and Wallace 2003; Davic and Welsch 2004; Meyer et al. 2007

- Important ecosystem functions performed in ephemeral, intermittent, and perennial headwater streams include the purification of water, removal of excessive nutrients and sediments before they reach downstream waters, processing of organic material and primary and secondary productivity.[9]
- Surface waters on reclaimed mines or along valley fills have year round high light availability, altered thermal regimes and reduced organic matter inputs.

III. Water Quality Impacts of Valley Fills

Pollutants added to ephemeral and intermittent stream channels will be transported downstream to larger rivers. The more surface mining and valley fill activity within a large watershed, the greater the cumulative transport of alkaline mine drainage pollutants to major rivers will be. The streams and rivers below valley fills receive alkaline mine drainage that include highly elevated concentrations of sulfate, bicarbonate, calcium and magnesium ions and which often include elevated concentrations of multiple trace metals. The combined toxicity of multiple constituents results in significant increases in conductivity and total suspended solids below valley fills. This decline in water quality leads to a loss of sensitive aquatic organisms even when downstream habitats are intact. The resulting high conductivity and high sulfates can persist long after mining activities cease and scientists have found no empirical evidence documenting recovery of macroinvertebrate communities in the streams impacted by alkaline mine drainage. The water quality impacts of MTMVF activities are more severe and more persistent than other land use changes within the southern Appalachians.

- Streams impacted by MTVF often have 30-40 fold increases in sulfate concentrations and sulfate concentrations in receiving waters continue to increase after mining activities end.[10] High sulfate concentrations can lead to impacts on aquatic organisms and ecosystem functions.
- Ions of calcium, magnesium, and bicarbonate increase dramatically in the waters so that electrical conductivity levels and total suspended solids in receiving streams below fills can be extremely high ("alkaline drainage syndrome"). Trace elements of iron, aluminum, zinc, and selenium are often elevated as well.[11]
- The cumulative effect of elevated levels of all these ions is highly correlated to biological impairment in streams below MTVF. Functionally important aquatic biota are sensitive to ionic stress which disrupts water balance and can cause stress or death.[12]

Typical mitigation projects do nothing to reverse the severe ecological consequences of the water quality impacts downstream from large scale surface mining operations.

IV. The Potential for Mitigating Watershed Scale Destruction

Mitigation for the loss of streams from valley fills generally includes offsite enhancement of streams structurally or onsite attempts to 'create streams' on or near valley fills by digging ditches and sculpting rocks in an artificial channel. However, there is no evidence that structural approaches like these that focus only on channel form e.g. creating artificial channels in former drainage ditches or channel manipulations and placement of instream structures, will lead to the recovery of the ecological functions that are lost by the valley fills. In addition, mitigation projects not only fail to address stream function but also fail to use generally accepted scientific protocols when using structural measures.

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[9] Baron et al. 2002; Hauer & Lamberti 2006; Fischenich 2006, Palmer & Richardson 2008

[10] Sams and Beer 1999; Brooks et al. 2002; Pond et al. 2008

[11] WVDEP database (see figures 3.2 and 3.3.); Brooks et al. 2002

[12] Goetsch and Palmer 1997, Chadwick et al. 2002, Kennedy et al. 2003, Kefford et al. 2003, Hassell et al. 2006; Pond et al. 2008

While mining companies are attempting to construct new stream channels in reclaimed mine lands, there are no examples of successful creation of streams in any setting. Any claim that the structure and function of high gradient, forested headwater streams could be recreated in the flat grasslands of a reclaimed mine is thus highly suspect. Even if channels are constructed with high quality habitat, the routing and timing by which rainwater and groundwater are delivered to these channels will be highly altered. As a result the channels are likely to be filled with waters polluted by alkaline mine drainage (resulting from subsurface flows through mining fill) or to flow only during major precipitation events. In either case, there is little reason to expect that these constructed channels would support the diverse fauna of Appalachian headwater streams or that they would even approximate the energetic and nutrient transport processes of the streams they are meant to replace.

The efforts proposed to mitigate for the permanent loss of streams buried under valley fills by enhancing other streams cannot replace the ecological functions or unique biota lost. These projects typically target perennial streams while fills are usually in ephemeral and intermittent streams. While stream functions take place in perennial streams, they do so at different rates and in different ways than those occurring in ephemeral and intermittent streams and the smallest streams harbor some species that are not found in perennial reaches. Also mitigation projects like those proposed by mining companies may produce only short term benefits while the valley fills represent a permanent loss of habitat and function from the river network. This represents an important temporal mismatch between valley fills and attempts to mitigate for the streams that are buried.

- Mitigation plans associated with mountain top mining have not used available methods for directly measuring ecological functions yet these processes must be measured in order to determine how and whether they may be brought back to the right levels and direction through mitigation. There are abundant scientific studies outlining how to make and interpret such measurements and how they can be used to evaluate a restoration project.[13]
- Mitigation plans propose stream creation to offset loss of streams that are buried but stream creation is beyond the realm of current science. Out of over 38,000 projects in the most comprehensive database of restoration there is not a single example in which building streams de novo has been shown to be successful.[14]
- Most mitigation plans that include stream enhancement or restoration are based on a morphological approach to stream restoration that has been extensively criticized in the scientific literature because of its failure to promote ecological recovery.[15]
- Restoration or enhancement of existing perennial streams cannot replace or compensate for the habitat or the unique functional role of lost ephemeral and intermittent streams.
- Mitigation based on diverting flow to sediment ditches will not replace stream function. Successful restoration requires that key processes and linkages beyond the channel reach be considered.[16]
- Mitigation approaches fail to include any mechanisms that will reduce the export of ions and trace metals from mined sites yet these are known to be associated with impaired aquatic biota even after mining activities cease.[17]

END OF EXECUTIVE SUMMARY

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[13] e.g., Peterson et al. 2001; Gessner and Chauvet 2002; Hauer and Lamberti 2006; Buckveckas et al. 2007; Roberts et al. 2007

[14] Bernhardt et al. 2005, Palmer et al. 2005

[15] Gillilan 1996; Shields et al. 1999; Kondolf et al. 2001; Juracek & Fitzpatrick 2003; Niezgoda & Johnson 2005; Smith& Prestegaard 2005; Slate et al. 2007; Simon et al. 2007; Roper et al. 2008

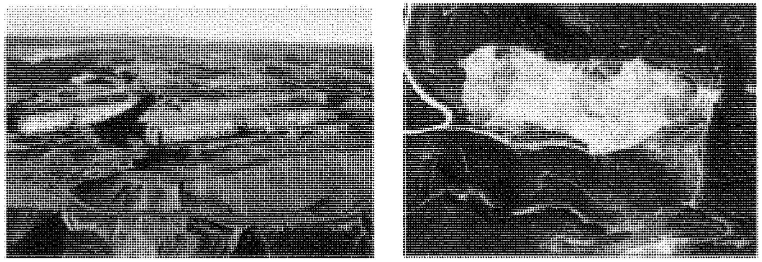
[16] Sear 1994; Stanford et al. 1996; Graf 2001; Palmer et al. 2005

[17] Pond et al. 2008

I. Watershed and Stream Alteration by Mountain Top Mining

Mountain top mining and valley fill operations (MTVF) have both local and regional effects on aquatic ecosystems. The most obvious impact of MTVF operations are the local destruction of stream segments that are buried beneath valley fills and the loss of streams that are converted to waste treatment systems in the form of ponds at the base of fills. Streams which have been filled no longer exist – thus MTVF leads to a net loss of stream habitat and stream and riparian ecosystem functions in the watersheds in which it occurs. In addition, the impacts of MTVF operations have far reaching downstream impacts through the export of sediments and dissolved substances (solutes) from mined watersheds. Further the removal of vegetation from mined watersheds, and the flattening of valley contours on mined sites fundamentally alter the patterns of water flow through impacted valleys and changes the delivery of water to larger receiving streams.

Figure 1.1: Photos of MTVF



(A) A view of a mountain top operation rock face. (B) An aerial view of a completed mining

The total amount of land impacted by surface mining has been growing as the price of energy has continued to rise in the U.S. As of 2004, the Office of Surface Mining reported that more than 1.1 million hectares of land in northern and central Appalachia were undergoing active mining operations (Loveland et al. 2003). Indeed, the most significant changes in land use and land cover in the central Appalachian Plateau were related to surface mining of bituminous coal (Loveland et al., 2003) and today, the dominant driver of land cover land use change in this region remains surface mining and reclamation (Townsend et al. 2009).

Table 1.1 Examples of cumulative impacts in two West Virginia watersheds (12 digit HUC)

Watershed (area)	% by area covered by surface mine permits	% including pending permits	% of 1st order stream length intersecting permitted mines or valley fills
Cabin Creek (22, 518)	25.6%	29.1%	32.1%
Laurel Creek (31,519)	26.5%	28.6%	37.3%

Data from several watersheds (12 digit HUC) in West Virginia provide an example of the size of impact (**Table** 1.1). This level of watershed alteration (even when the land is reclaimed) has significant impacts on receiving stream ecosystems. In fact, the impacts of mountain top mining are more severe than other land use changes within these watersheds (e.g. clear cutting, residential development) because they are immense in scale and lead to irreversible alterations of impacted watersheds The process of mining includes removing all vegetation, blasting or digging soil and rocks to reach the coal seams and moving this 'overburden' into valleys to form fills. Once filled, streams are completely destroyed and those streams remaining below the fills are impacted significantly (fully described in Part III below). The reason that the mountain-top mining has impacts that extent well beyond the immediate blast and fill areas is that as low-lying points on the landscape, streams integrate the effects of all activities within the watershed above them. In fact, the single best predictor of stream water quality to date is what fraction of a watershed is impacted (Yuan and Norton 2003; Allan 2004). The most current and quantitatively intensive work by Bunn and colleagues (2009) reinforces previous findings. They studied 53 streams in 15 major catchments comparing over 50 approaches to find indicators of stream ecosystem health and show that watershed impacts explained 73% of the variability in native fish species diversity. These analyses show that the single most important predictor of stream biotic communities are watershed attributes rather than local habitat. Many studies to date have shown that when impacts to watersheds exceed about 10% of the watershed area, there can be dramatic declines in aquatic biodiversity and water quality (Allan 2004; Booth et al. 2004; Morgan and Cushman 2005; Moore and Palmer 2005).

The significance of this type of research for MTVF is that: 1) cumulative land impacts within a watershed are extremely important to the ecological health of streams; 2) small scale mitigation, restoration and enhancement efforts are insufficient to offset watershed scale degradation.

Mechanisms by which mining leads to cumulative impacts. Three fundamental scientific principles are critical to understanding why cumulative impacts of MTVF on downstream aquatic resources are so important. First, changes at the watershed scale influence stream hydrology throughout the catchment (Brooks 2003). The timing and magnitude of stream flows result from complex interactions between rainfall, plants, topographic relief, and soil properties of all land above a drainage point (Tong and Chen 2002). Once vegetation is lost as occurs on mined and even reclaimed mine land, hydrological changes that negatively impact stream biota and water quality ensue (Simmons et al. 2008; Ferrari et al. 2009). Second, stream water chemistry is shaped by processes that occur as rainwater infiltrates the ground and moves through pore spaces and soil on its way to streams (Allan and Castillo 2007). Microbial processes between the water, soil, and rooted vegetation lead to biochemical transformations that influence water quality. Not only are these processes fundamentally altered by the dramatic land disturbance at mined sites but water emerging from valley fills carries with it dissolved constituents that are toxic or damaging to biota (discussed extensively in section III below). Third, downhill movement of water and one-way flow in stream networks means that whatever happens on land or in 1st and 2nd order streams (headwaters) not only determines sediment and water flow in streams and rivers below but also determines ecological structure and functions of larger waterways (Allan and Castillo 2007).

In short, MTVF within a watershed can directly destroy local stream reaches through filling or can degrade downstream reaches by altering the magnitude, timing and composition of water flow.

II. Structure and Function of Headwater Streams

Ephemeral, intermittent or perennial streams that are buried beneath valley fills represent a significant natural resource loss. As *headwater* streams they represent the points "where rivers are born" (*sensu* Meyer et al. 2003) because their flow and associated biota, sediment, and dissolved constituents feed all downstream waters. Any major changes affecting headwater tributaries or any activity that isolates or cuts off these tributaries from the lower part of the watershed will have profound consequences for hydrologic processes, sediment delivery, channel morphology, biogeochemistry, and stream ecology further downstream in the watershed which is why their loss due to mountain top mining is of such concern (Wipfli et al. 2007).

What's the difference between ecological structure and function? Streams and impacts to them can be characterized in two ways: structurally and functionally. Because the concept of ecosystem structure and function is so central to assessing MTVF impacts and mitigation (ENDNOTE) we provide a brief overview here. *Structural measures* evaluate ecological state at a point in time (Table 2.1) while functional attributes describe how the system is performing over time (Table 2.2). Examples of ecological *structure* include channel form, habitat features, and number of species; these are typically evaluated at a point in time and are dimensionless (e.g., number of species at a site, ratio of channel width to depth, index of biotic integrity) or are expressed along one dimension (e.g., channel depth in cm, number riffle habitats/100 m).

TABLE 2.1 COMMON STRUCTURAL ATTRIBUTES OF STREAMS

Structural Attribute	**Examples**	**Measurements required**	**Role**
Biomass	Algal, Plant, Insect, Fish, etc.	Mass/area; Collect, dry and weigh.	Food for higher trophic levels; Important in photosynthesis and secondary production.
Biodiversity	Diatoms, Invertebrates, Fish, Amphibians, Riparian Vegetation	# Species per unit length or area of stream (species richness), Index of Biotic Integrity, EPT taxa, Shannon-Weiner Index etc.	Many species valued in themselves but loss of biodiversity may result in loss of function and eventually collapse of ecosystems (see text)
Habitat	Pools, Riffles, Substrate types, Riparian vegetation, Woody Debris	Presence/absence or # per unit length of stream	Structure for reproducing, feeding, escaping predation, may enhance flow complexity.
Geomorphic metrics	Ratios: Riffle:Pool, Width:Depth, Sinuosity, Slope, Particle size and heterogeneity, Depth of Hyporheic Zone, Bankfull bench	Measured during stream walks, Photographs, or Surveying equipment	Provides the template or "vessel" for water [flow], influences turbulence and other aspects of flow and sediment transport
Hydrologic metrics*	Water stage (depth), Wetted channel perimeter, Bankfull stage, Peak Discharge events,	Stage recorder or staff, rulers, survey equipment, visual estimate of bankfull bench	Delivers food and oxygen to biota, disperses young and adults, transports waste products; Reproduction often tied to annual flow

*hydrologic metrics can be considered functional metrics if there is a time series of measurements. E.g., an annual hydrograph is developed using gage or pressure transducer data.

Functional attributes describe processes and rates and thus they are expressed per unit time (e.g., discharge in ft^3/sec, photosynthesis in umoles/meter^2/sec). Sometimes functional measures are expressed in a dimensionless fashion (e.g., ratio of photosynthesis to respiration) but the important point is that they still describe some process that characterizes 'how the system is performing' not just 'how the system is'. Measurements of ecological functioning evaluate dynamic properties of ecosystems that underlie an ecosystem's ability to provide vital goods and services (Gessner and Chauvet 2002). Functions reflect system performance and their measurement requires quantification of ecological processes over time such as primary production or nutrient uptake. The scientific literature on ecological functions is now quite extensive and while different words may be used by different people, there is broad agreement among the scientific community that the primary ecological functions of healthy streams include: the purification of water, the removal of excessive levels of nutrients and sediments before they reach downstream waters, the processing of organic material (decomposition or biological utilization), and primary and secondary productivity (growth of photosynthetic organisms and consumers) (Baron et al. 2002; Hauer and Lamberti 1996, 2006; Fischenich 2006, Allan and Castillo 2007; Palmer and Richardson 2008). These functions are supported by ecological processes (sometimes also called functions) including: the normal flux of water, the processing of nutrients at the same rate and form as unimpacted streams, the decomposition of organic matter at rates typical of nearby unimpacted streams, and, microbial, primary and secondary production the same as healthy streams (Palmer et al. 1997; Naiman et al. 2005).

TABLE 2.2 ECOLOGICAL FUNCTIONS OF HEADWATER STREAMS

Ecosystem function	**Ecological Process that supports this**	**Measurements required**	**Without it what happens**
Water Purification a) Nutrient Processing	Biological uptake and transformation of nitrogen, phosphorus	Direct measures of **rates** of transformation of nutrients; for example: microbial denitrification, conversion of nitrate to N_2	Excess nutrients can build up in the water making it unsuitable for drinking or to support life
Water Purification b) Processing of contaminants	Biological removal of materials such as excess sediments (e.g., removed by riparian plants) or toxins (taken up by plants or microbial processes that moving them from the water)	Direct measures of contaminant flux (e.g., the movement of sediment into and down streams). This is a **rate.**	Toxic contaminants kill biota; excess sediments smother invertebrates (kill them), foul the gills of fish (kill them), etc; water not potable
Decomposition of organic matter (organic matter processing)	The biological (mostly by microbes and fungi) degradation of organic matter (could be leaf material or other input such as sweater or organic wastes)	Decomposition is measured as a **rate**. Usually expressed as the slope of a line showing weight loss over time of organic matter heated to high temperatures to convert the particulate carbon to gas (CO2)	Without this, excess organic material builds up in streams, leading to low oxygen levels which leads to death of invertebrates and fish and the water is not something anyone would want to drink
Production (Primary = algae & aquatic plant; Secondary = growth of organisms like insects, fish, etc	Measured as a rate of new plant or animal tissue produced over time	Primary - measure the **rate** of photosynthesis in the stream; for secondary, you measure growth rate of organisms	Primary production supports the food web; secondary production (fish) we often eat or it (inverts) supports fish.
Temperature Regulation	Water temperature is "buffered" by sufficient infiltration in the watershed & riparian zone AND shading of the stream by riparian vegetation.	Measure the **rate** of change in water temperature as air temperature changes or as increases in discharge occur.	If water infiltration or shading reduced (e.g., via clearing of vegetation), water heats up beyond what biota are capable of tolerating
Flood Mediation/Control	Slowing of flow from land to streams so flood frequency and magnitude reduced; intact flood-plains buffer increases in flow; flow spreads out over floodplain & energy absorbed; also healthy riparian vegetation in the watershed increases infiltration into soils & uptake of water by plants before it reaches the stream	Measure the **rate** of infiltration of water into soils OR discharge in stream in response to rain events (discharge = **rate** of water flow measured in volume per time...m^3/sec)	Without the benefits of floodplains, healthy stream corridor and watershed vegetation you see increased flood frequency and flood magnitude
Biodiversity support	All of the processes above contribute to the maintenance of biodiversity. For example, primary production and the flux of organic materials into streams help support diverse living assemblages	Measure the number of species and how abundance varies among them; this function is not a rate per se but because it is critical to the support of all other functions, it is included in the table.	Headwater streams support extremely **high** biodiversity and many rare species that contribute food for higher trophic levels and help maintain functions such as organic matter processing

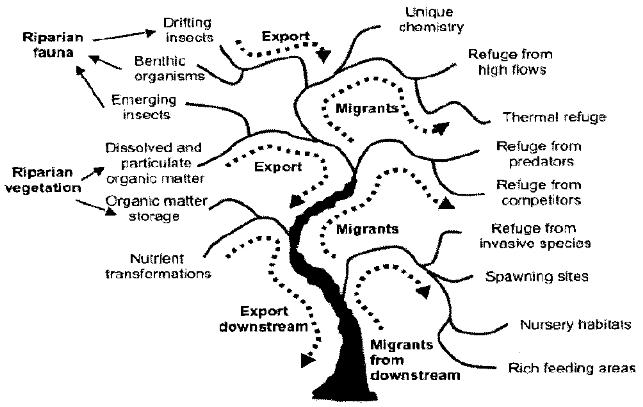
Headwater streams (ephemeral, intermittent, or perennial) that are buried or degraded by MTVF represent a major loss from a structural and functional perspective. The role of headwater streams in supporting high levels of biodiversity has been emphasized in a great deal of scientific research (Lowe and Likens 2005; Meyer et al. 2007). These small streams provide habitats for a rich array of species, which enhances the biological diversity of the entire river system. Some of the species are unique – i.e., the only place in a river network these species occur is in the headwaters (Erman and Erman 1995; Stout and Wallace 2003). They also provide a refuge from predators and changes in temperature for some species (Franssen et al. 2006) and are important spawning and nursery grounds for some species.

Meyer et al. (2007) provide the best review of biodiversity in headwater streams citing over 150 peer-reviewed papers (Fig. 2.1). They also provide a succinct summary of why headwater streams rich in biodiversity are important along with citations of the supporting scientific studies including:

- Headwaters Support Many Species That Occur Nowhere Else in the River System
- Headwaters Provide Unique and Highly Diverse Physico-chemical Habitats
- Headwaters Provide a Refuge from Predators
- Headwaters Provide a Refuge from Competitors
- Headwaters Provide a Refuge from Alien Species
- Headwaters Are Essential for Species Living in Larger Streams
- Species Migrate to Headwaters for Spawning and Nursery Habitats
- Headwaters Provide Rich Feeding Grounds
- Headwaters Provide Thermal Refuges
- Headwaters Provide a Source of Colonists and a Network of Movement Corridors
- Headwaters Supply Food to Neighboring Ecosystems
- Biological Activity in Headwaters affects Downstream Food for Higher Tropic Levels

Summary of Headwater Stream Biodiversity: The dominant group of algae in headwater streams are diatoms and it is common to find 30-60 species some of which are only found in headwaters (Sherwood et al. 2000).Thirty to forty species have been found in southern Appalachian headwaters (Greenwood, 2004; Greenwood and Rosemond 2005) and they are particularly common on bryophytes and rocks (Meyer et al. 2007). These bryophytes are important primary producers in headwater streams and four species dominate in high-gradient Appalachian streams (Glime, 1968). Among the most important decomposers in headwater streams, fungi can be quite diverse. Gulis and Subekropp (2004) reported finding over 51 taxa of hyphomycete fungi in two small southern Appalachian streams and they and others (Barlocher and Graca, 2002) have shown that when inputs of leaf litter declines, biodiversity also declines and that species composition of fungi is influenced by the diversity of litter inputs.

Invertebrate diversity is particularly high in headwater streams (Clark et al. 2008). Rather than providing an extensive list, we provide a few examples for Appalachian region. McCabe and Sykora (2000) found 18 species of caddisflies. Stout and Wallace (2003) sampled 23 intermittent streams and found over 86 insect genera from more than 47 families species. Small ephemeral and intermittent steams are often unmapped and appear unimportant to the untrained person yet mayflies, stoneflies, and caddisflies have been found right where the water emerged from the ground (a seep) and Stout and Wallace showed that just 150 m downstream the number of species doubled or tripled. Amphipods, isopods, copepods, cladocerans and ostracods are particularly common and the latter three may reach abundances of > 10,000/m^2 (Galassi et al. 2002).



The impacts of mountain top mining are more severe than other land use changes within these watersheds (e.g. clearcutting, residential development) because they are immense in scale and lead to irreversible alterations of impacted watersheds

Figure 2.1. Factors that contribute to the biological importance of headwater streams in river networks. Attributes on the right benefit species unique to headwaters and also make headwaters essential seasonal habitats for migrants from downstream. On the left are biological contributions of headwater ecosystems to riparian and downstream ecosystems. From J.L. Meyer, D.L. Strayer, J.B. Wallace, S.L. Eggert, G.S. Helfman, and N.E. Leonard. 2007. The contribution of headwater streams to biodiversity in river networks. Journal of the American Water Resources Association 43(1): 86-103.

Meyer et al. (2007) documented that many of the smaller interstitial taxa such as rotifers, gastrotrichs, oligochaetes are diverse and can reach incredibly high abundances in headwater streams (Table 2.3). Fish can also be abundant in headwaters and while their diversity generally increases with stream size, many of the headwater species are unique so headwaters may disproportionately contribute to network-wide diversity and play a critical role in the genetics of fish populations (Meyer et al. 2007, Burridge et al. 2008). Generally the species founds in these small streams are small in body size such as minnows, darters and

Table 2.3. Invertebrates other than Mollusks, Crustaceans, and Insects that are Common in Headwaters.
(from Meyer et al. 2007)

Group	Typical Species Richness in Headwaters	Typical Density in Headwaters (no./m^2)	Key References
Turbellaria	3–30	1,000–10,000	Kolasa (1983, 2002)
Gastrotricha	3–30 (?)	10,000–300,000 (?)	Strayer and Hummon (2001), Balsamo and Todaro (2002)
Rotifera	20–200	10,000–1,000,000	Schmid-Araya (1998), Wallace and Ricci (2002)
Nematoda	10–100	5,000–500,000	Traunsperger (2002)
Tardigrada	1–10	1,000–10,000 (?)	Nelson and McInnes (2002)
Oligochaeta	3–30	1,000–50,000	Schwank (1981a,b)
Acari	5–50	100–10,000	Di Sabatino *et al.* (2002, 2003)
Total	40–450	28,000–1,880,000	

sculpins but also may include salmonids such as those found in cold North Carolina headwaters (Moyle and Herbold 1987). Even when intermittent streams are not running, they may support fish in isolated pools – these pools are often maintained by local groundwater inputs. A surprising fraction of the trout population (almost 50%) have been found to spawn in some intermittent streams in California – such studies are rare so while we know of no studies with similar data for Appalachian headwaters, this may be common in that region as well. Trout and salmon typically spawn in the smallest of channels even when it means half of their body is out of water while the move up these channels.

Where fish are absent in Appalachian streams, amphibians are common and are typically the top aquatic predators. Their production in 1st and 2nd order streams is higher than that found in larger streams (Wallace et al. 1992) and salamanders are the most common vertebrate in headwaters (Davic and Welsh 2004). Frogs, toads, and reptiles can also be common in some headwater streams (Meyer et al. 2007). Ephemeral and intermittent streams provide vital habitat for amphibians, many of which are state and/or federally threatened and endangered (Reid and Ziemer 1994; Davic and Welsh 2004). Many amphibian species are most abundant in intermittent streams, perhaps because they offer freedom from predators (Reid and Ziemer 1994). In Appalachian streams, larvae of the Blue Ridge two-lined salamander *Eurycea wilderae* is abundant (Johnson et al. 2006). Many stream salamanders require headwater seeps and small streams in forested habitats to maintain viable populations (Petranka 1998). Plethodontid salamanders are extremely diverse in Appalachia, and their lungless condition appears to be an adaptation for small headwater streams, which are their principal larval habitat, where they spend from a few months to five years (Beachy and Bruce 1992). Yet, they are also very vulnerable. Ford et al. (2002) have shown that diversity and abundance of salamanders in the southern Appalachian mountains is reduced when forests are clear cut even after 75 years of re-growth is >75. Loss of salamander populations from headwater streams can have ecosystem-wide consequences since they influence insect population dynamics, regulate detritus food webs, and link stream and terrestrial food webs (Davic and Welsh 2004).

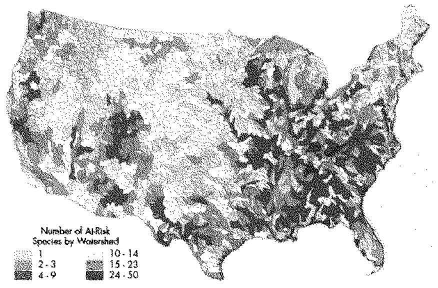
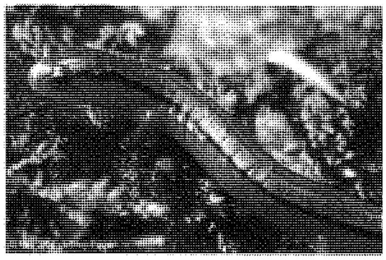


Figure 5. Hot Spots for At-Risk Fish and Mussel Species

Figure 2.2. Hotspots for at-risk fish and mussel species. From Master et al. 1998



A Blue Ridge Salamander: common in Appalachian headwaters

The streams and rivers threatened by MTVF activities support among the highest levels of aquatic diversity in North America (**Fig. 2.2**, Master et al. 1998). Because the southern Appalachians escaped glaciation, these are among the oldest mountainous ecosystems on Earth. Nearly 10% of <u>*global*</u> salamander diversity and 10% of freshwater mussel diversity are found within streams of the Southern Appalachian Mountains. (Green & Pauley 1987; Master et al. 1998). Where mining activities destroy stream habitat and degrade stream water quality many of these taxa become locally extinct and for species with small geographic distributions mining activities will contribute to their global extinction.

Ecosystem Functions of Headwater Streams. There is abundant scientific evidence that headwater streams play disproportionate roles in many ecological processes. Sediment produced in headwater systems moves through channel networks and alters channel morphology (Benda and Dunne 1997a, 1997b). Headwater streams are also the streams that have the closest contact between water and soil – as a result they are the sites of high chemical and biological activity which influence the water quality throughout the downstream river network. Organic matter is delivered to headwater streams from the surrounding riparian vegetation and transported downstream to larger channels – trees drop leaves and contribute wood to streams that shape healthy channels and fuel aquatic food webs (Webster et al. 1999). After wood, leaves and other dead vegetation enter streams, they begin decaying to produce detritus – this mixture of organic matter supports the downstream food web by enhancing productivity, population density, and community structure of stream biota (Wipfli and Gregovich 2002).

The headwater channels are sometimes described as being analogous to the very small passageways in the human lung that accomplish most of the important work in exchanging gases between the respiratory and circulatory system. They do much of the processing of source materials for delivery to sustain the downstream ecosystem including water, organic matter, and even biota that disperse (Clark et al. 2008). Cut them off and the patient starts to suffer a condition like emphysema. The natural filtration system and timing of delivery of water and associated constituents from upstream tributaries to larger channels downstream are delicately adjusted among components of the system. There is a substantial body of science documenting their roles in watershed health (Clark et al. 2008). Because headwater systems make up a major portion (70 - 80%) of the total catchment area (Meyer and Wallace 2001), headwater streams are important sources of sediment, water, nutrients, and organic matter for downstream systems. Thus any major changes affecting headwater tributaries or any activity that isolates or cuts off these tributaries from the lower part of the watershed will propagate downstream, and will have consequences for hydrologic processes, sediment delivery and channel morphology, biogeochemistry, and stream ecology further downstream in the watershed.

MTVF activities fundamentally alter the energetics of streams directly impacted by mining and valley fills by changing the light environment and removing vegetation. Surface waters on reclaimed mines or along valley fills have year round high light availability, altered thermal regimes and reduced organic matter inputs. All of the streams which receive alkaline mine drainage may become more susceptible to nutrient pollution and less capable of performing the valuable ecosystem service of nitrogen removal (*discussed in section 3*).

ENDNOTE, SECTION II

The Clean Water Act and its implementing guidelines require that permits authorizing valley fills be issued only if those permits do not result in adverse effects on the aquatic environment. In order to determine whether those permits have such an effect, the guidelines require the Corps of Engineers to evaluate both the structure and the function of streams that would be filled pursuant to those permits. There has been considerable controversy since a 2007 ruling by a federal district court in West Virginia that called into question decisions by the US Army Corps to permit several mountaintop mining operations based in part on inadequate consideration of ecological functions. The 4th Circuit Court of Appeals[a] subsequently reversed the decision but not before the Huntington, West Virginia office of the Corps released a regulatory guidance document for making functional assessments on streams.[b] The plantiffs in the federal case filed for a re-hearing before the Court of Appeals which was denied in 2009. At the heart of the scientific issue is how natural resource *value* is assessed: are structural attributes such as channel shape, habitat types, and rapid biotic assessments adequate or must ecosystem functions be measured and used in evaluating impacts and mitigation requirements.

[a] The federal district court in West Virginia issued the order to remand the decisions and permits to the Corps for further consideration on 3/23/2007 (Ohio Valley Coalition vs. U.S. Army Corps of Engineers; Civil Action No. 3:05-0784). However, on 2/13/2009, the 4th Circuit Court of Appeals reversed this decision arguing that the Corps should be allowed deference in using 'best professional judgment' for methods to evaluate impacts and mitigation requirements.

[b] Interim Functional Assessment Approach for High Gradient Streams within the State of West Virginia, Public Notice no. LRH-2007-IFAA-01; dated July 16, 2007.

III. Water Quality Impacts of Mountain Top Mining and Valley Fills

Mountain top mining leads to:

- Higher annual water export from the watershed as a result of the removal of vegetation and a significant decrease in evapotranspiration
- Higher rates of rock weathering as a result of the fragmentation and exposure of mined rock to air and water
- Increased concentrations of solutes weathered from exposed rock in stream water – especially the high SO_4^{2-}, Mg^{2+}, Ca^{2+}, HCO_3^- associated with alkaline mine drainage
- Increased likelihood of elevated concentrations of trace elements and toxic metals derived from parent material in stream water.
- Decreased abundances or local extinction of sensitive aquatic organisms, with the potential for altered ecosystem function

It is important to note that mining results in increases in both the concentration of solutes <u>and</u> in the volume of water exported from the watershed. This means that the total mass of solutes delivered to downstream ecosystems is higher than concentration changes alone would suggest

$$\text{Flux (lbs yr}^{-1}) = \text{Flow (m}^3\text{ yr}^{-1}) * \text{Concentration (lbs m}^{-3})$$

Thus individual valley fills not only profoundly impact stream water quality, community structure and ecosystem functions immediately downstream of the fill, but multiple valley fills within larger watersheds have cumulative effects on larger downstream rivers through increasing loads of dissolved substances derived from alkaline mine drainage.

Increased concentrations of solutes weathered from exposed rock in stream water – especially the high SO_4^{2-}, Mg^{2+}, Ca^{2+}, HCO_3^- associated with alkaline mine drainage

Sulfate. Sulfate is an acid anion that has been well studied for decades as an important acid rain associated pollutant. Just as coal burning in power generation produces SO_x aerosols, the exposure of coal seams during coal mining provides many opportunities for the leaching of SO_4^{2-} into surface waters. Unlike SO_x emissions which distribute S aerosols regionally, mining activities lead to a localized point source of SO_4^{2-} to the drainage network. As a consequence of regional SO_x emissions ('acid rain'), freshwater systems throughout North American and Europe have had 10-fold or greater increases in SO_4^- concentrations. In contrast, mining impacted streams in WV often have 30-40 fold increases in SO_4^{2-} concentrations (Brooks et al. 2002; Pond et al. 2008) with 13 streams in the 2009 WVDEP database[18] having SO_4^- concentrations higher than found in seawater (>2717 mg L^{-1}). The relationship between mining activities and high sulfate concentrations is so well established that the 2008 WVDEP West Virginia Integrated Water Quality Monitoring and Assessment Report suggested that SO_4^{2-} concentrations >50 mg L^{-1} could be used as an indicator of mining activity (Fig. 3.1). <u>Id.</u> at 21.

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[18] Upon request, Jeffrey Bailey of the WV Department of Environmental Protection provided a MS Access version of their water quality database to E.S.B. on March 27, 2009

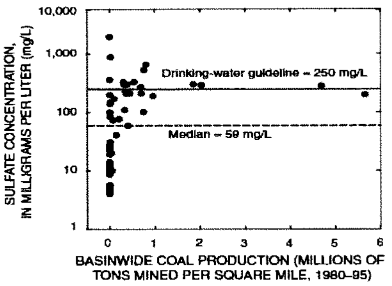


Figure 3.1. Sulfate concentrations in WV mountain streams relative to basinwide coal production. FROM Paybins, Messinger, Eychaner, Chambers and Kozar. Water Quality in the Kanawha–New River Basin West Virginia, Virginia, and North Carolina, 1996–98 U.S. Geological Survey Circular ; 1204 [*this report appears as an attachment to the 2001 EIS on Mountain top mining and valley fill operations*]

The headwater mountain streams of WV that are being impacted by mountain top mining were historically dilute with low nutrient levels. An earlier study in major watersheds of West Virginia directly linked increases in river sulfate load to increasing coal production in the watershed (Sams and Beer 1999) and through time-series analysis suggested that sulfate concentrations in streams continue to increase after mining activities end (Sams and Beer 1999). Likewise, a USGS NAWQA study found that, in the Kanawha–New River Basin, total Fe and Mn decreased in stream basins as a result of reduced coal production between 1991 and 1998, while sulfate concentrations continued to increase (Paybins et al. 1998). Both of these studies document an increase in SO_4^{2-} loading to major river systems that corresponds to increases in coal extraction within their watersheds.

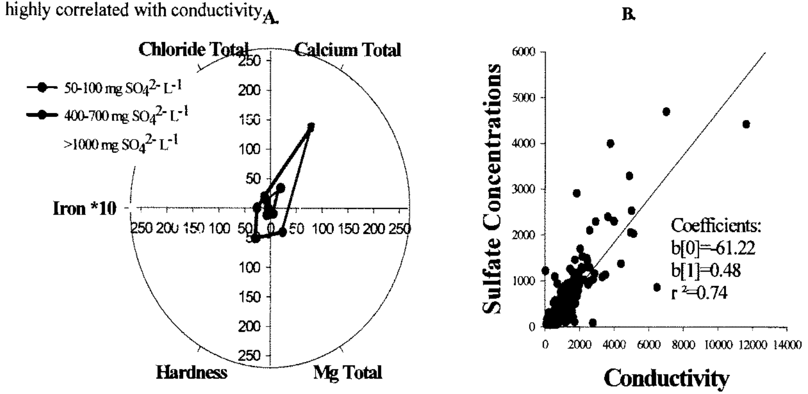
This fundamental change in the chemistry of headwater streams can have important local and watershed scale impacts on aquatic organisms and ecosystem functions. Elevated sulfate concentrations will stimulate microbial sulfate reduction in stream and wetland sediments. As sulfate concentrations increase, the production of sulfide also increases and this has important implications for the receiving ecosystems. Sulfide is directly phytotoxic to many aquatic plants (reviewed in Wang and Chapman 1999; Lamers et al. 2002; van der Welle et al. 2008).

Elevated sulfide also has important biogeochemical impacts. Sulfide binds strongly with iron (Fe) in sediments – converting it to pyrite minerals. While this has positive benefits in terms of reducing Fe concentrations in sulfate rich mine drainage, it also has implications for nutrient pollution. High sulfate loading can also make freshwater ecosystems more sensitive to nutrient pollution by preventing abiotic reactions that bind phosphorus (P) to Fe and sequestering P in inaccessible forms in the sediments. High sulfide can also inhibit nitrification (the process by which ammonium is converted to nitrate) in sediments and thereby dramatically reduce denitrification rates – again contributing to a reduced N removal efficiency within S polluted sediments and promoting or enhancing nitrogen eutrophication (Joye and Hollibaugh 1995).

Co-Occurring Contaminants. While an increase in sulfate loading is the most predictable consequence of mountain top mining in the Appalachians, many other substances are released to surface waters as a result of mining activity. In these valleys, the presence of significant carbonate and base cations in parent material neutralizes the acidity of sulfate leaching, but leads to dramatic increases in Ca^{2+}, Mg^{2+} and HCO_3^- ions. This natural acid buffering potential leads to an increase in the pH of receiving streams (rather than the more well understood acidification associated with acid mine drainage). The release of these ions contributes to dramatic increases in the electrical conductivity and total suspended solids within the water column of receiving streams. An analysis of all small streams (width <10m) from the WVDEP database for which there are no residences recorded in the watershed (residences = 0) and for which SO_4^{2-} concentrations are >50 mg L-1 captures streams with varying degrees of mining impacts. For this dataset, sulfate concentrations are highly correlated with conductivity (**Fig. 3.2B** R^2=0.74) and higher

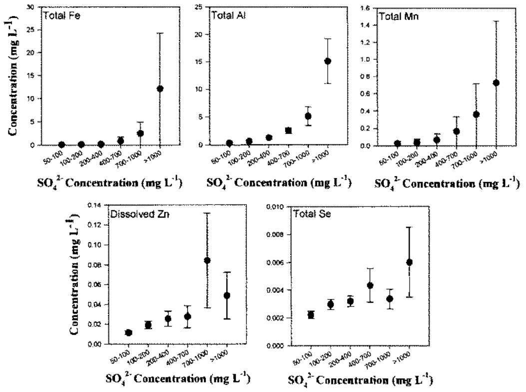
SO_4^{2-} concentrations are associated with higher Ca, Cl, Fe, Mg and Hardness values (**Fig. 3.2A**) – all of which contribute to heightened ionic stress in these impacted streams.

Figure 3.2. Panel A shows the concentrations of alkaline drainage associated constituents for streams from the WV DEP database that very in their [SO_4^{2-}] concentrations. Streams with higher [SO_4^{2-}] have higher mining activity and these streams have higher concentrations of Ca, Cl, Fe, Mg and total hardness than streams with low [SO_4^{2-}]. Panel B, this alkaline mine drainage "syndrome" associated with high [SO_4^{2-}] is highly correlated with conductivity.



The abundance of each trace element (excepting Cu) also increases with SO_4^{2-} concentration (**Fig. 3.3**).

Figure 3.3. Concentrations of trace elements +/- one standard error within categories of SO_4^{2-} loading for the WVDEP database (all streams <10m wide with no residences and [SO_4^{2-}] > 50 mg L^{-1}



Elevated Conductivity. Recent studies by Hartman et al. (2005) and Pond et al. (2008) compared water quality between paired reference and valley fill impacted streams and found that specific conductivity in the filled sites was at least twice as high as in the reference streams (Figure 3.4A). Typical specific conductance levels in low order West Virginia streams measured in previous research ranged from 13 to 253 µS/cm (Angradi 1996; Pond et al. 2008, while valley fill streams exceed these values (502–2540 µS/cm) (Hartman et al. 2005 and Pond et al. 2008) (Fig. 3.4A).

For many streams it is the cumulative or additive impact of elevated concentrations of multiple stressors that leads to biological impairment – and this is undoubtedly a part of the reason that conductivity (a cumulative measure of ionic strength) is such an effective predictor of biological impairment (Figs. 3.4 B&C)[19]. The ionic stress associated with high conductivity can have direct toxicity as well as providing an indication of the additive impacts of a variety of solutes. High conductivity can be directly toxic to aquatic organisms by disrupting osmoregulation (Pond et al. 2008). This is particularly important for aquatic insects with high cuticular permeability. Mayflies in particular are highly sensitive to ionic stress as they regulate their ion uptake and release using specialized structures within their gills, integument and internally via Malphigian tubules (Komnick 1977, Gaino and Rebora 2000, Pond et al. 2008). For these sensitive taxa, large increases in certain ions can disrupt water balance and ion exchange processes and cause organism stress or death. Tests for conductivity toxicity for mayflies have often proved inconclusive (Goetsch and Palmer 1997, Chadwick et al. 2002, Kennedy et al. 2003, Kefford et al. 2003, Hassell et al. 2006), yet studies performed to date typically perform ecotoxicological tests on hardy organisms that are easy to rear in lab settings (i.e., Hexagenia, Centroptilum, Cloeon, Isonychia) and which are likely to be less sensitive than the mayfly genera that appear especially susceptible to ionic stress (e.g., ephemerellids, heptageniids) (*discussion in* Pond et al. 2008). Rather than being directly lethal, high conductivity may encourage sensitive taxa to drift out of the reach (Wood and Dykes 2002) – an effect that would not be measured in the closed vessels of laboratory trials, but which could strongly alter community structure in the field.

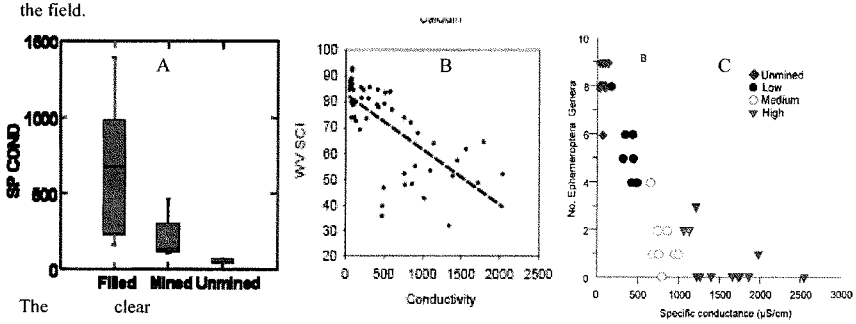


Figure 3.4. (A) The background conductivity of WV mountain streams in µS/cm "from an online presentation by USEPA Region 3 Scientists Greg Pond and Margaret Passmore "**Revisiting The Analysis of the Condition Of Streams In The Primary Region Of Mountaintop Mining/Valley Fill (MTM/VF) Coal Mining**" http://www.cpe.vt.edu/cmrs/presentations/GregPond.pdf). Accessed on 30 March 2009.; (B) data from Fulk et al. 2003 (which appeared as a supplement to Final Programmatic Environmental Impact Statement on Mountaintop Mining/Valley Fills in Appalachia – 2005); (B) Figure excepted from Pond et al. 2008.

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[19] The WVSCI is the West Virginia Stream Condition Index. The metric summarizes family level identifications on benthic macroinvertebrate assemblages as a "bioassessment" tool for evaluating the condition of wadeable streams. The metric includes six biological metrics that represent the structure and function of the benthic macroinvertebrate community (Pond et al. 2008b).

patterns linking high conductivity to a loss of Ephemeroptera taxa (Fig. 3.4C) has ecosystem scale importance since these mayfly taxa often account for 25 to 50% of total macroinvertebrate abundance in the least disturbed Central Appalachian streams (Pond et al. 2008). The finding that entire orders of benthic organisms are nearly eliminated in MTM streams suggest that alkaline mine drainage is fundamentally changing the structure of aquatic macroinvertebrate communities (Pond et al. 2008).

It is widely recognized that individual contaminants rarely exist alone, and although many ecotoxicological studies examine the impacts of single contaminants on laboratory organisms – it is the actual combined toxicity of constituents in field settings that is of interest (Wang and Zin 1997). In cases where an association of contaminants is well characterized (e.g., the trace metals and cations associated with alkaline or acid mine drainage or the road runoff associated with high traffic volume corridors), a concentration-addition method should be applied which assesses their cumulative impact (Wang and Zin 1997). A lack of laboratory ecotoxicological effects of any isolated component of the complex mixture of solutes associated with alkaline mine drainage pollution should not be used to defer control of the obvious pollution problems caused by the combined toxicity of multiple constituents. The weight of evidence suggests that mining activities in watersheds often degrade downstream water quality and lead to dramatic alterations in macroinvertebrate community structure (Fig. 3.5). Mine sites may vary considerably in the extent to which they impact regulated solutes in downstream waters, yet the valley fill operations studied to date are clearly causing heightened conductivity and high SO_4^{2-} concentrations.

These increases in conductivity and sulfate are associated with a loss of sensitive macroinvertebrate taxa from affected stream reaches (Fig. 3.5[20]).

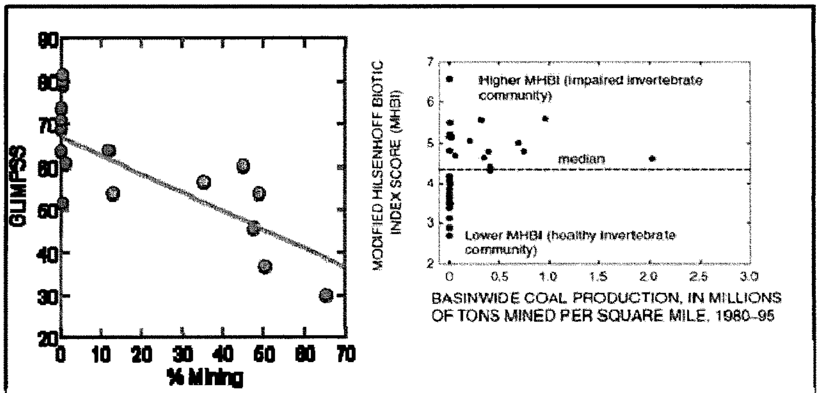

Figure 3.5. Panel A shows the relationship between the genera based macroinvertebrate metric for WV streams (GLIMPSS[3]) and mining activity [http://www.cpe.vt.edu/cmrs/presentations/GregPond.pdf]; Panel B shows a family level macroinvertebrate metric (the Hillsenhoff Biotic Index, MHBI) vs. basinwide coal production [figure from Paybins et al. 2003]

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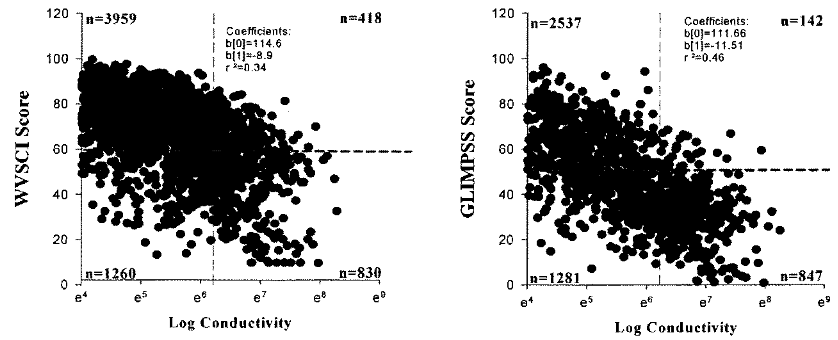
[20] The GLIMPSS index is a newly developed, genus based assessment of stream macroinvertebrate communities developed by US EPA Region 3 scientists which assesses stream condition based on the genera level taxonomic identification. This metric has proven much more sensitive to known environmental stressors.

There are strong correlative relationships within the WVDEP database which demonstrate that there are water quality thresholds beyond which there is little likelihood of protecting benthic communities from impairment. Figure 3.6 shows conductivity vs. WVSCI and GLIMPSS scores for all of the samples from small streams (<10m) taken during the summer in the mountains ecoregion of West Virginia. In this simple analysis a line is drawn at the divide between impaired and unimpaired scores (60 for WVSCI, 50 for GLIMPSS) and a second line is drawn through the data at the conductivity of 500 μS/cm –the conductivity level that appears to be a threshold for sensitive mayfly taxa according to Pond et al. 2008. Numbers within each quadrant represent the total number of unique samples in each situation.

A comparison of these graphs shows that it becomes increasingly unlikely to find an unimpaired aquatic benthic community as conductivity increases (as evidenced by the significant negative correlations between macroinvertebrate community integrity as measured by either WVSCI or GLIMPSS). Indeed, 86% of the West Virginia mountain streams in the WVDEP database with conductivity exceeding 500 μS/cm were scored as impaired using the genera based GLIMPSS index. Using the more lenient WVSCI index, 67% of all West Virginia mountain streams with conductivities greater than 500 μS/cm were classified as impaired. Similarly, 81% of all West Virginia small mountain streams with conductivity greater than 1000 μS/cm were scored as impaired using the WVSCI index, and 91% of those streams were scored as impaired using the GLIMPSS index.

Figure 3.6: WVSCI and GLIMPSS Scores vs. Conductivity - All Summer Mountains Data for streams <10m wide



Consequently, as conductivity (and the associated SO_4^{2-}, Ca^{2+}, Mg^{2+}, HCO_3^- and trace metals) increases in West Virginia mountain streams – the biological community is degraded. Sensitive species (especially Ephemerellidae and Heptageniidae mayflies) are lost from these systems. High conductivity and high sulfates can persist long after mining activities cease (Sams and Beer 1999, Paybins et al. 2003, Pond et al. 2008), and there is little empirical evidence documenting recovery of macroinvertebrate communities in the streams impacted by alkaline mine drainage.

In addition, the differences in sensitivity between WVSCI and GLIMPSS methodologies have important long term consequences when WVSCI is used to assess mitigation projects. The resulting data will likely mask important impacts to genera that belong to families of benthic organisms where there is a wide spectrum of sensitivity to increased conductivity. This means that significant harm to the biological integrity of stream ecosystems could be missed or understated when WVSCI is used for mitigation monitoring.

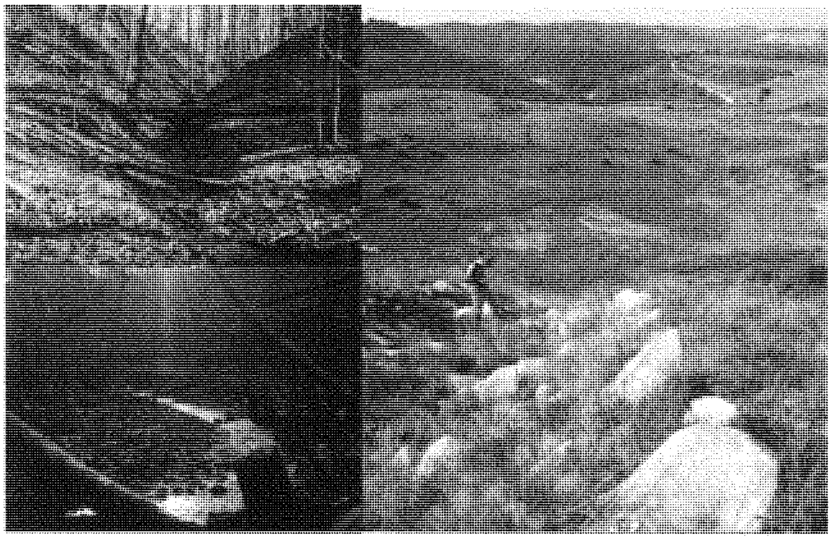
IV. The Potential for Mitigating Watershed Scale Destruction

The 404 guidelines mandate permit applicants to avoid, minimize and mitigate impacts on the waters of the United States to prevent significant degradation of waters of the United States. When impacts are unavoidable, stream habitat and functions lost through mining and filling are subject to amelioration through mitigation. Because mitigation actions must replace lost stream resources and ecological functions, the value of those natural resources and functions must be assessed prior to their loss. This value(s) is then used to determine how much mitigation is required.

Compensatory mitigation to replace lost stream habitat and functions may occur through a variety of actions but they generally fall into two categories:

- Stream enhancement/restoration - Restoration or enhancement of degraded streams in areas adjacent or contiguous to the mining site typically involves stabilizing a streambank, re-shaping a channel, or replanting riparian vegetation. Enhancement and restoration actions are typically applied to perennial streams even if the streams that are lost due to mining are ephemeral or intermittent.
- Stream creation (Fig. 4.1) – Attempts to create a stream by excavating a ditch and placing structures like boulders and rocks into the channel are often proposed to replace streams that are filled. These creation attempts are often undertaken on or near a valley fill and they usually rely on the fill or mined area for their water source.

Figure 4.1: Photos of natural intermittent and perennial streams (left) and a created channel (right) along a valley fill



A restoration or stream creation plan may attempt to build or fix individual components or channel segments but no existing channel restoration or mitigation procedures are yet designed to reintegrate the different parts of the drainage network back into a functioning whole after the network has been dismembered.

***Deficiencies of plans to mitigate for the loss of streams due to MTVFs fall into six major categories*:**

1. **<u>Mitigation plans fail to assess ecosystem functions.</u>** As described earlier in this document, healthy streams are living, functional systems which support a number of critical ecological processes (Table 2.2): the processing of nutrients, the decomposition of organic matter and, microbial, primary and secondary production (Palmer et al. 1997a; Naiman et al. 2005; Palmer and Richardson 2008). To date mitigation plans associated with mountain top mining have not used readily available methods for directly measuring ecological functions yet these processes must be measured in order to determine how and whether they may be brought back to the right levels and direction through mitigation. There are now abundant scientific studies outlining how to make and interpret such measurements (e.g., Peterson et al. 2001; Gessner and Chauvet 2002) and how such measurements can be used to evaluate the success of a restoration project (Buckveckas et al. 2007; Roberts et al. 2007).

Use of well-accepted methods for measuring ecological functions (e.g., see Hauer and Lamberti 1996, 2006) is important because ecological functions evaluate dynamic properties of ecosystems that underlie an ecosystem's ability to provide vital goods and services (Gessner and Chauvet 2002; Falk et al. 2006; Fischenich 2006, Palmer and Richardson 2008). Functions reflect system performance and their measurement requires quantification of ecological processes such as primary production or nutrient uptake (Hauer and Lamberti 1996, 2006). This should be reflected in the mitigation plan if the plan is to mitigate functions that are lost due to the mining through of streams. Functional measures have been used to compare degraded vs. restored vs. reference streams (Roberts et al. 2007; Buckveckas 2007; Kaushal et al. 2008). and have been shown to be quite sensitive to degradation and restoration (e.g., Fig. 4.2) but to date measurements of functions for created or restored MTVF streams have not been published thus there is no evidence the mitigation practices result in healthy, fully functional streams.

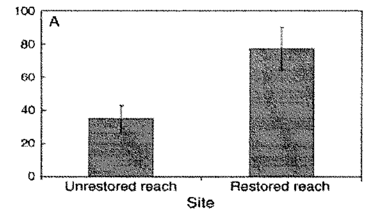


Figure 4.2: Denitrification rate - µg N/kg soil/day (from Kaushal et al. 2008)

<u>2. Mitigation plans fail to adequately assess ecosystem structure</u>. Even the structural measures typically used in mitigation projects are inadequate and fail to comply with minimum scientific standards. For example, baseline measurements such as macroinvertebrate assessments are frequently one time measurements instead of measurements made on several dates across different seasons or years. Invertebrate diversity and composition change throughout the year and particularly following high flow events which can dramatically reduce diversity and abundance for short periods of time (days to a week typically). If samples are only collected once then findings can not be unambiguously interpreted – if abundances or diversity are low is this because the sampling happened to be done right after a rainstorm or following a drought? This is particularly problematic in mining and mitigation contexts because the streams are ungauged so there is no way to know what flow levels that immediately preceded the sampling.

Another problem is that invertebrate sampling methods described in mitigation plans rely on the use of nets or other devices to capture fauna in the water or on the streambed, yet many intermittent streams have diverse and abundant fauna in that live subsurface. As Collins et al. (2007) have shown, "streams with no visual evidence of surface flow may contain subsurface flowpaths with water chemistry and biota comparable to coupled perennial surface flow reaches". Indeed, assessments of ecosystem structure using most rapid bioassessment methods assume that the presence of water in the channel is a pre-requisite for stream health. Indeed, ephemeral and intermittent channels are *supposed* to have wet and dry periods and some important ecosystem functions are actually enhanced by alternating wet and dry periods (e.g., denitrification; Euliss et al. 2008).

Assessments of stream chemistry (another structural measure) for mitigation is also typically done using samples collected once or at best twice in the streams to be impacted or enhanced for credits. Yet snapshots of chemistry tell you little about many chemical parameters that can fluctuate dramatically depending on rainfall or inputs from upstream. Organisms are surrounded by stream water continuously for extended periods of time and spikes in contaminants or changes in temperature or dissolved oxygen that only last hours to days may be lethal to them. Thus one shot sampling efforts fail to pick up such 'threshold' events.

Most surprising in many mitigation documents are indications that streams are only visually assessed and often by a single person i.e., no direct measures are made. Even if photographs are taken, they do not provide sufficient information to arrive at a valid ecological assessment of a stream. Quantitative, direct measurements of plant diversity, faunal diversity and abundance, channel characteristics and other structural attributes should be made by several individuals after cross-calibrating methods. No where in the mitigation plans have we seen references to the repeatability of physical or biological assessments or when a calibration exercise was completed, if a all. Yet, the National Research Council has emphasized that many well-meaning but unsuccessful stream restoration projects have been caused by inadequate analysis of the physical characteristics and processes that govern stream form and function (NRC 1992).

Finally, it is inappropriate to use structural measures as surrogates for functional measures because there is no scientific peer reviewed study linking stream structure with stream function. In fact, most mitigation plans that include stream enhancement or restoration are based on a morphological approach to stream restoration that has been extensively criticized in the scientific literature because of its failure to promote ecological recovery (Gillilan 1996; Shields et al. 1999; Kondolf et al. 2001; Juracek & Fitzpatrick 2003; Niezgoda & Johnson 2005; Smith& Prestegaard 2005; Slate et al. 2007; Simon et al. 2007; Roper et al. 2008).

3. Stream creation is outside the scope of accepted science. MTVF projects destroy fully healthy streams which are often in pristine watersheds. Many mitigation plans propose to re-grade the land and then construct a channel that has similar dimensions (width, depth, slope, sinuosity, etc) to the one destroyed. Thus the goal is to create a stream yet all the natural flow paths and landscape topography have been destroyed. This is not even in the realm of anything that has been scientifically tested and is certainly not within the realm of what is considered ecological restoration. As 'evidence' that stream creation is a routine practice, mitigation plans often cite projects that are actually channel reconfigurations or projects that have spatially shifted a section or meander of a channel – these are *not* the same as stream creation because for the former, the natural flow-paths are still intact.

In practice, ecological stream restoration varies along a continuum from: removing on-going impacts to a stream (e.g., preventing toxic inputs) and letting the system recover on its own; to enhancing in-stream habitat or the surrounding riparian zone (e.g., adding coarse woody debris to streams and planting vegetation) in an otherwise healthy stream; to full scale restoration that involves manipulations of an *existing* stream channel (e.g., re-grading banks and planting trees along a stream with eroding banks) (Williams et al. 1997; FISRWG 1998; Karr and Chu 1999).

Some mitigation plans refer to channel creation projects as "restoration" or "reconstruction" but while the latitude and longitude of the streams may be similar to what they were before, everything else that defines an ecologically healthy stream will be gone or will have been dramatically altered at the end of the mining period (e.g., flow paths, riparian soil and streambed biogeochemistry, groundwater-surface water (hyporheic) exchange rates, mature riparian vegetation, etc). In fact, a 1999 study singles out mountaintop removal mining and valley fills in West Virginia and adjacent states as the greatest contributor to earth moving activity in the United States (Hooke, 1999). Further, there is no evidence provided that the groundwater-surface water exchange, the concentration of suspended sediments, or the water quality in the new channel will be similar to what is in the undisturbed streams presently.

Based on our work leading a national project that developed the first comprehensive database on stream and river restoration for the U.S. (38,000 projects in the database; Bernhardt et al. 2005, Palmer et al. 2005) and on extensive work with scientists and restoration practitioners, we do not know of a single case in which building streams in the manner outlined in mitigation plans have been shown to work, much less fully compensate for ecological functions lost when a stream is destroyed. Contrary to suggestions made in the mitigation plans, the very concept of creating streams with levels of ecological functioning comparable to natural channels on sites that have been mined-through remains untested and quite unlikely to succeed. There are no peer-reviewed scientific studies referenced in mitigation plans that demonstrate healthy streams can be created after this level of impact to the land has occurred. Even with far less damage to a site, stream restoration projects that involve channel modification have an extremely high failure rate (Smith and Prestegaard 2005; Tullos et al. 2009; Palmer et al. 2009).

4. Morphologically based channel designs are not ecologically based. Most mitigation plans that include stream enhancement or restoration are based on the "Natural Channel Design" (NCD or Rosgen approach) approach but the NCD approach to stream restoration is not an *ecological* restoration approach and it has never been shown to promote ecological recovery. In fact, results from recent studies point in the opposite direction (Tullos et al. 2009). Evidence to date suggests that extensive channel engineering which is typical of the NCD approach may in fact cause damage to streams in need of restoration i.e., species diversity may actually decrease following restoration and may decrease over time (Palmer et al. 2009).

The NCD approach is fundamentally focused on channel form (structure) not ecological function. This approach was designed by Rosgen (1994) to address channel stability based only on building a channel structure (shape, slope, etc) that is able to transport the sediment and water inputs that are expected to be delivered to the stream prior to completion. There is no scientific evidence supporting the assumption that restoration of channel form will lead to full restoration of function (Palmer et al. 1997b; Hilderbrand et al. 2005; Falk et al. 2006). How a stream looks (its *form)* is simply not the same as how it processes (its *function)* material and supports life (primary producers, invertebrates, etc).

Most MTVF stream mitigation plans assume that selection of a channel type from a channel classification scheme such as those proposed by Rosgen (1994) will necessarily result in full ecological restoration, but they also assume that use of the NCD or Rosgen approach guarantees successful creation of a channel from a geomorphic and hydrologic perspective. However, channel designs based on a classification system that has not been fully evaluated at the site can lead to serious failures (Smith and Prestegaard 2005). As indicated in Palmer et al. (2005): "Attempts to develop restoration designs based on application of a single classification system across many environments have led to many failures in North America (e.g., Kondolf et al. 2001), because the specific processes and history of the river under study were not adequately understood." If mitigation projects fail and channels are unstable, this could cause new environmental degradation. However, even if they are geomorphically stable, this does not address restoration of function. Indeed, the Rosgen scheme of classification does not deal with ecological functions at all.

While use of the Rosgen scheme for stream restoration has been very common in the past, current science (published in many peer-reviewed scientific journals) has documented numerous reasons that use of this scheme for restoration can be extremely problematic (Gillilan 1996; Shields et al. 1999; Kondolf et al. 2001; Juracek and Fitzpatrick 2003; Niezgoda and Johnson 2005; Smith and Prestegaard 2005; Slate et al. 2007; Simon et al. 2007; Roper et al. 2008). In fact, an analysis of > 75 channel reconfiguration projects overwhelmingly showed that restoration of biodiversity failed (Palmer et al. 2009).

The fundamental problem with classification based restoration approaches is that they assume fixed endpoints and rigid classification schemes in which the type of stream desired can be achieved by constructing a specific channel form. Yet, streams are living systems – far more than rock-lined ditches. Even from a practical point of view, restoration is far more than creating some design based on external appearance. The fundamental distinction between form and function of stream channels is not acknowledged by mitigation plans, which focus on structural aspects of channels and ignores functional aspects. The NCD method in no way takes into account a whole array of biophysical factors that determine the ability of the channel to support all of the living resources in pristine streams in the area. Such factors include: intensity and duration of sunlight reaching the stream, which is determined in part by the vegetative structure; inputs of organic matter upon which the food web depends; nitrogen and carbon levels in the soil and streambed; etc.

5. Restoration/enhancement of perennial streams do not mitigate for impacts to ephemeral and intermittent streams. Headwater streams contribute to the aquatic ecosystem in important ways that make them different from perennial streams. In particular, intermittent and some ephemeral streams provide unique habitat for a diverse population of insects and other animals, from macroinvertebrates to salamanders (Collins et al. 2007). The interaction of groundwater and surface water that takes place in these stream segments helps purify the stream and regulate the downstream water temperature, affecting both aquatic life and water quality below. As these intermittent and ephemeral streams characteristically are found in forested hollows, with considerable riparian vegetation, they play an elevated role in nutrient processing and the decomposition of organic matter. In turn, these processes directly affect the downstream water quality, aquatic life, and other values. Intermittent and ephemeral streams have unique characteristics that distinguish them from perennial streams. The most obvious difference is hydrological – surface water is only present part of the year and this attribute leads to the support of unique species and characteristic communities of organisms that would not exist if flow were perennial.

We elaborated on the importance of intermittent and headwater streams earlier but it is important to note their unique roles with respect to: evolution of diversity; support of unique species and assemblages of organisms; provision of refugia that are critical to the life history of many species; and contribution to ecosystem processes including biogeochemical cycling, water and sediment storage and transport.

The evolution of some amphibians (particularly salamanders) and the origins of their diversity are tied to the type of periodic inundation and drying "cycle"– it prevents year-round colonization of competitors and predators who otherwise may dominate these habits to the exclusion of amphibians (Davic and Welsh 2004). Because intermittent and ephemeral streams have a seasonal mosaic of habitat types they typically support fauna that may not be found in perennial reaches -- these fauna may be able to withstand dry periods but would not compete well with species common in perennial reaches (Bond and Cottingham 2007). Some species rely on intermittent or ephemeral reaches as refuges from predation or rely on them for spawning -- Erman and Hawthorne (1976) found that from 1972 to 1975, an estimated 39-47% of the adult rainbow trout (*Salmo gairdneri*) in a Sagehen Creek, California spawned in an intermittent stream while several permanently flowing tributaries attracted only 10-15% of the run.

Intermittent and ephemeral streams are also critical to biogeochemical processes that have watershed scale impacts (e.g., influence nutrients downstream) and streams that go through wet and dry cycles may support high rates of denitrification (Butturini et al. 2003). Further, intermittent and ephemeral streams supply water and sediments which are important to downstream perennial reaches (Bond and Cottingham 2007). Finally, these smallest of streams act as a link between terrestrial ecosystems and perennial reaches and when they are re-wet following dry periods, the inundation of dry organic matter (especially in forested region) may release large amounts of dissolved organic matter to downstream reaches (Bond and Cottingham 2007).

6. Constructed channels do not have the energetic base, thermal or flow regimes to support the native aquatic community. The energetic basis of the stream food web of mountainous Appalachian streams is leaf litter from the surrounding trees (Wallace et al. 1995). For most of the year, bacteria, fungi and aquatic insects consume the leaves and wood that fall or are washed into the stream from the surrounding forest (Wallace et al. 1982). There may be brief periods of the year (between snowmelt and leaf out and between autumn litterfall and first snow) when aquatic plants (algae) are important food resources. Constructed streams on or below valley fills are in high light environments, with early vegetation consisting primarily of short-stature grasses. With abundant light, algal production is likely to be high (Hill et al. 1995). Further, with the open canopy, temperatures may reach levels that native fauna can not acclimate to. Thus, while the forested stream ecosystem is fueled by leaf litter from the surrounding forest, the created streams will be fueled by algal production. Without a forest canopy, water temperatures in the constructed streams will be significantly hotter in summer and significantly colder in winter than in the forested streams.

Further, there is no evidence that diversion of water flow to ditches or low-lying points creates a stream. Sub-surface and surface flow paths to natural streams may be complex and the residence time of the water in the groundwater varies before it reaches streams (Gregory et al. 1991; Jones and Mulholland 2000). Without a thorough scientific study including a hydrological analysis of groundwater, surface water, and hyporheic interactions (rates of flow and flow paths), there is no evidence that the water resources left after the mining and mitigation will compensate for what was lost. Yet there is abundant scientific evidence that these hydrological interactions determine ecosystem functions including rates of whole stream metabolism, nutrient processing, organic matter decomposition, productivity and reproduction of invertebrates and fish (Allan and Castillo 2007; Baron et al. 2002). In one of the leading hydrologic journals, Wohl et al. (2005) recently reiterated this point: "successful restoration requires that key processes and linkages beyond the channel reach (upstream/downstream connectivity, hillslope, floodplain, without question; water, sediment and hyporheic/groundwater connectivity) be considered. The importance of these linkages is organic matter, nutrients and chemicals move from uplands, through tributaries, and across floodplains at varying rates and concentrations." In short, mitigation based on diverting flow to sediment ditches will not "replace" stream functions and showing this would require data and detailed studies. Certainly "removing interior barriers and reconstructing outlets [from drainage control structures]" combined with the placement of a few rock vanes and root wads, will not convert mining drainage ditches to streams that replace ecological functions that were permanently lost.

Successful restoration requires that key processes and linkages beyond the channel reach (upstream/downstream connectivity, hillslope, floodplain, and hyporheic/groundwater connectivity) also be considered (Sear 1994; Stanford et al. 1996; Graf 2001; Palmer et al. 2005). The importance of these linkages is without question; water, sediment, organic matter, nutrients and chemicals move from uplands, through tributaries, and across floodplains at varying rates and concentrations.

7. Existing mitigation approaches fail to include any mechanisms that will reduce the export of SO_4^{2-}, HCO_3^-, Ca^{2+}, Mg^{2+}, Fe and trace metals from mined sites, or that will remediate these impacts for the water columns of constructed channels. Most mitigation plans merely state that channels will be constructed using natural channel design approaches and that their success will be gauged based upon their structural similarity to reference sites. If the water flowing through these mitigated channels comes into contact with overburden it will contain the characteristic signature of alkaline mine drainage. Thus the capacity for even a channel that is "structurally and hydrologically" similar to reference streams to support a diverse aquatic fauna and an ecosystem functional capacity similar to those lost when unmined streams are buried will be very constrained. The severe water quality degradation associated with water flowing through mined landscapes will constrain mitigation success. The mitigation projects associated with MTVF operations are not designed to actually mitigate for the severe water quality impacts generated, and these long-term, long-distance impacts represent unmitigated stressors to the stream reaches below valley fills and to the full river network extending downstream.

8. Current monitoring requirements for mitigation projects will not assure ecological success. Mitigation_projects are typically monitored for 5 to 10 years after completion. The required monitoring suffers from the same short falls that have been previously discussed, failure to measure stream functions and inadequate structural measures. In addition, while the burial of streams is permanent many stream enhancement projects will be of short duration (testimony says 20-25 years). Thus monitoring of 5-10 years will miss the temporal differences between impacts and the mitigation intended to offset them. Indeed, since the time frame for full forest re-growth that is required for full restoration of ecosystem functions and biodiversity is on the order of many decades, monitoring should continue for at least 30 years.

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From Senator Boxer:
Q1. In your opinion, can the adverse water quality impacts of mountaintop removal coal mining be offset or mitigated with currently available restoration techniques? If these water quality impacts can't be effectively mitigated, then what are the long-term consequences of losing biological functions of these streams?

Answer: Likelihood of mitigation success. The impacts of mountaintop mining with valley fills ("MTM/VF") are immense and irreversible, and there are no scientifically credible plans for mitigating these impacts.

Mitigation for the loss of streams from valley fills generally includes offsite enhancement of streams structurally (i.e., adding rocks or re-grading a streambank), or, onsite attempts to 'create streams' on or near valley fills by digging ditches and sculpting rocks in an artificial channel. However, there is no evidence that structural approaches like these that focus only on channel form, e.g. creating artificial channels in former drainage ditches or channel manipulations and placement of in-stream structures, will lead to the recovery of the ecological functions that are lost by the valley fills. In addition, mitigation projects not only fail to address stream function but also fail to use generally accepted scientific protocols when using structural measures.

While mining companies are attempting to construct new stream channels in reclaimed mine lands, there are no examples of successful creation of streams in any setting. Based on work leading a national project that developed the first comprehensive database on stream and river restoration for the U.S. (>37,000 projects in the database; Bernhardt et al., 2005, Palmer et al. 2005) and on extensive work with scientists and restoration practitioners, I do not know of a single case in which building streams in the manner outlined in MTM/VF mitigation plans have been shown to work, much less fully compensate for ecological functions lost when a stream is destroyed. Any claim that the structure and function of high gradient, forested headwater streams could be recreated in the flat grasslands of a reclaimed mine is thus highly suspect.

Even if channels are constructed with high quality habitat, the routing and timing by which rainwater and groundwater are delivered to these channels will be highly altered. As a result, the channels are likely to be filled with waters polluted by alkaline mine drainage (resulting from subsurface flows through mining fill) or to flow only during major precipitation events. In either case, there is little reason to expect that these constructed channels would support the diverse fauna of Appalachian headwater streams or that they would even approximate the energetic and nutrient transport processes of the stream they are meant to replace. Typical mitigation projects do nothing to reverse the severe ecological consequences of the water quality impacts downstream from large-scale surface mining operations.

The use of stream restoration or enhancement projects for mitigation is also problematic because they are frequently done in perennial streams whereas impacts are usually in ephemeral streams or intermittent streams. Intermittent and ephemeral headwater streams have unique roles with respect to: evolution of diversity; support of unique species and assemblages of organisms; provision of refugia that are critical to the life history of many species; and contribution to ecosystem processes including biogeochemical cycling, water and sediment storage and transport. Thus, there is a structural and functional mismatch between the loss of ephemeral and intermittent streams and the enhancement of perennial streams. ?

Answer: long-term consequences of losing biological functions. The long-term impacts of the failure to effectively mitigate the impacts of mountaintop mining are significant. Many studies to date have shown that when impacts to watersheds exceed 10-15% of the watershed area, there can be dramatic declines in aquatic biodiversity and water quality (Allan 2004; Booth et al. 2004; Morgan and Cushman 2005; Moore and Palmer 2005). Yet, for example, documents from the Huntington Army Corps of Engineers indicate that individual permits issued for valley fills in southern West Virginia in 2008 will contribute to cumulative impacts of subwatersheds anywhere from 17 to 51%. In the major Coal River watershed, cumulative disturbance is 12.8% of 891 square miles. Thus, dramatic impacts are occurring in entire regions of central Appalachia.

Three fundamental scientific principles are critical to understanding why cumulative impacts of MTM/VF on downstream aquatic resources are so important. First, changes at the watershed scale influence stream hydrology throughout the catchment (Brooks 2003). The timing and magnitude of stream flows result from complex interactions between rainfall, plants, topographic relief, and soil properties of all land above a drainage point (Tong and Chen 2002). Once vegetation is lost, as occurs on mined and even reclaimed mine land, hydrological changes that negatively impact stream biota and water quality ensue (Simmons et al. 2008; Ferrari et al. 2009).

Second, stream water chemistry is shaped by water processes that occur as rainwater infiltrates the ground and moves through pore spaces and soil on its way to streams (Allan and Castillo 2007). Microbial processes between the water, soil, and rooted vegetation lead to biochemical transformations that influence water quality. Not only are these processes fundamentally altered by the dramatic land disturbance at mined sites but water emerging from valley fills carries with it dissolved constituents that are toxic or damaging to biota. Pollutants added to ephemeral and intermittent stream channels will be transported downstream to larger rivers. The more surface mining and valley fill activity within a large watershed, the greater the cumulative transport of alkaline mine drainage pollutants to major rivers will be. The cumulative effect of alkaline mine drainage is highly correlated to biological impairment in streams below MTM/VF sites and can persist long after mining activities cease. Scientists have found no empirical evidence documenting recovery of biological communities in the streams impacted by alkaline mine drainage. The water quality impacts of MTM/VF mining are more severe and more persistent than other land use changes within the southern Appalachians.

Further, in 2005 the US Environmental protection Agency and other federal and state agencies completed an environmental impact statement on the impacts of mountaintop mining and valley fills (USEPA 2005). Over 1,200 stream segments were examined. A key finding was that the valley fills used for waste disposal are a primary source of selenium contamination. Given the size and placement of these fills, selenium leaching and associated pollution of downstream aquatic habitats, left untreated, will continue. Since that time the West Virginia Department of

Environmental Protection has identified many streams downstream from mountaintop mining sites that are impaired by selenium. EPA clearly, and correctly, recognized selenium as a substantial ecological risk. In addition, downstream from a large mining complex that is a known selenium hotspot, there is a fish consumption advisory due to bioaccumulation of selenium in the fish.

Third, downhill movement of water and one-way flow in stream networks mean that whatever happens on land or, in 1st and 2nd order streams (headwaters), not only determines sediment and water flow in streams and rivers below but also determines ecological structure and functions of larger waterways (Allan and Castillo 2007). In short, MTM/VF within a watershed can directly destroy local stream reaches through filling or can downgrade downstream reaches by altering the magnitude, timing and composition of water flow.

From Senator Cardin:

Q1. Can you explain:

- **i. What contaminants from MTM/VF sites cause the elevation in conductivity;**
- **ii. How it gets into the water;**
- **iii. What is the correlation between conductivity and species decline?**

Answer: Contaminants that cause the elevation in conductivity. The water quality impacts at MTM/VF sites are more severe and more persistent than other land use changes within the southern Appalachians. Streams impacted by MTM/VF often have 30-40 fold increases in sulfate concentrations and sulfate concentrations in receiving waters continue to increase after mining activities end (Sams and Beer 1999; Brooks et al. 2003; Pond et al. 2008). High sulfate concentrations can lead to impacts on aquatic organisms and ecosystem functions. Ions of calcium, magnesium, and bicarbonate increase dramatically in the waters so that electrical conductivity levels in receiving streams below fills can be extremely high ("alkaline drainage syndrome"). Trace elements of iron, aluminum, zinc, and selenium are often elevated as well (WVDEP database; Brooks et al. 2003). The cumulative effect of elevated levels of all these ions is highly correlated to biological impairment in streams below MTM/VF sites. Functionally important aquatic biota are sensitive to high conductivity which causes ionic stress disrupting water balance and causing stress or death (Goetsch and Palmer 1997; Chadwick et al. 2002; Kennedy et al. 2003; Kefford et al. 2003; Hassell et al. 2006; Pond et al. 2008).

Answer: How contaminants get into the water. The fragmentation and exposure of mined rock to air and water results in high rates of rock weathering, which leads to increased concentrations of a number of chemical constituents in the stream water below fills. The exact composition of the discharge depends on the concentration of trace elements and toxic materials in the parent material. It is important to note that mining results in increases in both the concentration of solutes and in the volume of water exported from the watershed. This means that the total mass of solutes delivered to downstream ecosystems if higher than concentration changes alone would suggest.

Answer: Correlation between conductivity and species decline. For many streams it is the cumulative or additive impact of elevated concentrations of multiple stressors (even though the concentration of any one solute may be low) that leads to biological impairment–and this is undoubtedly a part of the reason that conductivity (a cumulative measure of ionic strength) is such an effective predictor of biological impairment. The ionic stress associated with high conductivity can he direct toxicity as well as providing an indication of the additive impacts of a variety of solutes. High conductivity can be directly toxic to aquatic organisms by disrupting osmoregulation (Pond et al. 2008). This is particularly important for aquatic insects with high cuticular permeability. Mayflies in particular are highly sensitive to ionic stress (Komnick 1977; Gaino and Rebora 2000; Pond et al. 2008). For these sensitive taxa, large increases in certain ions can disrupt water balance and ion exchange processes and cause organism stress or death. Consequently, as conductivity (and the associated SO4 2-, Ca2+, Mg2+, HCO3- and trace metals) increases in central Appalachian mountain streams–the biological community is degraded (Figure 1, below). Sensitive species (especially Ephemerellidae and Heptageniidae mayflies) are lost from these systems. High conductivity and high sulfates can persist long after mining activities cease (Sams and Beer 1999; Paybins et al. 2003; Pond et al. 2008), and there is little empirical evidence documenting recovery of biological (macroinvertebrate) communities in the streams impacted by alkaline mine drainage. Thus, many thousands of miles of downstream reached have been impacted by the resulting sediment and chemical pollutants that are transmitted throughout the river network.

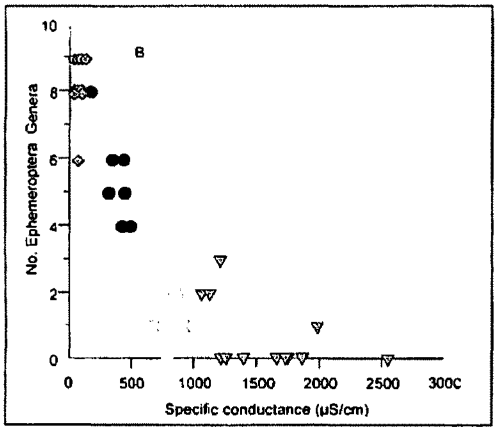

Figure 1. Number of sensitive insect (mayflies) groups (genera) as a function of stream conductivity in West Virginia streams with different levels of mining impact. Mayflies are widely recognized by the scientific and management community as indicators of water quality. From Pond et al. (2008). "Downstream effects of mountain top coal mining." Journal of the N. American Benthol. Society. 27:717-737.

Q2. When a valley is buried under contaminated mine spoil the restoration of functional hydrology and ecologically significant stream is difficult. As part of your work you have evaluated stream restoration projects, did some of those projects involve creating streams and if so could you describe their functionality?

Answer: restoration of hydrology and ecology. When contaminated mine spoil fills a valley and buries a stream, the stream is completed destroyed along with all of its biota and the ecosystem functions is previously provided. Even if you could dig a new channel in the same place, the mining activities have removed the forests and altered the mountain summit extensively (typically flattened) thus all of the natural water flow paths, the vegetative inputs to streams, the riparian soil and the streambed biogeochemistry are fundamentally different or totally absent. For this reason, the ecological or hydrological conditions will never be the same as what was present prior to the MTM/VF. Even ACOE permitting documents acknowledge that the hydrology in MTM/VFs is altered permanently.

Answer: Stream creation.

Stream creation as described in mining permit proposals typically involves digging channels that are similar in physical form (e.g., width, depth) to un-impacted headwater streams and are on or below a valley fill. A recently released federal rule refers to stream creation as a valid form of mitigation while acknowledging the lack of science documenting its effectiveness[1]. There are certainly no peer-reviewed publications documenting the successful creation of the hydrological and ecological structure and functions of a stream. I have evaluated hundreds of stream restoration projects in person (on the ground) and have led an effort to review written records on >37,000 stream restoration projects in order to develop a stream restoration database for the U.S. (www.restoringrivers.org). Even after all of this research, I know of no cases in which a stream was created de novo and was fully functional ecologically. It is important to note that re-directing a section of an existing stream has been done but this is *not* creating a stream de novo. Stream creation is simply not within the realm of current science – we do not have the tools or knowledge to do this and even if we could, doing so below a mining site would prevent full ecological recovery due to the hydrological and chemical contaminant issues.

Q3. Dr. Palmer – isn't it true that only a few streams are lost for every mine in operation?

Answer: Extent of stream loss. The foot print of stream fills at a single mining operation may vary from fractions of an acre to hundreds of acres (USEPA 2005, p. III-33). A large recently proposed mine in West Virginia will permanently fill over 8 miles of streams.[2] Many studiers to date have shown that when impacts to watersheds exceed about 10-15% of the watershed area (regardless of watershed size), there can be dramatic declines in aquatic biodiversity and water quality (Allan 2004; Booth et al. 2004; Morgan and Cushman 2005; Moore and Palmer 2005).

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[1] U.S. EPA and U.S. ACOE. Federal Register. Vol. 73 (70) April 10, 2008

[2] http://www.lrh.usace.army.mil/_kd/Items/actions.cfm?action=Show&item_id=14541&destination=ShowItem

So the streams filled at a single mine may represent a significant portion of an individual stream or subwatershed. Thus, significant local water quality impacts may occur.

In small subwatersheds cumulative impacts from coal mining operations frequently exceed 10% (Table 1, below). Even more importantly, major watersheds in central Appalachia are impacted by numerous mining operations causing significant cumulative impacts and dramatic declines in aquatic biodiversity and water quality. For example, in the Laurel Creek of the Big Coal River in WV, 28% of the *total* stream length have been buried beneath valley fills or impacted by surface mines. In the larger Coal River watershed cumulative disturbance is 12.8% of 891 square miles (570,726 ac). Thus, dramatic impacts are occurring in entire regions of central Appalachia.

Table 1. Percent of watershed covered by past, present, and pending mining permits based on ACOE permit Decision Documents for all new Clean Water Act 404 dredge and fill individual permits issued in 2008 in West Virginia. 2008 Permits were those reflected in online notification bulletins.

Mine	West Virginia Watershed	Watershed acreage	% of Watershed Covered by Mining Permits*	Decision Document Page
Coal Mac, Phoenix No. 5	Island Creek	67,342	21.90%	1. (p. 37)
	Pigeon Creek	91,037	19.00%	
Keystone Industries, Rush Creek	Rush Creek	2,934	25.80%	2. (p. 44)
Independence, Twilight	West Fk -Pond Fk	27,389	24.40%	3. (p. 100,105)
Loadout, Nellis Mine	Fork Creek	8,861	17.15%	4. (p. 66)
Hobet Mine No. 22	Upper Mud River	22,457	31.86%	5. (p. 103-104)
Appalachian Fuels	Smithers Creek	19,000	33.70%	6. (p. 45, 46)
Alex Energy / South	Whitman Creek	8,040	51%	7. (p. 72

*Percentages based on permitted areas and may not reflect actual disturbance.

Further, the Mountaintop Mining Programmatic Environmental Impact Statement ("MTMEIS") found that in 2002 more than 1,200 miles of stream channels in central Appalachia had already been buried by valley fills or directly harmed by mining. Later studies by the Office of Surface Mining found that from October of 2001 to June of 2005, mining permits impacts yet another 535 miles of stream nationwide and approximately two-thirds of those impacts were from valley fills. Losses of this magnitude mean some downstream reaches may be permanently impaired.

The headwater streams of the southern Appalachians are a biodiversity hotspot, supporting hundreds of species (some unique to these smallest of streams) that require stream habitat for all or part of their life cycle. The organisms living within headwater streams are well adapted to habitats with large fluctuations in flow and populations persist through occasional droughts and floods within stream sediments and isolated pool habitats. Despite their resilience to fluctuating flows, these organisms are not adapted to the dramatic changes in water chemistry that result from valley fills. In particular, the diverse historic assemblages of salamanders and mayflies are lost from polluted streams. According to studies done for the MTMEIS, not only is the region "known to have the highest regional concentration of aquatic biodiversity" in the country but also loss of these species "would have a disproportionately large impact on the total aquatic genetic diversity of the nation." (USEPA 2005; App. I, p. 79-80).

The loss of these ecosystems is also critical to the provision of water that is clean and abundant in supply to the larger downstream streams and rivers. The fragmentation and exposure of mined rock to air and water results in high rates of rock weathering, which leads to increased concentrations of a number of chemical constituents in the stream water below fills. Some of these cause acute toxicity in aquatic life, but many of them cause chronic low level stress to organisms. The chronic stress from many chemicals adds up to serious problems for organisms. The high level of impairment found in streams below mining valley fills is because the additive impact of all this stress is simply too much for many species. Thus, it is the cumulative impact of elevated concentrations of multiple stressors that leads to biological impairment. Many thousands of miles of downstream reaches have been impacted by the resulting sediment and chemical pollutants that are transmitted throughout the river network.

Q4. Isn't it true that the levels of these chemicals you mentioned are very low in streams below valley fills?

Answer: level of chemical contaminants. I provided extensive information on this topic for Senator Cardin's Question 1 (above) and will not repeat that text here. I tried to explain how pervasive and serious the contaminant inputs are to streams below MTM/VF sites. I will add that water quality of these streams is a serious issue, because when Selenium enters the aquatic food web it can reach levels that are toxic to fish and wildlife, such as birds. Selenium occurs naturally in coal. It is leached out from coal and overburden that fills valleys when they are exposed to air and water. Professor Dennis Lemly of Wake Forest University, who is a world expert on selenium and its ecological impacts, has completed numerous studies and a white paper he wrote on the topic was submitted as part of the hearing. I refer you to this paper for details, but describe the seriousness of the issue very briefly here. Because selenium can be bioaccumulated in the tissue of organisms, even small quantities in the water can lead to major problems for organisms: as you move up the food chain, Se is concentrated more and more and can cause severe abnormalities, death, or reproductive failure. But it is not only small quantities that are found in streams below MTM/VF sites. Selenium in discharge from a mountaintop removal coal mining operation in West Virginia polluted downstream receiving waters to levels that far exceed toxic thresholds for fish (from Lemly 2008, 2009). The maximum concentration (82 ug/L) is over fifteen times the threshold for toxic bioaccumulation.

We know that this is a major problem in Appalachian streams impacted by mountaintop mining, because a major environmental impact study was completed in 2005 by four federal agencies and the West Virginia DEP (EPA 2005). Over 1200 stream segments were examined, finding that the valley fills used for waste disposal are a primary source of selenium contamination. Because of the size and placement of these fills, selenium leaching and associated pollution of downstream aquatic habitats, left untreated, will continue in definitely.

Q5: As part of your work, have you evaluated stream restoration projects and, if so, did some of those projects involve creating streams?

Answer: stream creation. This is answered in Q2 (above).

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Senator CARDIN. Well, thank you, Dr. Palmer, and thank all of you for your testimony. Let me ask a couple of questions and then I will yield to Senator Alexander.

Dr. Palmer, you make a pretty convincing case in regards to public health and environmental risks associated with the contaminants from mountaintop removal as well as the loss of the headwaters the impact that has had on the environment.

My question to you is, how effective would remedial programs be to mitigate these damages? Are there ways in which we can restore the environmental damage caused by these fills? Is there any effective way to reverse this after the damage has been done?

Ms. PALMER. Well, so far there is no scientific evidence that that can be done. I mention that the impacts persist a very long time, even after mining has stopped. The U.S. Geological Survey and others have done studies, for example, in watersheds where mining has been ceased for a number of years and they are still finding high levels, for example, of selenium. In some cases, are talking 50 years out.

So, what it means is that you really cannot reverse that, not at least in any time span that we can relate to as humans.

Two forms of mitigation are the ones that I have seen most often: attempts to create streams, as I mentioned, by digging a ditch and moving water through it; and, attempts to restore streams that are nearby.

When you have taken the entire top of the mountain off, you have fundamentally altered the hydrology. Headwater streams are supported primarily, or to a large extent, by groundwater inputs. When you have a valley fill in, and a flat top mountain, when it rains on that mountain, the water moves into the valley fill and it actually infiltrates very rapidly. You get a larger discharge out of that valley fill than those streams below it have ever experienced. It tends to be much more constant. And very little of that, or none of that, has passed through the normal groundwater paths that a healthy stream would receive.

Keep in mind that when it rains in a healthy watershed, the vegetation, the soil bacteria and those very specific layers of soil that are present in these forests help remove contaminants, if there are any, in the rainwater. They also supply the water with nutrients. And as that water soaks into the ground, it reaches a point and it moves laterally to the headwater streams. That is why they say this is where rivers are born.

So, it is hard to imagine, without geological time passing and getting new mountains back, how you could possibly ever replace those streams that are lost.

Senator CARDIN. Well, thank you for that answer.

Secretary Huffman, I want to get to your point about the fact that there is more fill than just coming from mountaintop mining. I understand that point. I want to know what you think you can do in West Virginia to deal with the headwater issue. From your testimony, you indicate that is an issue. What can be done in order to restore or to preserve the headwater streams that you think is effective without denying these permits?

Secretary HUFFMAN. Well, there has been a lot of activity over the past 10 years. We have been through a cycle, at a more lower level that is similar to the debate today in the last 1990s and the early part of this decade regarding some of these similar type activities. One of the many results of that was an attempt to come up with different formulas for reducing the size of the valley fills because it was recognized that that was an issue that was growing in West Virginia.

Subsequently, the sizes of the valley fills that are being permitted have shrunk. But I think an unintended consequence of that is the number of valley fills has increased.

There is a lot of work that needs to be done. A lot of the things that Dr. Palmer is talking about are currently being researched and experimented with and we think that is the nature of environmental regulatory programs and the protection of the environment is for the science to continue to be the driver, we agree with that, and research dollars need to be invested and solutions sought. Absolutely.

Senator CARDIN. Let me yield to Senator Alexander. I will have a few questions after Senator Alexander is finished.

Senator ALEXANDER. Thanks, Mr. Chairman. Again, I apologize to the witnesses for, well, when I was Governor I could schedule things properly. But the Senate does not work that way, does it?

[Laughter.]

Senator ALEXANDER. Our subcommittee hearing ran and I had to be there for it and then we had our vote. So, I will read the testimony that you have sent it and consider it very carefully. It will be a part of our record. And this is just the first of our hearings on this subject.

I want to Mr. Sloan, if I may, and if I ask you a question that you answered when I was not here, excuse me, but I would like to make sure that I get it.

Am I correct that, as we define it today, the coal mining practices in Tennessee do not remove the tops of mountains and place them in streams? Is that correct today?

Mr. SLOAN. That is correct, Senator.

Senator ALEXANDER. In the past 15 or 20 years, did we have mountaintop removal, by that definition?

Mr. SLOAN. Not by that definition. We did have very limited, our staff has gone back some 15 or more so years ago and identified one case where we had a mountaintop removal which we would define there as that the mountain was not returned to some proximate contour of the historical contour of the mountain. That does not mean that there had not been mountaintop landscapes significantly affected by the mining activity, but not mountaintop removal as we defined it.

Senator ALEXANDER. Would it be possible, under current Federal law, for a mountaintop, well, for coal mining, to take excess waste and dump it in streams in Tennessee?

Mr. SLOAN. Boy, that is an interesting question. It is particularly interesting for us because we administer both the Federal Clean Water Act as well as our own Water Pollution Control Act. And under our Water Pollution Control Act, there is no question that we do not allow it.

In administering the Clean Water Act, and particularly the 401 certification, it would be our, it is a hypothetical, in a way, because we are administering both now. But, my thought is that we would not certify valley fills under 401 simply because we could not be satisfied that there would be no net loss of resources.

Senator ALEXANDER. But your administration may not be there. Will it be there for another year-and-a-half? And would you agree that, in order to make sure that we do not have those excess wastes put in valley streams again, that we should change the Federal law in the way that Senator Cardin and I have suggested?

Mr. SLOAN. I would absolutely concur with that. I think for West Virginia, Virginia, Kentucky, Tennessee, all of Appalachia, all those of us who are charged with oversight of environmental laws, consistency, clarity, is at a premium. And we do not have it today. And there are a number of pieces of legislation, particularly the Appalachian Restoration Act, I think, that brings clarify and consistency, and that is very important to us.

Senator ALEXANDER. We have talked about mining practices in Tennessee. But is it not possible, or likely, that mountaintop removal has had some effect on waters that come into Tennessee from other States?

Mr. SLOAN. Very possible. I have to say that certainly we share some very important rivers with our neighboring States, one of which is Virginia. I am very proud of an MOU that we have with Region 3 and Virginia DMME, the Department of Mining, Minerals and Energy, as well as Virginia DE, too, which focuses on the Clinch and the Powell and the extraordinary aquatics there.

But it really does take a regional approach. It takes partnership. I am delighted that we have it there and we are making, I think, some good progress on the relative impacts occurring in the neighboring States.

Senator ALEXANDER. I remember that, some time ago, when I was still Governor, Governor Allen and I did some work together on that.

I have one last question, if I may. Mr. Chairman, most of our coal mining in Tennessee is in four upper Cumberland counties which are naturally beautifully counties and they have historically been among our poorer countries, more low-income families. That is changing somewhat now, based on my visits, because of the natural beauty of the area and the parks in the area. People are moving in. Money is coming in, creating more tourism and jobs.

I know the Governor of Tennessee has talked to me before about his interest in evaluating how we can make certain that we have appropriate coal mining in the area but, at the same time, we do not do anything to damage the natural beauty of the area, not just for environmental reasons, but because of the importance of raising family incomes by tourism and by bringing people in who buy farms and buildup the property tax.

I think back on the Great Smoky Mountain National Park, which is celebrating its 75th anniversary this year. While it is nearly, what is managed, is nearly a wilderness area, all of the incentive for it 75 years ago was for economic development. It was a bunch of people in the eastern United States who said well, why are all these parks out west? We want one, too. We want the tourists. And we want their dollars.

So, what is the Governor's attitude, and yours, about the importance of maintaining the parks and the natural beauty of the area as a way of raising family incomes in the upper Cumberland part of Tennessee?

Mr. SLOAN. I think both the State, as well as the Federal Government, have invested largely in assuring public access and public lands on the plateau. I had said earlier that we have roughly 600,000 acres on the plateau that are public lands. We have over 80 State and Federal parks and natural areas, including the Big South Fork Scenic River and Recreational Area. And 2 years ago, the Governor acquired conservation interests in over 130,000 acres on the plateau, which is the largest land acquisition for the State of Tennessee, and for the enjoyment of the people of Tennessee, since the Great Smoky Mountains.

So, I think that is a value that is held very highly by this administration and by the entire State.

Senator ALEXANDER. Thank you very much. And you might tell the Governor that at the subcommittee meeting that I just went to on the Interior Appropriations Committee bill, that the full committee approved another $5 million or so for the purchase of lands in upper Cumberland regions. So I would want to make sure that, at the same time we dealt with legislation like this, Mr. Chairman, that it was not inconsistent with that.

Thank you for allowing me a little extra time for my questions.

Senator CARDIN. I appreciate it very much.

I just want to follow up on the economic issue for one moment, because, in all of our States in the Appalachia, the tourism dollars seem to be increasing rather dramatically. It is a beautiful area. I live close by and I have been up to Appalachia many times. It is a growing industry. We have the numbers and the numbers seem to be growing. It seems to me that some of the environmental risks and public health risks are counter to the economic opportunities of this region.

Secretary Huffman, one thing that I think I noticed in your testimony, and I just want to challenge if, for a moment, and give you a chance to respond. One of the arguments that have been made on the fills is the flattening of the mountaintops, particularly as for development. It gives you economic development opportunities. And yet the studies that I have seen show that there is very little development being done in these lands that are basically being left in these conditions. Very little has been developed. I think Mrs. Gunnoe has a point about how people do not want to live near these areas anyway.

Do you have any indication about the economic development opportunities associated with this? I think I saw that somewhere in your testimony, and I just want to give you a chance because it seems like just the opposite is true.

Secretary HUFFMAN. Well, Senator, that is a very good question. Historically, we have not been very good at taking advantage of the opportunities that the reclaimed mine land would offer and present for the local communities in rural West Virginia. A couple of changes recently have taken place that is changing that whole dynamic.

First of all is the post-mining land uses that are being selected now, and this is a trend that has been going on for 5 or 6 years, has been to select the forestry reclamation approach. Nearly 80 percent, I think it is about 78 percent, nearly 80 percent of the post-mining land uses that are chosen for all of our surface mining activities in the State are what is called the forest or reclamation approach. That consists of reestablishing the native hardwood forest. We are basically planting trees. And there is a science to that. It is not a matter of sticking a seed in the ground.

So that has been the vast majority of the reclamation approaches that have been taking place recently. Just this last legislative session, in fact it was last week, Governor Manchin signed into law a post-mine land use bill that would bring together the local redevelopment authorities and get local buy-in and force them, or require them, to develop a land use master plan for their county as it relates to surface mining and ensure that any time there is an opportunity to take advantage of a reclamation project on a mine site, that that is done in a coordinated fashion.

Historically, we have not communicated very well. We have not done a very good job with that and the Governor recognizes that is an issue and we are moving in that direction.

We are building, if you do not mind me, please stop me if you want me to stop——

Senator CARDIN. I want you to give as much West Virginia commercial time as you want to take on potential development. And I want you to have those reclamation projects and I want to make sure our water supply is clean and I want to make sure that we deal with the environmental risks here.

I am going to put into the record a number of studies, to be included in the record, and they show, let me just give you this number, one shows that there have been over 5,800 valley fills in West Virginia and Kentucky over the last 10 years. A VA Tech professor estimates that less than 1 percent has been reclaimed for economic development. I do not know, again, we will look at those specific numbers.

I only raise this because we hear about the economics. All of us, Senator Alexander and I, started off by saying coal is an important part of America. In West Virginia and Kentucky, there is great potential for economic growth that we think may be hampered by mountaintop recoveries. We think that needs to be taken into consideration when the economic argument is made.

We are here to talk about public safety, the water, et cetera. But we hear the economic arguments. And, in some respects, I think if you use the economic arguments, it is another reason to stop mountaintop recoveries, because I think you have a much better chance of economic growth without that type of activity and the reclamation issues are much more complicated when you have taken off the mountaintop.

I want to ask one more question, to Mrs. Gunnoe, and that is that you gave a pretty vivid picture of what you have to live with. That picture is certainly very compelling. I want you to tell me whether you have experienced a high instance of flash floods or uncontrolled issues as a result of the mountaintop operations near you. Have you experienced a difference as a result of these operations?

Ms. GUNNOE. I have. A tremendous difference. I have lived there, first, I have lived there for 41 years. I am 41 years old. I have lived there my entire life. And I have watched many rain storms come and go. Since the valley fill, it is almost a given. When we get rain, we get flooded.

There have been times that I have had the water raise with no rain at all. So, literally, the coal companies, something happened back on the mine site, and the water raised. The sun was shining, the rain had nothing to do with it. Yes, I was flooded with no rain. It definitely changes the entire aquifer, the entire everything.

The hollow that I live in, literally, you have two mountains that come in together, it has changed everything simple because the water itself, the increase in the water itself, has washed away the bottoms of the mountains. With that, it has allowed the mountains to slide in and then wash away again. And then behind it all, you have got this huge plug known as a valley fill and it has literally devastated every bit of our property in Amalfus Hollow.

And it continues to do it. It is literally washing away the land that I live on. I am the only one that lives in this hollow. I know every step of it and I have known every step of it my entire life and there is nothing, I mean, even the, I will tell you, the sun never did come through my bedroom window all of my life. Since they took the mountaintop off, the sun now comes in my bedroom window. Now there is a change you would not think about.

It dramatically changes everything, especially the water flow. The water flow takes on a life of its own, if you will. It literally meanders and goes wherever it wants to.

I would like to point out, too, that you have, with a mine site behind me, you have 1,183 acres in one operation and you have 746 acres in another operation. That is almost 2,000 acres of nothing but rock. That does not absorb water. Water runs off of it. And when the water runs off on it, it runs off of it in such a way that it tears everything in its sight out. Literally, when I was flooded in 2003, the floodwaters included live, standing trees.

Senator CARDIN. Well, once again, we thank you for really putting a face on this issue.

Mrs. GUNNOE. I appreciate that.

Senator CARDIN. We hear about the impact, but until you know someone who has experienced it first hand, it does not have the type of impact that your testimony has had.

Mrs. GUNNOE. Thank you.

Senator CARDIN. Senator Alexander.

Senator ALEXANDER. The only other thing I would say is that I am glad, Mr. Chairman, that you emphasized the economic part of it. I mean, first, I do not think that any of us need to make any apology for enjoying the beauty of the natural outdoors. Nobody in east Tennessee does. If you walk down the street and ask people why they live there, that is what they will tell you.

But also, I could go into the Sevier County Chamber of Congress, which is close to Butcher Holler where Dolly Parton grew up, and that was a poor county before the Great Smoky Mountain National Park. If you go in there now and ask this county, which is 80 percent Republican, what their No. 1 chamber of commerce issue is, it is clean air. Because they want to have an environment that people will want to come visit and spend their money.

As I look at the area we are looking at in Tennessee, where we have, I mean I know these counties pretty well. It is Claiborne County and Campbell County and Anderson and Finchers. Those are our big coal producing counties, and those are beautiful places. They are beginning to get a lot of the kind of economic development around the several State parks in the region and particularly the Big South Fork area, which has a lot of horse trails that are not allowed in the Smoky Mountain parks.

You have people moving in, spending money, buying houses, the property tax levels are going up and, if you tear up the mountains and fill up the streams, why, they will go somewhere else.

So, I hope that either the Governor or us sometime, Mr. Sloan, the Federal Government, can do a relative study of the value of the clean water and natural beauty of the area in producing dollars in the pockets of people who need higher family incomes. I think we have shown that by properly managing it, we can have coal mining and natural beauty in our area. I believe we can do that.

This is very important testimony and all of you have made a real contribution to our understanding of this and, as time goes on, we will have a chance to consider the legislation Senator Cardin has prepared. I am very proud to be a co-sponsor with him of that legislation.

Senator CARDIN. Let me join Senator Alexander in thanking you all for your testimony today. It furthers the record that we have on this issue. I know that Senator Boxer is interested in the results of this hearing, and other members of the Committee. Without objection, there are other statements from other members of the Committee which will also be made a part of the record.

And with that, the Subcommittee will stand adjourned. Thank you all very much.

[The referenced statements were not received at time of print.]

[Whereupon, at 4:58 p.m., the subcommittee was adjourned.]

[Additional material submitted for the record follows. More documents are retained in the Committee's files.]

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Health Disparities and Environmental Competence: A Case Study of Appalachian Coal Mining

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ABSTRACT

We propose broadening the concept of cultural competence to include *environmental competence.* Environmental competence refers to the ability of both public and private health providers and policymakers to be responsive to the constellation of physical, social, and economic environments in which patients and populations live. This concept is illustrated by examining health and economic disparities unique to coal mining areas of Appalachia, and discussing methods by which environmental competence may be developed and practiced. An understanding of environmental competence will allow providers and policymakers to form collaborative networks to address health disparities in Appalachia and other areas.

HEALTH DISPARITIES ARE differences in the incidence, prevalence, and burden of disease among specific populations that are not the result of population preference or need.[1] Drivers of health disparities include exposure to environmental toxins; social, behavioral, and cultural risk factors; reduced access to health services; low income and education; and stress from minority racial or ethnic status.[2–5] In addressing health disparities, health providers have been rightly urged to develop cultural competence.[6,7] We propose broadening this concept to include *environmental competence,* which refers to the ability of both public and private health providers and policymakers to be responsive to the physical, social, and economic environments in which patients and populations live.

To date, research on health disparities has largely focused on identifying disparities related to race, income, ethnicity, and culture.[8] Cultural competence has been identified as a way to more effectively serve disparate cultural groups.[9–11] However, studies on health and the built environment recognize the health impacts of unsafe neighborhoods, lack of access to safe exercise opportunities and healthy food, air pollution, poor indoor air environments, and social stressors.[12–15] Low-income people disproportionately live and work in environments with high levels of carcinogens or other toxins that interact with susceptible genes to cause disease.[2,14–16]

Physical environmental stressors have dramatically increased in recent years and can no longer be ignored in efforts to address and reduce health disparities. Consider a recent study by the Environmental Working Group, which found 287 industrial chemicals and pollutants in umbilical cord blood from 10 randomly selected babies born in US hospitals.[17] The umbilical cord blood contaminants included pesticides, consumer product ingredients, and wastes from burning coal, gasoline, and garbage. Contaminants included eight perfluorochemicals used as stain and oil repellants in fast food packaging, clothes and textiles; and dozens of brominated flame retardants. Of the 287 chemicals detected, at least 180 are known to cause cancer in humans or animals, 217 are toxic to the brain and nervous system, and 208 cause birth defects or abnormal development in animal tests. The report points out, and additional analysis has confirmed, that pre-natal and early childhood chemical exposures are often much more harmful than later exposures.[18] The authors state that the leading suspect regarding recent increasing rates of autism, certain childhood cancers, obesity, asthma, and other health problems is that of exposure to industrial chemicals.

This snapshot of toxins in newborns is a reflection of growing ecological problems stemming from population growth and growth in per capita consumption of all types of consumer goods and services [19–20] combined with inadequate monitoring of environmental toxicity. Popula-

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tion growth and per capita consumption growth means growing demands for food, water, and energy.[21–23] Examples of growing trends include the deteriorating quality of fresh water, increases in contaminated fish and a deteriorating fish supply, deforestation, erosion of dry land, urbanization, and species loss.[24–25] In spite of technologies that have improved per unit efficiencies, the aggregate amounts of services consumed have been increasing, causing serious concerns about the sustainability of ecosystems.

In addition, two significant environmental challenges, one physical and one economic, are recognized as crucial and requiring immediate attention: climate change, with large potential health impacts;[26] and growing energy scarcity combined with rising energy prices. The challenges posed by these issues carry potentially profound consequences for health care security and sustainability.[27–28] Health-related threats from climate change include heat, fires, flooding, food shortages, and changes in disease risks.[26] A growing long-term gap between supply and demand for energy[29–30] is resulting in energy cost increases that drive up costs for food, transportation, and healthcare.[31] Long-term rising energy prices undermine the viability of our economy, raising the likelihood that Medicaid and Medicare reimbursements will shrink in the coming decade,[29–30] and that health care costs and the transportation cost of accessing health care services will increase. Health planning that is responsive to these growing physical and economic environmental risks can optimize community responses, and highlights the need to develop environmental competence among public health and healthcare leaders.

Unfortunately, the current emphasis on basic and clinical research has been conducted largely in isolation from public health and the social sciences, undermining the interdisciplinary research approach necessary for addressing the complexities of health disparities. Poor communication among public health leaders, private health care providers, and environmental health experts including those from the Environmental Protection Agency (EPA) has resulted in an information gap regarding environmental exposures and health, impeding progress in efforts to address these problems.[32] Recent initiatives have improved coordinated tracking capacity around these issues,[33,34] but much room for improvement remains, especially at the community level.[35,36]

HEALTH IMPACTS OF COAL MINING IN APPALACHIA: A CASE STUDY

A quintessential example of the physical, economic, and social problems that arise from population growth and growing energy demand is that of coal mining in Appalachia. Appalachia is the mountainous area of the eastern United States consisting of 417 counties and independent cities in 13 states and containing a population of approximately 23 million people.[37] Appalachia includes all of West Virginia and parts of Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Virginia. The region has long been characterized by high levels of poverty and higher rates of illness compared to the nation as a whole. For example, Appalachia has higher rates of diabetes, heart disease, and some forms of cancer compared to the country.[38,39] The National Institutes of Health (NIH) explicitly recognizes the elimination of health disparities in Appalachia as one of its objectives.[40]

Within Appalachia, intense coal mining occurs in some areas, and not at all in others. Anecdotally, residents of Appalachian coalfield communities report illness resulting from exposure to coal mining activities that pollute local air and water.[41] Stories of coal mining communities describe pervasive social, economic, and environmental disadvantages.[42] In contrast, representatives of the coal industry highlight the economic contributions that coal mining provides to the region.[43]

Recent research evidence shows that persons who live in coal mining communities experience higher hospitalization rates for hypertension and lung disease,[44] experience higher mortality rates from a variety of causes,[45–47] and report higher rates of chronic illnesses and lower health status[48] compared to other Appalachian or national residents. Coalfield residents also experience higher levels of poverty and unemployment, lower income levels, and are more likely to lack health insurance. The health disparities are partly a reflection of the socioeconomic disadvantages but persist after controlling for these effects, and suggest that environmental pollution risks unique to coal mining locations are a contributing factor.

Table 1 summarizes some of the differences found in coal mining areas. Variables were taken from the 2005 Area Resource File (ARF). Coal production data were taken from the Energy Information Administration, and coal counties were defined to include those with at least 2 million tons of coal mined from 2000–2002 to match sociodemographic time periods.[49] Appalachian counties were identified from Appalachian Regional Commission designations.[37]

Environmental risks are reflective of the air and water quality problems associated with the coal mining industry. Coal contains numerous harmful carcinogens and other toxicants that are released into the environment during its mining and processing, including lead, arsenic, mercury, sulfur, cadmium, beryllium, and others.[50] Ghose[51] has documented air pollution problems around Indian coal mining and processing activities, and studies in the US have revealed water contamination issues around mining activities.[52–54]

As the population grows and oil prices rise, coal is increasingly being mined, offering a stark choice that to date has favored energy consumption over climate change mitigation or public health concerns. Between 1996 and 2005, coal production in the United States increased by 67 million tons,[55–56] and increased worldwide by 1.2 billion tons.[57] Additional coal mining and the construction of additional coal-fired power plants also foretells increased carbon and toxic emissions. Coal contains more carbon dioxide per unit of energy than oil or natural gas, and is responsible for about 40% of total CO_2 emissions in the United States.[58] Over 90% of national mercury and sulfur

TABLE 1. DISPARITIES BETWEEN COAL MINING AREAS, OTHER AREAS OF APPALACHIA, AND THE REST OF THE UNITED STATES

	Coal mining areas	*Other areas of Appalachia*	*Rest of United States*
Total mortality rate per 1,000[b]	11.82	10.51	10.19
Mortality rate per 1,000 from:			
Cancer[c]	2.52	2.29	2.27
Ischemic heart disease[c]	2.62	2.09	2.06
Diabetes[c]	0.42	0.32	0.30
Chronic lung disease[b]	0.67	0.58	0.55
Other indicators:			
Infant mortality per 1,000 before age 1[d]	8.96	7.93	7.32
Low-birth weight (<2500 grams)[b]	90.58	83.02	74.67
% high school education[d]	57.57	57.45	60.73
% college education[b]	7.92	11.76	17.29
Median household income[b]	$24,248	$31,342	$35,886
Median per capita income[b]	$17,522	$19,878	$23,189
Unemployment rate[b]	7.93	6.67	5.35
Poverty rate[b]	20.67	16.59	12.63

[a] Figures are age, race/ethnicity and sex-adjusted least square means.
[b] Significant difference among all three means.
[c] Coal mining areas are significantly different compared with the rest of the United States or other areas of Appalachia.
[d] Coal mining areas and other areas of Appalachia are different from the rest of the United States.

dioxide emissions for electricity generation comes from coal.[58–59]

Mountaintop removal mining enables quicker access to coal with lower labor costs, but intensifies environmental degradation; surface mining as a percent of total mining in West Virginia increased from 19% to 42% between 1982 and 2005.[60] The EPA estimates that, between 1985 and 2001, 724 miles of Appalachian streams were permanently destroyed, and 4 million acres will ultimately be impacted, by mountaintop removal mining.[61] Because coal mining areas are characterized by environmental degradation, persistent poverty, and lack of alternative economic opportunities, an increasing demand for coal will perpetuate and deepen health disparities in these mining areas. Growth in coal-mining and increases in destructive mining practices means that entire communities are exposed to polluting methods of mining and processing, not just the miners.

CONCLUSIONS AND RECOMMENDATIONS

Many of the infamous economic and health disparities associated with Appalachia are concentrated within a fraction of this area, the 16% of counties where the heaviest coal mining takes place. Coal mining areas compared to either the nation or to the rest of Appalachia, are characterized by elevated mortality rates from a variety of causes, and from higher rates of poverty, higher unemployment, lower income, and lower rates of college education. Discrepancies in mortality from cancer, diabetes, and ischemic heart disease are related solely to coal mining areas; other areas of Appalachia are not statistically different from the rest of the nation.

The causes of these health disparities are complex, representing impacts of poverty, low education, lack of economic opportunities, environmental pollutant exposure, limitations in physical infrastructure (e.g., exercise facilities, access to healthy food), problems with access to health services, and perhaps social or cultural characteristics that are unique to these areas.[62] To eliminate health disparities in coalfield communities is thus a major challenge, but one that must be addressed, and one that can be addressed in part through efforts to improve environmental competence.

Regarding pollution from the coal mining industry itself, there is at present poor understanding of the pollution types, quantities, and transport routes that impact local communities. Studies done in Great Britain and India suggest that local air pollution from coal mining and preparation is severe.[63–66] There is evidence that water pollution resulting from coal mining and preparation is a problem in Appalachia,[52–53] but studies that link health to water quality are needed. Local public health studies of these issues may prove illuminating.

Environmentally competent health care providers in coal mining areas of Appalachia may consider the potential environmental hazards that impact their patients and promote or exacerbate chronic disease. Based on these considerations, providers might recommend behavioral changes for their patients such as the use of bottled rather than tap or well water, installation of water or air filters, or even the possibility for patients with chronic disease to relocate to other, less polluted communities. Making these recommendations requires first that providers have environmental awareness about the locations where their patients live.

The incorporation of environmental competence into public health planning and patient care involves not only pollutants but other features of the economic and built environments. It may well be unrealistic, for example, to counsel a patient with diabetes to alter her diet if there are no grocery stores within a certain radius of the patient's home, and where the only realistic food outlet, as exists in some portions of Appalachia, is a mini-mart linked to a gas station. Similarly, counseling low-income, overweight patients to increase exercise levels may be unsuccessful if the only paved walking surfaces available are narrow, winding mountain roads without sidewalks where coal trucks rumble past on regular intervals.

Tools that can be used to document environmental health disparities are needed. Researchers have begun working on such tools. Measures can encompass social processes, environmental contaminants/exposures, body burdens of environmental contaminants, and health outcomes.[16] Educational materials for physicians to provide to parents to promote environmental safety for children are in use;[67] materials like these may be generalized to other applications and patient groups. Another electronic tool that may be developed for use in physician offices is a quick, automated checklist linked to a patient's address to alert the physician to the health-promoting amenities (parks, grocery stores, exercise facilities, etc.) that are present or absent in the patient's vicinity, and to highlight the environmental hazards (e.g., a facility that pollutes local air and water through crushing and cleaning coal) proximate to the address.

In the primary care setting, approaches that connect public and private health through establishing procedures for environmental competence can be optimized. Public health authorities working collaboratively with the EPA could provide information on-line to facilitate health providers in becoming environmentally competent. Continuing Medical Education (CME) credits may be provided for physician efforts to develop their knowledge and skills in this area. Patients can be empowered through health education in the primary care setting, so that they can create health for themselves, and become advocates of environmentally healthy environments. Health education can be tailored to the Appalachian experience and culture, for example, by recognizing that women in the community often see themselves as primarily responsible for the health of their families.[68] For Appalachian low-income persons and members of minority groups in particular, one-on-one, caring interactions are critical in health education processes, which could be provided in part through training low cost alternative providers.[63]

Through collaborative approaches between public and private health sectors and the EPA, access costs can be minimized and benefits maximized. The combination of effective policy and community effort has the potential to revolutionize the forces affecting health determinants. Communities are already taking the initiative to combat complicated chronic conditions like asthma and obesity.[13] Attempts to tackle complex environmental concerns are therefore not farfetched.

Environmental competence can drive strategic planning to increase community resilience in meeting future physical and economic environmental challenges. Critically, the public and private health care systems need to be aware of nontrivial probabilities of growing unemployment and uninsurance, growing transportation costs in accessing health care, rising food costs, growing environmental toxins and contaminants, and impacts from climate change. Collaborative strategic planning by public and private health providers and the EPA would enable strategic responses to these significant challenges. Environmentally competent providers will help create environmentally competent patients, who can be empowered to understand how to become advocates for better environmental health in the areas in which they live.

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Mortality Rates in Appalachian Coal Mining Counties: 24 Years Behind the Nation

Michael Hendryx

ABSTRACT

Appalachia has higher morbidity and mortality compared to the nation, and suffers greater socioeconomic disadvantages. This article investigates the relationship of coal mining to elevated mortality rates in Appalachia. Total mortality rates for the years 1999–2004 were investigated in a national county-level analysis that included coal mining as the primary independent variable. Counties in Appalachia where coal mining is heaviest had significantly higher age-adjusted mortality compared to other Appalachian counties and to other areas of the country. Elevated mortality rates persisted in Appalachian coal mining areas after further statistical adjustment for smoking, poverty, education, rural-urban setting, race/ethnicity, and other variables. After adjustment for all covariates, Appalachian coal mining areas were characterized by 1,607 excess annual deaths over the period 1999–2004. Adjusted mortality rates increase with increasing coal production from 1 to 7 million tons. These findings highlight environmental inequities that persist in Appalachian coal mining areas. Reducing these inequities will require development of alternative economies and promotion of environmental justice through regulatory and allocative policy changes.

APPALACHIA HAS LONG been characterized by social inequalities and health disparities.[1–4] Recently, the contributions that the coal mining industry makes to these inequalities and disparities has come under closer attention. Coal mining areas are linked to higher population hospitalization rates for some cardiovascular and respiratory conditions,[5] and to higher reported rates of some forms of chronic illness and poorer reported health status.[6] Compared to other parts of Appalachia, coal mining areas are also characterized by poor socioeconomic conditions including higher levels of poverty and lower education rates.[7]

The purpose of the current study was to extend prior research on the community health impacts of the Appalachian coal mining industry through an examination of mortality rates. The study tests whether mortality rates are elevated in Appalachian coal mining areas, and whether elevated mortality, if found, is due solely to socioeconomic conditions or if an additional effect specific to coal mining persists. The study also examines temporal trends in mortality in coal mining areas. Three hypotheses are tested:

1. Coal mining areas of Appalachia will be associated with higher total mortality rates compared to the rest of Appalachia and the nation, both before and after adjustment for socioeconomic covariates.
2. Mortality rates will be higher in Appalachia compared to the nation, but these rates will not remain elevated after controlling for socioeconomic effects.
3. Elevated mortality in Appalachian coal mining areas will be present over the time period 1979 to 2004.

METHODS

Design

The study is a retrospective investigation of national mortality rates for the years 1979–2004. The level of analysis is the county (N = 3,141; missing data on covariates reduced the sample by 61 cases for regression analyses). The study is an analysis of anonymous, secondary data sources and meets university Internal Review Board standards for an exception from human subjects review.

Data

Mortality data were obtained from the Centers for Disease Control & Prevention (CDC) measuring county-level mortality rates per 100,000, age-adjusted using the 2000

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US standard population.[8] Total mortality rates were examined for all internal causes, excluding causes from external factors (homicide, suicide, motor vehicle accidents, other accidents.) All ages were included. Analyses for hypotheses 1 and 2 use mortality figures for the years 1999–2004 combined, and analysis of hypothesis 3 uses annual mortality figures for the years 1979 through 2004.

Coal production data were obtained from the Energy Information Administration (EIA)[9–14] measured as tons of coal mined in every county each year for the years 1999–2004. Levels of coal mining were not normally distributed across counties. To estimate exposure, two primary analyses were conducted. The first examined mortality based on dividing counties across the country into four groups: Appalachian counties with no coal mining, Appalachian counties with coal mining up to four million tons combined over the six years 1999–2004, Appalachian counties with coal mining greater than four million tons, and other counties in the nation with no coal mining (104 non-Appalachian counties where coal mining took place were deleted from the analysis.) The choice of 4 million tons divided Appalachian coal mining counties approximately in half, with 65 Appalachian counties mining less than 4 million tons over these years, and 67 with more than 4 million tons. The second method estimated per capita exposure, found by dividing county tons mined by the county population from the 2000 Census; counties were grouped into four levels: no mining in Appalachia, per capita exposure up to 200 tons per person, per capita exposure greater than 200 tons, and no mining in the rest of nation (used as the referent).

A series of supplementary analyses were conducted to test for the robustness of findings across alternative specifications of coal mining. One set of analyses examined coal mining effects when the higher category of coal mining was based on integer levels from one to seven million tons. A second set correspondingly examined per capita exposure effects at 50-ton increments from 50 to 400 tons per capita. A third set examined whether differences in mortality rates were related to surface mining versus underground mining. A fourth set examined whether mortality rates in coal mining areas were elevated only in Appalachian coal mining areas or in coal mining areas throughout the nation.

Coal production figures for years prior to 1999 are not readily available for all counties, therefore, tests of hypotheses 1 and 2 were constrained to mortality rates from the period 1999 to 2004. There is, however, considerable historical evidence that Appalachian counties characterized by heavy coal mining during recent years were also heavy coal mining areas in previous years and decades, simply as a consequence of the presence of economically minable coal in these areas.[15–18] Therefore, the test of hypothesis 3 examined historical mortality rates from 1979 to 2004, using coal production data from 1999–2004 to identify heavy coal mining counties in Appalachia.

Data on covariates were obtained from the 2005 Area Resource File,[19] CDC Behavioral Risk Factor Surveillance System (BRFSS),[20] and the Appalachian Regional Commission.[21] Selection of covariates was based on previously identified risk factors or correlates of elevated mortality.[22–32] Covariates included smoking rates; percent male population; percent of the population with college and high school education; poverty rates; race/ethnicity rates (percent of the population who were African American, Native American, Non-white Hispanic, Asian American, using White as the referent category in regression models); percent without health insurance; physician supply (number of active MDs and DOs per 1,000 population); rural-urban continuum codes grouped into metropolitan, micropolitan, and rural; Southern state (yes or no, South equal to Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia); and Appalachian county (yes or no as defined by the 417 counties or independent cities in 13 states recognized by the Appalachian Regional Commission). CDC smoking rates were available for states and some county-based metropolitan areas; the state average was used when the specific county rate was not available.

Analysis

Analyses were conducted using bivariate correlations, general linear models and ordinary least squares multiple regression models to test for the association between coal mining and mortality, without and with control for covariates.

RESULTS

Table 1 shows total age-adjusted mortality rates for the four groups of counties before adding covariates. Mortality rates were highest in heavy coal mining areas of Appalachia, and were lowest in non-coal mining areas outside Appalachia. Other areas of Appalachia, either without mining or with lower levels of mining, had intermediate mortality rates.

Bivariate correlations were examined to test for multicollinearity among independent variables. The county poverty rate was highly correlated to percent of the population without health insurance ($r = .82$); therefore, the insurance variable was dropped from further analysis.

Table 2 shows multiple regression results that consider effects of covariates on mortality. Results for each model specification, total tons or tons per capita, were almost identical. Appalachian counties with lower levels of mining were not associated with differences in mortality, but counties characterized by high levels of coal mining had significantly higher mortality after accounting for effects of age, smoking, poverty, education, race/ethnicity, rural-urban setting and other measures. Higher mortality was also predicted independently from smoking, lower education, poverty, African American or Native American race, living in the South, and urban setting. A greater supply of physicians was related to higher mortality. A greater percentage Hispanic population was related to lower mortality. The Table 1 and Table 2 findings support the first two study hypotheses.

Based on the 2000 US Census, the population of Ap-

Table 1. Age-Adjusted Mortality per 100,000 for 1999–2004 by County Type[1]

Appalachian coal-mining ≥4 million tons	*Appalachian coal-mining <4 million tons*	*Other Appalachian*	*Rest of nation*
950.2 a	890.7 b	884.1 b	820.2 c

[1] Model F = 53.67 (df = 3, 2,973), $p < 0.0001$. Letters a, b, and c indicate means significantly different at $p < 0.05$ using post-hoc Ryan-Einot-Gabriel Welsch multiple range test.

palachian counties where mining exceeded 4 million tons was 3,883,143. The age-adjusted death rate in coal mining areas compared to non-Appalachian, non-mining counties before covariate adjustment translates to 5,048 excess annual deaths in Appalachian coal mining areas for the years 1999–2004. After covariate adjustment, the coefficient (41.39) for the mining effect measured in tons translates to 1,607 excess annual deaths in Appalachian coal mining areas.

To examine the stability of effects at different defined levels of "high" coal mining, the regression models were repeated with all covariates for integer levels of high coal mining from 1 to 7 million tons, along with a model where Appalachia was included but the coal mining variables were not (see Figure 1). High levels of coal mining were significant at all levels, but the effect for Appalachia without coal mining was not. Furthermore, the coefficient for the coal mining effect increased from 1 to 5 million tons before leveling off, suggesting a dose-response effect up to the 5 million ton level, beyond which the smaller number of counties meeting the definition of high mining suggests possible statistical power problems (N = 49 counties at 7 million tons). Even at one million tons, the estimated number of deaths was substantially higher than the estimate for the Appalachian region in general before inclusion of coal mining into the model. (Results are not shown for the corresponding tests of per capita exposure, but were significant at all levels from 50 to 400 tons, and the magnitude of the coefficient increased with increasing exposure.)

Models were also run separately for surface mining and underground mining, both within Appalachia and nationwide. Coal mining effects were significant for Appalachia and the combined analysis for both underground and surface mining, but not for coal-mining limited to ar-

Table 2. Multiple Regression Results to Predict 1999–2004 Age-Adjusted Mortality

	Coal mining measured in tons			*Coal mining measured in tons per capita*		
Variable	*Unstandardized coefficient*	*Standard error*	p<	*Unstandardized coefficient*	*Standard error*	p<
Intercept	783.5	57.7	0.0001	785.2	57.7	0.0001
Coal mining <4 million tons	1.50	11.59	0.90	—	—	—
Coal mining ≥4 million tons	41.39	11.69	0.0004	—	—	—
Coal mining <200 tons per capita	—	—	—	8.58	10.82	0.43
Coal mining ≥200 tons per capita	—	—	—	40.76	12.69	0.0013
Appalachian region (no coal mining)	−3.16	5.99	0.60	−3.02	6.00	0.62
Smoking rate	4.70	0.54	0.0001	4.69	0.54	0.0001
Metropolitan county	51.66	4.20	0.0001	51.64	4.20	0.0001
Micropolitan county	21.47	4.14	0.0001	21.54	4.14	0.0001
Percent male	0.03	0.87	0.97	0.03	0.87	0.98
Primary care physicians per 1000	4.76	1.43	0.0009	4.79	1.43	0.0008
South region	29.10	5.05	0.0001	29.04	5.06	0.0001
Poverty rate	6.55	0.52	0.0001	6.56	0.52	0.0001
Percent African American	1.53	0.16	0.0001	1.54	0.16	0.0001
Percent Native American	1.90	0.24	0.0001	1.90	0.24	0.0001
Percent Hispanic	−1.75	0.17	0.0001	−1.72	0.17	0.0001
Percent Asian American	−0.90	0.80	0.26	−0.90	0.80	0.26
High school education rate	−1.79	0.41	0.0001	−1.77	0.41	0.0001
College education rate	−3.24	0.36	0.0001	−3.25	0.36	0.0001

[1] Model adjusted $R^2 = 0.54$; F = 219.7 (df = 16, 2,959), $p < 0.0001$.
[2] Model adjusted $R^2 = 0.54$; F = 219.3 (df = 16, 2,959), $p < 0.0001$.

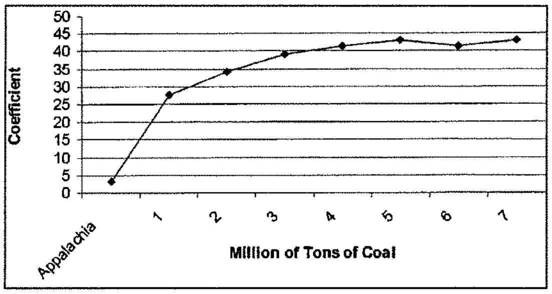

FIG. 1. Mortality per 100,000 in high Appalachian coal mining areas, 1999–2004, adjusting for all covariates, by level of mining. Appalachia refers to the effect of the Appalachia regional variable without consideration of coal mining. The Appalachia variable was not significant but all levels if mining were at $p < .009$ or better.

eas outside Appalachia (the analysis of non-Appalachian coal mining effects deleted Appalachian coal mining counties). Results are summarized in Table 3.

As the test of hypothesis 3, total age-adjusted mortality rates for the years 1979 to 2004 are shown in Figure 2 for three groups: Appalachian counties with coal mining > = 4 million tons, other Appalachian counties (either no mining or mining less than 4 million tons), and other counties in the nation. Mortality rates are significantly different across time ($p < .0001$), county type ($p < .0001$), and the time-county interaction ($p < .002$). Rates decline significantly over time for all groups, but are consistently highest for high coal mining areas of Appalachia. Compared to 1979, the mortality rates for 2004 were 13.3% lower in coal mining areas, 11.2% lower for other areas of Appalachia and 15.3% lower for the rest of the country; that is, the rate of decline was less for Appalachia and coal mining areas compared to the nation. Mortality rates for coal mining areas in 2004 are about the same as those for counties outside of Appalachia from 1980.

DISCUSSION

Results show that higher mortality in Appalachia is due to poverty, smoking, poor education, and race-related effects. Once these factors are accounted for, non-coal mining areas of Appalachia have death rates no different than the rest of the country. Coal mining areas, however, show elevated age-adjusted mortality both before and after adjustment for covariates. This is the case when Appalachian coal mining is the focus, but not for coal mining areas outside of Appalachia. Age-adjusted mortality rates for Appalachian coal mining areas lag about 24 years behind national rates outside Appalachia.

Causes of elevated mortality in coal mining areas may reflect behavioral, cultural, and economic factors only partly captured through available covariates, but may also reflect environmental contamination from the coal mining industry. That effects were found for Appalachian coal mining areas but not coal mining areas elsewhere may reflect the unique relationship of mining activity to topography and population centers characteristic of Appalachia. Coal mining is a major industrial activity in eight Appalachian states.[33] Mountaintop removal mining methods have become more prevalent in Appalachia, and often occur close to population centers; in West Virginia, surface mining constituted 42% of total mining tonnage in 2006, compared to 19% in 1982.[34] Coal contains mercury, lead, cadmium, arsenic, manganese, beryllium, chromium, and many other toxic and carcinogenic substances[35] and the mining and preparation of coal at local processing sites releases tons of annual ambient particulate matter and contaminates billions of gallons of water.[36–38] Coal preparation involves crushing coal into smaller particles, mixing coals of different qualities prior to sale, transporting coal via truck and rail, and remov-

TABLE 3. ADJUSTED REGRESSION COEFFICIENT FOR THE HIGH COAL MINING VARIABLE ($\geq$4 MILLION TONS), BY MINING TYPE (SURFACE, UNDERGROUND, AND COMBINED), AND BY INCLUSION OR EXCLUSION OF NON-APPALACHIAN COAL MINING AREAS

	Surface mining	*Underground mining*	*Combined*
Coal mining in Appalachia only	43.25 ($p < 0.001$)	42.08 ($p < 0.001$)	41.39 ($p < 0.0004$)
Coal mining outside of Appalachia	−2.71 ($p < 0.84$)	15.84 ($p < 0.38$)	5.14 ($p < 0.65$)
Coal mining nationwide	17.21 ($p < 0.06$)	31.56 ($p < 0.002$)	21.50 ($p < 0.006$)

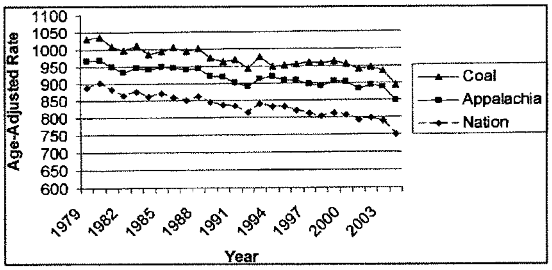

FIG. 2. Age-adjusted mortality per 100,000, 1979–2004, by county type (Appalachian coal mining, other Appalachian, or rest of nation). Model F = 1422.7 (df = 3, 81,622, $p < .0001$).

ing impurities through a chemical washing process. These preparation activities take place near the mining sites for both underground and surface operations. In addition to impurities removed by washing, chemicals used in the washing process may themselves be toxic.[39] The contaminated water, called slurry, is held in impoundment ponds or injected underground, where it poses risk of leaking into freshwater sources.[40] There are 111 impoundment ponds in West Virginia alone, holding more than 140 billion gallons of coal slurry.[41]

The environmental health impacts of the coal mining industry may operate through water and air transport routes. Shiber[42] reports elevated arsenic levels in drinking water sources in coal mining areas of central Appalachia. Other studies of water quality near coal mining in Appalachia have been conducted[43–45] showing that surface water and private well water are contaminated in ways consistent with coal slurry. Studies of local air quality in Appalachian coal mining communities have not been done, and constitute an important next step in this line of research. However, particle constituents in ambient air from coal mining or processing may occur at fine ($PM_{2.5}$) or coarse (PM_{10}) modes.[46] Coal particulates may also interact with diesel particulate matter; diesel engines are commonly used at mining and processing sites. Research has linked urban air pollution to premature mortality[47,48] possibly from the exacerbation of acute or preexisting illness. It may be the case that pollution from coal mining and processing activities has a similar effect.

Ironically, removal of coal impurities and crushing of coal into smaller pieces, although intended as an environmental protection step and to increase the efficiency of burning, result in impurities being left behind in the vicinity of coal mining communities. The coal cleaning process is described as "removing" impurities prior to burning,[49] but it would be more precise to say that these impurities are merely "relocated."

Limitations of the study include the ecological design, the imprecision of covariates, and the limited availability of coal mining data. Individual causes of mortality and their relationship to mining or other variables may be suggested but cannot be proven with a county-level analysis. Smoking was imprecisely estimated, and other behavioral contributions to mortality such as diet or alcohol consumption were not included, although these behavioral variables are known to correlate with other measures that were included such as education and poverty. Coal mining was measured only for the years 1999–2004; for the test of hypothesis 3 the reasonable but unproven assumption was made that this estimate reflected earlier mining activity. Mining effects in Appalachia were found for both underground and surface techniques (although the coefficient was slightly higher for surface mining); more specific forms, such as mountaintop removal versus other forms of surface mining could not be examined. Furthermore, key aspects of coal processing, including chemical washing and transportation, could not be linked to mortality data because of the lack of data specificity. Given that both surface and underground mining were related to mortality, it is important that future research examine population health effects from mining industry activity that are common to both methods, including relating operations of local coal processing facilities to measures of air and water quality and to health outcomes.

Ultimately, regardless of whether the persistently elevated mortality rates found in Appalachian coal mining areas result from environmental, social, economic, or behavioral causes, it is clear that serious health disparities persist in these areas and must be addressed. The underlying causes of health disparities are founded in economic, educational, and environmental injustices.[50–52] To reduce and eliminate disparities requires that these root causes be attacked. For coal mining areas of Appalachia, this means that alternative and sustainable economies be developed, as a continued reliance on a coal-based economy will only perpetuate disparities. Results also highlight the need for improvements in environmental equity: people who live in these areas are subject to environmental degradation and exposure to pollutants in exchange for development of a relatively cheap energy source for many of the rest of us to enjoy.

The argument is often made that coal mining is an important economic contributor to the areas of Appalachia where mining takes place,[53] and therefore that mining should be protected and encouraged. The first part of this argument is correct, but the second part is fallacious. Coal mining perpetuates poverty, environmental degradation, economic underdevelopment, and premature death. That it is an important part of a perpetually weak economy is no endorsement for its continuation. Coal mining remains an important part of these economies because underdeveloped infrastructure, blasted landscapes, poorly educated workforces, environmental health hazards, and chronically unhealthy populations perpetuate themselves over time and present strong discouragement to new business and population immigration.

Construction of more diverse, alternative economies should be undertaken. Such efforts could include sustainable timber or agriculture, development of marketable alternative energy such as wind power, investments in education and technology, and entrepreneurial ventures. Microcredit programs may be attempted as has been done successfully in parts of the developing world.[54] Business incubators to support small start-up ventures have been implemented in other parts of Appalachia [55] and may be extended to the coalfields. Ecosystem restoration to reclaim lands destroyed by mining may create jobs and business opportunities.[56] Regulatory and allocative policies may be implemented and enforced to require coal companies to reduce environmental impacts and to return greater portions of coal revenue to the places where the coal is mined, rather than to corporate offices located outside the region.

Finally, we should recognize that coal is mined primarily because there is a national and international market for it, whether or not it benefits the local population. Global initiatives are underway to increase use of alternative energy sources, and to re-calibrate the price of coal through consideration of environmental costs via carbon taxes or cap-and-trade programs. Such initiatives are critical to mitigate effects of climate change, and if implemented could dramatically reduce reliance on this polluting energy source.[57] Reductions in the external demand for coal will provide a crisis and an opportunity for the people of the Appalachian coalfields to redefine themselves and create healthier environments in a post-carbon world.

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Mortality in Appalachian Coal Mining Regions: The Value of Statistical Life Lost

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SYNOPSIS

Objectives. We examined elevated mortality rates in Appalachian coal mining areas for 1979–2005, and estimated the corresponding value of statistical life (VSL) lost relative to the economic benefits of the coal mining industry.

Methods. We compared age-adjusted mortality rates and socioeconomic conditions across four county groups: Appalachia with high levels of coal mining, Appalachia with lower mining levels, Appalachia without coal mining, and other counties in the nation. We converted mortality estimates to VSL estimates and compared the results with the economic contribution of coal mining. We also conducted a discount analysis to estimate current benefits relative to future mortality costs.

Results. The heaviest coal mining areas of Appalachia had the poorest socioeconomic conditions. Before adjusting for covariates, the number of excess annual age-adjusted deaths in coal mining areas ranged from 3,975 to 10,923, depending on years studied and comparison group. Corresponding VSL estimates ranged from $18.563 billion to $84.544 billion, with a point estimate of $50.010 billion, greater than the $8.088 billion economic contribution of coal mining. After adjusting for covariates, the number of excess annual deaths in mining areas ranged from 1,736 to 2,889, and VSL costs continued to exceed the benefits of mining. Discounting VSL costs into the future resulted in excess costs relative to benefits in seven of eight conditions, with a point estimate of $41.846 billion.

Conclusions. Research priorities to reduce Appalachian health disparities should focus on reducing disparities in the coalfields. The human cost of the Appalachian coal mining economy outweighs its economic benefits.

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The Appalachian region of the United States has long been associated with severe socioeconomic disadvantages.[1-3] These disadvantages translate to poor public health outcomes including elevated morbidity and mortality rates for a variety of serious, chronic conditions, such as diabetes, heart disease, and some forms of cancer.[4-6] The problems are so severe and persistent that the National Institutes of Health (NIH) has included Appalachia among its target priorities for the reduction and elimination of health disparities.[7]

Coal mining constitutes a major economic activity in some portions of Appalachia.[8] As with Appalachia in general, the region's coal mining areas have been linked to socioeconomic disadvantages.[1,9,10] Appalachian areas where economic disadvantage has been most persistent over time are those characterized by low economic diversification, low employment in professional services, and low educational attainment rates.[2] These features are characteristic of tobacco- and coal-dependent economies.[11] Rural economies dependent on sole-source resource extraction are vulnerable to employment declines and market fluctuations.[12]

Based on social disparities models[13,14] that link poor health to socioeconomic disadvantage, one would expect to see elevated morbidity and mortality in mining areas resulting from the socioeconomic disadvantages that are prevalent in these areas. Recent empirical studies have indeed confirmed that health disparities exist in coal mining regions of Appalachia compared with other areas of the region or the nation, including elevated mortality rates for total causes, lung cancer, and some chronic illnesses.[15-19] These studies showed that mortality is related to higher poverty, lower education levels, and smoking behavior, and also suggested that environmental pollution from the mining industry is a contributing factor.

The reliance on coal mining in some areas of Appalachia constitutes a de facto economic policy: coal is mined because it is present and because there is a market for it. However, other economic policies could be developed if reliance on this resource was not in the best interest of the local population. This study evaluated the costs and benefits associated with the Appalachian coal mining economy. We first estimated the number of excess annualized deaths in coal mining areas for the period 1979 through 2005 and converted those estimates to monetary costs using value of statistical life (VSL) figures from prior research.[20-23] Then, we compared VSL costs with an estimate of the economic benefits of coal mining to test whether the economic benefits of coal mining in Appalachia exceeded the estimated VSL costs.

METHODS

Design

This study retrospectively investigated national mortality rates for the years 1979–2005. The level of analysis was the county (n=3,141). We compared four groups: counties in Appalachia with levels of coal mining above the median, Appalachian counties with levels of mining below the median, non-mining counties in Appalachia, and other counties in the nation. The study, an analysis of anonymous, secondary data sources, met university Internal Review Board standards for an exception from human subjects review.

Data

We obtained publicly available mortality data for 1979 through 2005 from the Centers for Disease Control and Prevention (CDC). These data measure county-level mortality rates per 100,000, age-adjusted using the 2000 U.S. standard population.[24] We examined total mortality rates for all causes, and included all ages.

We obtained coal employment and production data from the Energy Information Administration (EIA),[25] measured as tons of coal mined in every county every year for the years 1994–2005. The EIA does not provide county-specific data prior to 1994. For the current study, we defined coal mining areas as counties with any amount of coal mining during those years. For some analyses, we divided coal mining counties into those with higher or lower amounts of mining based on a median split of production figures. In most cases, counties that mined coal in one year did so in most or all years, due simply to the presence of economically minable coal in the county. However, we placed seven counties that had small amounts of mining prior to 1997 and no mining after that time with the non-mining counties to focus the analysis on areas with more contemporary mining, as some analyses were limited to the period 1997–2005. There is also considerable historical evidence that Appalachian counties characterized by coal mining during recent years were also coal mining areas in previous years and decades,[1,26-28] so we used mining during the 1994–2005 period as a proxy for mining during the entire study period.

We obtained data on county socioeconomic characteristics from the 2005 Area Resource File[29] and the Appalachian Regional Commission.[30] Area Resource File data were in turn drawn from U.S. Census data and were based either on the 2000 Census or on multiyear estimates when available. We used these data to compare coal mining areas with other areas using the following categories: median household income (the mean for 2000–2002), poverty rates (the mean for

2000–2002), 2000 high school and college education rates, and 2000 unemployment rates. We obtained smoking rates from Behavioral Risk Factor Surveillance System survey results from CDC,[31] supplemented with additional data found by reviewing all 50 states' public health websites.

We calculated estimates for the VSL based on prior VSL research conducted by U.S. regulatory agencies.[20–23] VSL estimates were based on trade-offs between risks (e.g., probability of mortality from breathing polluted air) and money (e.g., the cost of reducing that risk), and provided a reference point to assess the benefits of risk-reduction efforts. VSL estimates are used by government agencies such as the Environmental Protection Agency (EPA), Food and Drug Administration, and others to conduct cost-benefit analyses of pollution control policies or other public benefit programs. The two estimates that we used in the current study were (*1*) the calculated mean VSL of $3.8 million per life across 18 U.S. regulatory agency studies reported by Viscusi and Aldy and (*2*) the EPA estimate of $6.3 million to represent environmental policies pertinent to the current investigation.[23] We measured both of these estimates in 2000 dollars, and converted them to 2005 dollars as described further in this article.

We estimated the economic benefit of coal mining from a 2001 report of the direct, indirect, and induced economic contributions of the coal mining industry in Appalachia.[32] This report was based on earnings and coal production in 1997. Direct contributions include earnings from coal company employees, including laborers and proprietors; indirect and induced contributions include earnings by other sectors based on multiplier effects of the industry (e.g., supplies purchased locally by coal companies and coal company employee expenditures on other goods and services). We made adjustments to reflect the 4.35% mean annual increase in the Consumer Price Index between 1997 and 2005, and the 11% decline in Appalachian coal mining employment during the same time period.

In addition to these economic benefits, some states imposed coal severance taxes that provided additional economic input to these states.[32] West Virginia, for example, imposed a 5.0% coal severance tax on the sales price per ton, the tax in Kentucky was 4.5%, and in Tennessee it was $0.20 per ton. In contrast, states also provided various tax incentives related to the coal industry: Maryland, Ohio, and Virginia provided a corporate tax credit of $3.00 per ton for burning indigenous coal, and the credit in Kentucky was $2.00 per ton. Alabama and Virginia provided tax incentives to coal companies to increase production. The final estimate of economic contributions included the adjusted sum of the indirect, direct, and induced contributions, plus the net contributions of the severance tax, minus the tax credits.

Analysis

We analyzed the data using SAS® 9.1.3.[33] We tested mean group differences using least squares linear models. Where indicated, post-hoc Type I error corrections used the Ryan-Einot-Gabriel-Welsch Multiple Range Test. We conducted ordinary least squares multiple regression models with age-adjusted mortality as the dependent variable and mining, socioeconomic, and demographic indicators as independent variables to identify mining effects independently of other effects. We converted unadjusted and covariate-adjusted annual mortality rates to excess number of deaths in mining areas using census population data, and then multiplied these figures by the VSL estimates to find a range of the economic cost of coal mining, which we then compared with the estimated economic benefit.

There is evidence that some health impacts from economic and environmental disadvantage occur in the short term,[34–37] but that other effects are delayed.[38,39] Discounting future costs is one way to account for delayed effects; however, discounting has proponents[23,40,41] and detractors,[36] and there are unknowns in the choice of time periods, discount rates, and uncertainties of how people value future health benefits.[42] Nevertheless, we conducted a discount analysis based on previous research that used a 10-year, 3% discount rate to study cancer mortality;[38] we selected a 2% discount to recognize that not all health impacts would be delayed. We compared the 2005 benefits of coal mining with future discounted VSL costs using eight scenarios, including lower or higher VSL, unadjusted or adjusted covariate analysis, and Appalachia or the nation as the comparison group.

RESULTS

Socioeconomic characteristics

Table 1 presents socioeconomic indicators and age-adjusted mortality rates for four groups of counties: Appalachian counties with levels of mining above the median, Appalachian counties with levels of mining below the median, Appalachian counties with no mining, and the rest of the nation. Significant post-hoc differences between groups were corrected for Type I error at $p<0.05$. Coal mining areas fared significantly worse on all indicators compared with non-mining areas of Appalachia and/or the nation. These conditions worsened as levels of mining increased: the highest levels of unemployment and lowest incomes

Table 1. Socioeconomic measures and annual age-adjusted mortality from 1979 to 2005 for four groups

Socioeconomic measure	*Appalachian counties with coal mining above the median*[a]	*Appalachian counties with coal mining below the median*[a]	*Non-mining Appalachian counties*	*Rest of nation*	P-*value*
Number	70	69	274	2,728	
Median household income[b]	$28,287	$30,614	$33,078	$36,622	0.0001
Poverty rate[c]	18.0	16.5	14.5	13.3	0.0001
Percent of adults with high school education[d]	69.8	71.3	71.5	78.3	0.0001
Percent of adults with college education[b]	11.2	12.6	13.8	17.0	0.0001
Unemployment rate[e]	7.0	6.0	5.0	4.7	0.0001
Age-adjusted mortality per 100,000[f]	1,049.0	1,007.3	985.6	932.7	0.0001

[a] The median split refers to mining counties with greater than, or less than, the median tons of coal mined during the combined years 1994–2005; this median figure is 7,785,000 tons.

[b] Higher coal mining was significantly different from all groups; lower coal mining was significantly different from the nation.

[c] Both coal mining locations were significantly different from others.

[d] All three Appalachian groups were significantly different from the nation.

[e] Higher coal mining was significantly different from all groups, and lower coal mining was significantly different from all groups.

[f] Higher coal mining was significantly different from all groups, and both other Appalachian groups were significantly different from the nation.

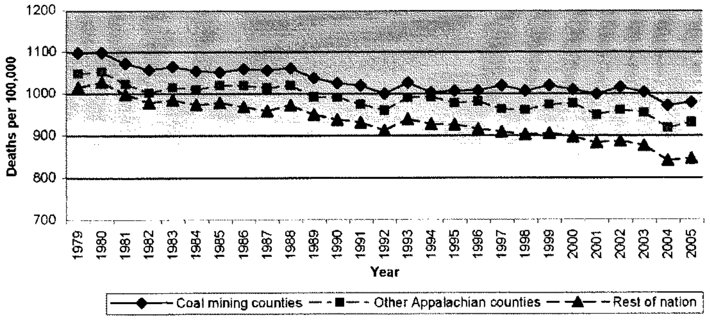
were located in the areas where the heaviest mining activity took place. For two indicators, poverty and unemployment, the disparity was unique to mining areas; that is, an Appalachian disparity compared with the nation did not exist outside of coal mining areas. Age-adjusted mortality was highest in areas of heaviest coal mining.

Reductions in employment in the industry over time indicated the poor economic conditions of mining areas. The number of coal miners in Appalachia declined from 122,102 to 53,509 between 1985 and 2005. This decline corresponded to increases in mechanized mining practices and the growth of surface mining, which requires fewer employees than underground mining per ton mined.[43]

Age-adjusted mortality rates

The Figure presents the age-adjusted total mortality rates for three groups of counties for 1979 through 2005. We combined higher and lower levels of mining for this analysis. Significant main effects were present for time (F=869.8, $p<0.0001$) and county group (F=23.6, $p<0.0001$), and for the interaction of time and group (F=24.8, $p<0.0001$). (Mortality rates are sometimes studied using log normal distributions; we repeated this test on the log values of mortality rates

Figure. Total age-adjusted mortality per 100,000 for the years 1979–2005, by county group



and still found significant main effect and interaction terms at the same levels of *p*-values.) Historic trends showed declining mortality rates for all groups, but coal mining areas had the highest rates for every year. Non-mining areas of Appalachia had intermediate rates. The time × group interaction indicated that the gap between non-Appalachian counties and both other county groups increased; this increasing gap became most evident in 1997 and subsequent years as shown in the Figure. As illustrated, the mean gap between coal mining areas and the nation in the first five years (1979–1983) was 77.6 excess deaths per 100,000 and increased to 126.0 excess deaths per 100,000 during the last five years (2001–2005). The trend between coal mining areas and other areas of Appalachia was more complex, as the gap between these groups of counties declined prior to 1997, but has increased since then.

Across all years, the mean number of excess age-adjusted deaths in mining relative to non-mining areas of Appalachia was 42.74 per 100,000. The population of the coal mining regions of Appalachia was 9,301,033, based on the mean of the U.S. Census figures for 1980, 1990, and 2000. Multiplying deaths per 100,000 (42.74) by the population in 100,000 units (93.01) resulted in an excess of 3,975 annualized deaths in coal mining areas of the region compared with the rest of Appalachia.

When we limited the analysis to the more recent period, 1997–2005, we found the number of excess annualized deaths to be 4,432. (This estimate used only the 2000 U.S. Census population for Appalachia to best match the mortality time period.) If mortality rates in coal mining areas were equal to the nation outside Appalachia, the number of annualized averted deaths would be 8,840 for the period 1979–2005, and 10,923 for the period 1997–2005.

Covariate-adjusted mortality

Regression models examined two time periods: 1979–2005 and 1997–2005. For each time period, one model used national data and one was limited to Appalachian counties. The results of all four analyses indicated that higher age-adjusted mortality was independently related to coal mining counties in Appalachia after controlling for smoking rates, rural-urban location, percent male population, supply of primary care doctors, a regional South variable, poverty, race/ethnicity, and education. We selected these covariates to be consistent with other research on this topic.[16–19] We considered income and percentage of the population without health insurance, but then dropped them because of their high correlation with poverty. The covariates were themselves correlated with mortality. For example, we linked higher mortality with poverty, lower education, smoking, and higher percentages of African American and Native American populations.

The model for the national analysis across all years is summarized in Table 2; other models were similar. As shown, the coefficient for the mining effect after controlling for covariates was 31.06. Multiplied by the population of mining areas, this translated to 2,889 excess deaths. In other words, of the 8,840 excess age-adjusted deaths found in mining areas, 2,889 remained after accounting for smoking, race, poverty, physician

Table 2. Regression model results[a] to estimate total age-adjusted mortality per 100,000 for 1979–2005 from mining, socioeconomic, and other variables: a national analysis

Variable	*Unstandardized coefficient*	*Standard error*	*P-value*
Intercept	1,047.57	45.42	0.0001
Mining (yes/no)	31.06	7.46	0.0001
Appalachia (yes/no)	−2.57	4.96	0.6100
Smoking rate	3.08	0.44	0.0001
Rural-urban continuum code	−9.19	0.56	0.0001
Percent male population	−0.29	0.69	0.6800
Primary care physicians per 1,000	7.25	1.17	0.0001
South region of U.S. (yes/no)	24.01	4.04	0.0001
Poverty rate	5.24	0.41	0.0001
Percent African American	1.82	0.13	0.0001
Percent Native American	2.90	0.18	0.0001
Percent nonwhite Hispanic	−1.50	0.14	0.0001
Percent Asian American	−0.81	0.62	0.2000
Percent with high school education	−2.03	0.32	0.0001
Percent with college education	−3.34	0.28	0.0001

[a] Model F=355.67 (degree of freedom = 14, 3,125), $p<0.0001$; adjusted R^2 = 0.61

supply, education, and other variables. We also found this adjusted estimate for the number of excess deaths for the other three models, as shown in Table 3.

Estimated costs and benefits of coal mining

The assessment of the coal mining industry in Appalachia resulted in an estimate of the 1997 economic contribution valued at $6.5 billion.[32] This estimate included direct, indirect, and induced earnings impacts. To the extent that employment in the mining industry has experienced a downward trend,[43] future declines in employment would reduce this impact estimate. Comparing the economic report with EIA figures[25] indicated an 11% decrease in employment in Appalachian coal mining from 1997 to 2005. We adjusted the impact estimate, which was based on employment figures, downward by 11% to account for this decrease in employment. However, we increased the estimate based on the mean 4.35% annual increase in the Consumer Price Index between 1997 and 2005. The resulting contribution of the coal mining industry in 2005 dollars may be estimated at $7.798 billion. State income from coal severance taxes added about $458 million to coal's economic contribution to the region in 2005 dollars, and tax credits reduced this amount by about $168 million, for a final total of $8.088 billion.

We used two VSL estimates: $3.8 million and $6.3 million per life.[23] We based these figures on 2000 dollars. Adjusting for the mean 4.60% annual increase in the Consumer Price Index between 2000 and 2005 resulted in VSL estimates of $4.67 million and $7.74 million expressed in 2005 dollars. Table 3 summarizes the estimates of the human cost of Appalachian coal mining by multiplying these VSL estimates with the estimates of excess deaths during varying time periods and comparison groups. The analysis is presented for both unadjusted and adjusted deaths. In the unadjusted analysis, resulting estimates ranged from $18.563 billion to $84.544 billion, all of which were higher than the estimate of the beneficial economic impact of coal mining for the region. To identify a point estimate, we used the lower VSL estimate of $4.67 million, selected the more recent time interval 1997–2005, and selected the mortality difference between coal mining areas and the nation based on the fact that the NIH goal is to equate health in Appalachia to the nation. Using this estimate, we determined the cost associated with coal mining in Appalachia as $50.01 billion per year.

After adjusting for other mortality risks, the VSL analysis continued to show excess costs relative to the economic benefits of mining. Estimates ranged from $8.236 billion to $18.166 billion. In the case of adjusted estimates, using the higher EPA VSL figure of $7.74 million was defensible because adjusted deaths more likely reflected environmental health impacts of mining; the resulting point estimate was $18.166 billion per year.

Discount analysis

Table 4 summarizes the results of the discount analysis. This analysis used as the starting point the 2005 benefits of coal mining and the 1997–2005 estimate of excess deaths to reflect more current conditions. A 2% 10-year discount resulted in future VSL costs that exceeded current benefits for seven of eight scenarios. The only exception was for the smaller VSL that compared mining areas with other Appalachian areas adjusted for all covariates. Social disparity models indicated the importance of both socioeconomic and environmental variables and, therefore, the appropriateness of an unadjusted analysis: all four unadjusted results showed discounted VSL costs exceeding current benefits, with a point estimate

Table 3. Unadjusted and adjusted costs of coal mining by VSL estimate and comparison group

	Cost estimates in billions for excess deaths in coal mining areas in comparison with other Appalachian counties and the nation, by time period			
VSL	*Appalachia, 1979–2005*	*Appalachia, 1997–2005*	*Nation, 1979–2005*	*Nation, 1997–2005*
Unadjusted				
$4.67 million	$18.563	$20.697	$41.283	$51.010
$7.74 million	$30.766	$34.304	$68.422	$84.544
Number of excess unadjusted annual deaths	3,975	4,432	8,840	10,923
Adjusted				
$4.67 million	$8.236	$8.491	$13.492	$10.923
$7.74 million	$13.646	$14.071	$22.361	$18.166
Number of excess adjusted annual deaths	1,763	1,818	2,889	2,347

VSL = value of statistical life

Table 4. Discounted VSL costs in billions of dollars based on a 10-year 2% discount rate[a]

	Cost in billions compared with Appalachia		*Cost in billions compared with the nation*	
Discounted VSL	*Unadjusted*	*Adjusted*	*Unadjusted*	*Adjusted*
$3.83 million	$16.979	$6.965	$41.846	$8.991
$6.35 million	$28.141	$11.543	$69.356	$14.902

[a] Results are for two VSL estimates, for adjusted and unadjusted effects, and for comparisons with non-mining Appalachia and the nation.

VSL = value of statistical life

of $41.846 billion under the same assumptions used to select the non-discounted point estimate.

DISCUSSION

Age-adjusted mortality rates were higher every year from 1979 through 2005 in Appalachian coal mining areas compared with other areas of Appalachia or the nation. We found the highest mortality rates in areas with the highest levels of mining. Over time, the gap in mortality rates between coal mining areas and other areas of Appalachia and the nation has increased. The disparity became particularly noticeable after 1996. Consistent with social disparities models,[13,14] the results of the current regression analyses and other research suggest that poverty, low education level, smoking behavior, and environmental pollutants are among the factors that lead to higher mortality rates in coal mining areas.[15,18,19] Higher mortality may also be due in part to conditions of elevated stress[44] caused by economic disadvantage and environmental degradation. The results suggest, but do not prove, that a coal mining-dependent economy is the source of these continuing socioeconomic and health disparities. The call by NIH for research to reduce and eliminate Appalachian health disparities should focus on eliminating disparities in the coalfields.

Previous research that examined specific forms of mortality in coal mining areas found that chronic forms of heart, respiratory, and kidney disease, as well as lung cancer, remained elevated after adjusting for socioeconomic and behavioral factors.[16,18,19] Elevated adjusted mortality occurred in both males and females, suggesting that the effects were not due to occupational exposure, as almost all coal miners are men. These illnesses are consistent with a hypothesis of exposure to water and air pollution from mining activities. There is evidence that the coal mining industry is a significant source of both air and water pollution.[45–50] In the current study, the adjusted VSL costs indicate that the potential environmental impacts of mining exceed the economic benefits of mining.

Eliminating the mortality disparity in coal mining areas would result in savings of an estimated 3,975 to 10,923 lives per year based on choice of comparison group. The results of the unadjusted analysis showed that the corresponding VSL estimates outweighed the economic benefits of coal mining by up to an order of magnitude, and the point estimate outweighed the benefits of mining by a factor of six.

Discounting the majority of VSL costs 10 years into the future still resulted in costs that exceeded benefits in seven of eight tests. Social disparities models indicated that socioeconomic disadvantage should not be "adjusted away"; all four unadjusted tests showed future costs exceeding current benefits.

Socioeconomic disadvantage is a powerful cause of morbidity and premature mortality.[51–53] Coal mining regions have higher unemployment and poverty rates compared with the rest of Appalachia or the nation, and this economic disadvantage appears to be a contributing factor to the poor health of the region's population. Areas with especially heavy mining have the highest unemployment rates in the region, contrary to the common perception that mining contributes to overall employment. The weakness of local coal-dependent economies is also evident from census data showing that migration has resulted in population loss from mining areas relative to non-mining areas. For example, coal mining counties in West Virginia experienced a mean net loss of 639 people to migration between 1995 and 2000, compared with a mean net migration gain of 422 people in non-mining counties.[54]

We limited the calculation of costs and benefits to those occurring in the Appalachian mining industry. For example, we did not include benefits such as the economic productivity resulting from coal combustion in factories nor the costs of premature deaths from air pollution caused by burning coal in those factories.[39] We intentionally limited the analysis to an assessment of the costs and benefits of the coal mining industry for the people of Appalachia.

We selected the VSL estimates that we used from studies by government agencies to reflect costs and benefits of policies for the population at large. We excluded VSL estimates derived from labor market studies, which typically result in higher mean VSLs for working-age populations, so that all people, regardless of age, were included at equal value. Although studies have generally confirmed that the VSL declines with age, regulatory policies to improve environmental health also have disproportionate benefits for the elderly.[23] The U.S. federal government has established that age discrimination (discounting the life value of older people) in VSL estimates is contrary to official policy.[22]

Limitations

First, despite the significant associations between coal mining activity and both socioeconomic disadvantage and premature mortality, it cannot be stated with certainty that coal mining causes these problems. It is not possible to determine what the economic and public health outcomes would be in these areas in the absence of mining. However, given the literature on the impacts of social disparities and the previously documented problems of coal-dependent economies, such a causal link seems likely.

Second, we had no direct measures of environmental pollutants to determine what role they play in excess mortality. We concluded that such an impact was possible given the results of the regression models and previously cited literature on the environmental consequences of coal mining.

Third, the discount analysis contained uncertainties. It was difficult to understand the time lag and the appropriate discount rate to apply to account for an unknown proportion of excess mortality due to delayed effects given available data.

Finally, the cost estimates may be conservative because they do not consider reduced employment productivity resulting from medical illness, increased public expenditures for programs such as food stamps and Medicaid,[32] reduced property values associated with mining activities,[55] and the costs of natural resource destruction.[56] Natural resources such as forests and streams have substantial economic value when they are left intact,[57] and mining is highly destructive of these resources. For example, Appalachian coal mining permanently buried 724 stream miles between 1985 and 2001 through mountaintop removal mining and subsequent valley fills, and will ultimately impact more than 1.4 million acres.[58] Coal generates inexpensive electricity, but not as inexpensive as the price signals indicate because those prices do not include the costs to human health and productivity, and the costs of natural resource destruction.

CONCLUSIONS

In response to this and other research showing the disadvantages of poor economic diversification,[2] it seems prudent to examine how more diverse employment opportunities for the region could be developed as a means to reduce socioeconomic and environmental disparities and thereby improve public health. Potential alternative employment opportunities include development of renewable energy from wind, solar, biofuel, geothermal, or hydropower sources; sustainable timber; small-scale agriculture; outdoor or culturally oriented tourism; technology; and ecosystem restoration.[10,59] The need to develop alternative economies becomes even more important when we realize that coal reserves throughout most of Appalachia are projected to peak and then enter permanent decline in about 20 years.[60]

Various efforts have been proposed to reduce carbon dioxide emissions to combat climate change. However, tighter pollution emission standards, carbon tax, cap-and-trade, and carbon sequestration proposals, even if effective, will only address how coal is burned. Such proposals ignore how coal is extracted, processed, and transported prior to burning. These preconsumption processes carry their own significant economic, environmental, and health costs.

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Hospitalization Patterns Associated with Appalachian Coal Mining

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Abstract

The goal of this study was to test whether the volume of coal mining was related to population hospitalization risk for diseases postulated to be sensitive or insensitive to coal mining byproducts. The study was a retrospective analysis of 2001 adult hospitalization data (N=93,952) for West Virginia, Kentucky and Pennsylvania, merged with county-level coal production figures. Hospitalization data were obtained from the Health Care Utilization Project National Inpatient Sample. Diagnoses postulated to be sensitive to coal mining byproduct exposure were contrasted with diagnoses postulated to be insensitive to exposure. Data were analyzed using hierarchical non-linear models, controlling for patient age, gender, insurance, co-morbidities, hospital teaching status, county poverty, and county social capital. Controlling for covariates, the volume of coal mining was significantly related to hospitalization risk for two conditions postulated to be sensitive to exposure: hypertension and chronic obstructive pulmonary disease (COPD). The odds for a COPD hospitalization increased 1% for each 1,462 tons of coal, and the odds for a hypertension hospitalization increased 1% for each 1,873 tons of coal. Other conditions were not related to mining volume. Exposure to particulates or other pollutants generated by coal mining activities may be linked to increased risk of COPD and hypertension hospitalizations. Limitations in the data likely result in an underestimate of associations.

Hospitalization Patterns Associated with Appalachian Coal Mining

Introduction

Over the past several years, coal has become more competitive as a source of power and fuel because of 1) energy security concerns, 2) an increase in the cost of oil and gas, 3) evidence for the near term occurrence of peak global oil production, and 4) concerns about nuclear power. The U.S. has 27% of all known coal reserves (Folger 2006). The U.S. Department of Energy estimates that 153 new coal-fired power plants will come on line by 2030 (Klara and Shuster, 2007.) Increases in coal mining in response to these pressures pose potential adverse health risks for persons who live in the vicinity of the mining activities.

Anecdotal evidence on the negative health effects of living near coal mining sites in Appalachia is widespread. Residents reported serious health consequences they experience from living in the coalfields (Goodell 2006). Water quality studies documented contaminated well water in West Virginia and Kentucky communities consistent with coal slurry toxins (McSpirit and Dieckmann 2003; Stout and Papillo 2004). However, quantitative research on the relationship between residential proximity to coal mining sites and health consequences is rare; research conducted has been limited to studies in Great Britain and to a narrow range of respiratory illnesses. These studies found elevated levels of particulate matter (PM) (Pless-Mulloli et al. 2000a) and increased symptoms of respiratory morbidity (Pless-Mulloli et al. 2000b; Brabin et al. 1994; Temple and Sykes 1992) associated with residential proximity to coal mining sites. Contaminated dust from coal washing activities is a significant local phenomenon (Ghose and Banerjee 1995). The harmful exposures faced by coal miners – diesel particulates, dust, chemicals, fuels, and elemental toxins (Scott et al. 2004) – may be found in less concentrated form but for larger populations of individuals living near the mining sites.

Previous research has established an association between hospitalization patterns and daily measures of air pollution in metropolitan areas (Simpson et al. 2005; Wellenius et al. 2006; Barnett et al. 2006; Yang et al. 2004; Yang et al. 2007). These hospitalizations, for cardiovascular disease, asthma and other respiratory diseases, are thought to result from exacerbations of existing illnesses from PM. A similar phenomenon may exist for residents exposed to pollution from coal mining activities. However, previous research on residential proximity to coal mining (Pless-Mulloli et al. 2000b; Brabin et al. 1994; Temple and Sykes 1992) has not examined hospitalization patterns. Therefore, the current study examines the relationship between hospitalization patterns and coal mining production among residents of three Appalachian states in the United States: Kentucky, Pennsylvania and West Virginia.

Methods

Design. The study is a retrospective analysis of 2001 person-level hospitalization data from Kentucky, Pennsylvania and West Virginia, merged with 2001 county-level data on tons of coal mined and other county-level data.

Sample and Data Sources. Hospital data are taken from the Health Care Utilization Project (HCUP) National Inpatient Sample (NIS) of short stay general hospitals for 2001. These data are coordinated through the Agency for Healthcare Research and Quality (AHRQ), and are available as de-identified discharge abstracts for research purposes. The NIS data represents approximately a 20% probability sample of all hospitals in participating states. For the current study, adults 19 and over with all diagnoses were included, except for maternal cases and transfers from other hospitals, resulting in a sample of 93,952 hospitalizations from 90 sampled hospitals. Maternal cases were excluded so as not to confound denominators in the hospitalization rates with normal labor and delivery, instead limiting the denominator to forms of illness or injury. Not every state participates in the NIS, and among those that do, only some provide the county identifier field. Among major coal producing Appalachian states, counties were identified in the NIS data by Kentucky, Pennsylvania and West Virginia, and thus are included in this study.

Coal production figures for 2001 were obtained from the Energy Information Administration (Annual Coal Report, 2002.) The figures included the tons of coal mined in thousands from each county in both underground and surface mines. There were 73 counties represented in this database (including counties that mined no coal) with matching records in the NIS sample.

Other county indicators included percent of population in poverty from US.Census data, and a measure of county production of social capital, standardized to a mean of 0 across all counties in the nation.(Rupasingha et al. 2006). Social capital has been shown in other research to be an important correlate of population health (e.g., (Lochner et al. 2003).

Variables. NIS variables used for analysis include patient age (categorized as 19-44, 45-64, 65-74, 75+), gender, payer (insured or uninsured), diagnoses, and hospital teaching status (teaching hospitals are academic health centers that conduct patient care, research and medical education, and that tend to serve most complex cases.) The Federal Information Processing Standards (FIPS) code was used to identify the county location of the hospital. The dependent variable was found from the diagnosis given in the primary diagnostic field. Diagnoses were grouped into those postulated to be "coal exposure sensitive" and "coal exposure insensitive." The list of candidates for sensitive conditions is preliminary and based on previous health risks reported in the literature for coal miners, findings established from exposure to air particulate pollution, or evidence for kidney or cardiovascular disease related to exposure to toxins found in association with coal mining (Wellenius et al. 2006; Barnett et al. 2006; Navas-Acien et al. 2005; Nishijo et al. 2006; Coggon and Taylor 1998; Sarnat et al. 2006; Noonan et al. 2002; Navas-Acien et al. 2004) Where to place lung cancer is unclear; risk of lung cancer was linked to diesel particulate matter (Monforton 2006), but other research found no elevated risk for lung cancer among miners after controlling for smoking behavior (Montes et al. 2004); for this study lung cancer was tentatively positioned in the "sensitive" column. A list of postulated coal exposure sensitive and insensitive conditions is provided in Table 1. The list of potential insensitive conditions is not intended to be final or exhaustive but to offer a sample of "control" conditions that are expected to be unrelated to coal mining exposure. Each diagnosis is thus a dichotomous variable, and the question becomes whether an exposure sensitive diagnosis is significantly higher in coal mining areas as a proportion of total hospitalizations, whereas exposure insensitive conditions should not differ as a function of coal mining intensity.

Other NIS variables are used as covariates. These include age, gender, uninsurance, hospital teaching status, and co-morbidities. Co-morbidities are measured in two ways. First, by the count of non-missing secondary diagnosis fields ranging potentially from 0 to 14, and second, by a Charlson index (Charlson et al. 1987) calculated for each case based on diagnostic codes reported by Romano et al. (1993) and scored 0 to 3 to indicate increasing severity of co-morbidities.

Coal production was not normally distributed across counties. Because more than half of the counties produced no coal, a square root transformation was preferred over a log transformation. The coal production variable was transformed by taking the square root of tons of coal measured in thousands. The coal production variable was linked to the hospital records at the county level.

Analysis. After descriptive analyses, inferential analyses determined whether hospitalizations for "exposure sensitive" and "exposure insensitive" conditions were significantly elevated as a function of coal production, accounting for other variables likely to correlate with health indicators. The analysis was done at the person-level using HLM 6.03 multi-level Bernoulli modeling for the dichotomous presence of the dependent variable diagnosis. The square root of county-level coal production was included as a level 2 predictor. Level 1 (person-level) covariates included gender, age, uninsurance status, hospital teaching status, co-morbidity count and Charlson index. Level 2 (county-level) covariates included social capital and poverty rates. The intercept effect was treated as a random variable but other predictors were treated as fixed. Results are reported for final population estimates with robust standard errors. Significant coal effects are identified based on odds ratios greater than 1 at the 95% confidence interval.

Additional analyses examined gender differences to confirm that coal effects were not limited to men, who may be current or former miners, and to examine scatterplots between observed and expected level 2 residuals to confirm adequate model fit.

Results

Table 2 summarizes descriptive characteristics of study variables. The average age of the sample was about 67, and about 56% of patients were female. The most common diagnoses among those coded for analysis were congestive heart failure, ischemic heart disease, chronic obstructive pulmonary disease (COPD), and diabetes.

Table 3 summarizes hierarchical model results. Greater coal mining was positively related to more hospitalizations for two postulated coal sensitive conditions, hypertension and COPD. It was not significant for other conditions, including the potential insensitive conditions. There was a significant *negative* relationship between coal production and hospitalization for lung cancer and kidney disease.

The odds ratios are expressed relative to the square root of coal in thousands of tons. Transforming the odds ratios back to the original metric results in the odds of a COPD hospitalization increasing 1% for each 1,462 tons of coal, and the odds for a hypertension hospitalization increasing 1% for each 1,873 tons of coal.

The possibility that the results may reflect current or former miners who live in the area, rather than a general population effect, may be dismissed through an examination of gender effects. Almost all coal miners are men. Results for the significant COPD model show no gender effect, and results for the significant hypertension model show a higher risk for women.

The scatterplot of observed to expected model residuals was examined to determine whether the level 2 errors in the model were randomly distributed. Figure 1 shows that observed and expected errors are closely related. This figure is for the hypertension model, but the COPD model showed similar results. The correlation between observed and expected error in Figure 1 was 0.98.

Discussion

This is the first study to show that hospitalizations for COPD and hypertension are significantly elevated as a function of Appalachian coal production at the county level. The risk increases significantly as the volume of coal mining rises. The effects might be a result of exposure to PM associated with mining activities such as coal extraction and washing (Ghose and Banerjee 1995), exposure to diesel particulate matter from operation of engines at mining sites (Monforton 2006), or some interactive combination thereof.

Effects were not found for other conditions that were hypothesized to be sensitive to coal exposure, including kidney disease, lung cancer and forms of heart disease. This might be due to exposure effects that are too weak to exert negative impacts on residents, limitations in the precision of the hospitalization data (discussed in more detail below), or time lags between exposure and illness. Exposure effects were not found for any of the potential insensitive conditions. These lists of sensitive and insensitive conditions are only a starting point for refined classifications as knowledge on this topic progresses.

Limitations of this study include the ecological design, which prohibits drawing a definitive causal link between the hospitalization event and coal mining activities. Adjustments were made for a set of demographic and county indicators, but it is possible that other unmeasured variables may contribute to poorer health in a way that is confounded with coal mining. Smoking and obesity, in particular, were not measured. However, the reverse finding for lung cancer suggests that coal production and smoking patterns are not confounded. Air pollution levels from industrial sources were also not measured, although power plants tend to be located in population centers and along major rivers, whereas primary coal mining locations often occur in separate, more rural areas. The weather patterns associated with a particular season might also affect both illness and volume of mining (i.e., a cold winter increases susceptibility to illness and increases economic demand for coal); this issue may be addressed in future research by examining effects for longer time intervals. The use of the proportional hospitalization indicator, like a proportional mortality ratio, has limitations (Miettinen and Wang

1981; Decoufle et al. 1980), such as its dependence on the relative frequency of coal sensitive to insensitive conditions in the population.

The data are also limited by the geographic crudeness of the county measure: some persons may live in a coal mining county but some distance from the mining activities, while others live across county lines but closer to mining sites. Future research would be improved by obtaining a more refined geographic match between residence and coal mining activities; possibilities include secondary census tract data (e.g., Vassilev et al. 2001), or primary data collection studies with Geographic Information System (GIS) indicators. Unfortunately the coal production figures for this study were not available on those smaller scales.

A significant limitation of the hospitalization data is that the county identified the location of the hospital, not necessarily the location where the patient resided. Persons who were transferred from other hospitals were excluded from analysis, but this is not a complete solution. To the extent that people move from one area to another for hospital care, this introduces error into the measurement. This error appear to be random rather than systematic, making detection of effects more difficult but not creating bias in the direction of effects. To make an argument for biased results due to patient mobility, one would have to argue that people differentially move from non-coal mining areas to coal mining areas for hospital care, for only COPD and hypertension and not for other conditions, and that this occurs relative to the intensity of mining. This particular pattern of movement seems unlikely. To the extent that error is random, with some patients moving into and out of coal producing areas for care, coal mining effects will be underestimated.

Another limitation of hospitalization data is that it is an indicator that is influenced by various other factors, including the quality of the ambulatory care system, and payer or geographic variation in diagnostic practices, in ways that could not be measured. COPD and hypertension in many cases are instances of ambulatory care sensitive conditions. If the quality of outpatient care for these conditions is systematically poorer in coal mining areas, this might result in more frequent hospitalizations, but again, one would have to argue this poor quality phenomenon selectively for COPD and hypertension, when other ambulatory care sensitive conditions, such as diabetes, showed no relationship to coal mining. Local diagnostic practice variations, such as distinctions between adult asthma and COPD, may also introduce error into estimates, as may differences due to type of payer.

The teaching status of the hospital was a variable that sometimes affected admission patterns. Teaching status likely interacts with mobility patterns, where patients with complex or serious illnesses are more likely to travel from their area of residence to a teaching hospital for specialty care. To the extent that teaching hospitals are located in urban areas where coal mining does not take place, this pattern may obscure possible coal related effects. Lung cancer and kidney disease represent serious, complex illnesses, and hospitalization for these conditions were marginally higher as a function of teaching status ($p<.10$), which may help to account for their non-significant links to coal mining. Hypertension and COPD, on the other hand, were related to less severe co-morbidities and unrelated to hospital teaching status, suggesting that these conditions are more likely to be treated at local hospitals near the patient's residence.

Despite the data limitations, which may be expected to dilute the magnitude of effects, effects were found for two health problems that are consistent with an exposure hypothesis. The inhalation of PM is associated with hypertension (Ibald-Mulli et al. 2001; Brook 2005; Urch et al. 2005; Krewski et al. 2005) and COPD (Brabin et al. 1994; Coggon and Taylor 1998) among miners and residents and in lab conditions. Individuals with hypertension show increased association between systemic inflammation and ambient PM2.5 (particulate matter with a mass mean aerodynamic diameter <=2.5 micrometers.) (Dubowsky et al. 2006) The current study may be detecting the acute effects from residential exposure to PM at a certain time, or a chronic exposure effect which accumulates over time into increased risk of hospitalization. Other research has found that long-term exposure to ambient air pollution is related to higher incidence and mortality rates from cardiopulmonary disease and lung cancer (Miller et al. 2007; Krewski et al. 2005). Additional research using more refined methods will be necessary to isolate the nature and magnitude of the exposure effect. Future research may employ primary data collection efforts in targeted communities distal and proximal to coal mining activities to collect data on physiological measures and disease incidence for residents in these communities. Future studies need to clearly identify specific processes and pollutants that exert pathologic effects on local populations.

Conclusions

The health consequences of exposure to mining activities reflects only a portion of the entire coal production and consumption cycle. Coal mining poses occupational hazards to miners (Scott et al. 2004), its burning contributes to air pollution and subsequent health hazards (Wellenius et al. 2006), and carbon emissions contribute to climate change with potential global health risks including infectious epidemics, disruptions in the food chain, increased asthma prevalence, lung damage from ozone, and health consequences of floods and droughts (Patz et al. 2005; Bernard et al. 2001; Epstein 2005). The health risks from residential proximity to mining present an additional negative consequence that results from reliance on this energy source.

If exposure effects are supported by further research, economic analyses of coal's contribution to domestic productivity may need to be revised to take into account the lost productivity and medical care costs linked to residential proximity to mining. Calculation of pollution levels in geographic areas may be developed to account for both the production and consumption of carbon-based energy. Implementation of national or state environmental and public health policies may be indicated to protect nearby citizens from mining byproduct exposure.

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Table 1. List of potential candidates for coal sensitive and coal insensitive conditions, with corresponding diagnostic codes.

Coal sensitive		**Coal insensitive**	
Category	*ICD-9 codes*	*Category*	*ICD-9 codes*
Lung cancer	162	Diabetes	250
COPD	490-492, 494-496	Musculoskeletal and connective	710-739
Hypertension	401-405	Organic psychoses	290-294
Kidney disease	580-589		
Congestive heart failure	428		
Ischemic heart disease	410-413		
Asthma	493		

Table 2. Descriptive summary of study variables.

Variable	Mean or %	St. deviation	Min. – Max.
Person-level (N=93,952)			
Mean age	66.9	14.3	19-105
Mean co-morbidity count	4.12	2.10	0-9
Mean Charlson index	0.41	0.65	0 - 3
% female	55.7		
% uninsured	1.57		
% teaching hospital admissions	33.2		
% with primary diagnosis of:			
COPD	3.33		
Asthma	0.92		
Hypertension	1.39		
Kidney disease	1.09		
Congestive heart failure	9.61		
Ischemic heart disease	4.57		
Diabetes	7.62		
Lung cancer	0.40		
Organic psychoses	0.49		
Musculoskeletal and connective disorders	3.83		
County-level (N=73)			
Tons of coal x 1000	1957.70	6643.16	0 – 44303
Square root (tons of coal x 1000)	20.94	39.25	0 – 210.48

Percent population below poverty	15.22	6.69	4.8 – 37.7
Social capital index	-0.17	0.42	-1.14 – 0.50

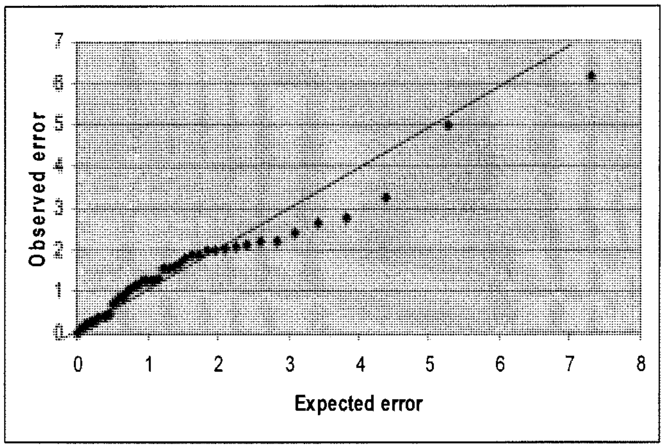
Table 3. Hierarchical model results, coal production effects controlling for person and county covariates.

	COPD			LUNG CANCER	
Independent Variables	Odds ratio	95% Confidence Interval		Odds ratio	95% Confidence Interval
Coal production	1.003	1.001-1.006		.997	.993-1.000
County poverty rate	1.017	.987-1.048		1.010	.966-1.056
Social Capital	-.467	.416-.945		1.205	.641-2.266
Age	1.154	1.098-1.213		1.216	1.076-1.374
Female	.979	.870-1.102		.681	.545-.851
Teaching status	.789	.584-1.065		1.775	.931-3.382
Co-morbidity count	.918	.901-.935		.878	.823-.936
Charlson index	.664	.600-.735		3.602	3.220-4.029
Uninsured	.681	.464-.999		.238	.079-.714
	HYPERTENSION			DIABETES	
Coal production	1.003	1.001-1.005		.998	.994-1.001
County poverty rate	.992	.957-1.027		1.045	.980-1.113
Social Capital	.701	.413-1.190		1.504	.614-3.685

Age	1.086	1.033-1.141		.605	.582-.629
Female	1.218	1.061-1.399		.899	.849-.951
Teaching status	1.236	.707-2.158		.978	.833-1.147
Co-morbidity count	.977	.944-1.012		.906	.885-.928
Charlson index	.913	.847-.985		.983	.936-1.033
Uninsured	1.739	.976-3.098		1.808	1.559-2.098
	KIDNEY DISEASE			ORGANIC PSYCHOSES	
Coal production	.997	.994-.999		.998	.994-1.001
County poverty rate	1.000	.972-1.030		1.003	.965-1.043
Social Capital	.639	.408-1.000		1.812	.833-3.941
Age	1.077	1.010-1.149		1.251	.986-1.589
Female	1.005	.908-1.112		.563	.465-.681
Teaching status	1.269	.975-1.635		.509	.151-1.717
Co-morbidity count	1.441	1.352-1.536		1.025	.918-1.145
Charlson index	.909	.807-1.024		.702	.590-.835
Uninsured	.465	.192-1.130		1.039	.452-2.392
	ISCHEMIC HEART DISEASE			MUSCULO-SKELETAL	
Coal production	.998	.995-1.002		1.002	1.000-1.004
County poverty rate	1.002	.973-1.032		.985	.957-1.014
Social Capital	.957	.643-1.428		2.629	1.653-4.181

Age	1.108	1.066-1.151		.987	.938-1.039
Female	.733	.697-.771		1.177	1.062-1.305
Teaching status	.999	.741-1.347		1.044	.798-1.365
Co-morbidity count	1.037	1.005-1.069		.869	.837-.903
Charlson index	.809	.771-.849		.741	.680-.809
Uninsured	1.494	1.077-2.073		.463	.294-.729
	ASTHMA			CONGESTIVE HEART FAILURE	
Coal production	.999	.996-1.003		1.000	.999-1.001
County poverty rate	.981	.941-1.022		1.009	.986-1.033
Social Capital	.898	.554-1.453		.823	.604-1.121
Age	.598	.549-.651		1.324	1.280-1.368
Female	2.536	2.010-3.199		1.028	.963-1.098
Teaching status	.855	.617-1.183		.757	.591-.970
Co-morbidity count	.898	.875-.923		1.119	1.096-1.143
Charlson index	.448	.388-.517		1.049	1.004-1.095
Uninsured	.690	.468-1.018		.885	.567-1.381

Figure 1. Scatterplot showing observed and expected level 2 residuals for hypertension model.



WATER QUALITY FROM UNDERGROUND COAL MINES IN NORTHERN WEST VIRGINIA (1968-2000)

Jennifer Demchak, Louis M. McDonald, Jr., and Jeff Skousen

INTRODUCTION

Acid mine drainage (AMD) is a serious problem from both surface and underground coal mines. According to the U.S. Environmental Protection Agency (1995) approximately 10,000 km of streams have been affected by AMD in the four states of Pennsylvania, Maryland, Ohio, and West Virginia. Many mines currently discharging AMD were operated and abandoned before enactment of the Surface Mining Control and Reclamation Act (SMCRA) of 1977. The Act provided standards for environmental protection during mining operations and placed the responsibility of AMD control and treatment on the operator (SMCRA 1977). The Act also provided a means for reclaiming abandoned mines by taxing current coal operators, which generates funds for abandoned mine land reclamation programs. Even with millions of dollars spent in reclaiming abandoned mine lands, these abandoned mines still generate more than 90% of the AMD in streams and rivers in the region and most of this acidic drainage flows from underground mines (Faulkner 1997, Zipper 2000).

Because these sites were abandoned before 1977, no company or individual is responsible to treat the water and therefore the receiving streams are polluted and are essentially unusable. High flows and high levels of pollution (high acidity and metal concentrations) necessitates the use of chemicals for treatment, which tend to be expensive and labor intensive. Costs for chemicals, dispensing equipment, electricity for pumps, and manpower all add up to significant public expense if the treatment entity is a government agency or utility. Perhaps the largest cost to the public is the unavailability of the waterbody for use and the accompanying impaired aesthetics and degraded water quality. Therefore, simple and inexpensive treatment approaches are being sought as well as a better understanding of the natural processes within mines that affect water quality over time.

An understanding of the behavior of acid-producing materials within abandoned mines would allow an estimate the longevity of acid discharge, which will aid in determining remediation strategies and the short and long-term costs of treatment. However, the changes in flow and water quality over time from surface and underground mines are not well documented. Surface mining generally removes 90% or more of the coal thereby leaving little in the backfill for continued reaction and acid generation. The coal that does remain was broken apart by blasting and the acid products are leached fairly rapidly, typically within 16 to 20 years (Meek 1996). Special handling of toxic materials may reduce the amount of pyrite oxidized, and the addition of alkaline material during mining may neutralize acid *in-situ*, both of which decrease the total acid load coming from the site (Brady et al. 1990, Perry and Brady 1995, Rich and Hutchinson 1990, Rose et al. 1995, Skousen and Larew 1994). During the 20 years after reclamation, discharge water quality may reach pre-mining levels. Acid discharge from underground mines usually lasts much longer, sometimes 50 to 100 years (Wood et al. 1999).

The earliest model for the longevity of AMD from underground mines was the former British Coal Corporation's 'rule of thumb' for below-drainage mines. Iron concentrations in an abandoned mine were assumed to decrease by 50% during each subsequent pore volume flushing (the time period required for the mine pool to be filled with water). For example, if 10 years are required for a mine to fill with water, the iron concentration should decrease by half every 10 years. This suggests an exponential decay as described by Glover (1983).

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Other researchers have observed that the most severe drainage occurs within the first few decades and even the largest systems settle to lower levels within 40 years. For mines in the UK, a neutral pH was reached within 30 years, and after 40 years the iron concentrations were less than 40 mg/L (Wood et al. 1999). Jones et al. (1994) also showed that underground mine water in Pennsylvania changed from acidic to neutral over a period of decades.

Younger (1997) has categorized the acid load that flows from underground mines as "vestigial" or "juvenile" acidity. Vestigial acidity is associated with the first-time flushing of acid products from the mine during initial abandonment and flooding. Juvenile acidity, is produced from ongoing pyrite oxidation due to fluctuations in the water table and may persist for hundreds of years depending on the hydrology of the underground mine system. The longevity of AMD at a given site is dependent on the rate of depletion of both the vestigial and juvenile acidity.

These descriptions of AMD longevity may not apply to shallow drift mines where ventilation facilitates pyrite oxidation and contamination continues for decades until the pyrite is exhausted (Younger et al. 1997). In above-drainage underground mines, water does not generally flood the mine and the water flows out at the down-dip side of the mine. In these situations, the rate of dilution is greatest where the volume of the mine is small, the recharge rate is high, and water flow out of the mine is high (Younger 1997). Another concern with these above-drainage mines is the fluctuation of water levels due to seasonal variations in precipitation. During low water levels, pyrite oxidation forms iron-hydroxysulfate solids, which settle on coal and rock surfaces due to evaporation. When the water levels rise, these acid products dissolve and are released into the mine pool. Pyrite oxidation can continue to occur on the wet, oxidized mineral surfaces, producing a continuing cycle of acidity production (Younger 1997).

Discharge chemistry is affected by several primary factors. One important factor is the coal seam, and more specifically the pyrite content of the mined coal seam. Each coal seam is unique with relatively predictable chemical and physical features, which may affect discharge water quality.

The mining method and degree of coal removal within a mine are other variables affecting discharge chemistry. Room and pillar underground mining (the most common method in this area) often left more than 50% of the coal as support for the roof. After abandonment, this coal continues to weather and crack away from the pillar, allowing more of the pyrite in the pillar to react. Remining old underground mines by surface mining has the potential to improve pre-existing acid discharges by removing coal pillars and then reclaiming the site to current reclamation standards, which often includes mitigating any acid mine drainage potential (Hawkins 1994, Richardson and Doughterty 1976).

Previously mined sites with acid discharges can be also affected by subsequent, adjacent surface mining. The flow may decrease because the surface overlying the recharge area has been reclaimed and vegetated, which could decrease infiltration into the underground mine. This effectively decreases the size of the mine pool and the subsequent flow rate out of the mine. Adjacent surface mining may also cause the collapse of the roof in portions of the mine, thereby changing flow paths or altering interconnection of certain areas. The collapse of pillars or roof rocks could create fresh pyrite surfaces for AMD reactions to take place and increase acid production. The degree of disturbance in a mine is difficult to predict and its ensuing impact on mine water chemistry is also difficult to predict over time.

A study in 1968 identified and sampled numerous underground mine discharges in the northern West Virginia coal region. Most of these discharges were coming from above-drainage underground mines. We revisited those sites in 1999 and 2000 and analyzed the water from the same discharge points. Several of the sites also had been sampled and analyzed in 1980, which provided an intermediate time to check acidity and iron concentrations from the mine. From this data set, we determined the change in water quality during this 30-year period and evaluated the factors that may have been responsible for their change. We tried to correlate these changes to disturbance effects and coal seam differences.

METHODS AND MATERIALS

Fifty underground mines and their associated discharges were sampled and used for water quality comparison. The sites were located in Preston and Monongalia Counties of West Virginia, and Fayette County in Pennsylvania. The sites were found according to marked locations on Valley Point, Cuzzart, Kingwood, Masontown, and Morgantown North USGS quadrangle maps. The discharges all drained underground drift mines to various streams within the Monongahela River Basin. Most mines operated in the Upper Freeport and Pittsburgh coal seams, but a few sites mined the Bakerstown, Upper Kittanning, and Lower Freeport seams. The drift mining method was generally used in hilly areas where coal seams outcrop along the contour and where the seam is nearly flat or slightly dipping.

The Pittsburgh coal seam is the lowest member of the Monongahela Series. The seam has a moderate sulfur content (1.5 to 2.0%) and a low ash content (6%). The Pittsburgh coal is composed of alternate layers of coal and slate or shale. A typical Pittsburgh coal cross-section shows a 3-m layer of good coal, a 0.7-m layer of bone coal or slate, and another 3-m layer of good coal. The Pittsburgh coal along the Monongahela and Cheat Rivers is located close to the surface (Hennen and Reger 1914).

The Upper Freeport coal seam is the topmost strata of the Allegheny Formation of the Pennsylvanian System. Freeport coal is relatively low in sulfur (<1.5%) and has a moderately low ash content (8 to 12%). It is a multiple-bedded seam that is divided into a top coal and bottom coal, separated by a shale interlayer, all averaging a total of six feet in thickness (Hennen and Reger 1914). The overlying strata in the Conemaugh Group contains several massive sandstones and some shales. Limestone or alkaline-bearing rock units are not generally found within 50 m above the Upper Freeport coal in this area, so very little overlying geologic material is available for acid neutralization (Hennen and Reger 1914).

1968 Study

A previous study was conducted from 1968-1970 where field crews were sent out to identify all coal mines within the Monongahela River Basin and to sample their discharges. Each crew worked from 7.5-minute USGS topographic maps on which they outlined mine boundaries and indicated mine openings. Field sheets were also completed at each site with location and overburden information. Sites with a discharge were identified on the maps, flow rates were determined, and the water was sampled. The flow was measured when possible with a bucket and stopwatch. For larger flows, the crew installed a V-notch weir and measured flow rate. These values were recorded on the field sheet. In the field at the time of water collection, the pH of the discharge was measured using an electrometric pH meter, and temperature was checked with a lab grade thermometer. These values were recorded on the field sheet.

Two water samples were taken at each discharge in this early study: 1) a plastic quart bottle was filled, put on ice, and then analyzed in the laboratory for acidity, alkalinity, hardness, sulfate, and pH; and 2) a glass bottle was filled, treated with acid, and then analyzed in the laboratory for metals (total iron, manganese, aluminum). Water samples were delivered to the laboratory each Friday where they were analyzed using methodology from the latest edition of Standard Methods. Water analyses were monitored for accuracy and precision by running periodic samples of reference standards (Personal communication, Gary Bryant, U.S. EPA 1999).

1999 Study

Mine sites and their associated point discharges were located on the USGS topographic map marked by the 1968 crew. Based on observations of the surrounding conditions, each site was categorized as disturbed or undisturbed. Undisturbed meant that the site appeared to have remained untouched since 1968 and where no obvious influence had occurred to the mine site or within the underground mine. Disturbed suggested that either surface mining had occurred in the area since 1968 or the area has been reclaimed or remined.

Discharges were sampled as close to the mine portal as possible. Flows were calculated using a measured cross-sectional area and flow velocity or an estimate was made. Two water samples were taken at each sample point: 1) a 250-mL unfiltered sample was taken for general water chemistry (pH, conductance, acidity, and alkalinity); and 2) a 25-mL, filtered sample was acidified to pH <2 with 0.5 mL concentrated nitric acid and used to determine metal concentrations.

Water pH, alkalinity, and acidity were determined by a Metrohm pH Stat Titrino System (Brinkman Instruments, Wesbury, NY). Conductivity was measured using an Orion Conductivity meter Model 115 (Orion Instruments, Beverly, MA). The metal analysis was preformed using an Inductively Coupled Spectrophotometer, Plasma 400 (Perkin Elmer, Norwalk, CT). Sulfate was measured turbidimetrically by flow injection analysis (Latchat Instruments, Milwaukee, WI).

Statistical Analysis

A subset of 28 sites for which a complete data set (pH, acidity, iron, aluminum and sulfate) was used for the statistical analysis. These 28 discharges emanated from 24 different mines. Analysis of variance was performed using a full model with main effects of Year, Disturbance, Coal Seam, and all possible interactions as class variables using PROC GLM (SAS Institute). Based on Type III sums of squares, the least significant term was dropped and a new analysis performed. This process was repeated until an optimal model for each parameter, the one that minimized the mean square error (MSE), was determined. Means for significant (alpha = 0.05) model terms were separated using Tukey's Honestly Significant Difference (alpha = 0.05).

RESULTS AND DISCUSSION

Overall models were significant for all parameters (Table 1) even though R^2 values were somewhat low. A low R^2 is not entirely unexpected given the large, inherent variability of this data set and the relatively simple model used. Other variables likely to affect the variance in this data set include mine age and size (Table 2), mining practices and mine pool stratification (Ladwig et al. 1984). A slow mixing of water at various depths occurs between the dilute, newly-recharged waters at the top of the mine pool and the more dense, deeper waters containing high dissolved solids. Depending on the location of discharge (whether pumped from low levels in the mine pool, or discharged freely at the top of the pool), the water quality coming from the same mine pool may be quite variable.

None of the main effects or interactions was significant for the parameter Flow (Table 1). The fact that there was no Year effect for Flow suggests that these two sampling years (1968 and 2000) were similar and that water quality data can be compared directly. This is an important consideration because water quality parameters are sensitive to flow, and the within and between year variability can be large. Flow can affect water quality by diluting concentrations being released from the mine or can make the discharge appear more severe during low flow conditions.

The main effects of Year and Coal Seam were significant for the water quality parameters Acidity, Iron, Aluminum, and Sulfate; but only the Year effect was significant for pH (Table 1). Water quality was better in 2000 than in 1968 and worse if draining from the Pittsburgh coal seam (Table 3). There was a significant Year*Coal Seam interaction for Acidity and Sulfate. There were small but significant improvements in Acidity and Sulfate on the Upper Freeport sites, but the largest improvements occurred on the Pittsburgh sites (Figure 1). Significant differences were found in water quality between the Upper Freeport and Pittsburgh sites in 1968, but these differences vanished in 2000. That is, the main effect of Coal Seam on Acidity and pH is due principally to the water quality differences in 1968. The same general trends were also observed for Iron and Aluminum. There was a significant Disturbance main effect for only Flow and Aluminum, suggesting that it is time and not disturbance that has the largest effect on water quality discharging from a mine. These trends support the idea that natural attenuation occurs within underground mines.

This attenuation may be similar to what occurs on surface mines. As water infiltrates into the mines, acid products are leached from the rocks, and eventually water quality can reach pre-mining levels (Meek 1996). This process may not be as straightforward in an underground mine, due to subsidence and ever changing flow paths. The attenuation can also be related to Younger's description of vestigial and juvenile acidity. The samples collected in 1968 may have been close enough to the time of mine closure to still be experiencing vestigial acidity. The samples collected in 2000 are examples of the juvenile acidity that continues to be released from the mines for up to 100s of years (Younger 1997). Our data set also suggests that the models established by Jones et al. (1994) and Younger (1997) can be applied to above-drainage, shallow, drift mines.

It is important to consider the age of the mines in order to determine the break-off between vestigial and juvenile acidity (Table 2). For six of the twenty-eight discharges, 1980 data was found and used to analyze the trend of vestigial and juvenile acidity (Figure 2). The data at these six discharges show the overall trend of improving from 1968 to 1980, and then improving more between 1980 and 2000, except for Lake Lynn 3 and Martin Creek 2. Cheat River 5 began operation in 1935, meaning it would be 45 years old when sampled in 1980. The vestigial acidity should have been released by this time, but the mine should continue to release lower levels of juvenile acidity. In 1980, the youngest mine was Martin Creek 2. It shows dramatic decreases in both iron and acidity concentrations as compared to the 1968 sample, even though sulfate increased. This one mine shows that it has released its vestigial acidity in less than 25 years. It would be valuable to have large data sets over time to determine the exact break-off point when acidity comes primarily from vestigial to juvenile.

During a study from 1966 to 1968 (U.S. EPA 1973), 191 openings were found from both active and abandoned surface and underground mines. Over 144 miles of stream were affected in this lower Cheat River area extending from Rowlesburg to Cheat Lake. In this early study, Muddy Creek contributed 25% of the acid load to the Cheat. Unpublished data from the U.S. EPA (Gary Bryant, personal communication, 2002) showed that the acid load from Muddy Creek in 1968 was about 2,595 tons/year. This is considerably lower than the measured acid load by the WVDNR (Table 5) where Muddy Creek contributed 7,428 tons/year in 1980 and 8,068 tons/year in 1995. The percentage of the acid load into the Cheat was about the same in 1968 and 1980, but a much higher percentage of acid in the Cheat came from Muddy Creek in 1995. Bull Run contributed 4,445 tons/year in 1968, compared with much lower numbers in 1980 and 1995. Mining of the Upper Freeport coal in Bull Run had largely been abandoned by the early 1970s, and there appeared to be a significant decrease in acid load coming from this stream during the next several decades. In contrast, mining in the Muddy Creek watershed continued through the 1980s and 1990s, and only recently was mining largely decreased in the watershed.

Over 30 miles of stream were degraded between Tunnelton and Kingwood in the tributaries of Pringle, Heather, Lick and Morgan Runs. The 1968 U.S. EPA study gave estimates of about 3,385 tons/year of acid coming from all four tributaries, but the estimates of acid load in 1980 and 1995 are much higher (Table 5).

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Table 1. Summary statistics for overall GLM model and significance level (Pr>F) for main effects and interactions.

	Parameters					
	Flow	pH	Acidity	Fe	Al	SO_4
	L/min	s.u.	---------------- mmol/L --------------------			
Overall Model						
Mean	74.5	3.4	14.3	3.8	3.3	20.6
MSE	28345	1.60	161.70	10.09	10.34	260.51
R^2	0.09	0.21	0.48	0.52	0.42	0.48
Pr>F	0.0773	0.0068	<0.0001	<0.0001	0.0003	<0.0001
Individual Model Terms	---------------------------- Pr > F ----------------------------					
Year	0.1135	0.0248	<0.0001	<0.0001	<0.0001	<0.0001
Coal Seam	na	0.0604	0.0019	0.0113	0.0483	0.0022
Disturbance	0.1011	na	Na	na	0.2463	na
Year * Coal Seam	na	0.1731	0.0077	0.0613	0.1101	0.0016
Year * Disturbance	na	na	0.2541	na	Na	0.0723
CoalSeam*Disturbance	na	na	Na	na	0.2336	na
Year*CoalSeam*Disturbance	na	na	Na	0.3727	0.2740	na

na: not applicable; signifies a term dropped from the model because excluding it decreased MSE.

Table 2. Mine name, the year the mine opened, disturbance category, coal seam mined and mine area affected, for each discharge point sampled in 1999-2000.

Discharge Point	Mine Name	Year Opened	Category	Coal Seam	Mine Area (ha)
Bull Run 1	Kimberly	1962	Undisturbed	UF	21
Bull Run 2	Roxy Ann	1957	Undisturbed	UF	923
Bull Run 3	Roxy Ann	1957	Disturbed	UF	923
Bull Run 4	Sherrey	1955	Undisturbed	UF	282
Cheat River 1	Morgantown North E		Undisturbed	Pittsburgh	
Cheat River 2	Morgantown North D		Disturbed	Pittsburgh	
Cheat River 3	Frederick No. 1 Mine		Disturbed	Pittsburgh	
Cheat River 4	Morgantown North A		Undisturbed	Pittsburgh	
Cheat River 5	Canyon Mine	1935	Disturbed	Pittsburgh	448
Cheat River 6	Mountain Run	1952	Disturbed	UF	311
Cheat River PA1	Morgantown North B		Disturbed	Pittsburgh	
Cheat River PA2	Morgantown North C		Undisturbed	Pittsburgh	
Fickey Run 1	Valley Point C		Undisturbed	UF	
Fickey Run 8	Tri State	1952	Disturbed	UF	78
Glade Run 1	Liston	1955	Disturbed	UF	26
Glade Run 2	Valley Point F		Undisturbed	UF	
Lake Lynn 1	Hollow	1943	Undisturbed	Pittsburgh	34
Lake Lynn 2	Canyon Mine	1935	Disturbed	Pittsburgh	448
Lake Lynn 3	Canyon Mine	1935	Disturbed	Pittsburgh	448
Martin Ck 2	Me	1955	Disturbed	UF	11
Martin Ck 3	Me	1955	Disturbed	UF	11
Middle River 1	Mountain Run	1952	Disturbed	UF	311
Muddy Ck 11	Ruthbell #3	1943	Disturbed	UF	35
Muddy Ck 2	Cuzzart C		Undisturbed	UF	
Muddy Ck 3	Shermike		Disturbed	UF	
Muddy Ck 6	Cuzzart B		Undisturbed	UF	
Muddy Ck 8	Cuzzart F		Undisturbed	UF	
Muddy Ck 9	Tri State	1952	Disturbed	UF	78

Table 3. Mean water quality for the main effects of year and coal seam.

		Flow	pH	Acidity	Iron	Aluminum	Sulfate
		L/min	s.u.	-----------------mmol/L--------------------			
Year	1968	na	3.1	22.8	6.4	5.3	30.4
	2000	na	4.0	5.9	1.1	1.4	10.8
Coal Seam	Pittsburgh	na	Na	21.7	5.2	4.6	29.8
	U. Freeport	na	Na	10.3	3.0	2.6	15.5

na: not applicable; signifies a term dropped from the model because excluding it decreased MSE.

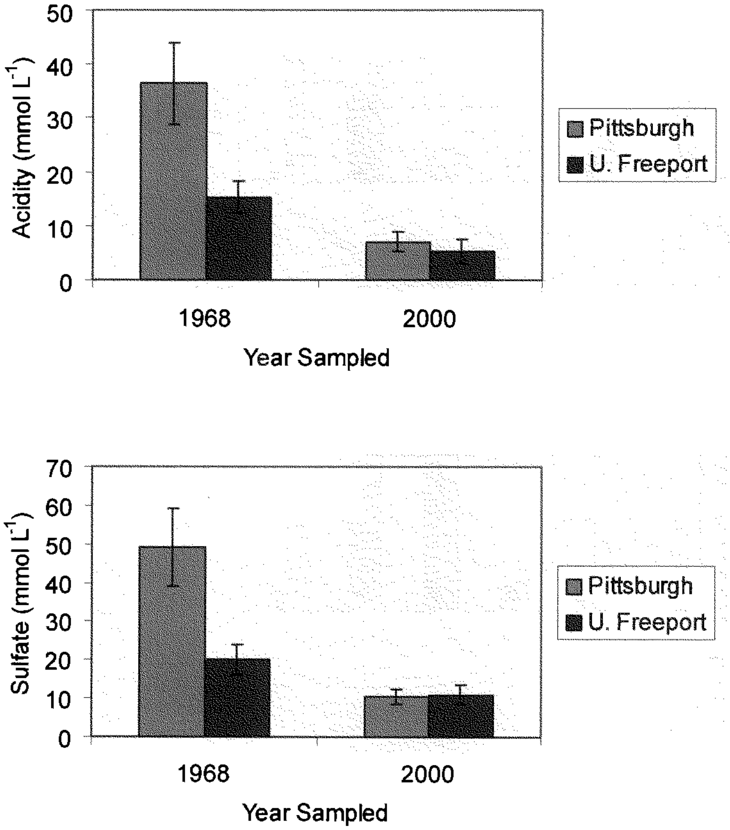

Figure 1. Year*Coal Seam interactions for sulfate and acidity. There is a significant difference between the Pittsburgh and Upper Freeport coal seam in 1968 for both acidity and sulfate, but not in 2000.

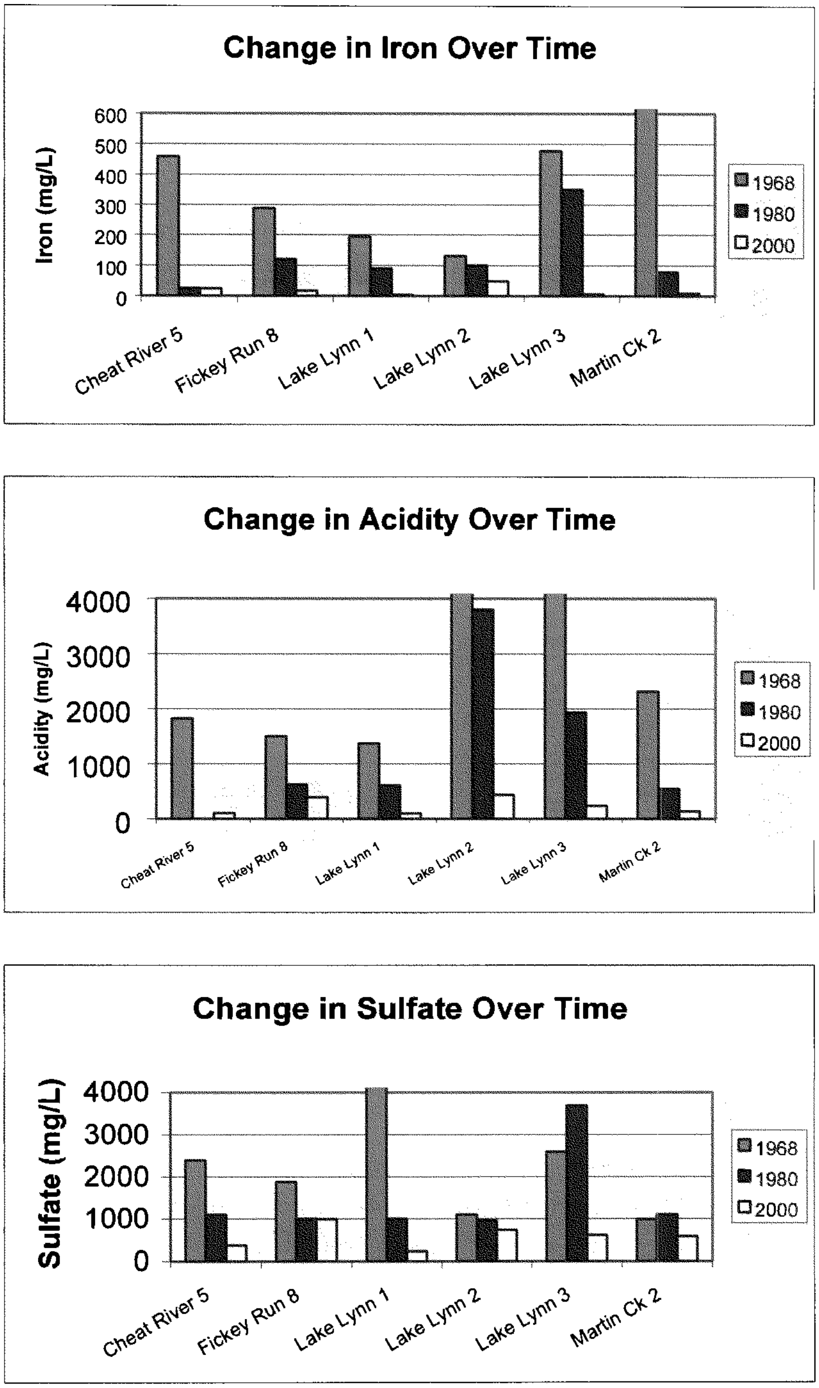

Figure 2: Water quality in 1968, 1980, and 2000 for six discharges.

Table 4: Water quality in 1968, 1980, and 2000 for six discharges.

Discharge	Year	pH	Flow	Acidity	Iron	Aluminum	Sulfate
		s.u.	L/min	------------------ mmol/L ------------------			
Cheat River 5							
	1968	2.6	19	1825	458	101	2392
	1980	2.6			25		1100
	2000	3.5	38	104	24	11	379
Fickey Run 8							
	1968	3	49	1505	288	84	1872
	1980	2.3	1	625	120		100
	2000	3.5	4	390	17	34	996
Lake Lynn 1							
	1968	2.8	38	1368	495	100	8861
	1980	2	1	605	90		1000
	2000	3.5	6	102	4	9	240
Lake Lynn 2							
	1968	3.2	38	4690	131	302	1105
	1980	2	1	3800	100		960
	2000	2.8	38	434	49	33	745
Lake Lynn 3							
	1968	3.1	480	4988	477	532	2593
	1980	2	1	1930	350		3690
	2000	2.9	6	237	7	33	619
Martin Ck 2							
	1968	2.7	57	2315	640	161	990
	1980	2.4	1	545	80		1100
	2000	4.2	38	135	10	4	587

Table 5. Acid load contributions of major tributaries in the lower Cheat River watershed at different times.

		1980[1]		1995[2]	
Tributary	Area	Acid	%	Acid	%
	Mi^2	tons/yr		tons/yr	
Pringle	9.8	2,463	9.4	1,254	5.6
Lick	4.7	3,833	14.6	5,173	22.9
Heather	2.1	1,054	4.0	863	3.8
Morgan	8.9	5,759	21.9	5,297	23.5
Greens	11.7	3,827	14.5	953	4.2
Muddy	34.0	7,428	28.2	8,068	35.8
Bull	11.6	1,934	7.3	948	4.2

[1] WVDNR 1980, [2] Titchenell and Skousen, 1996.

Aquatic Hazard of Selenium Pollution From Mountaintop Removal Coal Mining

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What is Selenium and Why is it a Concern?

Selenium is a naturally occurring chemical element in coal that can be released during the mining process and find its way into nearby aquatic habitats. Selenium in raw coal and overburden is leached out when these materials are exposed to air and water, and the leachate can pose a significant environmental hazard (Lemly 1985a). Mountaintop removal mining tends to maximize hazard because selenium-laden waste rock is disposed as valley fill, which places this selenium source in close proximity to streams and other surface waters. Once in the aquatic environment, waterborne selenium can enter the food chain and reach levels that are toxic to fish and wildlife (Figure 1). Impacts may be rapid and severe, eliminating entire communities of fish and causing reproductive failure in aquatic birds (Lemly 1985b, Ohlendorf 1989). Few environmental contaminants have the potential to detrimentally impact aquatic resources on such a broad scale, and even fewer exhibit the complex aquatic cycling pathways and range of toxic effects that are characteristic of selenium. This places added importance on identifying potential selenium sources and taking steps to effectively control discharges before aquatic habitats become contaminated. In recent years there has been an escalation in selenium pollution episodes associated with coal mining in North America and elsewhere (Lemly 2004), which has resulted in major environmental damage (Lemly 2008). However, because of the sheer volume of seleniferous material exposed, in combination with the practice of valley-fill waste disposal, mountaintop removal mining is most dangerous from an environmental risk perspective.

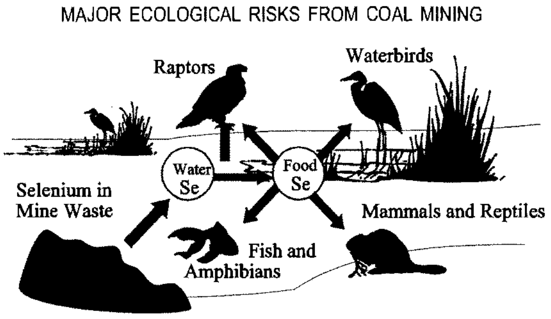

Figure 1. Pathways for selenium movement from coal mine wastes, bioaccumulation in food chains, and dietary exposure of fish and wildlife populations.

Why is Selenium Such a Toxic Hazard?

The most important principle to understand when evaluating the hazard of selenium from mountaintop removal coal mining is its ability to bioaccumulate. This means that a low concentration of selenium in water has the potential to increase by several orders of magnitude by the time it reaches fish and wildlife. For example, a water concentration of 10 ug/L (micrograms per liter or parts-per-billion) can increase to over 5,000 times that amount in fish tissues. Bioaccumulation causes otherwise harmless concentrations of selenium to reach toxic levels. Although fish do take up some selenium directly from water, most of it comes from their diet. Therefore, in order to protect fish from selenium poisoning it is essential to keep waterborne selenium below levels that cause biaccumulation in the food chain (Lemly and Smith 1987). Another important principle is that selenium can cycle in aquatic habitats by moving in and out of sediments. A large portion of the total selenium in a stream or reservoir may be present in sediments, deposited directly from water or from plants and animals as they die and decompose. However, this pool of selenium is not permanently removed from the system. Biological activity, water chemistry changes, and physical disturbance can mobilize selenium back into water and organisms. This means that the selenium in sediments remains active, and provides a significant source of pollution to bottom-dwelling invertebrates and the fish that feed on them. Case studies show that selenium in sediments can recycle into the water and food chain for decades after selenium inputs are stopped (Lemly 1997).

What Are The Toxic Effects and Toxic Concentrations?

Selenium exerts two main types of effects on fish: (1) direct toxicity to juveniles and adults, and (2) reproductive impacts from selenium that is passed from parents to offspring in eggs. Both of these modes of toxicity can occur at the same time so the threat from selenium poisoning is multifaceted. Type 1 toxicity can begin to occur if concentrations in the food chain reach 3 ug/g dw (micrograms per gram or parts-per-million, dry weight) and whole-body residues in fish reach 4 ug/g dw (Cleveland et al. 1993, Lemly 1993a, Hamilton 2003). This form of selenium poisoning involves changes in physiology that cause damage to gills and internal organs, ultimately resulting in death of the fish (Sorensen 1986). There may be no outwardly visible symptoms in this type of selenium toxicity or, if selenium concentrations are high enough, some fish may appear swollen from accumulation of fluid (edema) or have cloudy lenses (cataracts) in their eyes (Lemly 2002a). Type 2 effects occur when selenium present in egg yolk is absorbed by the developing embryo. A variety of developmental abnormalities can result in newly hatched larval fish, such as teratogenic deformities of the spine, head, and fins (Lemly 1993b, see Figure 2). Other toxic symptoms include hemorrhaging and swelling or edema (Gillespie and Baumann 1986, Hermanutz et al. 1993, see Figure 2). Most of these effects are lethal because they either kill young fish just after hatching or, in the case of some teratogenic deformities, prevent them from feeding normally and escaping predators as they grow (see Figures 3-4). Type 2 effects (reproductive failure) begin to occur at egg selenium concentrations of about 9 ug/g dw, which is equivalent to about 16 ug/g dw whole body in the parent (Coyle et al. 1993, Hermanutz et al. 1993). Adult fish may be unaffected by selenium concentrations that impair their ability to reproduce so the impact of selenium on a fish population must be assessed by something more than routine monitoring surveys, that is, simply finding fish does not indicate the absence of selenium toxicity (Lemly 2002b). Waterborne concentrations of selenium in the 1-5 ug/L range can bioaccumulate and begin the Type 1 and/or Type 2 effects. The exact number is site-specific, and depends on the kind of aquatic system (stream, river, reservoir, wetland, etc.), its biological productivity, and the chemical form of selenium present in the water. Case studies show that if waterborne selenium reaches 10 ug/L, complete reproductive failure can occur in reservoirs, and reproduction may be reduced by 40% in streams (Cumbie and Van Horn 1978, Lemly 1985b, Gillespie and Baumann 1986, Hermanutz et al. 1993).

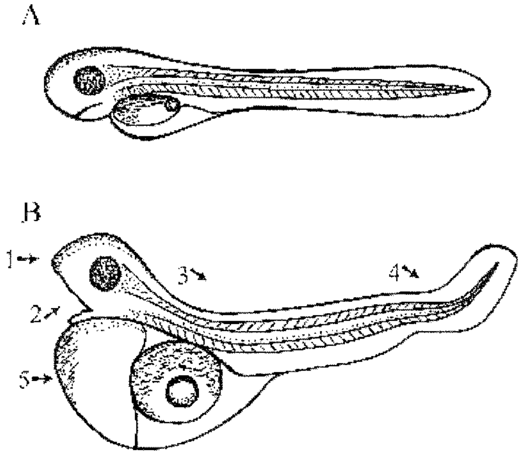

Figure 2. Typical appearance of larval fish at about 2-4 days after hatching. (A) Normal larvae with yolk absorption nearing completion and straight, developing spine, (B) Abnormal development due to selenium-induced terata: (1) deformed, pointed head; (2) deformed, gaping lower jaw; (3) kyphosis (curvature of the thoracic region of the spine); (4) lordosis (concave curvature of the lumbar and/or caudal region of the spine). Other symptoms of selenium poisoning that usually accompany terata include (5) edema (swollen, fluid-filled abdomen) and delayed yolk absorption.

Figure 3. One of the most common and outwardly visible teratogenic effects of selenium in fish is deformity of the spine. Shown here are examples of dorso-ventral abnormalities (kyphosis and lordosis).

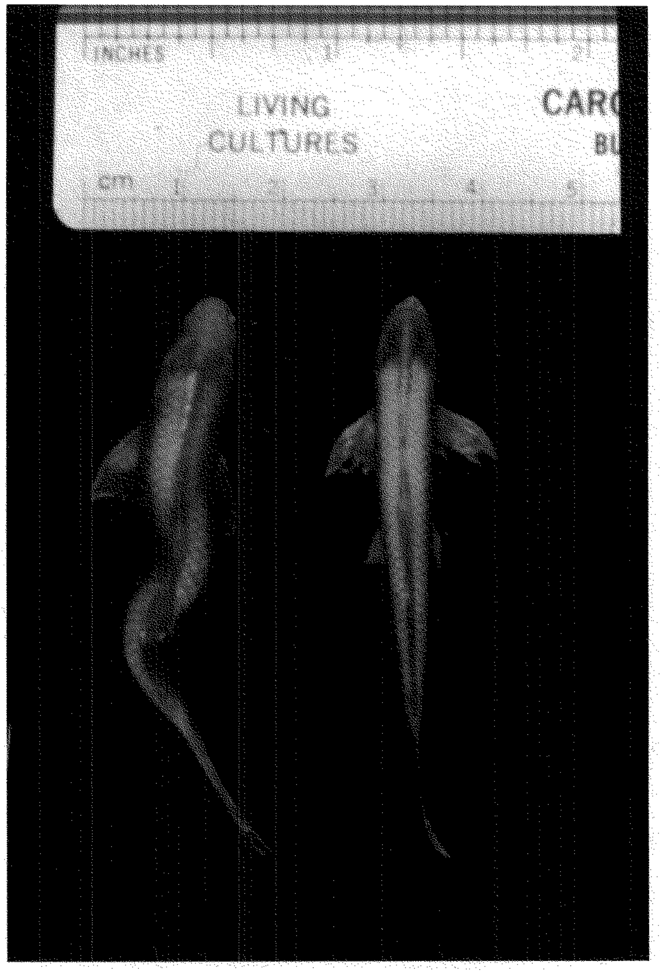

Figure 4. Lateral curvature of the spine (scoliosis) caused by exposure to elevated selenium. Individual on right is normal.

What Do We Know About Selenium Releases From Mountaintop Mining and Their Impacts?

In 2005 the US Environmental Protection Agency, in conjunction with the US Army Corps of Engineers, the US Department of the Interior's Office of Surface Mining and Fish & Wildlife Service, and the West Virginia Department of Environmental Protection, completed an environmental impact statement (EIS) on the impacts of mountaintop mining and valley fills (USEPA 2005). Over 1200 stream segments were examined. The EIS confirmed what biologists and ecotoxicologists in academia and other federal agencies had long suspected – mountaintop mining causes significant harm to aquatic habitats and the variety of life they support. A key finding was that the valley fills used for waste disposal are a primary source of selenium contamination. Given the size and placement of these fills, selenium leaching and associated pollution of downstream aquatic habitats, left untreated, will continue in perpetuity. Moreover, among all the environmental issues noted in the report's summary, selenium was the only trace element named as a specific threat – "Selenium levels may increase and negatively impact fish and macroinvertebrates leading to less diverse and more pollutant-tolerant species." The EPA clearly, and correctly, recognized selenium as a substantial ecological risk.

In the interim since EPA completed its EIS, much additional first-hand knowledge of the selenium risk has come to light due to actual case examples of pollution events. We now know that selenium concentrations in leachate from valley fills and other coal mining wastewater can far exceed the toxic thresholds for fish when bioaccumulation is factored in. For example, effluent from a mountaintop removal operation in West Virginia was found to contain as much as 82 ug/L selenium – an amount that is over fifteen times the threshold for toxic bioaccumulation (see Figure 5, Lemly 2008). This waterborne concentration was sufficient to pollute the Mud River and a downstream reservoir, substantially elevate selenium levels in fish tissues, and cause teratogenic deformities and other toxic effects in their offspring (see Figures 6-11). If waterborne selenium concentrations are not reduced, reproductive toxicity will spiral out of control and fish populations will collapse. The warning signs are evident. If a catastrophic event is to be avoided, actions must be taken now. Because of selenium's persistence in the environment, coupled with its ability to cycle from sediments back into the food chain, negative impacts on the fish community of the Mud River system are likely to continue for many years even if additional inputs from the mining waste were curtailed immediately. History has taught us a very important lesson: once an aquatic habitat is polluted by selenium, timely cleanup is difficult if not impossible.

Data from other watersheds that are undergoing mountaintop removal mining paint a grim picture for aquatic life. Monitoring reports reveal that selenium releases are widespread and alarmingly high. For example, documents obtained through FOIA (Freedom of Information Act) requests show that waterborne selenium concentrations in discharges can average over 60 ug/L (over ten times the threshold for toxic bioaccumulation) and 25 ug/L in downstream habitats (Figure 12, ACEE 2009). These selenium levels constitute a persistent toxic hazard to aquatic resources. The weight of evidence is substantial and indisputable. EPA's in-house evaluation, independent academic research, and private sector investigations all support the same conclusion: selenium pollution from mountaintop removal coal mining poses an imminent threat to aquatic life in central Appalachia.

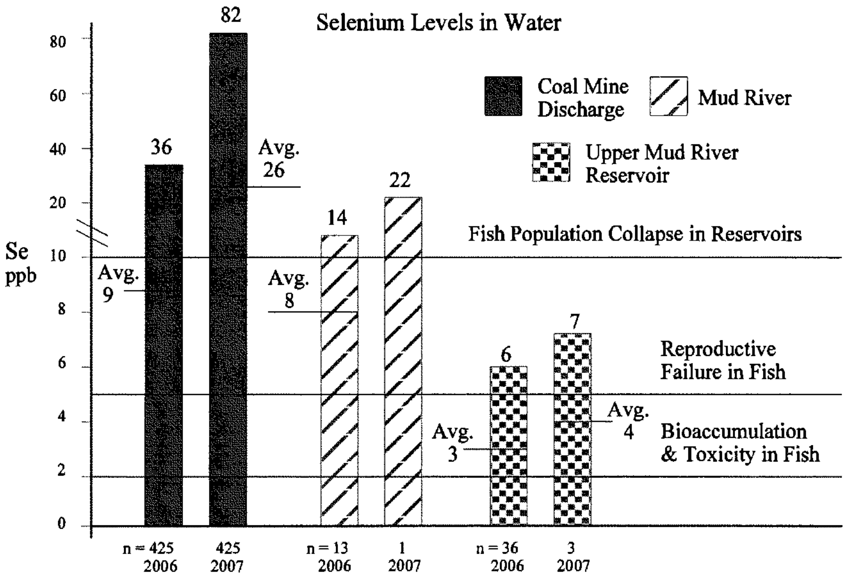

Figure 5. Selenium in discharge from a mountaintop removal coal mining operation in West Virginia polluted downstream receiving waters to levels that far exceed toxic thresholds for fish (Lemly 2008). The maximum in discharges (82 ug/L) is over fifteen times the threshold for toxic bioaccumulation.

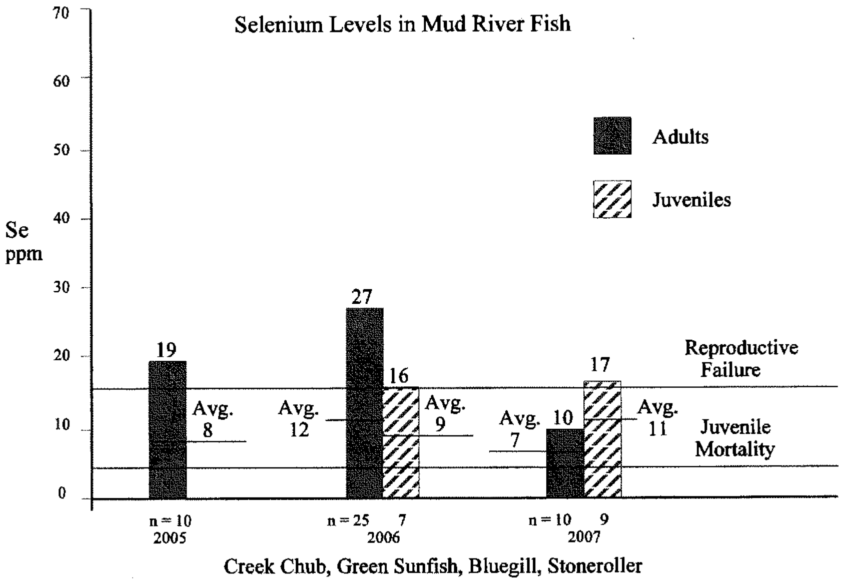

Figure 6. The Mud River, West Virginia was polluted with selenium released from a mountaintop removal coal mining operation. Bioaccumulation in the food chain caused selenium levels to exceed toxic thresholds for reproduction and survival in fish.

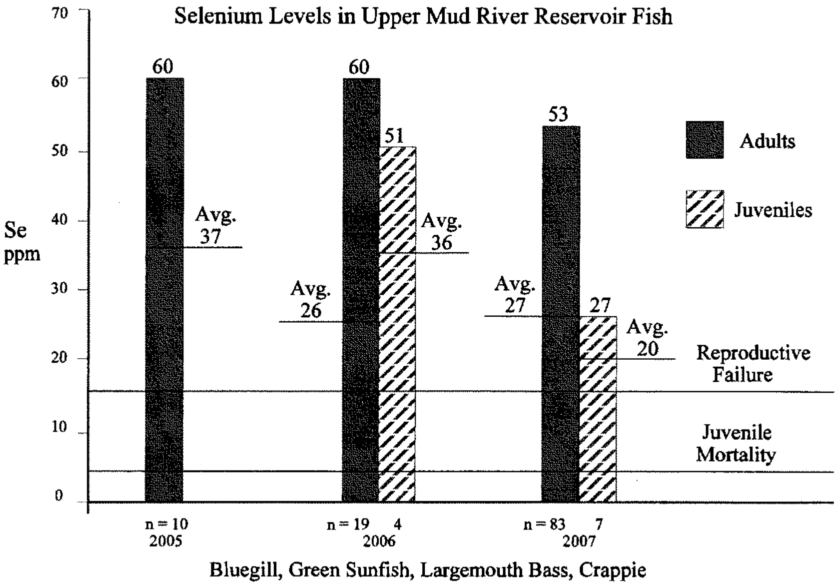

Figure 7. Selenium released from a mountaintop coal mining operation in West Virginia bioaccumulated in Upper Mud River Reservoir to levels that far exceed toxic thresholds for fish. These selenium levels indicate that the fishery of this reservoir could soon collapse due to reproductive failure.

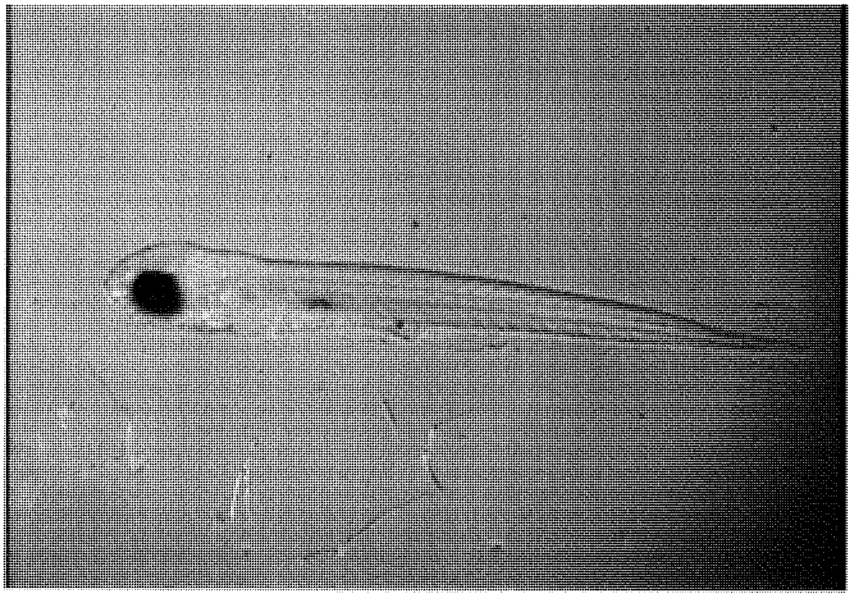

Figure 8. Side view of normal fish larva from Upper Mud River Reservoir, West Virginia, June 2007. Note normal eye development, straight spine, and complete yolk absorption with no evidence of edema or a swollen, deformed yolk sac.

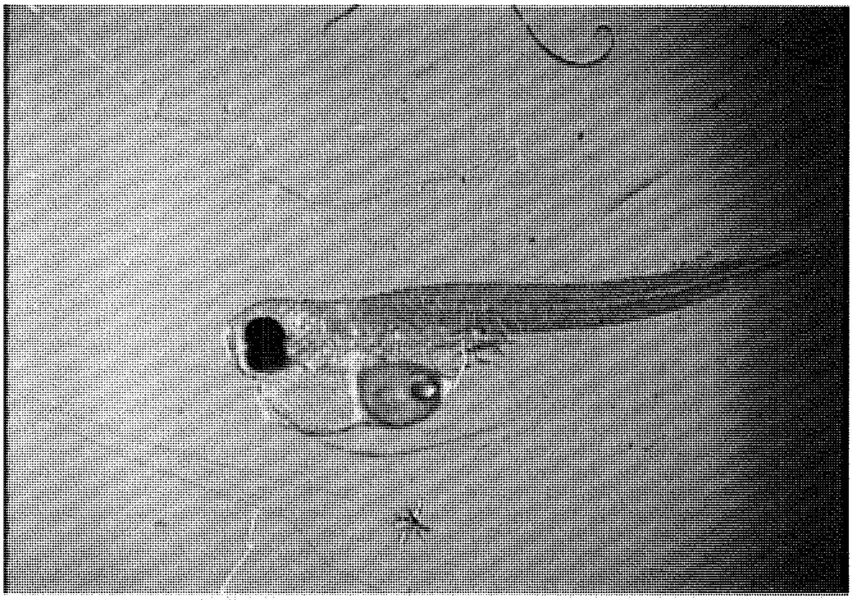

Figure 9. Side view of abnormal fish larva from Upper Mud River Reservoir, West Virginia, June 2007. Note the distended, fluid-filled yolk sac (edema) with delayed yolk absorption. This individual also has dorso-ventral curvature of the spine (kyphosis) and deformed pectoral fins and eyes (both eyes are on the same side of the head). All of these abnormalities are characteristic biomarkers of selenium poisoning, and will kill this fish before it has a chance to fully develop.

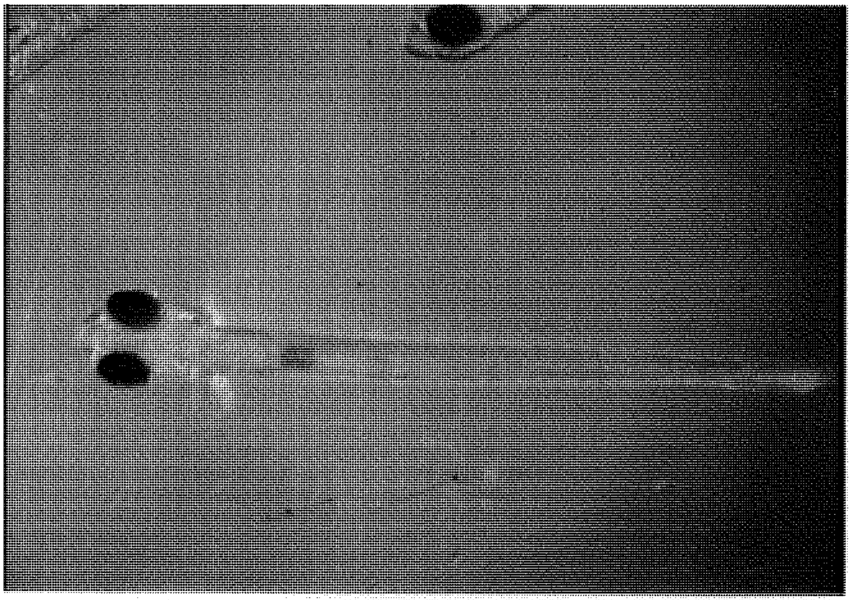

Figure 10. Dorsal view of normal fish larva from Upper Mud River Reservoir, West Virginia, June 2007. Note well developed pectoral fins and straight spine.

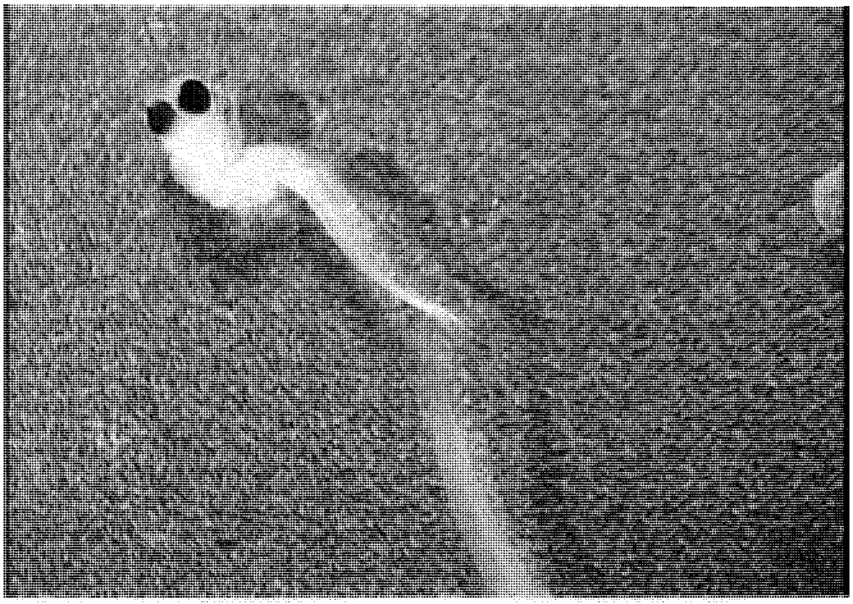

Figure 11. Dorsal view of abnormal fish larva from Upper Mud River Reservoir, West Virginia, June 2007. Note deformed spine in "S" shape, typical of scoliosis due to selenium poisoning. This fish will die because it cannot swim or feed normally.

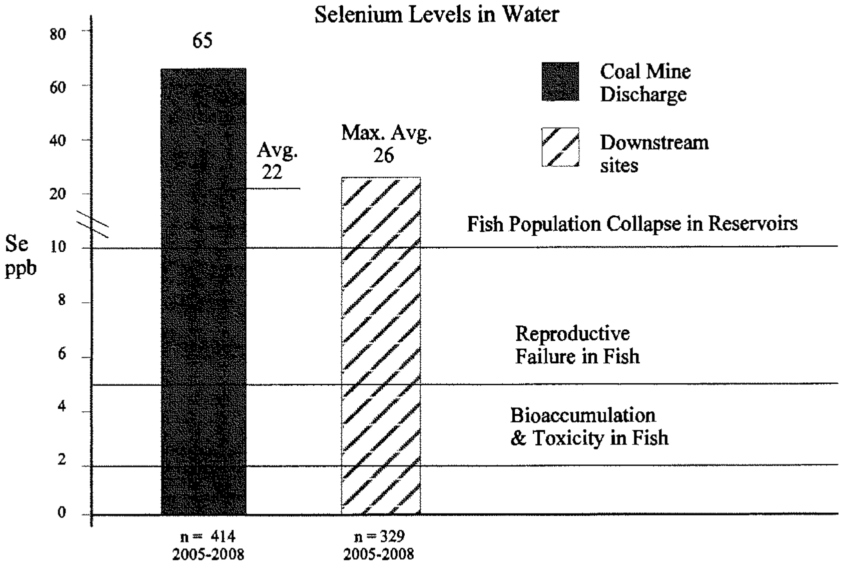

Figure 12. Waterborne selenium in discharges from Jacks Branch Coal, West Virginia, 2005-2008 (ACEE 2009). The discharges contained concentrations up to thirteen times the amount that can bioaccumulate and cause reproductive failure in fish. This mountaintop removal mining operation polluted downstream aquatic habitats to levels that can cause fish populations to collapse.

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U.S. Department of the Interior
U.S. Geological Survey

Flow Origin, Drainage Area, and Hydrologic Characteristics for Headwater Streams in the Mountaintop Coal-Mining Region of Southern West Virginia, 2000–01

By KATHERINE S. PAYBINS

Water-Resources Investigations Report 02-4300

In cooperation with the
U.S. Office of Surface Mining and the
U.S. Environmental Protection Agency

Charleston, West Virginia
2003

U.S. Department of the Interior
GALE A. NORTON, Secretary

U.S. Geological Survey
Charles G. Groat, Director

For additional information write to:

Chief, West Virginia District
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CONVERSION FACTORS

Multiply	By	To obtain
acre	0.00404686	square kilometer
cubic feet per second(ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
foot per mile (ft/mi)	0.1894	meter per kilometer
inch (in.)	25.4	millimeter

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F), and conversely, by the following equations:

$°F = (1.8)°C + 32$ $°C = (°F-32)/1.8$

Water year is calculated from October of calendar year one through September of calendar year two.

DATUMS

In this report, vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88), and horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83). Historical data collected and stored as National Geodetic Vertical Datum of 1929 have been converted to North American Vertical Datum of 1988 (NAVD 88) for this publication.

WATER-QUALITY ABBREVIATIONS

Specific conductance of water is expressed in microsiemens per centimeter at 25°C (µS/cm). This unit is equivalent to micromhos per centimeter at 25°C (µmho/cm), formerly used by the U. S. Geological Survey.

ACRONYMS

EPA	U.S. Environmental Protection Agency
MTRM EIS	Mountaintop Removal Coal Mining Environmental Impact Statement
OSM	U.S. Office of Surface Mining and Reclamation
SMCRA	Surface Mining Control and Reclamation Act
USGS	U.S. Geological Survey
WVDEP	West Virginia Department of Environmental Protection

Flow Origin, Drainage Area, and Hydrologic Characteristics for Headwater Streams in the Mountaintop Coal-Mining Region of Southern West Virginia, 2000–01

By Katherine S. Paybins

Abstract

Characteristics of perennial and intermittent headwater streams were documented in the mountaintop removal coal-mining region of southern West Virginia in 2000–01. The perennial-flow origin points were identified in autumn during low base-flow conditions. The intermittent-flow origin points were identified in late winter and early spring during high base-flow conditions.

Results of this investigation indicate that the median drainage area upstream of the origin of intermittent flow was 14.5 acres, and varied by an absolute median of 3.4 acres between the late winter measurements of 2000 and early spring measurements of 2001. Median drainage area in the northeastern part of the study unit was generally larger (20.4 acres), with a lower median basin slope (322 feet per mile) than the southwestern part of the study unit (12.9 acres and 465 feet per mile, respectively). Both of the seasons preceding the annual intermittent flow visits were much drier than normal. The West Virginia Department of Environmental Protection reports that the median size of permitted valley fills in southern West Virginia is 12.0 acres, which is comparable to the median drainage area upstream of the ephemeral-intermittent flow point (14.5 acres). The maximum size of permitted fills (480 acres), however, is more than 10 times the observed maximum drainage area upstream of the ephemeral-intermittent flow point (45.3 acres), although a single valley fill may cover more than one drainage area.

The median drainage area upstream of the origin of perennial flow was 40.8 acres, and varied by an absolute median of 18.0 acres between two annual autumn measurements. Only basins underlain with mostly sandstone bedrock produced perennial flow. Perennial points in the northeast part of the study unit had a larger median drainage area (70.0 acres) and a smaller median basin slope (416 feet per mile) than perennial points in the southwest part of the study unit (35.5 acres and 567 feet per mile, respectively). Some streams were totally dry for one or both of the annual October visits. Both of the seasons preceding the October visits had near normal to higher than normal precipitation. These dry streams were adjacent to perennial streams draining similarly sized areas, suggesting that local conditions at a first-order-stream scale determine whether or not there will be perennial flow.

Headwater-flow rates varied little from year to year, but there was some variation between late winter and early spring and autumn. Flow rates at intermittent points of flow origin ranged from 0.001 to 0.032 cubic feet per second, with a median of 0.017 cubic feet per second. Flow rates at perennial points of flow origin ranged from 0.001 to 0.14 cubic feet per second, with a median of 0.003 cubic feet per second.

INTRODUCTION

The surface mining of coal by means of mountaintop removal results in excess rock material (spoil), some of which is placed in headwater valleys adjacent to the mined area. The Code of Federal Regulations, crafted by the U.S. Office of Surface Mining and Reclamation (OSM), describes conditions for the placement of excess spoil in headwater valleys (valley fills) (Legal Information Institute, 2002a, 2002b). The 1999 and 2002 U.S. District court rulings interpret Surface Mining Control and Reclamation Act (SMCRA) and Clean Water Act regulations to allow the placement of valley fill material only in ephemeral streams and not within 100 feet of intermittent and perennial streams, unless the post-mining land use is designated as development (U.S. District Court for the Southern District of West Virginia, 1999). Coal-mining interests and some government leaders are concerned that if this rule is enforced, mountaintop-removal mining will cease to be feasible in West Virginia.

Five Federal and State agencies began cooperation on a Mountaintop Removal Coal Mining Environmental Impact Statement (MTRM EIS) in 1999 as a voluntary response to the court challenge dealing with SMCRA and the Clean Water Act mountaintop-removal enforcement issues.

Part of the MTRM EIS will assess the environmental effects on waters of the United States and on biota (U.S. Environmental Protection Agency, 1999). In support of this objective, the U.S. Geological Survey (USGS), in cooperation with OSM and the U.S. Environmental Protection Agency (EPA), reported the point of flow origins for perennial and intermittent headwater streams in the coal-mining region of southern West Virginia, and studied their hydrologic and drainage-area characteristics.

Purpose and Scope

This report describes the hydrologic and drainage area characteristics of intermittent and perennial headwater streams in southern West Virginia that were not affected by mining. The streams were examined in late winter or early spring (February through April), when the water table is at its highest elevation, and in autumn (October), when the water table is at its lowest elevation. The origin of continuous base flow was identified in 36 unmined headwater streams in southern West Virginia in February–April and October of both 2000 and 2001. Methods were developed to identify the origin of continuous base flow in hydrologic terms, and drainage-area characteristics were determined, including variations in drainage-area sizes upstream of flow-origin points over time. A better understanding of the relations between ephemeral, intermittent, and perennial headwater streams and their drainage-area characteristics will help regulators make sound decisions on valley-fill permits in West Virginia and adjacent states with similar issues.

Description of Study Area

Fifteen percent of the Nation's coal produced in 2000 was mined in West Virginia, and West Virginia leads the United States in coal exports (West Virginia Office of Miners' Health, Safety and Training, 2000). Coal is mined by means of both underground and surface methods. In recent years, it has become both economically and technologically possible to remove entirely multiple, thin layers of coal near the tops of the mountains. This type of mining is called mountaintop-removal mining. Large-scale mountaintop-removal mines generate excess fragmented rock material in the mining process that cannot be replaced at the top of the mountain once the coal is removed. This excess spoil is placed in valleys adjacent to the surface mines. West Virginia has approximately 1,700 valley fills ranging in size from less than 1 acre to 480 acres and with a median size of 12.0 acres (West Virginia Department of Environmental Protection, 2002). The streams in the study described here are within the region of mountaintop-removal mining, but had not yet been filled at the start of this work.

The 36 first-order stream sites are grouped within five study areas in the Appalachian Plateaus Physiographic Province in southern West Virginia (fig. 1), which is characterized by mountainous terrain (Fenneman, 1938; Fenneman and Johnson, 1946). The streams of the Appalachian Plateaus have eroded sedimentary rocks into steeply sloping hills and narrow valleys. A thin layer of regolith commonly overlies interbedded sandstone, conglomerate, siltstone, shale, coal, limestone, and dolomite rocks, all of which

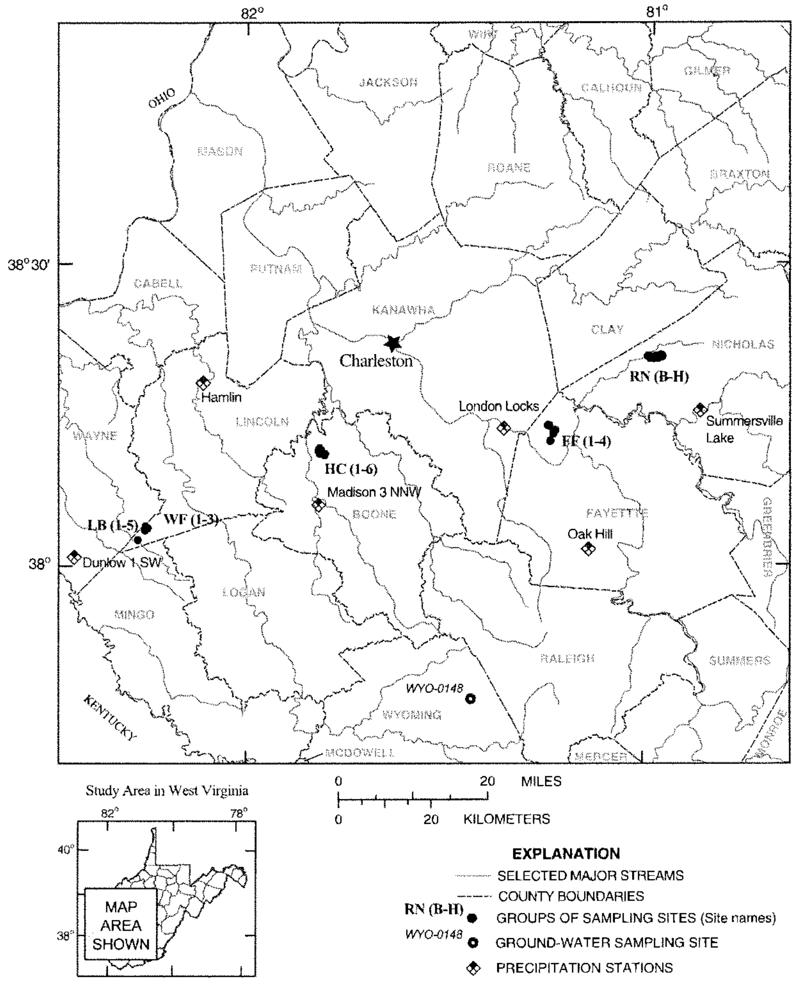

Figure 1. Locations of the study-area groups of sampling sites in the headwater streams of the mountaintop coal- mining region of southern West Virginia, 2000–01.

dip gently to the northwest across the region. Resistant bedrock exposed at the highest elevations (headwater regions) is most commonly sandstone or shale, but the thickness of this cap-rock layer is variable (Fenneman, 1938; Fenneman and Johnson, 1946; and U.S. Geological Survey, 1970). Most ground water flows along the valley walls through a series of fractures composed of joints, faults, and bedding planes, and in slump fractures (Wyrick and Borchers, 1981).

The climate of West Virginia is continental, with four distinct seasons and a large temperature variation between summer and winter (U.S. Department of Commerce, 1960; Messinger and Hughes, 2000). Mean monthly summer temperatures are about 65-75°F, while mean monthly winter temperatures are about 25-40 °F; these temperatures depend on elevation. Prevailing winds move generally from west to east. Due to local orographic uplift, the heaviest precipitation falls on the windward (southwest and western) sides of mountains, which have rain shadows on their leeward (northeast and eastern) sides. Throughout the warmer months, the region is affected by northeast-moving, moisture-laden maritime tropical air that produces spatially discrete showers and thunderstorm cells (U.S. Department of Commerce, 1960). In the colder part of the year, large low-pressure storms deliver precipitation over broader regions, but less total precipitation than warm-weather storms.

In general, the 2000 water year was drier than average, and the 2001 water year was an average year for precipitation and ground-water levels (Ward and others, 2001, 2002) (fig. 2). The October–March periods in both 2000 and 2001 were much drier than the 30-year average at all examined precipitation stations in southwestern West Virginia (U.S. Department of Commerce, 2000, 2001, and 2002a) (table 1). Precipitation at various stations in the period (April–September) preceding the October 2000 field work range from about 4 to 11 in. above normal. In the period preceding the October 2001 field work, precipitation was below normal at Dunlow and Madison (3.9 in. and 2.11 in., respectively), and 0.2–5.8 in. above normal at the other stations. In the northeast part of the study area, average annual precipitation is 1.8 in. greater than in the southwest part of the study area.

Table 1. Precipitation data for long-term National Oceanic and Atmospheric Administration monitoring sites within and adjacent to headwater streams in the mountaintop coal-mining region of southern West Virginia, 2000–01

[**Group of sites closest to precipitation station:** See figure 1 for site locations and names. **Normal monthly precipitation:** Totals calculated from U.S. Department of Commerce data from 1971–2000; precipitation data are in inches]

Precipitation station	Group of sites closest to precipitation station	October 1999 through March 2000	April 2000 through September 2000	October 2000 through March 2001	April 2001 through September 2001	Normal monthly precipitation		Normal annual precipitation
						October–March	April–September	
Dunlow 1 SW	LB, WF	10.06	29.69	[1]4.83	20.96	20.86	24.85	45.71
Hamlin	HC, LB, WF	19.56	27.95	[1]8.96	24.47	20.14	24.26	44.40
London Locks	FF	15.85	36.30	12.38	29.19	19.76	25.50	45.26
Madison 3 NNW	HC	12.55	31.76	[1]10.18	[1]25.00	20.73	27.11	47.84

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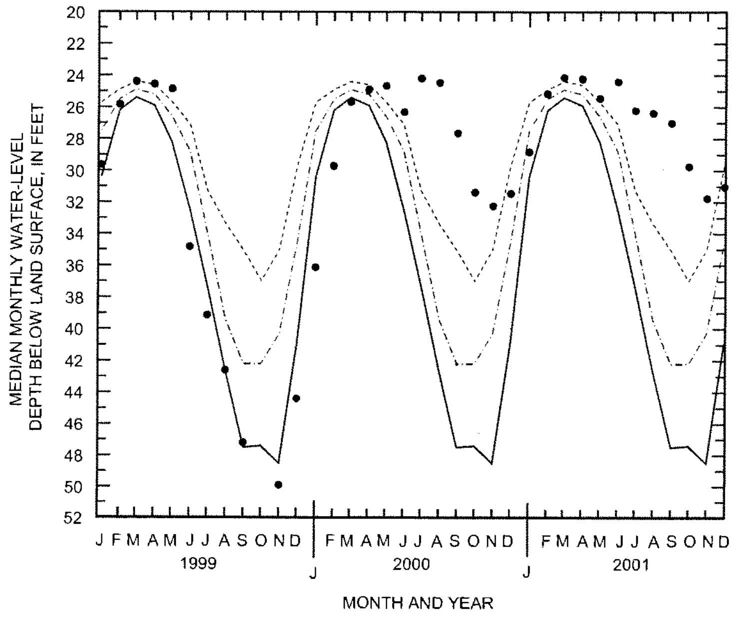
[**Group of sites closest to precipitation station:** See figure 1 for site locations and names. **Normal monthly precipitation:** Totals calculated from U.S. Department of Commerce data from 1971–2000; precipitation data are in inches]

Precipitation station	Group of sites closest to precipitation station	October 1999 through March 2000	April 2000 through September 2000	October 2000 through March 2001	April 2001 through September 2001	Normal monthly precipitation		Normal annual precipitation
						October–March	April–September	
Oak Hill	FF	11.95	33.86	11.25	30.69	20.62	25.59	46.21
Summersville Lake	RN	12.94	36.93	12.10	32.61	20.65	26.83	47.48

[1] One to nine days of precipitation data are missing for at least one month during the given time interval.



EXPLANATION

Definitions of Perennial, Intermittent, and Ephemeral Streams

Water in the environment is available in the air, in precipitation, in the ground, and on the land surface. The interface where the ground-water table intersects the land surface and becomes streamflow in a headwater channel is the point of flow origin. Streamflow derived from ground water alone is called base flow. Overland and near-surface flow contributing to streamflow are called surface and subsurface storm runoff (Black, 1991). When a stream receives base flow year-round, it is considered to be a perennial stream (fig. 3). Intermittent flow indicates a seasonal lowering of the water table during the summer and early autumn, as base-flow contributions to the channel cease. If a channel does not intersect the water table at any time of year, it is considered to be an ephemeral channel.

Given the natural hydrologic cycle, three basic types of definitions for perennial, intermittent, and ephemeral streamflow exist. Descriptive definitions are often obtained from cartographers, whose maps are used frequently in a legal and regulatory environment. Hydrologic definitions are based on observations and measurements of hydrologic phenomena, such as the relations between stormwater flow and ground water, and have recently been relied on more often in regulations. Biologic definitions combine the existence or absence of indicator species of benthic invertebrates with hydrologic phenomena.

Much research has focused on the stream-type, blue-line symbol on USGS maps at the 1:24,000 scale, in spite of the fact that the line symbol on these maps is not based on hydrologic criteria (Leopold, 1994). Even so, many state and local laws specifically state that this map series should be used when making any regulatory decisions. Specific topographic instructions to past USGS cartographers (U.S. Geological Survey, 1980) state that:

1. "...all perennial streams are published regardless of length."
2. "All intermittent streams are published that are longer than 2,000 feet" and
3. "In general, headwater drainage shown on the published map should terminate no higher than about 1,000 feet from the divide, or at the upper confluence of streams, whichever appears most appropriate."

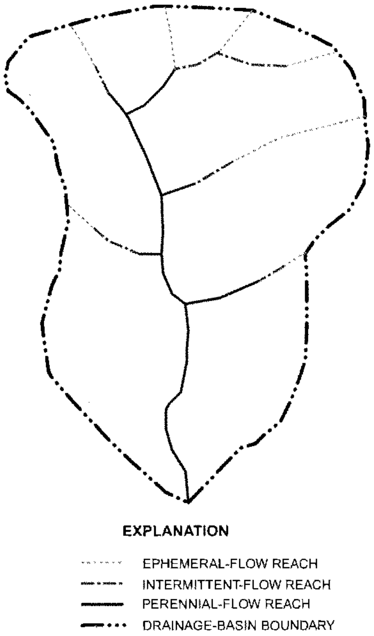


Figure 3. Ephemeral-, intermittent-, and perennial-flow patterns typical for the mountaintop coal-mining region of southern West Virginia.

These instructions indicate that headwater limits of blue lines on maps do not reflect actual field conditions. Generally, a far larger number of actual channels can be identified on the ground than are visible on a published map (Leopold, 1994). For instance, the topographic maps used in this study showed that only 12 of the headwater drainage areas had intermittent streams; but in this study, 36 headwater drainage areas were identified that had intermittent or perennial streams. Twelve of those 36 streams had intermittent flow, but no perennial flow in 2000 or 2001.

Hydrologic definitions of perennial, intermittent, or ephemeral streamflow in the eastern U.S. are based on the relations between stormwater and ground water, the timing and duration of continuous base flow, drainage area, channel characteristics, and presence or absence of substrate bedforms indicative of flowing waters (Hewlett, 1982; Stefania Shamet, U.S. Environmental Protection Agency, Region 3, written commun., 1999). A basic hydrologic definition, and the one used in this study, is modified from Langbein and Iseri (1960). A perennial stream is one that flows continuously, and thus has flow from both ground-water discharge and surface runoff. An intermittent stream flows only at certain times in the year, when it receives both ground-water discharge and storm runoff. Ephemeral streams flow only in direct response to surface runoff of precipitation or melting snow, and their channels are at all times above the water table. The West Virginia Department of Environmental Protection (WVDEP), Water Quality Standard CSR 46-1-1-2.9, defines intermittent streams as "streams which have no flow during sustained periods of no precipitation, and which do not support aquatic life whose life history requires residence in flowing water for a continuous period of at least 6 months". OSM regulations define an intermittent stream as a "stream or part of a stream that flows continuously for at least 1 month of the calendar year as a result of ground-water discharge or surface runoff; the term does not include a stream that flows for less than one month of a calendar year, and then only in direct response to precipitation in the immediate drainage area and whose channel bottom is always above the local water table." (Legal Information Institute, 2002a). Pennsylvania regulation 25 Pa. Code ϕ 87.1 includes a reference to channel substrate indicative of flowing water, or lack thereof, to further differentiate ephemeral from intermittent streams (Stefania Shamet, U.S. Environmental Protection Agency, Region 3, written commun., 1999).

Biologic interpretations of perennial, intermittent, and ephemeral streams are changing with increasing knowledge of benthic invertebrates and water-obligate fauna in headwater environments. Some taxa that are now known to be present in intermittent streams are currently used as indicators of continuous (perennial) flow (M.E. Passmore, U.S. Environmental Protection Agency, Region 3, written commun., 2002). A growing body of literature indicates that intermittent flows can support a diverse and abundant invertebrate and salamander assemblage (Feminella, 1996; Williams, 1996; Dietrich and Anderson, 2000; M.E. Passmore, written commun., 2002).

Acknowledgments

The author thanks USGS and OSM colleagues for their contributions to the field work and reviews. The USGS appreciates the time given and knowledge of the study area shared by Randall Maggard (Pen Coal Inc.), John McDaniel (Arch Coal, Inc.), Francis Meadows (Alex Energy, Inc.), Frank Rose (Pittston/Appalachian Co.), and Roger Wolfe (formerly of Mid-Vol Leasing, Inc.). The USGS is also grateful to David Vandelinde of the WVDEP for his assistance in securing contacts at the research sites.

STUDY DESIGN AND DATA COLLECTION

A multi-agency group, including the WVDEP, USGS, and OSM, selected 43 headwater streams for investigation from mountaintop-removal-mine permit maps. At each of these first-order streams, permits for filling with excess mining spoil were either pending or approved. Although 12 of the 43 drainage areas were shown on USGS 1:24,000-scale topographic maps as including intermittent streams, field inspections during this study showed that 36 of these drainage areas included intermittent or perennial streams. The 36 of 43 headwater streams evaluated for this study are in unmined drainage areas in Boone, Fayette, Lincoln, and Nicholas Counties, in the heart of the surface coal-mining region of southern West Virginia (fig. 1). Surface-mining activities precluded further visits to some basins. Some sites were not visited due to clearing of most vegetation in preparation for filling. Clearcutting significantly alters the hydrologic regime of a watershed by decreasing evapotranspiration and increasing surface and subsurface runoff (Helvey and Patric, 1965; Black, 1991; Fitzpatrick and others, 1998).

Each of the headwater streams was visited in February 2000, October 2000, March-April 2001, and October 2001 in order to identify the point of origin of continuous surface flow. Multi-agency teams made the February 2000 visit, while a USGS team made the next three visits. The point where base flow begins in the late winter or early spring corresponds to the highest water-table elevation, and is the point of intermittent-flow origin, or the boundary between ephemeral and intermittent flow (called the intermittent point). The point where base flow begins in the late summer and early autumn corresponds to the lowest water-table elevation, and is the point of perennial flow origin, or the boundary between intermittent and perennial flow (called the perennial point).

The field work done in February–April was timed to coincide with the wettest part of the year, with little evapotranspiration before leaf-out begins, and a ground-water table normally at its highest annual elevation in the region (fig. 2). The February–April field work thus documented the point of origin of continuous intermittent base flow (intermittent point) under conditions of no rainfall and subsequent storm runoff. Many streams throughout West Virginia have minimum base flows in late summer through early autumn, and maximum base flows in late winter or early spring (Ward and others, 2002). Different teams with different equipment visited each group of sites (FF, HC, LB, RN, WF) in February 2000. The accuracy of some of the global-positioning-systems (GPS receivers) varied between each group, and a few intermittent-point designations were mapped approximately for some sites, which may have introduced an immeasurable error for a few intermittent points. Project-planning complications delayed the 2001 site visits, and some understory plants were already leafed out during the April visits. The evapotranspiration from these plants probably had some effect on the measured variables.

October field work was timed before leaf-off to coincide with the dry conditions and the lowest water-table elevations generally observed in early autumn in the region (fig. 2). October field work thus documented the point of origin of continuous perennial base flow (perennial point), under conditions of no rainfall and subsequent storm runoff. There was no base flow in 20 headwater streams in October of either 2000 or 2001, and 12 streams contained no perennial flow in either 2000 or 2001 (table 2).

For each site, the field crew walked the full length of the stream channel to determine the location of the upstream limit of continuous surface flow. The geographic coordinates of the point or zone where streamflow was observed to be continuous in the channel and no flow was upstream were identified with a Precision Lightweight GPS Receiver (PLGR). The error in horizontal location for the PLGR system is 13 ft. If the GPS could not acquire a location for the upstream flow limit, a Bushnell rangefinder, with an error of 3 ft, was used to estimate the distance from a point where a GPS reading was acquired.

All visits included measurements of streamflow, water temperature, and specific conductance, except for the February 2000 visits (they were not included in the original study design). Streamflow was measured within 15 ft downstream of the flow origin point with one of three methods. A pygmy meter was used to measure flow velocity across a defined channel width when the channel was wide and deep enough for the meter. Floatable material was timed over a set distance to measure velocity when the channel was not deep enough to use the pygmy meter. The flow at a few sites was measured by timing the filling of a bucket of known volume. Water temperature was measured to help determine whether or not surface water contributed in a major way to the flow. (Surface-water temperature is generally higher than ground-water temperature in summer and lower in winter.) For autumn visits, when warmer water temperatures indicated possible upstream flow through channel sand or gravel deposits, the point of flow origin was reevaluated by hiking upstream to verify that no surface flow existed. Specific conductance was measured as a possible indicator of mine-water discharge, which generally has higher specific conductance than natural ground water. Conductance values measured in the field differed widely, however, despite the absence of coal mining upstream of the study sites.

To avoid the effects of stormwater runoff, streams were evaluated only if precipitation exceeding 0.1 in. was not recorded for at least 1 day prior to the visit (table 2). A continuous streamflow-gaging station (03204210) was operated during this study on a small, unmined headwater-stream site on Spring Branch near Mud, WV. The record from that station indicates that in both the spring and autumn of 2000, stormwater flow in a headwater basin (0.53 mi^2) generally passed the stream-gaging station within 24 hours of a precipitation event of less than 0.6 in. (fig. 4).

The drainage areas for the headwater-stream sites were assumed to be forested and previously undisturbed by deep or surface coal-mining activity. Because it was later discovered that surface mining likely had affected 7 of the original 43 headwater streams, they are not included in the following analysis of 36 sites (table 2). Six of the streams in McDowell County were accessible from a bench of a 1970s contour mine. The origin of flow for all six streams for all visits was at or near the base of the rubble pile downgradient from the mine bench. One Nicholas County headwater stream was dry during all visits, and there was no

Table 2. Location and drainage area of intermittent and perennial points in headwater streams in the mountaintop coal-mining region of southern West Virginia, 2000–01

[**Sampling site:** See figure 1 for site locations and names. *, No continuous flow identified in drainage area. **, Drainage area unavailable due to preparation for or actual filling with coal-mining spoil. ***, Drainage area not visited during field season. ****, Intermittent or perennial point identified upstream in one or more tributary valleys. *****, Perennial point identified downstream of two intermittent tributaries. --, not applicable; <, actual value is less than value shown]

Sampling site	Drainage area, in acres	Lati-tude	Longi-tude	number of days since rain	Drainage area, in acres	Lati-tude	Longi-tude	number of days since rain	Drainage area, in acres	Lati-tude	Longi-tude	number of days since rain	Drainage area, in acres	Lati-tude	Longi-tude	number of days since rain
FF1	19.4	38.1686	81.2498	4	8.1	38.1675	81.2495	2	*	--	--	5	**	--	--	--
FF1a	***	--	--	--	18.3	38.1786	81.2559	2	*	--	--	5	**	--	--	--
FF3	10.8	38.1829	81.2434	5	19.0	38.1833	81.2440	2	65.0	38.1852	81.2490	5	122.3	38.1870	81.2514	5
FF4	45.3	38.1898	81.2390	5	52.5	38.1889	81.2402	2	***	--	--	5	98.2	38.1886	81.2418	5
HC1a	12.0	38.1415	81.8027	1	15.0	38.1415	81.8029	1	54.0	38.1406	81.8056	2	28.5	38.1413	81.8035	2
HC1b	24.4	38.1390	81.8037	1	31.8	38.1394	81.8041	1	40.7	38.1402	81.8055	2	35.3	38.1396	81.8046	2
HC2	26.5	38.1418	81.8126	1	22.2	38.1420	81.8121	1	47.3	38.1406	81.8136	2	19.7	38.1412	81.8131	2
HC3a	***	--	--	--	24.2	38.1438	81.8185	1	23.4	38.1439	81.8183	2	24.1	38.1439	81.8185	2
HC3b	13.8	38.1420	81.8173	1	*	--	--	1	40.8	38.1436	81.8183	2	22.8	38.1431	81.8178	2
HC4	****	--	--	--	****	--	--	--	****	--	--	--	23.0	38.1481	81.8206	2
HC4a	8.4	38.1486	81.8194	1	7.7	38.1486	81.8193	1	10.4	38.1484	81.8197	2	*****	--	--	--
HC4b	9.2	38.1478	81.8197	1	7.7	38.1478	81.8195	1	*	--	--	2	*****	--	--	--
HC5	9.6	38.1532	81.8167	1	*	--	--	1	*	--	--	2	*	--	--	2
HC6a	16.4	38.1476	81.8130	1	19.7	38.1481	81.8130	1	*	--	--	--	20.7	38.1485	81.8132	2
HC6b	18.0	38.1487	81.8134	1	17.9	38.1488	81.8137	1	*	--	--	--	18.0	38.1486	81.8133	2
LB1	***	--	--	--	10.8	37.9766	82.2724	1	*	--	--	10	*	--	--	2
LB2	***	--	--	--	12.7	37.9734	82.2670	1	*	--	--	10	*	--	--	2
LB3	***	--	--	--	17.7	37.9748	82.2632	2	52.0	37.9723	82.2622	10	*	--	--	2
LB4	7.9	37.9722	82.2589	3	10.1	37.9721	82.2585	2	*	--	--	10	*	--	--	2
LB5	***	--	--	--	13.1	37.9760	82.2586	1	34.0	37.9749	82.2570	10	34.8	37.9746	82.2572	2
RNB	11.3	38.3304	80.9854	2	**	--	--	--	**	--	--	--	**	--	--	--
RNC	40.6	38.3298	80.9981	1	***	--	--	--	44.2	38.3296	80.9983	4	66.5	38.3279	80.9991	1
RND	8.9	38.3293	81.0051	<1	13.3	38.3293	81.0057	2	*	--	--	4	*	--	--	1
RNE	30.6	38.3329	81.0106	1	43.2	38.3331	81.0127	2	*	--	--	2	66.1	38.3324	81.0158	1
RNF	19.4	38.3326	80.9920	1	23.2	38.3331	80.9920	8	41.9	38.3341	80.9922	2	*	--	--	1

Table 2. Location and drainage area of intermittent and perennial points in headwater streams in the mountaintop coal-mining region of southern West Virginia, 2000–01—*Continued*

Sampling site	2000 Intermittent point				2001 Intermittent point				2000 Perennial point				2001 Perennial point			
	Drainage area, in acres	Lati-tude	Longi-tude	Minimum number of days since rain	Drainage area, in acres	Lati-tude	Longi-tude	Minimum number of days since rain	Drainage area, in acres	Lati-tude	Longi-tude	Minimum number of days since rain	Drainage area, in acres	Lati-tude	Longi-tude	Minimum number of days since rain
RNG1	20.4	38.3329	80.9773	2	27.5	38.3331	80.9790	8	27.6	38.3332	80.9790	4	27.5	38.3332	80.9790	1
RNG2	31.4	38.3345	80.9787	2	28.0	38.3349	80.9779	8	***	--	--	--	28.4	38.3349	80.9781	1
RNG3	22.2	38.3329	80.9812	2	22.2	38.3329	80.9814	8	22.2	38.3329	80.9816	4	28.6	38.3336	80.9812	1
RNH	***	--	--	--	40.7	38.3396	80.9772	8	125.9	38.3428	80.9799	4	150.1	38.3439	80.9820	1
WF1a	14.5	37.9907	82.2377	3	24.7	37.9898	82.2368	8	*	--	--	10	*	--	--	2
WF1b	6.3	37.9881	82.2408	3	10.1	37.9880	82.2399	8	*	--	--	10	*	--	--	2
WF2a	10.7	37.9928	82.2347	3	10.7	37.9927	82.2348	8	*	--	--	10	*	--	--	2
WF2b1	15.9	37.9937	82.2330	3	14.9	37.9938	82.2331	8	*	--	--	10	*	--	--	2
WF2b2	22.2	37.9933	82.2344	3	21.2	37.9933	82.2346	8	*	--	--	10	*	--	--	2
WF3a	***	--	--	--	7.9	37.9966	82.2388	8	*	--	--	10	*	--	--	2
WF3b	10.9	37.9964	82.2394	3	12.1	37.9967	82.2393	8	*	--	--	10	*	--	--	2

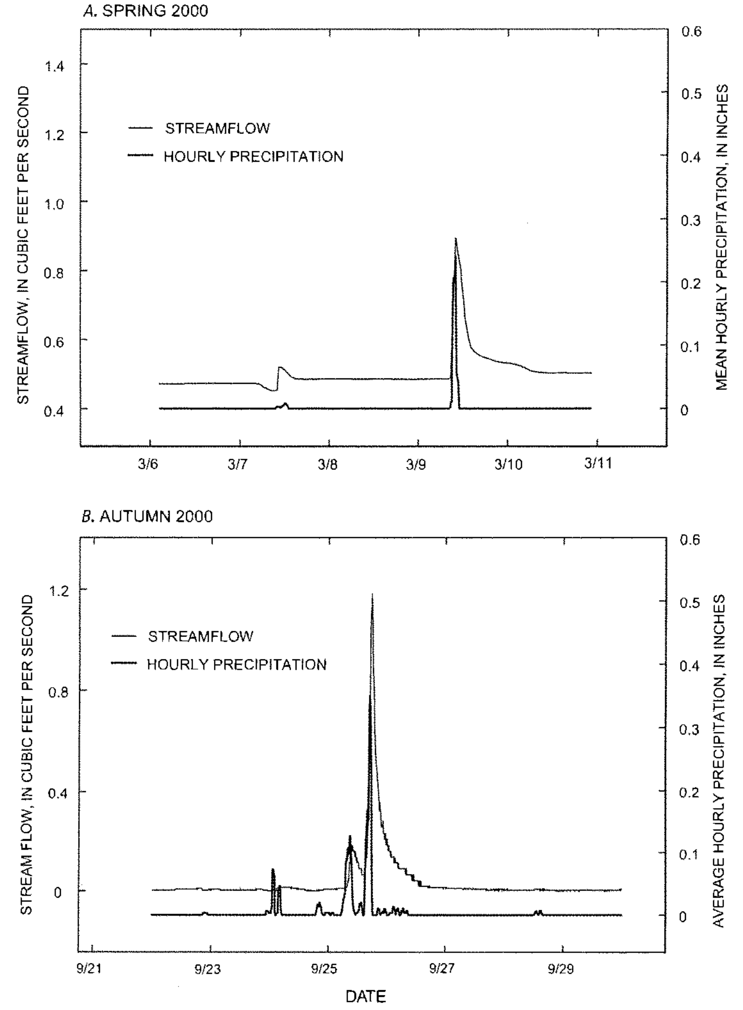


Figure 4. Streamflow and precipitation for the streamflow-gaging station (03204210) on a small stream near Mud, in the mountaintop coal-mining region of southern West Virginia during (*A*) a spring 2000 precipitation event, and (*B*) an autumn 2000 precipitation event.

apparent channel to the receiving stream at the mouth of the drainage area at an elevation of approximately 900 ft above sea level. A deep mine that dewaters some streams between approximately 900 and 1,200 ft above sea level, however, is suspected to be the cause of a lack of flow in that stream for most visits.

All collected data were put into spreadsheets, and all the intermittent- and perennial-point GPS locations were mapped digitally with ArcGIS 8.1 software. The coordinates of points were verified by comparison to digital orthophoto quarter-quadrangle maps and digital raster graphics (DRGs). Most GPS locations obtained in the field were accurate with respect to these datasets. Drainage areas of intermittent and perennial points were digitized at the 1:24,000 scale by use of the National Elevation Dataset (NED), which has a 30-meter horizontal accuracy (U.S. Geological Survey, 1999). Characteristics such as drainage area, elevation of origin point, mean drainage-area slope, aspect directions, and areal percentage of the dominant rock type were calculated for the drainage-area coverages on the basis of NED data, DRGs, and the digital geologic map of West Virginia (West Virginia Department of Environmental Protection, 1998). Mean drainage-area slope was calculated on the basis of the contour-band method of calculation (Horton, 1932; Eash, 1994); drainage-area slope can affect infiltration, surface runoff, soil moisture, and, possibly ground-water discharge to streams (Eash, 1994). A correlation analysis was used to assess the influence of the measured characteristics on intermittent- or perennial-point drainage area.

CHARACTERISTICS OF HEADWATER STREAMS

In the coal-mining region of southern West Virginia, intermittent points were identified for streams in 35 of 36 drainage areas, and perennial points were identified for streams in 20 of 36 drainage areas (fig. 1, table 2). There was no flow in 20 of the drainage areas included in this study in at least one spring or autumn site visit. Additionally, 23 intermittent points and 11 perennial points were visited 2 years in a row in order to give an indication of temporal variability of the origin of flow in response to climatic conditions.

Drainage Areas with Intermittent Flow

The highest elevation of the water table and the beginning of intermittent base flow (intermittent point) was identified for 35 headwater streams in February 2000 and March–April 2001 (table 2). For 27 sites visited in February 2000, the median drainage area was 15.9 acres; and for 31 sites visited in March or April 2001, the median drainage area was 17.9 acres. The smallest drainage area in either year upstream of an intermittent point was 6.3 acres, and the largest drainage area was 52.5 acres.

If a site was visited more than once, the intermittent point with the smaller drainage area was used in the balance of this analysis, because the current SMCRA and Clean Water Act issue under scrutiny is whether or not fill material can be placed in intermittent and perennial streams. The median drainage area of this subset of intermittent points (table 3) is 14.5 acres. The median basin slope of these drainage areas is 388 ft/mi. All following analyses are based on this subset of the data because not all of the sites were visited two times.

The median area for the 1,782 permitted valley fills in southern West Virginia is 12.0 acres (West Virginia Department of Environmental Protection, 2002), which is slightly smaller than the median intermittent-point drainage area (14.5 acres). The maximum size of a permitted fill (480 acres) is more than 10 times the observed maximum intermittent-point drainage area of 45.3 acres (table 3). Currently, some large fills cover more than one headwater drainage area.

In the northeastern part of the study area, mostly sandstone is exposed at the surface, intermittent-point elevations are higher (fig. 5A), and the average annual precipitation (approximately 47 in.) is generally greater. Intermittent points in the northeast had a median drainage area of 20.4 acres, and median basin slope of 322 ft/mi (table 3, figs. 5*B*, 5*C*). In the southwestern part of the study area, shale and sandstone are exposed at the surface, intermittent-point elevations are generally lower (fig. 5), and average annual precipitation (approximately 44 in.) is less. Intermittent points in the southwest had a median drainage area of 12.9 acres, and median basin slope of 465 ft/mi (table 3, figs. 5*B*, 5*C*).

Table 3. Selected drainage-area and hydrologic characteristics of intermittent points used in data analysis for headwater streams in the mountaintop coal-mining region of southern West Virginia, 2000–01

[**Sampling site:** See figure 1 for site locations and names. *, Data not collected in field season. **, Streamflow not measureable. ft, feet; ft/mi, feet per mile; ft^3/s, cubic feet per second; µS/cm; microsiemens per centimeter]

Sampling site	Region	Year	Drainage area, in acres	Intermittent point elevation, in ft	Basin slope, in ft/mi	Drainage area aspect	Dominant rock type	Percentage dominant rock type	Temperature, in °C	Streamflow, in ft^3/s	Conductance, in µS/cm
FF1	NE	2001	8.1	1,847	186	NW	sandstone	100	7	0.008	110
FF1a	NE	2001	18.3	1,493	338	SW	sandstone	100	11.5	.016	214
FF3	NE	2000	10.8	1,709	223	NW	sandstone	100	*	*	*
FF4	NE	2000	45.3	1,575	333	W-NW	sandstone	100	*	*	*
RNB	NE	2000	11.3	1,808	264	S	sandstone	100	*	*	*
RNC	NE	2000	40.6	1,595	416	SW	sandstone	100	*	*	*
RND	NE	2000	8.9	1,765	233	W-SW	sandstone	100	*	*	*
RNE	NE	2000	30.6	1,627	348	W	sandstone	100	*	*	*
RNF	NE	2000	19.4	1,732	275	N-NW	sandstone	100	*	*	*
RNG1	NE	2000	20.4	1,811	350	W-NW	sandstone	100	*	*	*
RNG2	NE	2001	28.0	1,791	322	W-SW	sandstone	100	7.5	**	27
RNG3	NE	2001	22.2	1,749	275	N-NW	sandstone	100	7.5	.021	36
RNH	NE	2001	40.7	1,601	433	NW	sandstone	100	8.5	.001	40
HC1a	SW	2000	12.0	1,076	393	SW	sandstone	100	*	*	*
HC1b	SW	2000	24.4	1,014	583	NW	sandstone	100	*	*	*
HC2	SW	2001	22.2	1,011	596	SW	sandstone	75	10	.018	283
HC3a	SW	2001	24.2	978	552	S-SW	sandstone	98	8	.032	534
HC3b	SW	2000	13.8	978	587	N-NW	sandstone	100	*	*	
HC4a	SW	2001	7.7	1,086	310	W-SW	sandstone	100	6.5	.022	616
HC4b	SW	2001	7.7	984	485	W-NW	sandstone	100	7	.002	349
HC5	SW	2000	9.6	971	488	W-NW	sandstone	100	*	*	*
HC6a	SW	2000	16.4	981	554	N	sandstone	91	*	*	*
HC6b	SW	2001	17.9	892	617	NE	sandstone	100	7.5	.008	55
LB1	SW	2001	10.8	1,053	380	W	shale	99	9	**	22
LB2	SW	2001	12.7	1,056	315	S-SW	shale	71	10.5	**	36
LB3	SW	2001	17.7	1,034	408	S-SE	sandstone	80	10	**	39
LB4	SW	2000	7.9	1,027	323	S-SE	sandstone	100	*	*	*
LB5	SW	2001	13.1	1,024	388	SE	sandstone	73	10	**	38
WF1a	SW	2000	14.5	1,096	343	S-SE	shale	67	*	*	*
WF1b	SW	2000	6.3	1,040	505	E-NE	shale	100	*	*	*
WF2a	SW	2001	10.7	899	513	N-NE	shale	51	9.5	.022	47
WF2b1	SW	2000	14.9	955	392	S-SE	sandstone	78	*	*	*
WF2b2	SW	2001	21.2	922	490	E	shale	92	7	.003	51
WF3a	SW	2001	7.9	1,011	365	N-NW	shale	99	5	.023	55
WF3b	SW	2000	10.9	1,001	444	NE	shale	100	*	*	*

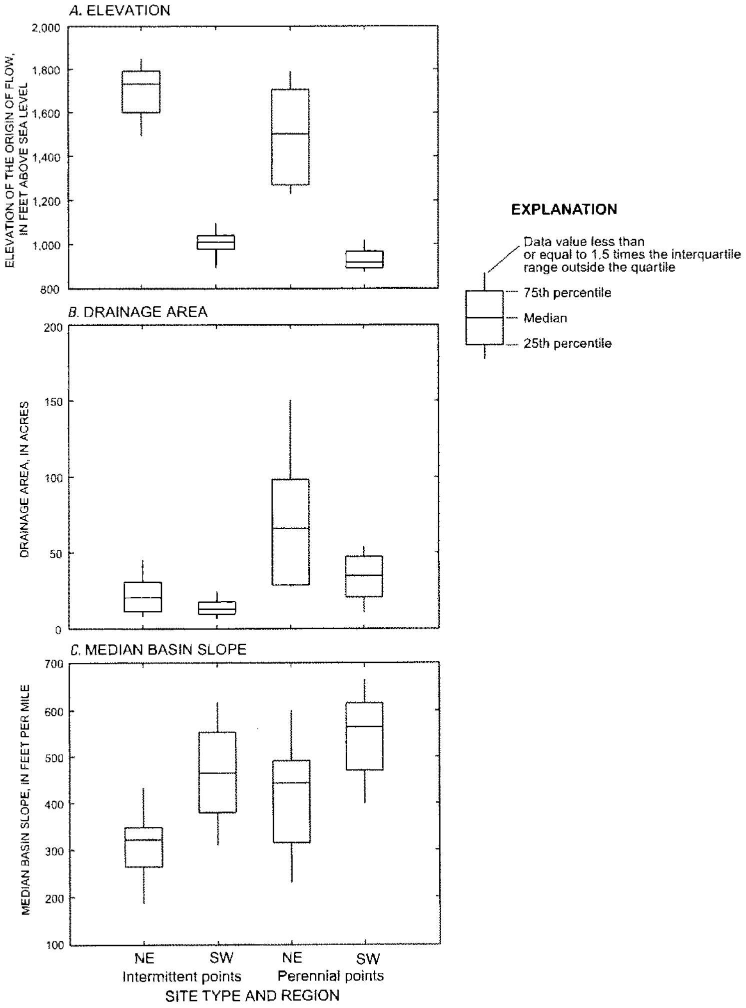


Figure 5. Distribution of (*A*) elevation, (*B*) drainage area, and (*C*) median basin slope for intermittent and perennial points in headwater streams of the mountaintop coal-mining region of southern West Virginia, 2000–01.

Intermittent-point drainage-area aspect, the general direction that water flows in a drainage area, varies from N to N-NW overall (table 3), and has a significant correlation with intermittent-point drainage area ($R = 0.23$, $p < 0.05$). Flow volume at intermittent points was small, with a median of 0.017 ft^3/s, and a range of 0.001 to 0.032 ft^3/s (table 3). Specific conductance ranged from 22 to 616 μS/cm, with a median of 51 μS/cm. Water temperature ranged from 5–11.5°C, with a median of 8.0°C.

Drainage Areas with Perennial Flow

The lowest elevation of the water table, and beginning of continuous perennial base flow (perennial point), was identified for 20 headwater streams in October of 2000 or October 2001 (table 2). For all October 2000 sites, the median drainage area was 41.4 acres, and for all October 2001 sites, the median drainage area was 28.5 acres. The 6-month period preceding the October 2000 visits to the perennial points was wetter than the period preceding the October 2001 visits (table 1).

If a site was visited in both years, the larger perennial-point drainage area between the two years was used in the statistical analysis (table 4); the stream above the lower perennial point is assumed to be intermittent. Also included are four sites that produced perennial flow in 2001, but not in 2000. The median drainage area upstream of this subset of perennial points was 40.8 acres. The minimum perennial-point drainage area was 10.4 acres, while the maximum drainage area was 150.1 acres. Drainage areas of perennial points had a greater range in size across the study area than did intermittent-point drainage areas; this result suggests that low base flow in the autumn may be more sensitive to local differences in climatic and drainage-basin conditions than high base flow in late winter and early spring. All of the following analyses are based on this subset of the data (table 4) because not all of the sites were visited two times.

Headwater streams had perennial base flow only where more than 80 percent of the bedrock exposed at the surface is sandstone, regardless of location within the study unit (table 4). Median elevation of perennial points (1,503 ft) was higher in the northeastern part of the study area (fig. 5*A*); the median drainage area was 66.1 acres and the median basin slope was 443 ft/mi (table 4, figs. 5*B*, 5*C*). Perennial points in the southwestern part of the study unit had a median elevation of 919 ft, a median drainage area of 34.8 acres, and a median basin slope of 563 ft/mi (table 4, fig. 5).

Drainage-area aspect for perennial points ranges from N to N-NW, with most basins facing SW, W-NW, and NW (table 4); drainage-area aspect was not significantly correlated to the drainage area of perennial points ($R = 0.36$, $p > 0.05$). Flow volume at perennial points varied little from site to site, with a range of 0.001 to 0.014 ft^3/s, and a median of 0.007 ft^3/s. Specific conductance varied from 32 to 721 μS/cm, with a median of 73 μS/cm. Water temperature ranged from 9.0 to 16.0°C, with a median of 12.8°C.

Of the 36 drainage areas evaluated during this study (table 2), six streams had no flow for only one visit and twelve streams were dry for both October visits. Half of these drainage areas contained at least 20 percent shale bedrock. Over half of the drainage areas were adjacent to at least one other drainage area with intermittent flow. Drainage-area aspect was evenly distributed in all directions. These observations suggest that local climatic and drainage basin conditions determine whether or not there will be perennial flow in a first-order headwater stream.

Temporal Variability in Intermittent and Perennial Drainage Areas

The point of flow origin for intermittent and perennial flow fluctuated over time, probably because of differences in environmental variables, including evapotranspiration, antecedent climatic conditions, and drainage basin conditions. This study quantified elevation, rock type, aspect, and basin slope for intermittent- and perennial-point drainage areas for two years at 23 and 11 sites, respectively.

The intermittent points were identified for 23 sites in both February 2000 and March–April 2001 (table 5). The intermittent-point drainage area varied by a median of 3.4 acres between these two periods overall. The regional pattern was evident in this analysis as well: northeastern intermittent-point drainage areas varied by a median of 7.0 acres, while southwestern drainage areas had a median variation of 1.9 acres. The drainage areas for intermittent points for February 2000 and March–April 2001 were significantly correlated by linear regression ($R = 0.87$, $p < 0.05$).

Table 4. Selected drainage-area and hydrologic characteristics of perennial points used in data analysis for headwater streams in the mountaintop coal-mining region of southern West Virginia, 2000–01

[**Sampling site:** See figure 1 for site locations and names. *, Data not collected in the October 2000 field season. ft, feet; ft/mi, feet per mile; ft^3/s, cubic feet per second; µS/cm; microsiemens per centimeter]

Sampling site	Region	Year	Drainage area, in acres	Perennial point elevation, in ft	Basin slope, in ft/mi	Drainage area aspect	Dominant rock type	Percentage dominant rock type	Temperature, in °C	Streamflow, in ft^3/s	Conductance, in µS/cm
FF3	NE	2001	122.3	1,244	539	NW	sandstone	100	14	<0.003	90
FF4	NE	2001	98.2	1,457	443	W-NW	sandstone	100	14	<.003	121
RNC	NE	2001	66.5	1,503	491	SW	sandstone	100	11	<.003	32
RNE	NE	2001	66.1	1,227	480	W	sandstone	100	12	<.002	44
RNF	NE	2000	41.9	1,618	315	N	sandstone	100	13	.011	43
RNG1	NE	2000	27.6	1,759	347	W-NW	sandstone	100	12.5	.014	*
RNG2	NE	2001	28.4	1,791	230	W-SW	sandstone	100	9	<.002	155
RNG3	NE	2001	28.6	1,706	301	N-NW	sandstone	100	11.5	<.002	47
RNH	NE	2001	150.1	1,270	600	NW	sandstone	100	11	<.003	90
HC1a	SW	2000	54.0	915	541	SW	sandstone	100	12.5	<.005	73
HC1b	SW	2000	40.7	945	596	NW	sandstone	100	12	<.010	61
HC2	SW	2000	47.3	919	664	SW	sandstone	82	13	.001	234
HC3a	SW	2001	24.1	978	554	SW	sandstone	98	16	<.003	360
HC3b	SW	2000	40.8	902	615	NW	sandstone	100	13	.003	195
HC4	SW	2001	23.0	879	589	W	sandstone	100	14	.002	600
HC4a	SW	2000	10.4	1,020	398	W	sandstone	100	13	.012	721
HC6a	SW	2001	20.7	873	563	N	sandstone	93	16	<.005	67
HC6b	SW	2001	18.0	892	620	NE	sandstone	100	14	<.003	73
LB3	SW	2000	52.0	958	470	S-SE	sandstone	88	11.8	<.003	62
LB5	SW	2001	34.8	968	453	SE	sandstone	89	12.5	<.003	38

Regional late winter to early spring precipitation patterns can create small, local differences in the drainage areas of intermittent points, but there was no clear direction to the differences, regardless of location in the study area. The period (October–March) preceding the 2000 field work was slightly wetter than the period preceding the 2001 field work (Ward and others, 2001, 2002) (table 1), but only 57 percent (13 of 23) of intermittent-point drainage areas were larger in 2001 than in 2000. Overall, October through March of both 2000 and 2001 were significantly drier than normal, which may have had a cumulative affect on the drainage areas of the intermittent points. There is a significant relation between drainage areas for intermittent points in March–April 2001 and perennial points in October 2000 ($R = 0.97$, $p < 0.05$).

The perennial points were identified for 11 sites in both October 2000 and October 2001. The drainage areas upstream of these perennial points varied by a median of 18.0 acres between 2000 and 2001 (table 5). The variation in drainage areas over time was much larger for perennial points (18.0 acres) than for intermittent points (3.4 acres), overall. Precipitation in the summer and early autumn in this region is delivered primarily by local convection thunderstorms, which can cause wide variability in water-table elevations across the region. Drainage areas of perennial points in October of 2001 were significantly correlated to drainage areas of perennial points in October 2000 ($R = 0.86$, $p < 0.05$).

There was a difference in the medians of the temporal variation in drainage areas for perennial points in the northern and southwestern regions. The median of the variation for the northeastern basins was 22.2 acres, and 11.7 acres for the southwestern basins. Perennial point drainage areas where the rock type is sandstone, which are distributed across the study area, varied by a median of 20.1 acres. Drainage areas with as much as

Table 5. Differences in drainage area between intermittent and perennial points in 2000 and 2001 for headwater streams in the mountaintop coal-mining region of southern West Virginia

[**Sampling site:** See figure 1 for site locations and names. **Dominant rock type:** The rock type listed represents greater than 50 percent of the surface geology. **Difference:** 2000 value minus 2001 value. *, Intermittent or perennial point not visited in both years.]

Sampling site	Region	Dominant rock type	Intermittent-point drainage areas, in acres			Perennial-point drainage area, in acres		
			2000	2001	Difference	2000	2001	Difference
FF1	NE	sandstone	19.4	8.1	11.3	*	*	*
FF3	NE	sandstone	10.8	19.0	-8.2	65.0	122.3	-57.3
FF4	NE	sandstone	45.3	52.5	-7.2	*	*	*
RNC	NE	sandstone	*	*	*	44.2	66.5	-22.2
RND	NE	sandstone	8.9	13.3	-4.4	*	*	*
RNE	NE	sandstone	30.6	43.2	-12.6	*	*	*
RNF	NE	sandstone	19.4	23.2	-3.8	*	*	*
RNG1	NE	sandstone	20.4	27.5	-7.0	27.6	27.5	0.2
RNG2	NE	sandstone	31.4	28.0	3.4	*	*	*
RNG3	NE	sandstone	22.2	22.2	.0	22.2	28.6	-6.4
RNH	NE	sandstone	*	*	*	125.9	150.1	-24.2
HC1a	SW	sandstone	12.0	15.0	-3.0	54.0	28.5	25.5
HC1b	SW	sandstone	24.4	31.8	-7.5	40.7	35.3	5.4
HC2	SW	sandstone	26.5	22.2	4.3	47.3	19.7	27.6
HC3a	SW	sandstone	*	*	*	23.4	24.1	-.7
HC3b	SW	sandstone	*	*	*	40.8	22.8	18.0
HC4a	SW	sandstone	8.4	7.7	.6	*	*	*
HC4b	SW	sandstone	9.2	7.7	1.5	*	*	*
HC6a	SW	sandstone	16.4	19.7	-3.3	*	*	*
HC6b	SW	sandstone	18.0	17.9	.1	*	*	*
LB4	SW	sandstone	7.9	10.1	-2.2	*	*	*
LB5	SW	sandstone	*	*	*	34.0	34.8	-.8
WF1a	SW	shale	14.5	24.7	-10.2	*	*	*
WF1b	SW	shale	6.3	10.1	-3.8	*	*	*
WF2a	SW	shale	10.7	10.7	.0	*	*	*
WF2b1	SW	sandstone	15.9	14.9	1.0	*	*	*
WF2b2	SW	shale	22.2	21.2	1.1	*	*	*
WF3b	SW	shale	10.9	12.1	-1.2	*	*	*

18 percent shale are in only the southwestern part of the study area, and had a median variation between years of only 0.8 acre.

Although the period (April–September) preceding October 2000 field work was wetter than the period preceding October 2001 field work, 36 percent (4 of 11) of perennial points had larger drainage areas in 2001, 36 percent (4 of 11) were larger in 2000, and 27 percent (3 of 11) varied less than one acre. Six perennial points not included in the statistical comparison of 11 sites did contain flow in 2001, but not in 2000 (table 2). As noted earlier, only drainage areas composed of mostly sandstone produced perennial flow.

The uncertainty in these results associated with GPS and mapping methods employed in this study is unknown, but the magnitude and significance of regression relations identified above suggest that the patterns identified here are robust for this small dataset. Variations in drainage-area size upstream of intermittent and perennial points over time probably are affected by antecedent climatic conditions and drainage basin conditions. However, the local conditions for small headwater basins are extremely variable, and relations of these conditions to intermittent and perennial points could not be defined with this limited study.

SUMMARY AND CONCLUSIONS

Characteristics of first-order perennial, intermittent, and ephemeral headwater streams in the mountaintop coal-mining region of southern West Virginia were measured and quantified in the late winter or early spring and autumn of 2000 and 2001. The origins of flow in headwater streams previously had not been examined in West Virginia, but are important to know because of the 1999 and 2002 U.S. District court rulings allowing the placement of valley-fill material only in ephemeral streams and not within 100 feet of intermittent and perennial streams.

The point of continuous base flow in a stream, after no recent precipitation, can be identified and mapped as the surface expression of the water table. The time of year of field work is an important factor in this approach. Many streams throughout West Virginia have their lowest base flows in late summer or early autumn, and their highest base flows in late winter or early spring. The point where base flow begins in the late winter or early spring corresponds to the highest water-table elevation, and is the point of intermittent-flow origin (intermittent point). The point where base flow begins in the late summer or early autumn corresponds to the lowest water-table elevation, and is the point of perennial-flow origin (perennial point).

The study area included 43 sites around the southern coal fields of West Virginia. Because previous coal mining affected 7 sites, only 36 sites were used in this study. For both intermittent and perennial streams in both years, flow at the point of origin was generally less than 0.01 ft^3/s. Specific conductance varied from 22–616 μS/cm for all sites and for all field seasons, and was not a good indicator of past mining history. Water temperature ranged from 5.0 to 11.5°C in the late winter or early spring, and from 9.0 to 16°C in the autumn.

The median drainage area upstream of 34 intermittent points was 14.5 acres, and ranged from 6.3 to 45.3 acres. The median size of permitted valley fills in southern West Virginia is 12.0 acres, which is comparable to the median area upstream of the intermittent point (14.5 acres). The maximum size of permitted fills (480 acres) is more than 10 times the observed maximum intermittent-point drainage area (45.3 acres). The intermittent points in the northeastern part of the study unit were underlain by sandstone bedrock, were higher in elevation, had higher antecedent precipitation totals, and had larger median drainage areas (20.4 acres) and less steep median basin slopes (322 ft/mi) than the southwestern intermittent points (12.9 acres; 465 ft/mi, respectively).

The median drainage area for 20 perennial points was 40.8 acres, and ranged from 10.4 to 150.1 acres. Perennial-point basins in the northeastern part of the study unit had a median elevation of 1,503 ft, a median drainage area of 66.1 acres and a median basin slope of 443 ft/mi. Perennial points in the southwestern part of the study unit had a median elevation of 919 ft, a median drainage area of 34.8 acres, and a median basin slope of 563 ft/mi. Only drainage areas underlain by sandstone bedrock produced perennial flow, regardless of geographic location.

Intermittent-point drainage areas varied over time by a median of 3.4 acres between two annual late-winter or early spring measurements for 23 sites. There was a regional pattern in this dataset: northeastern drainage areas for intermittent points varied by a median of 7.0 acres, while southwestern drainage areas for intermittent points varied by a median of 1.9 acres. The results indicate that local antecedent climatic conditions and drainage basin conditions control the location of the intermittent point.

Perennial-point drainage areas varied over time by a median of 18.0 acres between two annual autumn measurements for 11 sites. Perennial points in northeastern drainages varied over time by a median of 22.2 acres, whereas those in the southwestern drainages varied over time by a median of 11.7 acres. This could be partially explained by rock types, as shale was present only in the southwestern drainage areas; only drainage areas composed of mostly sandstone produced perennial flow. The October 2001 perennial-point drainage area was significantly correlated to the perennial-point drainage area of October 2000 ($R = 0.86$, $p < 0.05$). Twenty streams had no flow for one or two annual October visits. These drainage areas were adjacent to similarly sized drainage areas that did produce perennial flow. These factors suggest that perennial flow in a stream is controlled by very local climatic and drainage basin conditions at a first-order stream scale.

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Chapter 6

ACID MINE DRAINAGE CONTROL AND TREATMENT

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6.1 INTRODUCTION

6.1.1 Acid Mine Drainage Formation

Acid mine drainage (AMD) forms when sulfide minerals are exposed to oxidizing conditions in coal and metal mining, highway construction, and other large-scale excavations. There are many types of sulfide minerals. Iron sulfides common in coal regions are predominately pyrite and marcasite (FeS_2), but other metals may be complexed with sulfides forming chalcopyrite ($CuFeS_2$), covellite (CuS), galena (PbS), and sphalerite (ZnS). Pyrite commonly occurs with these other metal sulfides thereby causing AMD where Cu, Pb, and Zn are mined.

Upon exposure to water and oxygen, sulfide minerals oxidize to form acidic, sulfate-rich drainage. Metal composition and concentrations in AMD depend on the type and quantity of sulfide minerals present. The drainage quality emanating from underground mines or backfills of surface mines is dependent on the acid-producing (sulfide) and alkaline (carbonate) minerals contained in the disturbed rock. In general, sulfide-rich and carbonate-poor materials produce acidic drainage. In contrast, alkaline-rich materials, even with significant sulfide concentrations, often produce alkaline conditions in water.

Acidity in AMD is comprised of mineral acidity (Fe, Al, Mn, and other metals depending on the specific metal sulfide) and hydrogen ion acidity. Approximately 20,000 km of streams and rivers in the United States are degraded by AMD. About 90% of the AMD reaching streams originates in abandoned surface and deep mines. Since no company or individual claims responsibility for reclaiming abandoned mine lands (AML), no treatment of the AMD occurs and continual contamination of surface and groundwater resources results.

The oxidation of iron disulfides and subsequent conversion to acidity occur through several reactions (Stumm and Morgan, 1970). The chemical equations are given in Chapter 5. If any of the processes represented by the equations were slowed or altogether stopped, the generation of AMD would also slow or cease. Removal of air and/or water from the system, two of the three principal reactants, would stop pyrite from oxidizing. This occurs naturally where pyrite-bearing rock occurs in water-saturated zones. Only small amounts of pyrite are oxidized through weathering in undisturbed environments thereby generating only small amounts of acidity. This small amount of acid is naturally diluted or neutralized by surrounding rocks. However, when large volumes of pyritic material are exposed to oxidizing conditions, as in mining, the pyrite reacts on a large scale and water moves the reaction products (Fe, sulfate, and acidity) into underground and surface waters. Ferrous iron conversion to ferric iron is slow under abiotic (or strictly chemical) conditions. But iron-oxidizing bacteria, Thiobacillus ferrooxidans, greatly accelerate iron oxidation which, in turn, greatly speeds acid generation (Waksman, 1922). Biotic catalysis can increase acid generation up to a million times (Leathen et al., 1953).

Sulfur in coal and coal-bearing rock occurs as organic, sulfate, or pyritic forms (Chapter 4). Much of the sulfur in coal-bearing rock occurs as very small crystalline grains intimately mixed with the organic constituents of coal. Sulfur may also be disseminated in nearby layers of sandstone and shale (Temple and Koehler, 1954). The high sulfur content in coals and associated strata deposited in marine settings suggests that bacterial reduction of sulfate in seawater was the source of much of the pyrite found in coal.

Organic sulfur is complexed and inseparable from the coal, but is not chemically reactive and has little to no effect on acid-producing potential. Sulfate sulfur is found only in minor quantities in fresh coal and associated rocks. Sulfate is a reaction product of pyrite oxidation and therefore is not responsible for acid production. Pyritic or sulfide sulfur is the predominant species in coal and associated rocks and is the major acid-producer. Several types of pyritic sulfur are known based on physical appearance (Chapter 5).

The equations show that 1000 Mg of rock containing 1% sulfur, all as pyrite, would yield upon complete reaction 31.25 Mg of acidity. Therefore, 31.25 Mg of 100% $CaCO_3$ would be required to neutralize the acidity generated. When sulfur in the overburden or coal is exclusively pyrite, the total sulfur content of the rock accurately quantifies the acid-producing potential. When organic and/or sulfate sulfur are present in significant amounts, total sulfur measurements overestimate the amount of acid that could be formed upon oxidation. Therefore, removal of sulfates and organic sulfur may be necessary to increase the accuracy in predicting the acid-producing potential of partially weathered materials (Chapter 4).

The rate of pyrite oxidation depends on numerous variables such as reactive surface area of pyrite (Singer and Stumm, 1968), oxygen concentrations and solution pH (Smith and Shumate, 1970), the presence of Thiobacillus bacteria (USEPA, 1971), and catalytic agents (Caruccio et al., 1988). The possibility of identifying and quantifying the effects of these and other controlling factors with all the various rock types in a field setting is unlikely. Further, precise knowledge regarding oxidation rate is not needed for most real world situations when the acid-producing potential has been accurately evaluated from total sulfur (Smith and Sobek, 1978).

The alkaline content of overburden determines whether there is enough inherent neutralization potential (NP) to counteract the acid produced from pyrite oxidation. Of the many types of alkaline compounds present in rocks, only carbonates and clays occur in sufficient quantity to effectively neutalize AMD. A balance between the acid-producing potential and neutralizing capacity of an overburden sample will indicate the ultimate acidity or alkalinity that might be expected in the material upon complete weathering.

SMCRA requires coal operators and regulators to predict whether AMD may occur on a potential mine site before disturbance. Accurate prediction of AMD before surface mining requires a complete understanding of many components at a mine site. Three of the most important factors are: 1) overburden geochemistry, 2) method and precision of overburden handling and placement in the backfill during reclamation, and 3) the postmining hydrology of the site.

6.1.2 Overburden Analyses

Premining analyses of soils, overburden, and the coal pavement are required by law to ascertain the physical and chemical characteristics of the strata above and immediately below the coal bed (Chapter 4). Overburden characterization provides important information about overburden layers that are acid toxic, potentially acid-producing, neutral, or alkaline. Overburden analysis for surface mining begins with Acid-Base Accounting (ABA). This analytical technique provides a simple, relatively inexpensive, and consistent procedure to evaluate overburdens. It balances potential acidity (based on total or pyritic sulfur content) against total neutralizers (primarily carbonates) in an overburden sample. Samples containing more acid potential than alkaline material are shown to be deficient in neutralizing materials (□maximum needed□), while the reverse situation is shown as "excess" neutralizing materials.

Rock layers that are marginal (having about equal proportions of each type of material) can be subjected to leaching or weathering analyses (Skousen et al., 1987). Leaching/weathering procedures were devised to predict the chemical responses of a rock to weathering. The simulation tests are conducted over a predetermined time to estimate the rate of reaction of minerals in the rock. Leaching methods consist of placing a rock sample (ground to a specified particle size) into water-tight containers, flushing or flooding the containers with water, and collecting and analyzing the effluent for pH, acidity, alkalinity, iron, sulfate, etc. Leaching equipment may be varied and solvents may be recycled or heated during the leaching procedure. Several computer software programs are also available to model hydrogeochemical systems to predict AMD production. The models use overburden geochemical data, chemical and biological oxidation rates, anticipated water infiltration rates, and environmental conditions. These additional analyses sometimes supplement information given by ABA and can often help evaluate how a particular rock type may react in a backfill. Identification of the chemical production potential of overburden layers aids in developing overburden handling and placement plans.

6.1.3 Overburden Handling and Placement

The prevailing approach to control AMD in eastern USA is to keep water away from pyritic material. Once overburden materials have been identified and classified based on overburden analyses, the overburden handling and placement plan for the particular site must be carefully followed. Recommendations have focused on segregating and placing acid-producing materials above the water table on top of a 1- to 2-m layer of nontoxic material on the pavement, and then treating, compacting, and covering it with a clay cap or other type of sealant material to reduce surface water infiltration into this material (Skousen et al., 1987). In areas where limestone or other alkaline layers occur in the overburden, overburden materials may be blended to neutralize the acidic materials. Limestone should be added to the topsoil to neutralize any residual acidity and to raise the pH for vegetation establishment.

6.1.4 Postmining Hydrology

The hydrology of a backfill and its effect on AMD are very complex, but research on the movement of water into and through a mine backfill has provided some information on preventing and controlling AMD. Generally, the porosity and hydraulic conductivity of the materials in a backfill are greater than those of the consolidated rock overburden that existed before mining, and changes in flow patterns and rates should be expected after mining (Caruccio and Geidel, 1989). Often, the fine-grained topsoil placed over the backfill conducts water more slowly than the underlying coarse material, and thus the topsoil may determine the amount and rate of water movement into the backfill (Guebert and Gardner, 1992). As water moves into coarse materials in the backfill, it follows the path of least resistance. For example, water will flow through more permeable acid sandstones and around calcareous shales. The water continues downward until it encounters a barrier, the coal pavement, or other compacted or slowly permeable layer. Water does not move uniformly through the backfill by a consistent wetting front. The chemistry of the water emanating from the backfill will reflect only the rock types encountered in the water flow path, not the geochemistry of the total overburden (Ziemkiewicz and Skousen, 1992).

Diverting surface water above the site to decrease the amount of water entering the mined area is highly recommended. Alternatively, pyritic material can be placed where it will be rapidly and permanently inundated, thereby preventing oxidation of the acid-forming material. Inundation is only suggested where a water table may be re-established to cover acid-producing materials (such as below drainage deep mines), and has not been recommended for surface mined lands or above drainage deep mines in the mountainous Appalachian USA region. Upgradient of mined areas, water with low mineral acidity can be treated with limestone in the water course to improve water quality.

6.2 AT-SOURCE CONTROL OF ACID MINE DRAINAGE

Acid mine drainage control technologies are measures that can be undertaken where AMD formation has either already taken place or is anticipated to be a problem in the future. At-source control methods treat the acid-producing rock directly and stop or retard the production of acidity, whereas treatment methods add chemicals directly to acidified water exiting the rock mass. Coal companies mining in acid-producing areas of the eastern USA must often treat AMD, and they face the prospect of long-term to indefinite water treatment and its attendant liabilities. It is obvious that cost-effective methods which prevent the formation of AMD at its source would be preferable. Some control methods are most suitable for abandoned mines and others are only practical on active operations. Other methods can be used in either setting.

Some of the techniques described below are partially successful and have demonstrated less than 100% control of acidity produced on-site, and are considered failures by some people. While a technique that controls 80% of a site's acidity may not relieve a coal mine operator of liability, the method may be suitable for an abandoned mine reclamation program or a watershed restoration project. Removing a significant portion of the acid or metal load in a watershed by a partially-effective control strategy may improve the health of a stream to a point of re-introducing some fish species or re-establishing some designated uses of the stream. Alternatively, the method may be combined with another partial control scheme to achieve effluent limits. Since partial control methods are often the least costly, their use in combination with other techniques is often financially attractive. For example, a partial control method such as a dry barrier can be combined with alkaline amendment to reduce the amount of alkalinity required to offset acidity.

6.2.1 Alkaline Amendment to Active Mines

Recent studies have indicated that certain types of alkaline amendments can successfully control AMD from pyritic spoil and refuse (Brady et al., 1990; Perry and Brady, 1995; Rich and Hutchison, 1990; Rose et al., 1995). Nearly all alkaline amendment schemes rely on ABA to identify the required alkalinity for neutralization of pyritic materials. Alkaline amendment methods are a modification of the concept of selective handling. Selective handling seeks to blend acid-producing and acid-neutralizing rock units in the mining process to develop a neutral rock mass. Selective handling may also create a postmining hydrologic regime that minimizes the contact between acid-forming rock and groundwater, or it may isolate acid-producing rocks from the rest of the backfill by use of barriers. In the eastern USA coal fields, the pit floor is often rich in pyrite, so isolating it from groundwater may be necessary. Isolation methods can include building highwall drains which move incoming groundwater away from the pit floor or placing impermeable barriers on the pit floor. For example, acid-forming material can be compacted or capped within the spoil (Meek, 1994). If insufficient alkalinity is available in the spoil, then external sources of alkalinity may be imported (Skousen and Larew, 1994; Wiram and Naumann, 1995).

Limestone is often the least expensive and most readily available source of alkalinity. It has a NP of between 75 and 100%, and is safe and easy to handle. On the other hand, it has no cementing properties and cannot be used as a barrier.

Fluidized Bed Combustion (FBC) ash is produced at power generating plants that burn high sulfur coal or refuse in a FBC system. Sulfur dioxide emissions are controlled by injecting limestone into the combustion bed. At combustion temperatures, the limestone calcines leaving calcium oxide. About one-half of the CaO reacts with sulfur dioxide to form gypsum and the rest remains unreacted. Therefore, FBC ashes generally have NPs of between 20 and 40%, and they tend to harden into a cement after wetting (Skousen et al., 1997). Other power-generation ashes, like flue gas desulfurization products and scrubber sludges, may also have significant NP, which make them suitable alkaline amendment materials (Stehouwer et al., 1995).

Kiln dust, produced by lime and cement kilns, contains similar levels of CaO (15 to 30%) as FBC ash, but also contains 50 to 70% unreacted limestone. Kiln dust absorbs moisture and also hardens upon wetting (Rich and Hutchison, 1994). It is widely used as a stabilization and barrier material.

Steel-making slags are locally available in large quantities at low cost. When fresh, steel slags have NPs from 45 to 90%. Studies indicate that columns of steel slag maintain constant hydraulic conductivity over time and produce highly (>1,000 mg/L) alkaline leachate. Steel slag can be used as an alkaline amendment as well as a medium for alkaline recharge trenches. Slags are produced by a number of processes, so care is needed to ensure that candidate slags are not prone to leaching metal ions like Cr, Mn, and Ni.

Other alkaline materials may have higher NPs than limestone, but the source of the material should be checked and a complete analysis should be done to evaluate NP and metal content before use. Quicklime, kiln dust and hydrated lime all have higher activities than limestone, though it is not clear that the kinetics of pyrite oxidation favor readily soluble sources of alkalinity.

Phosphate rock has been used in some studies to control AMD. It may react with Fe released during pyrite oxidation to form insoluble coatings (Evangelou, 1995), but phosphate usually costs much more than other calcium-based amendments and is needed in about the same amounts (Ziemkiewicz and Meek, 1994).

Accurately predicting the amount of a particular alkaline amendment to add in a certain situation has significant cost and long-term liability implications. diPretoro and Rauch (1988) found sites with >3% NP as calcium carbonate equivalent in overburden produced alkaline drainages, while acidic drainage resulted at $\leq$1% NP. Brady and Hornberger (1989) suggest threshold values of NP $\geq$ 3% and S < 0.5% as guidelines for delineating alkaline-producing strata. Brady et al. (1994) showed that 3% net NP in an overburden caused alkaline drainage while less than 1% net NP produced acidic drainage from 38 mines in PA. They concluded that mining practices (such as selective handling, and concurrent reclamation) enhanced the effect of alkaline addition on reducing acidity. Further refinements (Perry and Brady, 1995) gave a value of 21 Mg/1000 Mg net NP (or 2.1%) to produce alkaline drainage on 40 sites in Pennsylvania. Alkaline addition of lime kiln dust at rates to neutralize the MPA was successful in producing alkaline drainage from a Pennsylvania site after mining (Rose et al., 1995).

Brady and Hornberger (1990) conclude that NP from ABA shows the strongest relationship with actual postmining water quality. This relationship is only qualitative (e.g. acid vs. non-acid), and NP must significantly exceed MPA in order to produce alkaline water. If NP and MPA are similar, AMD will most likely result.

Accurate, representative overburden analyses before mining are crucial in developing mining plans and alkaline addition programs in acid-producing areas. Therefore, it is best to generate cost-effective control strategies when acid problems are identified during premining planning (Chapter 4). Errors in predicting postmining water quality from premining overburden analyses include unrepresentative sampling of overburdens and inaccurate analyses (Rymer et al., 1991; Wiram and Naumann, 1995), and non-homogeneous placement of spoils. For example, Schueck (1990) reported AMD generation from a surface mine in Pennsylvania resulted largely from buried refuse and pit cleanings within an otherwise neutral to alkaline spoil matrix as identified by ABA.

Some spoils are composed of a mixture of acid-forming and alkaline rocks, while other materials like refuse are dominated by acid-producing rocks with no NP. In spite of significant alkalinity in overburdens, AMD originates from localized sites within the backfill. While finding the path of least resistance to the downstream side of the backfill, infiltrating water is influenced only by acid and alkaline rocks directly in its path. If water flows primarily through permeable acid sandstones, AMD can result, and the water flows freely to the nearest stream while the alkalinity in the pile remains unreacted. Unless contacted directly by acid water, most of the spoil limestone will remain in solid form. Thus, the presence of alkalinity in the backfill does not ensure that it will neutralize acidity. For efficient neutralization, the acid-forming and alkaline material must be thoroughly mixed. Where insufficient alkalinity is present, it is necessary to add alkaline material to the rock mass. If one relies on random spoil dumping, an overwhelming supply of alkaline material would be needed. This probably accounts for the reported field observations that two or more units of NP is required for each unit of MPA. If there is a consensus on the subject, it would appear that material mixtures with an NP/MPA ratio above 2 and an net NP above 30 Mg/1000 Mg (3% net NP) generate alkaline water. Even at high NP/MPA ratios, acidity may be produced if the acid-producing materials are incorrectly placed so that they intercept groundwater, or the alkaline material is added only to the surface (Lusari and Erickson, 1985). Thorough mixing during materials handling can reduce the required NP/MPA ratio considerably.

Addition of alkaline material to refuse is a relatively simple process. Since the refuse leaves the preparation plant on a belt conveyor or in a slurry line, the alkalinity can be metered directly into the refuse stream. Rich and Hutchison (1990 and 1994) reported a successful operation where 2% lime kiln dust is added to refuse at a preparation plant in West Virginia. Not only did the kiln dust prevent acid formation, it improved the strength of the refuse pile by absorbing moisture from the filter cake, allowing easy access for large haulage trucks. Currently at least eight preparation plants in the eastern USA are using this technique.

Adding alkalinity to spoil requires more care during mining and reclamation. The high volume of spoil necessitates applying alkalinity only to those rock masses that need it (like coal roof rock, partings and pavement). Surface mining operations can remove this rock with front end loaders after the prime excavator exposes the coal and place the acid-producing material in cells in the backfill for treatment with an alkaline amendment (Skousen and Larew, 1994). Since acid-producing rock types are often a small proportion of the total spoil, such a procedure results in efficient use of the alkaline material. Additional compaction is desirable during placement in cells. Often the final pit floor contains considerable pyrite, much of it within 30 cm of the coal. Two approaches can be taken: 1) remove the pyritic material and place it in cells for alkaline amendment, or 2) seal the pit floor with a self-cementing material such as FBC ash.

6.2.2 Alkaline Recharge Trenches

Alkaline recharge trenches (Caruccio et al., 1984) are surface ditches filled with alkaline materials. These trenches can minimize or eliminate acid seeps through an alkaline-loading process by placing alkaline material into contact with surface infiltrating water. Alkaline recharge trenches were constructed on top of an 8-ha coal refuse disposal site, which produced AMD seepage (Nawrot et al., 1994). After installing the alkaline recharge pools, acidity reductions of 25 to 90% were realized with concomitant 70 to 95% reductions in Fe and sulfate in seepage water. The following conclusions and recommendations were made:

--Use highly soluble alkaline materials (e.g. CaO, $Ca(OH)_2$ waste products),
--Maximize water volumes through the trench by directing surface flow into the pool,
--Use multiple alkaline recharge pools to increase chances of influencing groundwater flows,
--Construct infiltration paths into the backfill to improve alkaline diffusion and flushing,
--Allow sufficient time (possibly 3-5 annual cycles) for the effect to become apparent.

6.2.3 Bactericides

Anionic surfactants are used to control bacteria that catalyze the conversion of Fe^{+2} to Fe^{+3}, which can thereby control pyrite oxidation. They are used in situations where immediate control of AMD formation is important and work best on fresh, unoxidized sulfides. Bactericides are often liquid amendments, which can be applied to refuse conveyor belts or sprayed by trucks on cells of acid-producing materials in the backfill. Bactericides have also been used at metal mines (Parisi et al., 1994). One example of surfactant application was done in 1988 on a 4.5-ha refuse site in Pennsylvania. Surfactant was applied via a hydroseeder at rates of 225 kg/ha initially, then successive amounts were made as fresh refuse was deposited. Effluent from the pile showed a 79% reduction in acidity and a 82% decrease in Fe. Cost savings at the AMD treatment plant were $300,000 per year (Rastogi, 1994). Surfactants, by themselves, are not seen as a permanent solution to AMD. Eventually the compounds either leach out of the rock mass or are decomposed. However, slow-release formulations are commercially available and have been successfully used at regraded sites (Splittorf and Rastogi, 1995). Bactericides appear to work best when used in combination with other control methods, and can be useful in preventing acid conditions in pyritic rock piles which remain open for several years until the site is reclaimed.

6.2.4 Dry Barriers

Barriers are constructed from materials that retard the movement of water and oxygen into areas containing acid-producing rock. Barriers can achieve substantial reductions in water flow through piles, but generally do not control AMD completely. Grouts can be used to separate acid-producing rock and groundwater. Injection of grout barriers may significantly reduce the volume of groundwater moving through spoil. Gabr et al. (1994) characterized the groundwater flow of an acid-producing reclaimed site where a 1.5-m thick wall was installed by pumping a mixture of class F fly ash and portland cement grout into vertical boreholes near the highwall. After two years, the grout wall reduced groundwater inflow from the highwall to the spoil by 80%, resulting in one of two seeps completely drying up and substantially reducing the flow of the other seep.

Plastic liners are rarely used in mining because covering the large volumes of waste with a liner is usually too expensive. However, this method may be appropriate in settings where isolation of small pods of acid-producing material is possible. At the Upshur Mining Complex in West Virginia, Meek (1994) reported covering a 20-ha spoil pile with a 39-mil PVC liner. This treatment reduced acid loads by 70%. At the Heath Steele Metal Mine in New Brunswick, a soil cover was designed to exclude oxygen and water from the pile, and its performance was evaluated for five years (Bell et al., 1994). The capillary barrier consisted of a 10-cm gravel layer for erosion control, 30-cm gravel/sand layer as a evaporation barrier, 60-cm compacted till (conductivity of 10^{-6} cm/sec), 30-cm sand, and pyritic waste rock. The barrier excluded 98% of precipitation, and oxygen concentrations in the waste rock dropped from 20% initially to around 1%. In a similar study at the Waite Amulet Mine in Quebec, a barrier consisting of a 60-cm thick layer of compacted clay between two 30-cm layers of sand was placed over pyritic tailings (Yanful et al., 1994). After three years, the barrier reduced oxygen flux by 99% resulting in a 95% reduction in the rate of acid generation. The barrier excluded 96% of precipitation. Evaluations of capillary barriers by these and other studies (Nicholson et al., 1989; Rasmuson and Eriksson, 1986) indicate that this type of dry barrier can be an effective AMD control agent.

6.2.5 Wet Covers

Disposal of sulfide tailings under a water cover, such as a lake or fjord, is another way to prevent acid generation by excluding oxygen to sulfides. Wet covers also include flooding of above ground tailings ponds. Deposition of sulfide tailings under water has been used at various mines in Canada. Fraser and Robertson (1994) studied four freshwater lakes used for subaqueous tailings disposal and found the following:

--Reactivity of tailings was low since low dissolved metals were found in the pore water,
--Low metal dissolution from sediments indicated little impact of metals within the lakes,
--Biological communities existed in some of the lakes,
--Metal levels in fish were variable and depended on the history of the lake. Metal levels in fish appeared to be elevated in some parts of the lake while others were typical of background levels.

--Sulfide-rich Zn, Cu and Pb tailings were placed by slurry line into shallow (<8 m) Anderson Lake in north-central Manitoba since 1979. Pedersen et al. (1994) studied the site and concluded:

--Mine tailings were widely distributed on the lake floor,
--Sediments deposited in the lake had much organic matter,
--Anaerobic conditions developed at shallow depths,
--No Cd, Pb or Cu were being released from the submerged tailings,
--Very low amounts of Zn were dissolved into lake water from the tailings.

At Elliot Lake, Ontario Rio Algom Limited established a 65-ha flooded field demonstration site in which water depths of 0.5 to 1.0 m were developed in a series of terraces and dikes (Dave and Vivyurka, 1994). The first cell was completed and ready for flooding in October 1992. Over 50% of the sulfidic uranium tailing□s surface was treated with limestone and the top 15 cm was mixed. While flooding this cell, lime slurry was added to the inflow water for additional neutralization. At the end of flooding in December 1992, the surface water pH was 7 with acidity averaging 7 mg/L. This general water quality has been maintained for two years. For comparison, inflow from a nearby uncontaminated lake had an average pH of 6.4 and acidity of 5 mg/L and alkalinity of 4 mg/L. The tailings pond was in a valley so only the engineered dam at the downstream was exposed to air.

6.2.6 Alkaline Amendment to Abandoned Mines

Abandoned mines in the eastern USA generate more than 90% of the AMD in streams and rivers, most of which comes from underground mines. Abandoned underground mines are problematic because they are often partially caved and flooded, access is restricted, and reliable mine maps are often unavailable. Abandoned surface mines comprise huge volumes of spoil of unknown composition and hydrology. Rehandling and mixing alkalinity into the backfill is generally prohibitively expensive. These problems on abandoned mines were considered so intractable that they have only recently been addressed.

Filling underground mine voids with non-permeable materials is one of the best methods to prevent AMD from abandoned underground mines. Since underground mine voids are extensive (a 60-ha mine with a coal bed height of 1.5 m and a recovery rate of 65% would contain about 600,000 m^3 of voids), the fill material and the placement method must have very low unit costs. Mixtures of class F fly ash and 3-5% portland cement are used to control subsidence in residential areas. The slurries are injected through vertical boreholes at between 8 and 16 m centers. Research and demonstration projects are exploring both pneumatic (the use of air pressure) and slurry injection methods for placing FBC ash in abandoned underground mines

(Burnett et al., 1995). Preliminary results indicate that pneumatic methods can extend the borehole spacing to about 30 m at costs substantially less than those of slurry methods. On reclaimed surface mines still producing AMD, researchers in Pennsylvania saw small improvements in water quality after injecting coal combustion residues into buried pods of pyritic materials (Kim and Ackman, 1994; Schueck et al., 1994).

6.2.7 Remining and Reclamation

Remining is returning to abandoned surface or underground mines for further coal removal. Where AMD occurs, remining reduces acid loads by: 1) decreasing infiltration rates, 2) covering acid-producing materials, and 3) removing the remaining coal which is the source of most of the pyrite. Hawkins (1994) studied 57 discharges from 24 remined sites in Pennsylvania, and found contaminant loadings (e.g. flows and metal concentrations) were either reduced or unchanged after remining and reclamation. Short-term loads were sometimes increased during the first six months after remining and reclamation. Reduction in loads resulted from decreased flow rather than large changes in concentrations. An evaluation of ten remining sites in Pennsylvania and West Virginia showed eight of the sites to produce a net profit from coal sales. All the sites were reclaimed to current standards, thereby eliminating highwalls, covering refuse, and revegetating the entire areas. All sites also had improved water quality and some completely eliminated AMD coming from the site (Skousen et al., 1997). Faulkner and Skousen (1995) found significant reductions in acid loads after land reclamation, and the acid load reductions were due both to reductions in water flow from the site and reductions in acid concentration in the water.

Remining has been combined successfully with alkaline addition and special handling to change water quality from acid to alkaline at specific sites. Skousen and Larew (1994) described the surface remining of an underground mine in Preston County, West Virginia. Alkaline overburden from an adjacent mine was imported at a rate of 15,000 Mg/ha to the remining job at a cost of $0.55/Mg of coal removed. An average of about 18,000 Mg/ha coal was removed, making the cost of hauling the alkaline material to the site around $9,900/ha. Water quality from the deep mine prior to remining averaged pH 3.7 and 75 mg/L acidity, while after remining and reclamation, pH was above 7.0 with no acidity. Based on average premining water flows and analyses of the deep mine discharge on the site, the chemical cost for treating AMD on this site would have been around $200,000 over a 20-year period. The alkaline addition had a one-time cost of $45,000.

6.3 CHEMICAL TREATMENT OF ACID MINE DRAINAGE

Since the passage of SMCRA in 1977, coal mine operators have been required to meet environmental land reclamation performance standards established by federal and state regulatory programs. Operators must also meet water quality standards established in the Clean Water Act of 1972 (CWA), which regulates discharges into waters of the USA. In addition to a surface mining permit required by SMCRA, each mining operation must be issued a National Pollution Discharge Elimination System (NPDES) permit under CWA. Allowable pollutant discharge levels are usually determined by the USEPA□s technology-based standards, or the discharge levels may be based on the more stringent water quality-based standards. Water quality standards may apply where discharges are being released into streams with designated uses.

If AMD problems develop during mining or after reclamation, a plan to treat the discharge must be developed. Treatment of AMD includes neutralization of acidity and precipitation of metal ions to meet the relevant effluent limits. In most cases, a variety of alternative treatment methods can be employed to meet the limits specified.

NPDES permits on surface mines usually require monitoring of pH, total suspended solids (TSS), and Fe and Mn concentrations. Other parameters may be requested by the regulatory authority in a particular mining situation. In order for an operator to make a selection of an AMD treatment system, one must determine (in addition to the above parameters) the flow rate, sulfate concentration, and Fe^{+2} concentration in the AMD. The receiving stream's designated use and seasonal fluctuations in flow rate are also important. After evaluating these variables over a period of time, the operator can consider the economics of different chemicals and alternative AMD treatment systems. Most AMD chemical treatment systems consist of an inflow pipe or ditch, a storage tank or bin holding the treatment chemical, a means of controlling its application rate, a settling pond to capture precipitated metal oxyhydroxides, and a discharge point. The latter is the point at which NPDES compliance is monitored.

6.3.1 Chemicals Available to Treat AMD

Six chemicals are used to treat AMD (Table 6.1). Each chemical has characteristics that make it more or less appropriate for a specific condition. The best choice among alternatives depends on both technical and economic factors. The technical factors include acidity levels, flow, and the types and concentrations of metals in the water. The economic factors include prices of reagents, labor, machinery and equipment, the number of years that treatment will be needed, and the interest rate.

Enough alkalinity must be added to raise water pH so insoluble metal hydroxides will form and settle out of the water. The pH required to precipitate most metals from water ranges from pH 6 to 9 (except Fe^{+3}, which precipitates at pH $\geq$3.5). The types and amounts of metals in the water therefore heavily influence the selection of an AMD treatment system. Ferrous iron converts to a solid bluish-green $Fe(OH)_2$ at pH $\geq$8.5. In the presence of oxygen, Fe^{+2} oxidizes to Fe^{+3}, and $Fe(OH)_3$ forms a yellowish-orange solid (commonly called yellow boy) which precipitates at pH $\geq$3.5. In oxygen-poor AMD where Fe is primarily in the Fe^{+2} form, enough alkalinity must be added to raise the solution pH to 8.5 before $Fe(OH)_2$ precipitates. A more efficient way of treating high Fe^{+2} AMD is to first aerate the water (also outgassing CO_2), causing the Fe to convert from Fe^{+2} to Fe^{+3}, and then adding a neutralizing chemical to raise the pH to 6 or 7 to form $Fe(OH)_3$. Aeration after chemical addition is also beneficial because it greatly reduces the amount of neutralizing reagent necessary to precipitate Fe from AMD. Aluminum hydroxide precipitates at pH $\geq$ 5.0 but also enters solution again at a pH of 9.0. Manganese precipitation is variable due to its many oxidation states, but will generally precipitate at a pH of 9.0 to 9.5. As this discussion demonstrates, the appropriate treatment chemical can depend on both the oxidation state and concentrations of metals in the AMD (USEPA, 1983). Interactions among metals also influence the rate and degree to which metals precipitate. For example, Fe precipitation will largely remove Mn from the water at pH 8 due to co-precipitation, but only if the Fe concentration in the water is much greater than the Mn content (about 4 times more or greater). If the Fe:Mn ratio is less than 4, Mn is not removed by co-precipitation and a solution pH of ≥ 9 is necessary to remove it from solution.

6.3.1.1 Limestone

Limestone has been used for decades to raise pH and precipitate metals in AMD. It has the lowest material cost and is the safest and easiest to handle of the AMD chemicals. Unfortunately, its successful application has been limited due to its low solubility and tendency to develop an external coating, or armor, of $Fe(OH)_3$ when added to AMD. In cases where pH is low and mineral acidity is also relatively low (low metal concentrations), finely-ground limestone may be dumped in streams directly or the limestone may be ground by water-powered rotating drums and metered into the stream. These applications have recently been tried in West Virginia in AMD-impacted streams with great success. Limestone has also been used to treat AMD in anaerobic (anoxic limestone drains) and aerobic environments (open limestone channels). These latter two techniques are discussed later in this chapter under passive treatment systems.

Table 6.1. Chemical compounds used in AMD treatment.

Common Name	Chemical Name	Formula	Conversion Factor[1]	Neutralization Efficiency[2]	2000 Cost[3] $ per Mg or L	
					Bulk	<Bulk
Limestone	Calcium carbonate	$CaCO_3$	1.00	30%	$ 11	$ 16
Hydrated Lime	Calcium hydroxide	$Ca(OH)_2$	0.74	90%	$ 66	$110
Pebble Quicklime	Calcium oxide	CaO	0.56	90%	$ 88	$264
Soda Ash	Sodium carbonate	Na_2CO_3	1.06	60%	$220	$350
Caustic Soda (solid)	Sodium hydroxide	NaOH	0.80	100%	$750	$970
20% Liquid Caustic	Sodium hydroxide	NaOH	784	100%	$0.06	$0.16
50% Liquid Caustic	Sodium hydroxide	NaOH	256	100%	$0.29	$0.33
Ammonia	Anhydrous ammonia	NH_3	0.34	100%	$330	$750

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[1] The conversion factor may be multiplied by the estimated Mg acid/yr to get Mg of chemical needed for neutralization per year. For liquid caustic, the conversion factor gives L needed for neutralization.

[2] Neutralization Efficiency estimates the relative effectiveness of the chemical in neutralizing AMD acidity. For example, if 100 Mg of acid/yr was the amount of acid to be neutralized, then it can be estimated that 82 Mg of hydrated lime would be needed to neutralize the acidity in the water (100(0.74)/0.90).

[3] Price of chemical depends on the quantity being delivered. Bulk means delivery of chemical in a large truck, whereas <Bulk means purchased in small quantities. Liquid caustic prices are for L. Others in Mg.

6.3.1.2 Hydrated Lime

Hydrated lime is a commonly-used chemical for treating AMD. It is sold as a powder that tends to be hydrophobic, and extensive mechanical mixing is required to disperse it in water. Hydrated lime is particularly useful and cost effective in large flow, high acidity situations where a lime treatment plant with a mixer/aerator is constructed to help dispense and mix the chemical with the water (Skousen and Ziemkiewicz, 1996). Hydrated lime has limited effectiveness if a very high pH is required to remove ions such as Mn. Operators of lime treatment systems often increase lime application as Mn levels increase in the water. However, due to the kinetics of lime dissolution, increasing the lime rate increases the volume of unreacted lime that enters the metal floc settling pond.

Hydrated lime can be purchased in 20-kg bags or in bulk. Bulk lime is preferred by operators due to cost and handling advantages. It can be delivered by barge, truck, or train to many sites and handled pneumatically. Proper storage of $Ca(OH)_2$ is important in order to maintain its flow characteristics and thus ensure efficient use. The appropriate silo volume depends on the daily lime requirement, but should contain enough to cover periodic unexpected delays in delivery. The length of time that the system will be in operation is important because the large initial capital expenditure can be amortized over time.

6.3.1.3 Pebble Quicklime

Pebble quicklime (CaO) has been recently used in conjunction with the Aquafix Water Treatment System utilizing a water wheel concept (Jenkins and Skousen, 1993). The amount of chemical applied is dictated by the movement of the water wheel, which causes a screw feeder to dispense the chemical. The hopper and feeder can be installed in less than an hour. This system was initially used for small and/or periodic flows of high acidity because CaO is very reactive. Recently, however, water wheels have been attached to large bins or silos for high flow/high acidity situations. Preliminary tests show an average of 75% cost savings over NaOH systems and about 20 to 40% savings over NH_3 systems.

6.3.1.4 Soda Ash

Soda ash (Na_2CO_3) is generally used to treat AMD in remote areas with low flow and low amounts of acidity and metals. Selection of Na_2CO_3 for treating AMD is usually based on convenience rather than chemical cost. Soda ash comes as solid briquettes, and is gravity fed into water by the use of bins or barrels. The number of briquettes to be used each day is determined by the rate of flow and quality of the water to be treated. One problem with the bin system is that the briquettes absorb moisture, causing them to expand and stick to the corners of the bin. This hinders the briquettes from dropping into the AMD stream. For short-term treatment at isolated sites, some operators use a much simpler system employing a wooden box or barrel with holes that allows water inflow and outflow. The operator simply fills the barrel with briquettes on a regular basis and places the barrel in the flowing water. This system offers less control of the amount of chemical used.

6.3.1.5 Caustic Soda

Caustic soda (NaOH) is often used in remote locations (e.g., where electricity is unavailable), and in low flow, high acidity situations. It is commonly the chemical of choice if Mn concentrations in the AMD are high. The system can be gravity fed by dripping liquid NaOH directly into the AMD. Caustic is very soluble in water, disperses rapidly, and raises the pH of the water quickly. Caustic should be applied at the surface of ponded water because the chemical is more dense than water. The major drawbacks of using liquid NaOH for AMD treatment are high cost and dangers in handling.

Liquid NaOH can freeze during winter months, but there are several options available to deal with the freezing problem. These include burying the NaOH tank, installing a tank heater, switching from a 50 percent to a 20 percent solution, adding a small amount of antifreeze to the solution, and utilizing solid NaOH. Switching from a 50 percent to a 20 percent NaOH solution lowers the freezing point from 0° C to about -37° C. Antifreeze can be added at 1 L per 25 L of 50% NaOH to lower the freezing point from zero to -40° C. Solid NaOH, which may be delivered in a 30-kg drum or in bags, is reported by some operators to be cheaper and easier to handle than liquid NaOH.

Tanks housing NaOH can range in volume from 2,000 to 30,000 L. Large tanks are usually placed on a cement platform. The discharge line is fixed at the bottom of the tank and transports the NaOH solution to the seep, ditch, or pond. The rate of flow is controlled by a gate valve placed at the end of the discharge line.

6.3.1.6 Ammonia

Ammonia or sometimes called anhydrous (NH_3 or NH_4OH) is an extremely hazardous chemical that must be handled carefully (Hilton, 1990). A gas at ambient temperatures, NH_3 is compressed and stored as a liquid but returns to the gaseous state when released. Ammonia is extremely soluble in water and reacts rapidly. It behaves as a strong base and can easily raise the pH of receiving water to 9.2. At pH 9.2, it buffers the solution to further pH increases, and therefore very high amounts of NH_3 must be added to elevate the pH beyond 9.2. Injection of NH_3 into AMD is one of the quickest ways to raise water pH. It should be injected near the bottom of the pond or water inlet because NH_3 is lighter than water. The most promising aspect of using NH_3 for AMD treatment is its cost, especially compared to NaOH. A cost reduction figure of 50% to 70% is usually realized when NH_3 is substituted for NaOH (Skousen et al., 1990).

Major disadvantages of using NH_3 include: 1) hazards associated with handling the chemical, 2) uncertainty concerning nitrification, denitrification and acidification downstream, and 3) the consequences of excessive application rates (Faulkner, 1990). Specialized training and experience are important for the safe use of NH_3. Companies using NH_3 are required to conduct additional analyses such as temperature, total NH_3-N, and total acidity for discharge water and receiving streams. While NH_3 can be effective for Mn removal in many cases, this requires careful monitoring and attention, and overapplication of NH_3 often occurs. Therefore, in situations where Mn is the ion of primary concern (low Fe, high Mn water), a different chemical may be more appropriate (Faulkner, 1990).

6.3.2 Costs of Treating AMD

Costs have been developed for five AMD treatment chemicals under four sets of flow and acid concentration conditions (Table 6.2). These conditions are: 1) 189 L/min (50 gpm) and 100 mg/L; 2) 3780 L/min (1000 gpm) and 100 mg/L; 3) 945 L/min (250 gpm) and 500 mg/L; 4) 3780 L/min (1000 gpm) and 2500 mg/L. These conditions represent a sufficiently wide range for valid comparison of the treatment systems.

The costs for each technology were divided into installation costs and variable costs. Installation costs include piping, system foundation, site preparation, equipment, hardware, and labor. Labor costs were based on man hours at a wage scale of $27 an hour. Variable costs include reagent cost, annual labor, and maintenance. The amount of reagent was computed using acid neutralization formulas presented in Skousen and Ziemkiewicz (1996). Annual labor was estimated man-hours to run the system for one year multiplied by $27 an hour. Other variable costs include repair costs and electricity (Phipps et al., 1991).

The prices for the reagents, equipment, and labor were based on actual costs to operators in West Virginia in May 1996. The price for each chemical is given in Table 6.1, and varies due to whether the material was delivered in bulk or purchased in bags. The net present value (NPV) is the value of the total treatment system, plus annual operating and chemical expenses over the specified duration of treatment in 1996 USA dollars. A rate of 6% per year was used to devalue the dollar during future years of the treatment period. The annual cost was obtained by converting the total system cost (NPV) to an equivalent annual cost so that each system could be compared. The parameters used in the analysis were entered in a spreadsheet.

Use of Na_2CO_3 has the highest labor requirements (10 hours per week) because the dispensers must be filled by hand and inspected frequently (Table 6.2). Caustic has the highest reagent cost per mole of acid-neutralizing capacity and Na_2CO_3 has the second highest. Hydrated lime treatment systems have the highest installation costs of the five technologies because of the need to construct a lime treatment plant and install a pond aerator. However, the cost of $Ca(OH)_2$ is very low. The combination of high installation costs and low reagent cost make $Ca(OH)_2$ systems particularly appropriate for long-term treatment of high flow/high acid condition situations.

For a five-year treatment period, NH_3 had the lowest annual cost for the low flow/low acid situation (Table 6.2). Pebble quicklime was only about $160 per year more expensive than the NH_3 system but had lower reagent and higher installation costs. Caustic was third because of its high labor and reagent costs, and Na_2CO_3 was fourth due to high labor costs. Hydrated lime was the most expensive because of its high installation costs. With the intermediate flow and acid cases, NH_3 and CaO systems were by far the most cost effective, with $Ca(OH)_2$ and Na_2CO_3 next. Caustic was the most expensive alternative at this intermediate flow and acidity condition. In the highest flow/acidity category, the $Ca(OH)_2$ and CaO systems are clearly the least costly treatment systems, with annual costs of about $250,000 less than NH_3, the next best alternative.

6.3.3 Other Aspects of AMD Treatment Technologies

While the primary AMD chemicals and applications have been discussed, particular circumstances may require a different chemical, a combination of chemicals, and particular management patterns to implement the most cost effective method, or to meet more stringent effluent limits.

Other chemicals used sparingly in AMD treatment include flocculants or coagulants, which increase particle settling efficiency (Table 6.3). These materials are usually limited to cases where unique metal compositions require a specialized treatment system, or where aeration and residence time in settling ponds are insufficient for complete metal precipitation. Coagulants reduce the net electrical repulsive forces at particle surfaces, thereby promoting consolidation of small particles into larger particles. Flocculation aggregates or combines particles by bridging the space between particles with chemicals. Bridging occurs when segments of a polymer chain absorb suspended particles creating larger particles (Skousen et al., 1993).

The most common coagulants and flocculants used in water treatment are alum and $Fe_2(SO_4)_3$. These materials are also called polyelectrolytes and produce highly-charged ions when dissolved in water. Anionic polymers dissolve to form negatively-charged ions that are used to remove positively-charged solids. The reverse occurs with cationic flocculants. Polyampholytes are neutral, but when dissolved in water release both positively- and negatively-charged ions. Flocculants may be added to water as a liquid, or more commonly, placed in water as a gelatinous solid ("floc" logs).

Aeration is the process of introducing air into water. Oxidation occurs when oxygen in air combines with metals in the water. Once oxidized, Fe and Mn can come out of solution at pH values of 4 and 7, respectively. If the water is not or only partially oxidized, a solution pH of 8 to 10 is required for precipitation of these same metals. For this reason, aeration of water is a major limiting factor in many water treatment systems. If aeration and oxidation were incorporated or improved in the treatment system, chemical treatment efficiency would increase and costs could be reduced substantially. Oxidants (Table 6.3) are sometimes used to aid in the completion of the oxidation process to enhance metal hydroxide precipitation and reduce metal floc volume. The hypochlorite products (bleach), H_2O_2, and $KMnO_4$ are used in AMD situations and have demonstrated very effective oxidation. Calcium peroxide has been shown to oxygenate AMD as well as neutralize acidity (Lilly and Ziemkiewicz, 1992).

After chemical treatment, the treated water flows into sedimentation ponds so metals in the water can precipitate. Dissolved metals precipitate from AMD as a loose, open-structured mass of tiny grains called "floc". All chemicals currently used in AMD treatment cause the formation of metal hydroxide sludge or floc. Sufficient residence time of the water, which is dictated by pond size and depth, is important for adequate metal precipitation. Hilton (1993) found pond size to be too small on most AMD treatment sites to result in complete treatment of the water and precipitation of dissolved metals. The amount of metal floc generated by AMD neutralization depends on the quality and quantity of water being treated, which in turn determines how often the ponds must be cleaned. Knowing the chemical and AMD being treated will help determine the general floc properties and will provide an estimate of the stability of the various metal compounds in the floc.

Table 6.2. Costs in 2000 of five chemicals to treat acid mine drainage in West Virginia. The analysis is based on a five-year operation period and includes chemical reagent costs, installation and maintenance of equipment, and annual operating costs. The "Bulk" chemical prices in Table 6.1 were used to calculate the reagent costs for only the 189 L/min flow. The "Bulk" prices were used for higher flows. Neutralization efficiencies were not included in the reagent cost calculation.

Flow and Acidity Conditions

Flow (L/min)	189	3780	945	3780
Acidity (mg/L)	100	100	500	2500
Chemical				
Soda Ash				
reagent costs	$3,731	$44,000	$58,300	$1,166,000
repair costs	0	0	0	0
annual labor	14,040	14,040	14,040	14,040
installation costs	229	229	229	229
salvage value	0	0	0	0
Net present value	75,052	244,679	245,774	4,911,804
Annual cost	**$17,817**	**$58,086**	**$58,346**	**$1,166,046**
Ammonia				
reagent costs	$2,543	$22,440	$28,050	$561,000
repair costs	495	495	495	495
tank rental	480	1,200	1,200	1,200
annual labor	7,020	7,020	7,020	7,020
electricity	600	600	600	600
installation costs	1,936	6,357	6,357	6,357
salvage value	0	0	0	0
Net present value	48,547	139,117	162,749	2,407,725
Annual cost	**$11,525**	**$33,026**	**$38,636**	**$571,586**
Caustic Soda (20% Liquid)				
reagent costs	$5,174	$79,341	$99,176	$1,983,520
repair costs	0	0	0	0
annual labor	7,020	7,020	7,020	7,020
installation costs	283	5,478	5,478	5,478
salvage value	0	0	0	0
Net present value	51,601	368,398	451,950	8,389,433
Annual cost	**$12,250**	**$87,457**	**$107,292**	**$1,991,636**
Pebble Quicklime				
reagent costs	$1,478	$9,856	$12,320	$246,400
repair costs	500	2,500	2,500	10,000
annual labor	6,500	11,200	11,200	11,200
electricity	0	0	0	0
installation costs	16,000	80,000	80,000	120,000
salvage value	0	5,000	5,000	20,000
Net present value	49,192	162,412	172,790	1,127,220
Annual cost	**$11,678**	**$38,556**	**$41,020**	**$267,600**

Hydrated Lime				
reagent costs	$814	$9,768	$12,210	$244,200
repair costs	1,000	3,100	3,500	10,500
annual labor	6,500	11,232	11,232	11,232
electricity	3,500	11,000	11,000	11,000
installation costs	58,400	102,000	106,000	200,000
salvage value	5,750	6,500	7,500	25,000
Net present value	94,120	228,310	242,809	1,313,970
Annual cost	**$22,344**	**$54,200**	**$57,642**	**$311,932**

Table 6.3. Chemicals for acid neutralization, coagulation/flocculation, and oxidation

NAME	CHEMICAL FORMULA	COMMENTS
Acid Neutralization		
Limestone	$CaCO_3$	Used in anoxic limestone drains and open limestone channels.

Hydrated Lime	$Ca(OH)_2$	Cost effective reagent, but requires mixing.
Pebble Quick Lime	CaO	Very reactive, needs metering equipment.
Soda Ash Briquettes	Na_2CO_3	System for remote locations, but expensive.
Caustic Soda	$NaOH$	Very soluble, comes as a solid in drums, beads, or flakes, or as a 20% or 50% liquid. Cheaper in the liquid form.
Ammonia	NH_3 or NH_4OH	Very reactive and soluble; also purchased as aqua ammonia.
Potassium Hydroxide	KOH	Similar to caustic.
Magnesium Hydroxide	$Mg(OH)_2$	Similar to hydrated lime.
Magna Lime	MgO	Similar to pebble quicklime.
Calcium Peroxide	CaO_2	Used as a neutralizer and oxidant; either powder or briquettes.
Kiln Dust	$CaO, Ca(OH)_2$	Waste product of limestone industry. Active ingredient is CaO with various amounts of other constituents.
Fly Ash	$CaCO_3, Ca(OH)_2$	Neutralization value varies with each product.

Coagulants/Flocculants

Alum (aluminum sulfate)	$Al_2(SO_4)_3$	Acidic material, forms $Al(OH)_3$.
Copperas (ferrous sulfate)	$FeSO_4$	Acidic material, usually slower reacting than alum.
Ferric Sulfate	$Fe_2(SO_4)_3$	Ferric products react faster than ferrous.
Sodium Aluminate	$NaAlO_2$	Alkaline coagulant.
Anionic Flocculants		Negatively-charged surface.
Cationic Flocculants		Positively-charged surface.
Polyampholytes		Both positive and negative charges on surface based on pH.

Oxidants

Calcium Hypochlorite	$Ca(ClO)_2$	Strong oxidant.
Sodium Hypochlorite	$NaClO$	Also a strong oxidant.
Calcium Peroxide	CaO_2	Trapzene, an acid neutralizer.
Hydrogen Peroxide	H_2O_2	Strong oxidant.
Potassium permanganate	$KMnO_4$	Very effective, commonly used.

Ackman (1982) investigated the chemical and physical characteristics of AMD floc and concluded that each floc varied depending on the nature of the AMD, the neutralization chemical, and the mechanical mixing or aeration device used during chemical treatment. He stated the most important physical property is the floc's settleability, which includes both the settling rate and final floc volume. Furthermore, $Ca(OH)_2$ and Na_2CO_3 produced granular, dense flocs versus a more gelatinous, loose floc generated by NaOH or NH_3. The chemical compositions of flocs were generally composed of hydrated Fe^{+2} or Fe^{+3} oxyhydroxides, $CaSO_4$, $Al(OH)_3 \cdot 6H_2O$, $CaCO_3$ and $Ca(HCO_3)_2$, with trace amounts of Si, PO_4, Mn, Cu, and Zn.

Payette et al. (1991), using scanning electron microscope analyses, found that AMD neutralized by $Ca(OH)_2$ resulted in the formation of crystalline $CaSO_4$ as well as various amorphic metal hydroxides. Amorphic materials are those that have little or no structure and order, and have a tendency to dissolve more quickly than crystalline materials under the same conditions. Most minerals, on the other hand, show strong order, structure, and crystallinity. Amorphic materials may also become ordered or crystalline with time. Payette et al. (1991) showed that AMD floc was mostly amorphous at one hr after formation, while crystals were observed in the floc 24 hrs after formation. In a series of experiments on floc generation and stability, Brown et al. (1994a, b, c) found:

1. More floc was produced as the pH of the AMD solution was increased by chemical addition.
2. Each AMD source was unique in its reaction to four neutralization chemicals.
3. The amount of floc produced as a function of the amount of chemical added (termed its "efficiency") remained about the same across all pH ranges for $Ca(OH)_2$, NaOH, and Na_2CO_3. Ammonia became less efficient at high pH.
4. Sodium carbonate was needed in the highest amount to raise water pH to 7.5 or greater.
5. Floc volumes were lowest with Na_2CO_3 and highest with $Ca(OH)_2$ after one week of settling.
6. Greater settling time caused floc consolidation.
7. Flocs were composed of metals in ratios similar to the metal ratios of the AMD from which it was generated.
8. Flocs were primarily amorphic (having no crystalline structure), except for Na_2CO_3 flocs.
9. Flocs collected from ponds on mined areas showed little similarity in composition to flocs generated with the same AMD and chemical in the laboratory. The field flocs had soil particles mixed with the chemical floc.
10. Aging of AMD flocs caused more stable flocs, thereby decreasing their likelihood of releasing metals (Watzlaf and Casson, 1990). The greater stability of aged flocs remained even after re-introducing the flocs into acidic solutions. Aging in a dry environment resulted in better floc stability than flocs aged under water. Aging also caused floc consolidation.

Floc disposal options include: 1) leaving the floc submerged in a pond indefinitely, 2) pumping or hauling floc from ponds to abandoned deep mines or to pits dug on surface mines, and 3) dumping floc into refuse piles. Flocs pumped onto the surface of land and allowed to age and dry is a good strategy for disposal. In its oxidized and dried condition, AMD flocs can become crystalline and become part of the soil.

Lovett and Ziemkiewicz (1991) estimated NH_3 chemical costs for a site in West Virginia at $72,000 per year and floc handling costs at $486,000 per year. Based on a flow of 378 L/min for this site, Brown et al. (1994b) estimated that this site generated approximately 77,900 m^3 of floc per year. Dividing $486,000 by 77,900 m^3 of floc yields a cost of $6.25 per m^3 for floc handling and disposal on this site. Several mine operators observed that floc handling and disposal may cost up to $15 per m^3. Due to their high water content and the sheer volume of material, floc handling costs frequently exceed chemical costs by several times.

Each AMD is unique and the chemical treatment of any particular AMD source is site specific. Each AMD source should be tested with various chemicals by titration tests to evaluate the most effective chemical for precipitation of the metals. The costs of each AMD treatment system based on neutralization (in terms of the reagent cost, capital investment and maintenance of the dispensing system) and floc disposal should be evaluated to determine the most cost effective system.

6.4 PASSIVE TREATMENT OF ACID MINE DRAINAGE

Active chemical treatment of AMD to remove metals and acidity is often an expensive, long-term proposition. In recent years, a variety of passive treatment systems have been developed that do not require continuous chemical inputs and that take advantage of naturally-occurring chemical and biological processes to cleanse contaminated mine waters. Passive technologies include constructed wetlands, anoxic limestone drains (ALD), successive alkalinity-producing systems (SAPS), limestone ponds, and open limestone channels (OLC). Natural wetlands are characterized by water-saturated soils or sediments, with supporting vegetation adapted to reducing conditions in their rhizosphere. Constructed wetlands are man-made ecosystems that mimic their natural counterparts. Often they consist of shallow excavations filled with a flooded gravel, soil, and organic matter to support wetland plants, such as *Typha*, *Juncus*, and *Scirpus* sp. Treatment depends on dynamic biogeochemical interactions as contaminated water travels through the constructed wetland. ALDs are abiotic systems consisting of buried limestone cells that passively generate bicarbonate alkalinity as anoxic water flows through. SAPS combine treatment concepts from both wetlands and ALDs. Oxygenated water is pre-treated by organic matter removing O_2 and Fe^{+3}, and then the anoxic water flows through an ALD at the base of the system. Limestone ponds are ponds built over the upwelling of a seep, which are filled with limestone for treatment. OLCs are surface channels or ditches filled with limestone. Armoring of the limestone with Fe reduces limestone dissolution by 20 to 50%, so longer channels and more limestone is required for water treatment.

At their present stage of development, none of the passive systems can be reliably implemented as a single permanent solution for most AMD problems to meet effluent limits. Relative to chemical treatment, passive systems require longer retention times and greater space, provide less certain treatment efficiency, and are subject to failure in the long-term. However, a great many passive systems have realized successful short-term implementation in the field and have substantially reduced water treatment costs at many mine sites (Faulkner and Skousen, 1994). Current research seeks to better understand the dynamically complex chemical and biological mechanisms that occur within passive systems that are responsible for AMD treatment. Selection of an appropriate passive system is based on water chemistry and flow (Figure 6.1) and refinements in design are ongoing. As scientists and practitioners improve treatment predictability and longevity of passive systems, they will play a more important role in pollution abatement and environmental protection.

6.4.1 Constructed Wetlands

Research demonstrates that biological and chemical processes occurring in freshwater wetlands improve the chemical composition of AMD introduced into these ecosystems. Huntsman et al. (1978) and Wieder and Lang (1982) first noted amelioration of AMD following passage through naturally occurring *Sphagnum* bogs in Ohio and West Virginia. Studies by Brooks et al. (1985), Samuel et al. (1988), and Sencindiver and Bhumbla (1988) documented similar phenomena in *Typha* marshes. Although evidence suggests that some wetland plants show long-term adaptation to low pH and high metal concentrations (Keith Garbutt, unpublished data, West Virginia University), AMD eventually degrades the quality of natural wetlands contrary to federal laws designed for wetland protection and enhancement. Such regulations do not govern use of artificially constructed wetlands for water treatment, which lead to the suggestion that these engineered systems might provide passive low cost, low maintenance treatment of AMD (Kleinmann et al., 1983). Over a thousand wetlands have since been constructed to receive AMD from both active mines and abandoned mine lands. Highly variable treatment effectiveness and longevity have been observed (Dietz et al., 1994; Hedin and Nairn, 1992; Hellier et al., 1994; Kleinmann et al., 1991; Wheeler et al., 1991; Wieder, 1989). Consequently, the US Office of Surface Mining (OSM) will not currently allow the use of constructed wetlands as the sole on-site method for AMD treatment (OSM, 1988). However, properly constructed wetlands can reduce effluent concentrations of dissolved metals to meet effluent limits and have been effectively utilized at many sites to reduce the costs of conventional chemical treatments (Brodie, 1991).

Most AMD contains dissolved Fe, Mn, and Al. Constructed wetlands successfully remove Fe, but Mn and Al removal has been more variable (Stark et al., 1996). Mechanisms of metal retention within wetlands, listed in order of importance, include: 1) formation of metal oxides and oxyhydroxides, 2) formation of metal sulfides, 3) organic complexation reactions, 4) exchange with other cations on negatively-charged sites, and 5) direct uptake by living plants. Other mechanisms may include physical filtration of suspended metal colloids and adsorption/exchange of metals onto algal mats. Other beneficial reactions in wetlands include generation of alkalinity due to microbial mineralization of dead organic matter, microbial dissimilatory reduction of Fe oxyhydroxides and SO_4, and dissolution of carbonates.

The way in which a wetland is constructed ultimately affects how water treatment occurs. Two construction styles currently predominate: 1) "aerobic" wetlands consisting of *Typha* and other wetland vegetation planted in shallow (<30cm), relatively impermeable sediments comprised of soil, clay or mine spoil, and 2) "anaerobic" wetlands consisting of *Typha* and other wetland vegetation planted into deep (>30cm), permeable sediments comprised of soil, peat moss, spent mushroom compost, sawdust, straw/manure, hay bales, or a variety of other organic mixtures, which are often underlain or admixed with limestone.

6.4.1.1 Aerobic Wetlands

Aerobic wetlands promote metal oxidation and hydrolysis, thereby causing precipitation and physical retention of Fe, Al, and Mn oxyhydroxides. Successful metal removal depends on dissolved metal concentrations, dissolved oxygen content, pH and net acidity of the mine water, the presence of active microbial biomass, and detention time of the water in the wetland. The pH and net acidity/alkalinity of the water are particularly important because pH influences both the solubility of metal hydroxide precipitates and the kinetics of metal oxidation and hydrolysis. Hydrolysis lowers pH, so alkalinity in the water buffers the pH and allows oxidation to continue.

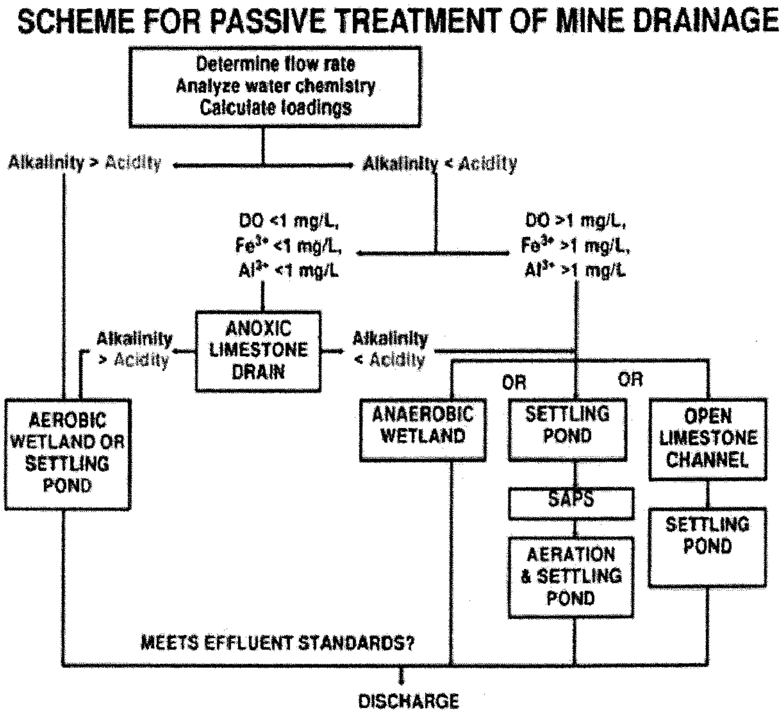

Figure 6.1. Flowchart for selecting a passive AMD treatment system based on water chemistry and flow (adapted from Hedin and Nairn, 1992).

Autooxidation reaction rates decrease a hundred-fold with each unit drop in pH. This decrease is partially compensated for by microbial Fe oxidation at pH ranges from 1 to 4. Following Fe oxidation, abiotic hydrolysis reactions precipitate Fe^{+3}. Therefore, aerobic wetlands are best used in conjunction with water that contains net alkalinity to neutralize metal acidity. Abiotic Mn oxidation occurs at pH >8 while microorganisms are thought to catalyze this reaction at pH > 6 (Wildeman et al., 1991). Manganese precipitation occurs much more slowly than Fe and is sensitive to the presence of Fe^{+2}, which causes chemical reduction of oxidized Mn. Consequently in aerobic net alkaline water, Fe and Mn precipitate sequentially, not simultaneously, with the practical result that several staged aerobic wetlands must be constructed in series if removal of both metals is to be attempted.

Brodie and co-workers at the Tennessee Valley Authority (TVA) have reported extensively on their use of staged aerobic wetlands to treat AMD generated by mine spoils, coal slurries, and coal ash (Brodie et al., 1993). A typical staged design might include an ALD (see next section) to passively add alkalinity to the source AMD, a settling basin to hold precipitated Fe flocs, followed by two or three aerobic wetland cells to sequentially remove additional Fe and Mn. TVA currently operates nine wetlands receiving moderate quality AMD (total Fe < 70 mg/L; total Mn < 17 mg/L; alkalinity 35 to 300 mg/L as $CaCO_3$), which require no further post-system treatment of water exiting the wetlands. Four TVA wetlands are associated with high Fe (>170 mg/L) and low influent alkalinity with resultant production of high metal acidity and low pH water. Two of these systems require NaOH treatment to comply with NPDES effluent limits, while two others use ALDs for further treatment of the effluent. A final TVA wetland system receives low Fe (<0.7 mg/L) and Mn (5.3 mg/L) and is ineffective in Mn removal. Based on their experience with these systems since 1985, Brodie suggests that staged aerobic wetland systems can accomodate Fe loads of up to 21 GDM (grams/day/m^2) even in the absence of excess alkalinity. Manganese loads up to 2 GDM can be accomodated if alkalinity is present.

Long-term successful treatment by a staged aerobic wetland also has been reported for net alkaline water (total Fe 89 mg/L; alkalinity 88 mg/L as $CaCO_3$) at the Simco constructed wetland near Coshocton, OH (Stark et al., 1994). Analysis of 73 sites in Pennsylvania suggested that constructed wetlands are the best available technology for many postmining ground water seeps, particularly those of moderate pH (Hellier et al., 1994).

6.4.1.2 Anaerobic Wetlands

Anaerobic wetlands promote metal oxidation and hydrolysis in aerobic surface layers, but primarily rely on chemical and microbial reduction reactions to precipitate metals and neutralize acidity. The water infiltrates through a thick permeable organic subsurface sediment that becomes anaerobic due to high biological oxygen demand. Several additional treatment mechanisms function, including metal exchange and complexation reactions, formation and precipitation of metal sulfides, microbially generated alkalinity due to reduction reactions, and continuous formation of carbonate alkalinity due to limestone dissolution under anoxic conditions. Since anaerobic wetlands produce alkalinity, their use can be extended to poor quality, net acidic, low pH, high Fe, and high dissolved oxygen (>2 mg/L) AMD. However, Wieder (1992) documents that the mechanism and efficiency of AMD treatment varies seasonally and with wetland age. Microbial mechanisms of alkalinity production are likely to be of critical importance to long-term AMD treatment. When wetlands receive high acid loads (>300 mg/L), the pH sensitive microbial activities are eventually overwhelmed. Therefore, like their aerobic counterparts, anaerobic wetlands are most successful when used to treat small AMD flows of moderate water quality. At present, the sizing value for Fe removal in these wetalnds is 10 GDM (Hedin and Nairn, 1992).

Sorption onto organic materials (such as peat and sawdust) can initially remove 50 to 80% of the metals in AMD (Brodie et al., 1988). Five different substrates (clay, topsoil, mine spoil, acid wetland soil, and non-acid wetland soil) with vegetation were no different in Fe removal than these materials without vegetation after one growing season (Brodie et al., 1988). This finding suggests that a particular substrate material, as long as it has metal retention capabilities, may not be as important as the conditions created by wetland plants and the presence of an anaerobic zone. Kleinmann et al. (1991) suggested adsorption and complexation by organic substrates may compensate for limited initial biological activity during the first few months of operation in a new wetland system. In a laboratory simulation, Henrot and Wieder (1990) observed that organic complexation in peat mesocosms was a significant retention mechanism during initial application of AMD, but saturated at 12 mg Fe per gram dry peat. They found little to no contribution by cation exchange reactions. A subsequent field study, which examined five wetland substrate types over a 25-month period, also demonstrated that exchange reactions were an insignificant sink for metal cations regardless of substrate type (Wieder, 1993). Organic complexation saturated the substrate after only 1 to 7 months of AMD input at 9 to 17 mg Fe per gram substrate. Although some natural inputs of organic matter occur annually at plant senescence, the physical filtering capacity of a wetland will ultimately be finite as all exchange and complexation sites become metal saturated. Substantial artificial inputs of organic matter have been used as a successful strategy to temporarily renew this filtering capacity, following an observed decline in wetland performance (Eger and Melchert, 1992; Haffner, 1992; Stark et al., 1995).

Insoluble precipitates such as oxyhydroxides, carbonates, and sulfides represent a major sink for metal retention in wetlands. Unlike exchange and complexation reactions, metal precipitate retention has no theoretical maximum, but is limited in reality by the physical density and volume of the material produced. For example, compared to diffuse amorphous Fe oxyhydroxides, Fe mono and disulfides are compact and dense precipitates, which occlude less wetland pore space volume per unit of Fe retained. The long-term stability of metal precipitates is unclear. Ferric hydroxides can be reduced with time to Fe^{+2} by anaerobic Fe-reducing bacteria in the wetland. Similarly, the use of Fe^{+3} as a pyrite oxidant under anaerobic conditions would result in Fe^{+2} in wetland effluents. About 50 to 70% of the total Fe removed from AMD by wetlands is found as Fe^{+3} hydroxides (Henrot and Wieder, 1990; Calabrese et al., 1991; Wieder, 1992). Oxyhydroxide formation depends both on the availability of dissolved oxygen and on the inital oxidation state of Fe in the AMD. Oxygen must be present for Fe^{+2} oxidation, whether it occurs abiotically or by *Thiobacillus* sp., so AMD often contains a mixture of Fe^{+2} and Fe^{+3}. However, Wieder (1993) reported significant retention of Fe^{+3} oxyhydroxides in anaerobic wetlands due to the preponderance of dissolved Fe^{+3} in their source AMD. Once Fe^{+3} is present, then oxygen is unnecessary for hydrolysis to the oxyhydroxide. When estimating oxyhydroxide formation, attention to laboratory procedures are essential to avoid analytical artifacts. Conventional aerobic extractions (Henrot and Wieder, 1990) can overestimate oxide formation by 10 to 20% compared with similar extractions performed under anaerobic conditions (Bhumbla et al., 1991; Calabrese et al., 1994).

Up to 30% of the Fe retained in wetlands may be found as reduced Fe and may be combined with sulfides (Calabrese et al., 1991; McIntyre and Edenborn, 1990; Wieder, 1992). Iron mono and disulfides form as a result of H_2S formation by microbial sulfate reduction in the presence of an oxidizable carbon source. In addition to its metal removal potential, sulfate reduction consumes acidity and raises water pH (Hedin and Nairn, 1992; Rabenhorst et al., 1992). In naturally occurring freshwater wetlands or lake sediments, sulfate reduction would not be expected to be a predominate process since sulfate concentrations are usually low in these ecosystems. High sulfate concentrations (200 to 2000 mg/L) are common in AMD and availability of this anaerobic electron acceptor results in selective enrichment for sulfate-reducing bacteria (SRB). Resulting activity of these bacteria in constructed wetlands has been documented at levels comparable to coastal marine sediments (i.e. 250 nmoles per gram per day)(Calabrese et al., 1991). Acidophilic strains are unknown, therefore constructed wetlands must provide protected niches for SRB to flourish and persist. Wieder (1992) reported transitory activity of SRB during the first year of wetland operation with very acidic AMD, but found the bacteria to be distributed throughout the entire wetland, including near-surface sediments. McIntyre and Edenborn (1990) and Calabrese et al. (1994) report persistence of SRB activity for longer periods, particularly in deep sediments adjacent to zones of subsurface limestone dissolution.

A variety of wetland substrates have been shown to provide sufficient dissolved organic carbon to support SRB activity, including non-traditional but increasingly available materials such as composted chicken litter (Gross et al., 1993). Wieder (1992) found greater rates of SRB activity in straw/manure or mushroom compost wetland substrates than peat. Inorganic FeS_x and organic sulfur (produced by attachment of S^{-2} or HS^- to organic matter) were dominant products of sulfate reduction in *Sphagnum*/limestone and straw/manure vs *Sphagnum* alone and mushroom compost wetlands, respectively (Wieder and Lang, 1982; Taddeo and Wieder, 1991). Based on their inorganic S data, Calabrese et al. (1991) and Rabenhorst et al. (1992) estimate that 30% of the total Fe retained was due to SRB activity. Bhumbla et al. (1991), working with direct measurement of extractable Fe pools, estimated that 15% of the Fe retained could be formed as sulfides.

Long-term retention of Fe sulfides and Fe oxyhydroxides in a wetland are not well understood. Under continued anoxic conditions and in the absence of soluble Fe^{+3}, pyrite should remain stable. Indeed, Calabrese et al. (1994) changed the influent to their anaerobic wetland from AMD to freshwater with no concomitant export of Fe^{+2}. Since their effluent pH was greater than pH 6 due to continued limestone dissolution, dissimilatory Fe reduction in surface sediments may have been inhibited (Wieder, 1994). Dissimilatory Fe-reducting bacteria (IRB) are important anaerobic microorganisms that occur in anoxic sediments (Lovely, 1993). These bacteria use soluble carbon as an energy source and solid Fe^{+3} oxyhydroxide as an electron acceptor, producing soluble Fe^{+2} and alkalinity as important reaction products. If SRB and IRB compete for the same carbon source in the presence of excess sulfate and Fe^{+3} oxyhydroxide, then IRB will competitively exclude SRB as the dominant microbial population (Chapelle and Lovely, 1992). Since Fe^{+3} oxyhydroxides commonly accumulate in surface waters of AMD wetlands adjacent to anoxic subsurface sediments, it is reasonable that such competition occurs. Vile and Wieder (1993) suggested that nocturnal Fe^{+2} export resulted both from dissimilatory Fe reduction and pyrite reoxidation. Both processes were probably inhibited during daylight by oxygenic photosynthesis of cyanobacteria and green algae resulting in net Fe^{+3} export, since influent AMD was 90% Fe^{+3}. Vile and Wieder (1993) note that those SRB and IRB activities produce significant alkalinity, but that hydrolysis of Fe^{+3} and pyrite reoxidation are sources of acidity. In their systems, microbial mechanisms of alkalinity generation were overwhelmed after two years of AMD exposure. These data suggest that microbial populations, thought to be as numerous in non-AMD impacted wetlands as in their natural counterparts (Duncan and Groffman, 1994), may gradually decrease in magnitude and diversity with time of AMD treatment, though there are many systems that show no decline in performance after several years. Some workers have indicated that wetland systems can be seeded with functional microorganisms (Davison, 1993) to introduce or re-establish microbial activity. However, experiments utilizing appropriate controls have not established the efficacy of this approach.

Experience with bioremediation of other wastes suggests that selection and enrichment of naturally-occurring microbial populations is a superior, more cost-effective approach (Alexander, 1993).

Calabrese et al. (1991) noted that their experimental wetlands continued to produce circumneutral effluent high in soluble Fe even after interstitial water within the organic substrate was significantly acidified. They suggested that the wetland had begun to function in a manner analogous to an anoxic limestone drain where AMD contained no dissolved oxygen and predominantly Fe^{+2} passively obtains carbonate alkalinity during passage through the limestone bed underlying the wetland. Their data show that heterotrophic oxygen consumption, dissimilatory Fe reduction and/or pyrite reoxidation continued to function in the wetland, since influent water contained measurable dissolved oxygen and mixtures of both Fe^{+3} and Fe^{+2}.

Relatively little work exists on the appropriate selection of plant species for wetlands, yet this can have important implications for the long-term success of a project. In constructed wetlands, higher plants serve several purposes including: substrate consolidation, metal accumulation, physical filtration of metal precipitates, stimulation of microbial processes, wildlife habitat, and aesthetics.

Wetland plant species vary in their ability to accumulate metals (Fernandes and Henriques, 1990). Some reports document elevated tissue concentrations (Spratt and Wieder, 1988), while others show little metal accumulation (Folsom et al., 1981). On an annual basis, uptake by *Typha* accounted for less than 1% of the Fe removed by volunteer wetlands treating AMD (Sencindiver and Bhumbla, 1988). While it may be true that metal concentration and accumulation in plant tissues may be small in any one year, plant tissue is a renewable resource. Old tissue is senesced yearly and new tissue, with new sites for metal accumulation, is produced. Thus, over the entire life of a wetland, plants may accumulate a significant portion of metals received in a wetland.

Several studies report on the effects of different plant species in wetlands. *Sphagnum* was the predominant wetland species found in AMD-treating wetlands and *Sphagnum* has a well-documented capacity to accumulate Fe (Gerber et al., 1985; Wenerick et al., 1989). However, Spratt and Wieder (1988) found that saturation of *Sphagnum* moss with Fe could occur within one growing season. Some have indicated that metal retention over the long term is limited in some wetlands because organic matter inputs by wetland plants is limited (Kleinmann, 1990). Many of the original constructed wetlands were vegetated with *Sphagnum* but few remained effective. Cattails (*Typha*) have been found to have a greater environmental tolerance than *Sphagnum* moss (Samuel et al., 1988). One of the reasons is cattails do not accumulate metals into their tissues through uptake. Sencindiver and Bhumbla (1988) found that cattails growing in AMD-fed wetlands did not have elevated concentrations of metals in plant tissues. Algae and a few other wetland species have also received attention due to the observation that enhanced metal removal was associated with algal blooms (Hedin, 1989; Kepler, 1988; Pesavento and Stark, 1986). In Colorado, algal mixtures were found to aerobically remove Mn from mine drainage (Duggan et al., 1992), presumably due to elevated pH resulting from algal growth. Probably the most important role that wetland plants serve in AMD treatment systems may be their ability to stimulate microbial processes. Kleinmann et al. (1991) explain that plants provide sites for microbial attachment, release oxygen from their roots, and supply organic matter for heterotrophs.

With any constructed wetland, it is important to allow the plants to establish for some time with uncontaminated water before AMD is applied to the system. Plants can suffer "transplantation shock", which can make them particularly susceptible to any environmental shock. Immediate inundation with AMD will certainly slow growth and development and in some cases may kill the entire wetland. If a wetland is built during the early to middle part of the growing season, the plants should be given one to two months to establish prior to AMD introduction. If a system is constructed late in the growing season, AMD flow should not begin until the next growing season.

Current practice is to plant a fairly dense monoculture of *Typha*. As passive treatment systems get bigger, the number of plants needed and the manpower required to plant them can lead to prohibitive expense. So some planting designs that do not fill the wetland with plants at its creation should be considered. Volunteer species are important components in some constructed wetland systems, but these are not generally part of the initial matrix from which a wetland will develop.

The choice of wetland species should be based on a knowledge of local conditions and the relative ability of species to tolerate the conditions found in a particular watershed and their ability to provide the functions listed above. For example, *Typha angustifolia* is extremely rare in West Virginia, although it is common in surrounding states. Thus a wetland planted with *T. angustifolia* in West Virginia is unlikely to flourish, while *Typha latifolia* does well. Similarly *T. angustifolia* and *T. latifolia* have different niches with respect to water depth. In general, the water depths usually employed in wetland systems are more suitable for *T. latifolia* than *T. angustifolia*. It should also be noted that since AMD is extremely variable, a plant community that thrives in one location may be completely inappropriate in a second nearby location if the composition of the AMD is different.

6.4.2 Anoxic Limestone Drains

Anoxic limestone drains (ALDs) are buried cells or trenches of limestone into which anoxic water is introduced. The limestone dissolves in the acid water, raises pH, and adds alkalinity. Under anoxic conditions, the limestone does not coat or armor with Fe hydroxides because Fe^{+2} does not precipitate as $Fe(OH)_2$ at pH 6.0. ALDs were first described by theTennessee Division of Water Pollution Control (TDWPC) (Turner and McCoy, 1990). Tennessee Valley Authority (TVA) subsequently observed that AMD seeping through a coal refuse dam was being treated passively by limestone contained in an old haul road buried under the dam. Once the water containing excess alkalinity reaches aerobic conditions at the ground surface, the metals oxidize and precipitate while the water remains near pH 6 (Brodie et al., 1990). TVA and TDWPC began building ALDs in 1989. Originally, ALDs were used for pre-treatment of water flowing into constructed wetlands. Brodie et al. (1993) reported that ALDs improved the capability of wetlands to meet effluent limitations without chemical treatment. Since 1990, ALDs have also been constructed as stand-alone systems, particularly where AMD discharges from deep mine portals. Faulkner and Skousen (1994) reported both successes and failures among 11 ALDs treating mine water in West Virginia. In all cases, water pH was raised after ALD treatment but three of the sites had pH values <5.0, indicating that the ALD was not fully functioning. When working correctly, the pH values of water in ALDs should achieve 6.0. Water acidity in these drains decreased 50 to 80%, but Fe and Al concentrations in the outflow, unfortunately, were also decreased. Ferric iron and Al will precipitate as hydroxides at this pH.

With Fe and Al decreases in outflow water, it is probable that some coating or clogging of limestone is occurring inside the ALD.

Longevity of treatment is a major concern for ALDs, especially in terms of water flow through the limestone. Eventual clogging of the limestone pore spaces with precipitated Al and Fe hydroxides, and gypsum is predicted (Nairn et al., 1991). For optimum performance, no Fe^{+3}, dissolved oxygen (DO), or Al should be present in the AMD. Selection of the appropriate water and environmental conditions is critical for long-term alkalinity generation in an ALD.

Since most AMD has mixed amounts of Fe^{+3} and Fe^{+2} and some DO, utilization of an ALD under these conditions compromises the effectiveness and longevity of the system. Current research involves pre-treatment of AMD with an anaerobic wetland to strip oxygen from the water and to convert Fe^{+3} to Fe^{+2} (Kepler and McCleary, 1994; Skousen, 1995). The anoxic water after passing through an anaerobic organic substrate wetland can then be directed downward into underlying limestone or introduced into an ALD. There are still many questions relative to the longevity of ALDs and the factors involved in limestone dissolution and metal precipitation in ALD environments. Like wetlands, ALDs may be a solution for AMD treatment for specific water conditions or for a finite period after which the system must be replenished or replaced.

6.4.3 Successive Alkalinity-Producing Systems

Recently, successive alkalinity producing systems (SAPS) have been implemented in the field (Kepler and McCleary, 1994). Acid water, from .1 to 3 m, is ponded over an organic compost of 0.2 to 0.3 m, which is underlain by 0.5 to 1 m of limestone. Below the limestone is a series of drainage pipes that convey the water into an aerobic pond where metals are precipitated. The hydraulic head drives ponded water through the anaerobic organic compost, where oxygen stripping as well as Fe and sulfate reduction can occur prior to water entry into the limestone. Water with high metal loads can be successively cycled through additional SAPS. Iron and Al clogging of limestone and pipes can be removed by flushing the system (Kepler and McCleary, 1997).

6.4.4 Limestone Ponds

Limestone ponds can be constructed over an AMD upwelling, seep or underground mine discharge. Limestone is placed in the bottom of the pond and the water flows upward through the limestone (Skousen et al., 1995). Based on the topography of the area and how the water emanates from the ground, the pond can be built to pond water from 1 to 3 m deep, containing 0.3 to 1 m of limestone immediately overlying the seep. The pond should be sized and designed to retain the water for 12 to 24 hrs for limestone dissolution, and to keep the seep and limestone under water. If limestone coating occurs by Al or Fe hydroxides, the limestone in the pond could be periodically disturbed with a backhoe to either uncover the limestone or to knock or scrape off the precipitates. If the limestone is exhausted by dissolution, then a load of fresh limestone can be dumped into the pond over the seep.

6.4.5 Open Limestone Channels

Open limestone channels (OLCs) are another means of introducing alkalinity to acid water (Ziemkiewicz et al., 1994). Past assumptions have held that armored limestone (limestone covered or coated with Fe or Al hydroxides) ceases to dissolve. Ziemkiewicz et al. (1997) found armored limestone to be 50 to 90% effective in neutralizing acid compared to unarmored limestone, and seven OLCs in the field reduced acidity in AMD by 4 to 62% compared to a 2% acid reduction in a sandstone channel. Open limestone channels show promise for neutralizing AMD in watershed restoration projects and AML reclamation project where one-time installation costs are incurred, little to no maintenance is required, and systems do not have to meet specific water quality standards. Long channels of limestone can be used to convey acid water to a stream or other discharge point. Based on flows and acidity concentrations, cross sections of stream channels (widths and heights) can be designed with calculated amounts of limestone (which will become armored) to treat the water. Open limestone channels work best where the channel is constructed on steep slopes (>20%) and where flow velocities keep metal hydroxides in suspension, thereby limiting their precipitation and plugging of limestone pores in the channel. Utilizing OLCs with other passive systems can maximize treatment and metal removal. If constructed correctly, OLCs should be maintenance free and provide AMD treatment for decades.

6.5 SUMMARY

Acid mine drainage occurs when geologic materials containing metal sulfides are exposed to oxidizing conditions. Subsequent leaching of reaction products into surface waters pollute over 20,000 km of streams in the USA alone. Mining companies must predict the potential of creating AMD on their operations before disturbance by using overburden analyses. On sites where a potential exists, special handling of overburden materials and quick coverage of acid-producing materials in the backfill should be practiced. Alkaline addition with materials such as kiln dust and FBC ash has shown favorable results in reducing or completely eliminating AMD problems. Placing acid-producing materials under dry barriers effectively isolates these materials from air and water. While not practiced much in the USA, placing acid-producing materials under water has shown good success in other regions where complete inundation is assured. Bactericides are useful in preventing AMD temporarily until a long-term control technology like a barrier is emplaced. Since many sites have produced AMD for decades before laws were passed, much effort has been concentrated on controlling AMD from abandoned mine sites. Injection of alkaline materials into underground mines and buried pods of acid material in surface mine backfills, remining of abandoned areas, and alkaline recharge trenches are AMD control technologies being tested currently.

Chemicals used for treating AMD after formation are $Ca(OH)_2$, CaO, NaOH, Na_2CO_3, and NH_3. Each chemical has advantages for certain water conditions and treatment. Caustic is generally used when Mn is the primary element to be removed from the water. Under low flow situations, all of the chemicals except $Ca(OH)_2$ are cost effective. Under high flow situations, $Ca(OH)_2$ and CaO are clearly the most cost effective due to low reagent cost compared to the other chemicals. Coagulants, flocculants, and oxidants are used in water treatment to meet more stringent effluent limits and to aid in floc settling efficiency. Floc, the metal hydroxides collected in ponds after chemical treatment, are disposed of in abandoned deep mines, refuse piles, or left in collection ponds. Studies show that flocs are relatively stable materials and metals contained therein do not resolubilize after disposal, especially if aged and dried.

Wetlands treat AMD by removing metals through: 1) formation of oxyhydroxides, formation of metal sulfides, exchange and organic complexation reactions, and direct plant uptake. Aerobic wetlands are used when water contains enough alkalinity to promote metal precipitation. Anaerobic wetlands are designed when AMD contains no alkalinity, and alkalinity is generated in these systems by microbial sulfate reduction and limestone dissolution in anaerobic sediments. Anoxic limestone drains use limestone under anoxic conditions to generate alkalinity. Under anoxia, limestone theoretically will not be coated or covered with Fe^{+3} hydroxides in the drain, decreasing the likelihood of clogging. Successive alkalinity-producing systems pre-treat oxygenated AMD with organic matter to remove oxygen and Fe^{+3}. The water is then introduced into an ALD or limestone underneath the organic matter. Open limestone channels use limestone in aerobic environments to treat AMD. Coating of limestone occurs but the limestone continues to dissolve and the reduced effectiveness of limestone dissolution is designed into the AMD treatment system. At present, most passive systems offer short-term treatment possibilities after which the system must be recharged or replaced. Further, few passive systems attain NPDES effluent limits and therefore are more practical for installation on abandoned sites or watershed restoration projects where effluent limits do not apply and where some removal of acid and metals will benefit stream restoration.

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REPORT

The effect of Appalachian mountaintop mining on interior forest

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Abstract Southern Appalachian forests are predominantly interior because they are spatially extensive with little disturbance imposed by other uses of the land. Appalachian mountaintop mining increased substantially during the 1990s, posing a threat to the interior character of the forest. We used spatial convolution to identify interior forest at multiple scales on circa 1992 and 2001 land-cover maps of the Southern Appalachians. Our analyses show that interior forest loss was 1.75–5.0 times greater than the direct forest loss attributable to mountaintop mining. Mountaintop mining in the southern Appalachians has reduced forest interior area more extensively than the reduction that would be expected based on changes in overall forest area alone. The loss of Southern Appalachian interior forest is of global significance because of the worldwide rarity of large expanses of temperate deciduous forest.

Keywords Appalachian mountains · Coal mining · Edge effects · Forest loss · Interior forest

Introduction

The increase in Appalachian mountaintop mining (Table 1) was fostered by the confluence of technological innovation and the 1990 amendments to the Clean Air Act (Fox 1999; Szwilski et al. 2001; Burns (2005). Tighter restrictions on emissions included in the 1990 amendments to the Clean Air Act prompted the mining and electrical generation industries to favor sources of low-sulfur coal from the Appalachian region at about the same time that development of larger and more efficient machinery became available for excavation and removal. These mining activities are occurring predominantly in the Southern Appalachians, centered on southern West Virginia, eastern Kentucky and southwestern Virginia (US EPA 2005).

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Table 1 Mountaintop mining methods

Steep-slope mining: coal mining and reclamation on natural slopes that exceed 20°, or on lesser slopes that require measures to protect the area from disturbance, as determined by the regulatory authority after consideration of soils, climate, the method of operation, geology, and other regional characteristics (30 CFR 716.2). Variances are provided so that reclamation does not have to return the land to its approximate original contour (AOC).
Source: Office of Surface Mining (4 August 2006; http://www.osmre.gov/rules/subchapterb.htm#V)
Mountaintop removal: coal mining and reclamation that remove entire coal seams running through the upper fraction of a mountain, ridge, or hill by removing all of the overburden and creating a level plateau or gently rolling contour. Variances are provided so that reclamation does not have return the land to its AOC (30 CFR 716.3).
Source: Office of Surface Mining (4 August 2006; http://www.osmre.gov/rules/subchapterb.htm#V)
Contour mining: A method typically used in mountainous areas of the eastern United States where coal seams are exposed in outcrops on hillsides and mountainsides. Mining that follows a coal seam along the side of a hill.
Sources: Office of Surface Mining (4 August 2006; http://www.osmre.gov/color5.htm)
Area Mining: A surface mining method that used in level to gently rolling topography or on relatively large tracts of land. Active area mine pits may be several miles long.
Source: Office of Surface Mining, Glossary: Acronyms and Terms (4 August 2006; http://arcc.osmre.gov/Glossary.asp)

The expansion of mountaintop mining in the Southern Appalachian region during the 1990s ultimately led to a lawsuit (Bragg versus Robertson, Civil Action No. 2:98-0636 US District Court, Southern District of West Virginia) in which the West Virginia Highlands Conservancy sued the West Virginia Department of Environmental Protection and the US Army Corps of Engineers alleging that deposition of mining spoil in nearby stream valleys violated the Clean Water Act (CWA) and Surface Mining Control and Reclamation Act (SMCRA) (US EPA 2005; TLPJ 1999). This court case and concerns expressed by other public and private entities resulted in an environmental impact assessment of mountaintop mining activities (US EPA 2005). Presumably because of the ongoing litigation, the environmental impact assessment focused primarily on watershed and water-quality impacts from depositing the overburden (rock overlying a coal seam) in nearby stream valleys, but also considered affects on: (1) groundwater and discharge; (2) interior forest birds; (3) noise and dust pollution and their potential impacts on human health, (4) success of re-vegetation of reclaimed mine sites, and several other factors (US EPA 2005). However, loss of interior forest per se was not considered as an environmental impact (US EPA 2005).

The ecological relevance of interior forest loss is equal to loss of water quality or interior forest birds. A host of ecological changes occur when forest changes from interior to edge (Laurance et al. 2002; Harper et al. 2005). Interior and edge forests are different in their composition, structure, and the ecological processes that govern them. Much of the forest cover throughout the Appalachians is interior because the forest is spatially extensive with little disturbance imposed by other uses of the land (Vogelmann et al. 2001; Riitters et al. 2002). Mountaintop mining poses a genuine threat to the interior character of Appalachian forests, and the threat is also globally significant because spatially extensive temperate deciduous forest is rare worldwide (Riitters et al. 2000).

The threat to Appalachian forests from mountaintop mining is compounded by the loss of the keystone (sensu O'Neill and Kahn 2000) ecological goods and services (Westman 1977; Costanza et al. 1997) they provide. There is less nutrient pollution to aquatic systems (Beaulac and Reckhow 1982; Frink 1991; Jones et al. 2001; Wickham et al. 2005), more moisture in the atmosphere (Hayden 1998; Pielke et al. 2002; Marshall et al. 2004), and a greater amount of habitat (SAMAB 1996; Robinson et al. 1995; Fahrig 2002) when the forest is spatially extensive and hence interior. The Appalachian region's recognized floral and faunal diversity (both aquatic and terrestrial) (Hinkle et al. 1993; SAMAB 1996; Pickering et al. 2003) is supported by the spatially extensive character of its forests.

The amount of interior forest loss is greater than the amount of forest loss resulting from a land-cover conversion because of spatial proximity (Skole and Tucker 1993; Weakland and Wood 2005). Interior forest that is adjacent to an area where forest is converted to another use loses its interior character because of the introduction of nonforest edges even though there was no "direct" conversion of the interior forest itself. In this report we will show that the loss of interior forest to mountaintop mining is greater than the amount of direct forest loss attributable to the practice. We will also show that the ratio of interior forest loss to forest loss increases as the impact of the disturbance (mountaintop mining) is considered over larger spatial scales.

Methods

We used temporal Landsat TM imagery (Fig. 1) and land cover from the circa 1992 and 2001 National Land Cover Databases (Vogelmann et al. 2001; Homer et al. 2004) to assess the impact of mountaintop mining on interior forest

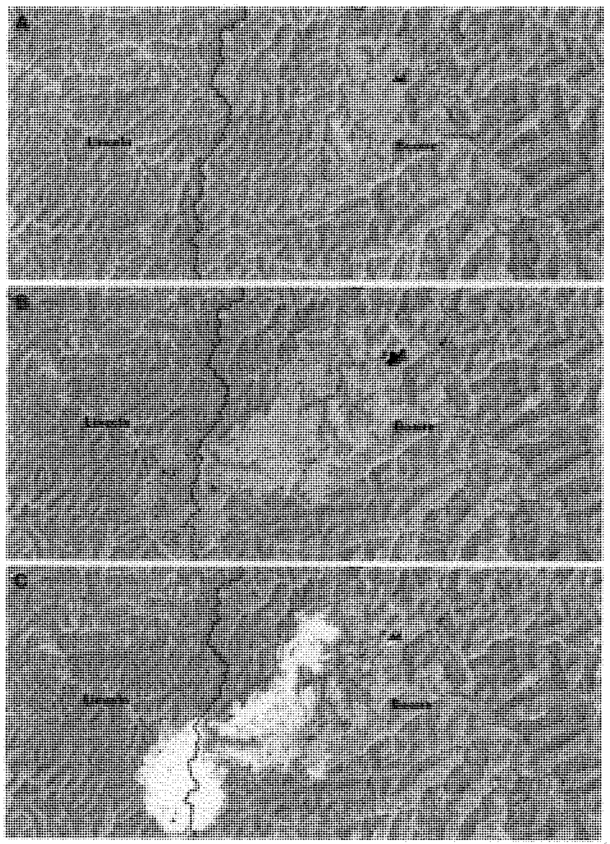


Fig. 1 False-color composite images of portions of Boone and Lincoln Counties in southern West Virginia for 1992 (A), 2001 (B), and 2001 with forest loss in yellow (C). Landsat TM bands 4, 5, and 7 are displayed in the red, green, and blue channels, respectively

loss. Methodological changes in land-cover classification between the circa 1992 National Land Cover Dataset (NLCD) (Vogelmann et al. 2001) and the 2001 NLCD (Homer et al. 2004) required additional calibration techniques to provide consistent land-cover classifications across the dates (Fry 2005). The calibration included six major steps: (1) both dates of the NLCD were reclassified from their approximate Anderson Level II to a coarser thematic Anderson Level I to establish areas of agreement; (2) areas of agreement were used as training data to generate individual decision-tree classifications (Homer et al. 2004) for each date; (3) new Anderson Level I classifications were compared to isolate types of change (including no change); (4) the new change and no change data were filtered with confidence thresholds from the decision tree to identify from and to labels; (5) the new, highest confidence areas (step 4) were used as training data for a second stage classification; (6) a final composite change map was created incorporating all prior intermediate steps. The land-cover change data resulting from the six-step calibration process were used to detect changes in interior forest.

Changes in interior forest at multiple spatial scales were estimated using image convolution: a fixed area window was moved over the land-cover maps one pixel at a time, and the number of forest pixels was recorded for the location of the center (focal) pixel. If a window was completely (100%) forested, the focal pixel was, by definition, interior for an area at least as large as the window. For each date, we tested square windows sizes of 2.25, 7.29, 65.61, 590.49, and 5,314.41 hectares (ha) (5.56, 18.01, 162.13, 1,459.13, and 13,141.47 acres, respectively). The corresponding side-lengths of the square windows were 5, 9, 27, 81, and 243 30-meter (m) pixels. One-half of the side-length approximates the linear distance between the focal pixel and the nearest nonforest boundary when the window is completely forested and nonforest occurs immediately adjacent to the window's edge. Sensitivity to the definition of interior forest was tested by relaxing the 100% threshold to 90%. Forest losses less than 0.45 ha (~1 acre) were ignored because binary classifications based on thresholds can be sensitive to small changes.

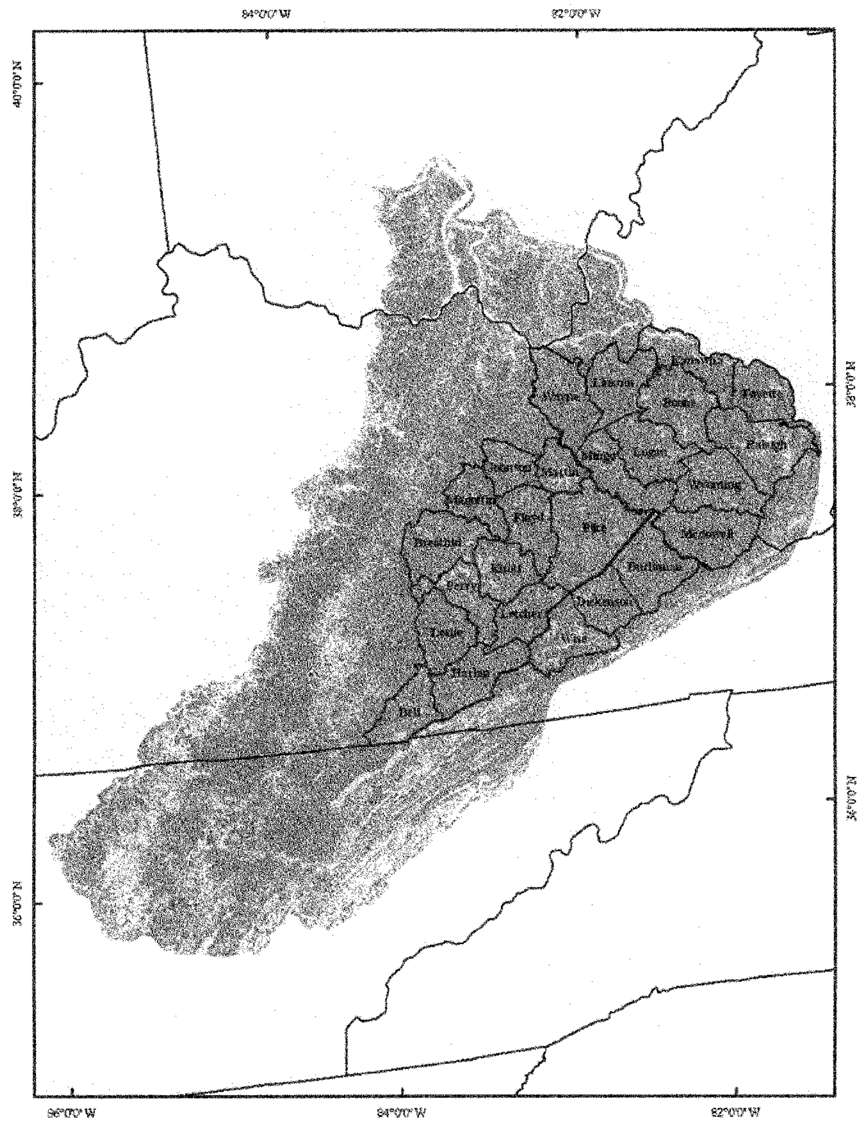
Fig. 2 The study area, outlined in green, covered a ▶ 19-county area in southern West Virginia, eastern Kentucky, and southwestern Virginia, plus smaller portions of Raleigh, Fayette, Kanawaha, Lincoln, and Wayne Counties in West Virginia, and Johnson County Kentucky. Forest on both dates is gray, forest loss is in yellow, and forest gain is red

Loss of forest due to factors other than mountaintop mining were excluded by examining color-composites of the Landsat TM imagery (Slonecker and Lacert 2001) to identify a smaller 19-county area (2,202,500 ha) where mining was the primary determinant of landscape change (Fig. 2). The county boundaries used to define the study area were adjusted when forest loss due to activities other than mountaintop mining were prevalent. For example, the green lines that do not track county boundaries in Fig. 2 were delineated to omit areas where mountaintop mining was not the primary driver of forest loss. To avoid bias near the study area boundary, image convolution was performed on the larger mapping region (Fig. 2) before extracting the smaller 2,202,500-ha study area.

Results

Approximately 95% of the 2,202,500-ha study area was forest in 1992, of which 4.2% was converted to another land cover by 2001. The estimated loss of interior forest ranged from 7.4% to 20.5% depending on the scale of analysis (Table 2A). Percentage interior forest loss was approximately 1.75–5.0 times greater that the percentage direct forest loss attributable to mountaintop mining. These results indicate that the loss of interior forest exceeded the actual amount of forest removed by mountaintop mining.

Relaxing the threshold used to define interior did not substantially change the ratio of interior forest loss to direct forest loss. Similar results were obtained when the threshold used to define interior forest was relaxed from 100% to 90% (Table 2B). Ratios of percentage interior forest loss to percentage direct forest loss were approximately 1.5–4.0 across the four smallest scales examined. There were no forested locales that met the 100% threshold for interior within the study area for the


84°0'0" W
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Wayne
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Kanawha
Boone
Fayette
Mingo
Logan
Raleigh
Johnson
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Wyoming
Magoffin
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Pike
McDowell
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Buchanan
Perry
Letcher
Dickenson
Leslie
Wise
Harlan
Bell
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largest scale (Table 2A), but there were about 1.9×10^6 ha of interior forest at the 5,314.41-ha scale (1992) when the threshold was relaxed to 90% (Table 2B). Approximately 21% of the interior forest (90% threshold) at the 5,314.41 ha-scale was lost to mountaintop mining by 2001.

The effect of mountaintop mining on the cove and mixed mesophytic forests that characterize the region (SAMAB 1996) was similar to the effect on forest as a whole. Based on geographic overlay of our fragmentation results (e.g., Riitters et al. 2003) with the GAP (Scott and Jennings 1998) vegetation maps for southern West Virginia, ratios of interior forest loss to direct forest loss for cove and mixed mesophytic forest communities ranged from 1.7 to 9.0 and 1.6 to 13.5, respectively (Table 3).

Mountaintop mining has had a significant effect on large-scale interior forest (90% threshold). In 1992, there were approximately equal likelihoods of meeting the 90% threshold for interior forest at the 2.25-ha and 5,314.41-ha scales (Table 2B). By 2001, mountaintop mining produced a consistent decline in interior forest conditions with increasing scale so that there were no longer approximately equal likelihoods of meeting interior forest conditions at the smallest and largest spatial scales examined. One consequence of the loss of large-scale interior forest (i.e., 5,314.41 ha) is that it barely spans the 2,202,500- ha study area in 2001 (Fig. 3). In 1992, the 2,202,500-ha study area was the predominant area of large-scale interior forest within the larger mapping region (Fig. 3), whereas by 2001 it became difficult to traverse the 2,202,500-ha study area and stay within interior forest.

The United States Environmental Protection Agency estimated that the 4,856,247 ha (12,000,000 acres) Southern Appalachian region was 92% forest and that mountaintop mining will remove 6.8% of the forest between 1992 and 2012 (US EPA 2005). With that estimate as a guide, it is possible to extrapolate our results to estimate the loss of interior forest for the Southern Appalachian region impacted by mountaintop mining (US EPA 2005). Based on the results in Table 2A, about 84% of the forest in our study area was interior at the 2.25-ha scale in 1992, and 7.4% of it was lost by 2001. Using the appropriate percentages, there were 4,467,747 ha of forest in 1992 across the Southern Appalachian region, of which 3,752,908 ha would have been interior forest at the 2.25-ha scale. Using the same ratios between interior forest loss and forest loss as shown in Table 2A, a 6.8% loss of forest would translate to a 12% loss of interior forest at the 2.25-ha scale for the Southern Appalachian region, or 450,349 ha. Corresponding estimates of interior forest loss at the 7.29- 65.61-, and 590.49-ha scales are 502,010, 316,810, and 5,930 ha, respectively.

Discussion

The environmental impact assessment of mountaintop mining focused on water-quality impacts

Table 2 Change in interior forest from 1992 to 2001. Percentage loss is relative to the amount of interior forest in 1992. Ratio equals percentage loss divided by total forest loss (e.g., 7.4/4.2 = 1.76)

Window size (ha)	Interior forest, 1992 (ha)	Interior forest, 2001 (ha)	Difference (ha)	Percentage loss	Ratio
A. Total forest loss = 4.2%; threshold for interior forest = 100%					
2.25	1,751,185	1,622,303	128,883	7.4	1.76
7.29	1,430,336	1,284,095	146,241	10.2	2.43
65.61	463,821	371,477	92,344	19.9	4.74
590.49	8,814	7,008	1,806	20.5	4.88
5,314.41	0	0	0	0	0
B. Total forest loss = 4.2%; threshold for interior forest = 90%					
2.25	1,911,999	1,781,059	130,940	6.8	1.62
7.29	1,878,127	1,722,035	156,092	8.3	1.98
65.61	1,833,369	1,621,314	212,055	11.6	2.76
590.49	1,853,840	1,550,075	303,765	16.4	3.90
5,314.41	1,895,717	1,489,420	406,297	21.4	5.10

Table 3 Change in interior cove and mixed mesophytic hardwood forest types from 1992 to 2001. Percentage loss is relative to the amount of interior forest in 1992. Ratio equals percentage loss divided by total forest loss (e.g., 4.5/2.4 = 1.88)

Forest type	Scale	Interior forest 1992 (ha)	Interior Forest 2001 (ha)	Difference	Percentage loss	Ratio
A. Total forest loss = 2.4% (cove), 3.1% (mixed mesophytic); threshold for interior forest = 100%						
Cove	2.25	116,983	111,697	5,286	4.5	1.88
	7.29	101,686	94,485	7,201	7.1	2.96
	65.61	37,217	30,812	6,405	17.2	7.17
	590.49	279	219	60	21.5	8.96
	5,314.41	0	0			
Mixed mesophytic	2.25	404,022	381,217	22,805	5.6	1.81
	7.29	349,722	320,943	28,779	8.2	2.65
	65.61	134,703	109,432	25,271	18.8	6.06
	590.49	1,134	665	470	41.4	13.35
	5,314.41	0	0			
B. Total forest loss = 2.4% (cove), 3.1% (mixed mesophytic); threshold for interior forest = 90%						
Cove	2.25	122,432	117,522	4,910	4.0	1.67
	7.29	120,646	114,562	6,085	5.0	2.08
	65.61	116,010	106,691	9,319	8.0	3.33
	590.49	118,979	102,595	16,384	13.8	5.75
	5,314.41	123,806	99,772	24,034	19.4	8.08
Mixed mesophytic	2.25	428,159	406,467	21,692	5.1	1.65
	7.29	423,771	398,446	25,265	6.0	1.94
	65.61	416,314	383,081	33,233	8.0	2.58
	590.49	425,925	374,099	51,826	12.2	3.94
	5,314.41	439,505	369,391	70,114	16.0	5.16

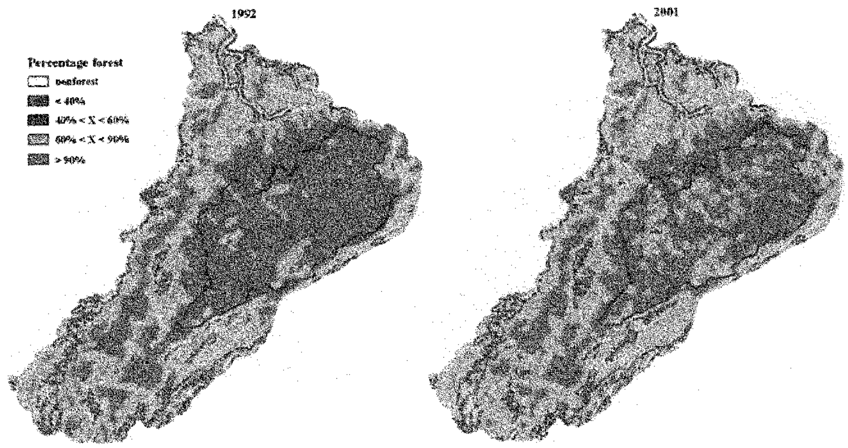

Fig. 3 Change in interior forest (90% threshold) at the 5,314.41-ha scale

related to sections 402 (point source discharges) and 404 (disposal of dredge and fill material) of the Clean Water Act, impacts on forest interior species, success of re-vegetation following reclamation, and other factors (USEPA 2005). The assessment did not consider possible impacts on the regional integrity of forest such as the loss interior forest. Our results indicate that interior forest loss is 1.75 to 5 times greater that the amount of forest loss attributable to mountaintop mining and that the ratio increases as the spatial scale of analysis increases. Similar ratios between interior forest loss and direct forest loss were found for cove and mixed mesophytic forest communities in the West Virginia portion of the study area.

Loss of interior forest in this study is not a loss of forest per se, but rather a change in the classification of forest from interior to edge. Fragmentation and introduction of edge change forest structure, composition, and ecological processes (Laurance et al. 2002; Harper et al. 2005). The condition and ecological functioning of forest changes from interior to edge. Forest edges have higher rates of atmospheric deposition (Weathers et al. 2001), higher proportions of exotic species (Harper et al. 2005), and fewer shade-tolerant taxa (Foster et al. 1998). Still, the effect of edges on forest is an emerging field (Harper et al. 2005), and one of the important issues is determination of ecological effects as a function of distance. Harper et al. (2005) reported edge effects that extended 100 m inward from the forest-nonforest boundary. Laurance et al. (2002) reported a maximum edge effect distance of 400 m, and Ramaharitra (2006) reported a maximum edge effect distance of 2,000 m. Our multi-scale analysis accounts for variability in the penetrating distance of the different edge effects reported in the literature. Edge effect distances of 100, 400, and 2,000 m are about equivalent to one-half of the side-lengths of 7 × 7, 27 × 27, and 133 × 133 30-m pixel windows, respectively. Our largest window size assumes edge effects from mountaintop mining penetrate approximately 3,650 m into adjacent forest. Future research may document edge effects penetrating 3.6 km into adjacent forest.

The spatially extensive character of forest in the Appalachians (Vogelmann et al. 2001; Riitters et al. 2002) provides the foundation for interior forest at large spatial scales. We estimate that mountaintop mining has changed between 1,806 and 128,883 ha of interior forest to edge (Table 2A), and the broader literature suggests that there are significant ecological differences between edge and interior forests. Our results also indicate that mountaintop mining is changing the spatial scale at which interior forest occurs in the region. At the 590.49-ha scale, interior forest occupied only 0.4% of the study area (8,814 ha) in 1992 and mountaintop mining eliminated about 20% of that very small proportion. It is not inconceivable that future activities will eliminate the remaining 590.49-ha scale interior forest, which would reduce the scale at which interior forest occurs in the region. The regional-scale loss of interior forest in Appalachia is of global significance because of the worldwide rarity of spatially extensive temperate deciduous forest (Riitters et al. 2000). Our results complement and extend the recently completed EIS (US EPA 2005) by quantifying an additional environmental impact and placing the impact in a global context.

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Reclamation Guidelines
for surface mined land

Powell
River
Project

How to Restore Forests on Surface-Mined Land

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Virginia Cooperative Extension Publication Number 460-123. Original 1992; Revised 2002; Updated 2009. *Pre-publication Draft.*

Introduction

Most coal-bearing lands in the Appalachian region were forested prior to mining. The region's forests are predominantly upland oak-hickory and Appalachian mixed-hardwoods. These forests provide many benefits to landowners and the public. Solid wood and paper products are perhaps the most tangible benefits, but a predictable flow of high-quality water from forested watersheds into regional streams is another vital benefit provided by the region's forests. Forests also fix carbon from the atmosphere; provide wildlife food and cover, recreational opportunities, and an aesthetically pleasing environment.

Surface mining completely removes the forest. Public Law 95-87, the Surface Mining Control and Reclamation Act of 1977 (SMCRA), mandates that mined land be reclaimed and restored to its original use or a use of higher value. Restoring forests on surface-mined land is challenging; however, reforestation research by Virginia Tech's Powell River Project since 1980 shows that restored forests can be equally or more productive than the native forests removed by mining. In addition, reforestation can provide low-cost and timely release of reclamation bonds for coal miners, and restored forests can provide economic returns to landowners.

The purpose of this publication is to provide practical, cost-effective guidelines to ensure successful forestland reclamation using the principles of reforestation silviculture. The following guidelines were developed from research and practical experience; they should help reclamation managers and landowners achieve reforestation success and renewal of the many benefits that forests provide.

These guidelines are consistent with the reclamation method known as the "***Forestry Reclamation Approach***" or FRA (Burger and Torbert, 1992. FRA reclamation was developed by the Virginia Tech Powell River Project and is advocated by the US Office of Surface Mining, the Appalachian Regional Reforestation Initiative (ARRI), and state reclamation agencies; and is consistent with SMCRA regulations throughout Appalachia and in the upper Midwest (see ARRI Publications 1 and 2).

Photo 1. A 50-year old hardwood forest on mined land.

Photo 2. A 16-year old pine forest on mined land.

Principles of Reforestation

The eastern deciduous hardwood forest with its hundreds of species of plants and animals is one of the most complex plant systems in North America. When land is surface-mined, the entire forest, including shrub layer, tree canopy, root stocks, seed pools, animals, and microorganisms, is removed. After mining and land reclamation, this complex forest, given enough time, will be restored to its original function and structure through a process called forest succession. Forest succession is a natural process whereby, following disturbance, the forest regains its original composition through a slow process of species replacement and site amelioration.

The original forest of oaks, hickories, basswood, dogwood, maple, Fraser magnolia, cucumber tree and other mid- to late-successional species is not instantaneously restored. Instead, pioneer species such as leguminous trees and shrubs and pine and hardwood species that can tolerate a wide range of acidity, fertility, moisture, and temperature become established first. The pioneer species will eventually yield to the more site-sensitive hardwoods. In the meantime, the mine soil is being conditioned, nitrogen and organic matter are being incorporated, populations of macro and micro plants and animals are increasing, a more diverse wildlife habitat is being created, and valuable wood products are being produced. The rate at which natural forest succession proceeds depends on the nature of the reclaimed site and adjoining undisturbed sites. We believe it would require several hundred years for the mid- to late-successional hardwoods to dominate if forest restoration were left entirely to nature.

The reforestation procedures recommended below are designed to accelerate forest succession while providing land stabilization and erosion control, bond release for the mining operator, and economic returns to land owners. A combination of grasses and legumes (used when necessary for erosion control), nurse shrubs and trees, and crop trees are established more or less simultaneously. Each plant type serves a specific reclamation function then yields to another plant type (Figure 1).

On sites reforested using these guidelines, tree-compatible hydroseeded grasses emerge first to quickly stabilize the mine soil surface. Grasses then yield to legumes when applied nitrogen is minimized. The slow-starting, ground-sprawling legumes (white clover, birdsfoot trefoil) allow trees to become established and grow before totally covering the ground. The legumes enrich the site and eventually give way to the tree cover. Nurse trees and shrubs condition the site for the crop trees and yield to the crop trees as they close canopy. This process of matching plant species to site conditions, matching plant species for their compatibility with each other in space and time, and managing tree stands to accomplish certain objectives as they develop, is called reforestation silviculture.

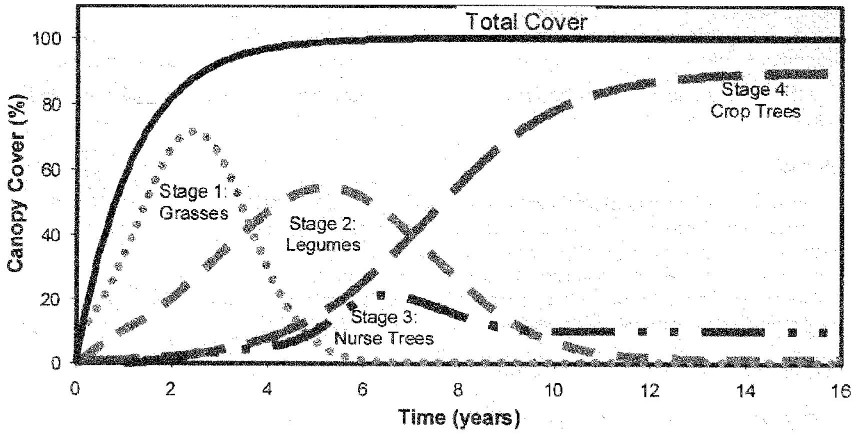

Figure 1. Reforestation silviculture seeks to stimulate natural processes known as forest succession. All vegetation types are established during reclamation. As time passes, grasses and legume groundcovers yield to nurse and wildlife trees, which are themselves overtopped by commercially valuable crop trees as the forest grows and matures.

Regulations and Performance Bonds

Most mined land planted with trees is designated as "unmanaged forest land" (or non-commercial forest land) in Virginia mining permits. Another forest land postmining land-use option is known as "commercial forest land" or "managed forest."

Several Appalachian states allow miners to define forested post-mining land uses as either "unmanaged" or as "managed" (or "commercial"). In Virginia, bond release requirements are similar for both commercial (managed) and unmanaged forest land, there are some subtle differences. Typically, unmanaged forest land is planted with both timber-producing species and wildlife and nitrogen-fixing shrub and tree species.

The "commercial forest land" option provides an opportunity to use alternative reclamation practices to achieve a wood-production forestry management objective and restore the original composition of the native forest. For commercial forestry, a minimum stocking of 400 trees per acre of native, commercial species is required, in addition to 40 wildlife trees or shrubs per acre. As with any land-use designation, the coal company must submit a simple management plan that explains how the proposed postmining land use is to be achieved. Additionally, a copy of the comments by the landowner concerning the proposed use must be submitted. These documents are required to show that the landowner is committed to the proposed commercial forestland, and that it can be reasonably achieved.

The guidelines offered in this bulletin were developed to increase the probability of timely performance-bond release as well as to ensure the establishment of productive forests. Regulatory requirements in this publication are specific to Virginia, but the general guidelines are applicable to reclamation in surrounding states. In Virginia, performance criteria for bond release can be achieved for forestland. Virginia DMLR Guidance Memorandum 22-08 reviews information relevant to regulatory compliance for forested post-mining land uses in Virginia.

Of particular importance are requirements relative to final surface grading, ground cover, and number of trees per acre.

Permitting

Successful reforestation, from a regulatory standpoint, starts with the mining permit. Ideally, all stakeholders including the coal operator, landowner, regulators, and consulting service providers are involved in permit writing and review. All should know and understand the approach, process, and expected result of the revegation and reforestation plan. Regulatory authorities will reference the mining permit when judging reclamation success. Mine permitting for productive reforestation is discussed in VCE Publication 460-141.

Mine Soil Selection and Placement

Federal and state regulations require natural soil, existing on sites prior to mining, be saved and placed on the reclaimed mine site after reclamation. This rule is waived for coal operators working on steep terrain where soil is shallow and difficult to recover, and when operators can show that topsoil substitutes are as good or better for the post mining land use as the original soil. Contemporaneous reclamation close to the mine pit reduces haulage costs and allows cost effective use of native soil on reclaimed surfaces. When needed, topsoil substitutes, usually consisting of a mix of overburden materials, must meet certain physical and chemical criteria in order to be a suitable growth medium for plants. Those criteria are different for native trees compared to criteria for commonly-used agricultural grasses. For native hardwood trees, topsoil substitutes should be neutral to slightly acid, sandy and loamy in texture, loose and well-aerated for good drainage, fertile without excessive saltiness, and the selected material should be 4 or more feet deep. For forestry post-mining uses, and when FRA procedures are used, regulations in Virginia and most Appalachian states allow rougher, looser, surface soils containing organic debris in order to produce mine soil characteristics conducive to good tree survival and growth.

Final Surface Grading

In the past, establishment of smoothly-graded slopes with lush vegetation during the first year was a goal for many reclamationists. Unfortunately, land reclaimed in this way is often compacted by excessive grading, and the ground cover vegetation is too dense for tree establishment. Most Appalachian forested landscapes are uneven, and many are strewn with rocks and boulders. Natural forest soils are rough and loose, allowing deeply-rooted woody species to become established and grow unimpeded.

Surface grading requirements and regulations vary by state but all Appalachian state regulatory agencies and US Office of Surface Mining support and encourage use of the "Forestry Reclamation Approach" reclamation methods which include low-compaction grading.

In Virginia, the Virginia Coal Surface Mining Control Reclamation Act of 1979 specifies that graded backfills "support the approved postmining land use." Compaction is only necessary "... where advisable to ensure stability..." (480-03 -19.816.102). Therefore, on level areas and short, gentle slopes, grading should be minimized to avoid surface soil compaction. After groundcover and tree establishment, small to medium gullies need not be filled unless they are associated with sedimentation problems or grow to the point where they would hinder forestry operations. Small to medium gullies may interfere with hayland/pasture uses, but do not interfere with forestry and wildlife habitat as they fill in and stabilize naturally. Minesoil compaction resulting from gully repair is counterproductive to successful reforestation.

Ground Cover Establishment

The SMCRA and its federal regulations require vegetative ground cover to be no less than that required to achieve the approved post mining land use and control erosion. Virginia Division of Mined Land Reclamation has issued a regulation that effectively eliminated the former 90 percent ground cover standard for mine sites on areas where the FRA is implemented. This regulation calls for minimizing ground cover competition with woody plants by limiting ground cover to that necessary to control erosion and support the post mining land use. A similar regulation is in place in Tennessee. As of this writing, a number of other states in the Appalachian Region are considering similar changes. Mining firms outside of Virginia are encouraged to check with their State Regulatory Authority concerning the current ground cover standard for success.

Number of Trees per Acre

In Virginia, the number of trees per acre and species selection differs between commercial forestland and non-commercial forestland. For commercial forestland, there must be at least 400 commercial trees/acre plus 40 wildlife trees or shrubs (a minimum of 440 trees/acre) for bond release. In Virginia, white pine is a common commercial species. Mixed hardwoods, including oaks, hickories, ashes, maples, and black cherry, and eastern white pine are commonly planted species that are considered commercial species. For non-commercial forest land, there must be at least 400 trees/acre, of which at least 40 must be wildlife trees or shrubs. Native invading trees count toward bond release if they are species suitable for the post-mining land use defined in the mining permit and at least one foot tall. Planting 550 crop trees and 60 to 100 wildlife or "nurse" trees per acre should achieve these required stocking densities, if soils and groundcover vegetation are compatible with tree establishment.

Table 1 summarizes the reforestation plan components and reclamation activities that must be executed properly to assure tree survival rates adequate to achieve bond release. Each of the reclamation activities is reviewed in detail in the text that follows.

Table 1. Major reclamation activities that, if executed properly, should assure planted seedling survival rates and tree counts adequate for bond release.

Reclamation Activity	**FRA**[a]	**Rationale**
Prepare the land for reforestation using the forestry reclamation approach: ✓ Use soil and topsoil substitutes suitable for trees and place at least 4 feet deep;	1 2	Land preparation using FRA procedures will produce loose soils of good quality that aid proper tree planting, help planted trees survive and grow at expected rates, and aid establishment of native volunteer plants.
✓ Avoid compaction by minimizing grading and leaving soils loose ; ✓ Use tree compatible groundcover when necessary to control erosion with low N and high P fertilization.	3	For forestry post-mining land uses, agricultural grasses and legumes are used only as needed to control erosion. Minimizing ground cover with tree-compatible species increases survival and growth of planted and volunteer species.
Select species that are best suited to the soil properties and landscape conditions that occur on the mining site.	4	Site conditions vary across the reclaimed area. Using species adapted to conditions, and grouping species where they are suited will increase survival and growth rates.
Use tree planters who are knowledgeable and skilled, and assure that they use good seedling stock, properly care for the seedlings from nursery to planting, and useand use planting rates adequate to achieve bond release.	5	Proper care of seedlings before and during planting, and use of proper planting procedures, is essential to achieving adequate survival.
Example:		
Select 5 crop tree species, 110 each per acre = 550 crop trees per acre. .		550 crop trees + 100 wildlife/nurse trees = 650 trees per acre total.
Select 4 wildlife/nurse tree species, 25 each per acre = 100 trees per acre.		If overall survival is 70%, 455 surviving trees per acre will assure bond release.

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[a] The Forestry Reclamation Approach is made up of 5 "steps" or procedures which are consistent with these guidelines (see ARRI Publication No. 2); the "FRA" column designates steps of the Forestry Reclamation Approach that correspond with these procedures.

Selecting Mine Soil Material

Carefully-constructed mine soils can be as deep and fertile as natural soils. Natural soils in steeply sloping areas of the Appalachians may be difficult to recover, store, and replace during reclamation. "Topsoil substitutes" containing large amounts of blasted overburden materials are allowed by law in some cases and can be used successfully as plant-growth media provided they are of equivalent or better quality than the original soil. But in order to be as productive as natural soils, the spoil materials must have desirable physical and chemical properties that are suitable for good growth of deeply-rooted trees. Natural soil should be recovered and used to the extent possible, even as a mixture with overburden materials. When natural soils are not recoverable or insufficient in quantity, the surface four feet of mine soil material should be easily-*weatherable* overburden, meaning that most rocks and boulders break apart and decompose quickly to fine soil materials. The soil texture of the fine-earth fraction should be loamy to sandy, and the mine soil should be low in total salts; mine soils should be moderately acid (pH 5.5 – 6.5) when native hardwoods are being planted. Most importantly, the mine soil must also be left uncompacted to a depth of four feet.

Trees have different mine soil requirements than forage grasses and legumes. Most grasses and legumes can tolerate compacted surfaces, high pH levels, and high levels of soluble salts; trees cannot. Even if trees survive under these mine soil conditions, they will not grow well. Trees require soils depths of at least several feet, while grasses can thrive in thinner soils because most of their roots are close to the surface.

As demonstrated by Photos 3, 4, and 5, mine soil properties can have a major influence on the growth of planted trees.

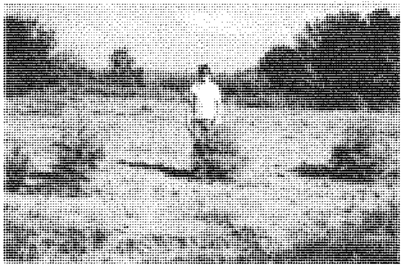

Photo 3. Eight-year-old white pine growing in compacted, unweathered shale mine soil.

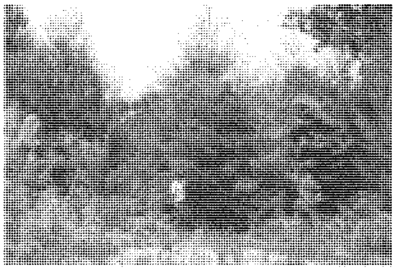

Photo 4. Eight-year-old white pine growing in loose weathered sandstone mine soil.

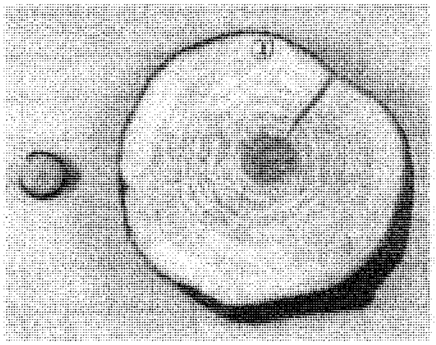

Photo 5. Cross-sections of 8-year-old white pine trees growing on compacted shale mine soil (right), and loose sandstone mine soils (left) (grid line spacing 1 inch).

Brown, oxidized sandstones, often found in deep layers near the land surface throughout the Appalachians, make excellent mine soils for trees provided they are not too acidic (in rare cases they may contain pyrite or high concentrations of manganese). Research studies and many observations of reclaimed sites in Virginia, West Virginia, and Kentucky show that tree survival and long-term growth is excellent on oxidized, moderately-acid, mixtures of brown, weathered sandstone mixed with some siltstone/shale materials (Burger and others 2007). This rock mixture provides good drainage, aeration, and fertility, and when mixed with native soil, the added organic matter and soil organisms provide an all-important biotic component that adds life to the new mine soil. In general, siltstone and shale that occur directly above or below coal seams should be avoided. These rock types usually have high levels of soluble salts, a high pH or a very low pH, and compact to greater densities when trafficked. Some of the white or blue-gray unweathered sandstones that occur further below the surface will be less productive but are acceptable for forest land when these are the "best available materials" on the mine site. However, these spoils weather very slowly and should only be used when native soil or brown, weathered sandstone and siltstone are not available.

All native topsoils should be recovered and used when possible, and mixing even small amounts of fresh soil with overburden will improve the site's suitability for trees. Fresh topsoil typically harbors seeds and roots of tree and shrub species that can grow into viable seedlings when conditions are right. Fresh, native soil aids seedling survival, as beneficial fungi and microorganisms help seedlings obtain water and nutrients. In places where the soil handling cost makes it impractical to obtain large amounts of fresh soil for use in reclamation, small amounts of soil (a truck load here and there, placed so it can be distributed during grading) will aid reforestation success. Spoil selection guidelines for reforestation are summarized in Figure 2 and Table 2.

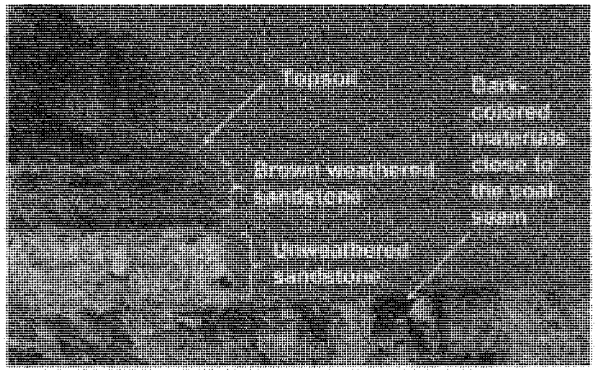

Figure 2. Overburden materials differ in suitability for use as reforestation growth media (Table 1).

Table 2. General Guidelines for Selecting Reforestation Soil Materials (E = Excellent, G = Good, F = Fair, P = Poor, should be avoided).

Material	E G F P	Comment
Topsoil	X	Includes anything that can be removed with a dozer prior to blasting. It can be mixed with other materials, even in small quantities, to provide organic matter, beneficial microorganisms, fungi, and nutrient pools.
Brown Weathered Sandstone	XXX	Includes top 20-30 feet of rock material on most sites; can be used alone or mixed with suitable materials from deeper in the overburden sequence.
Unweathered Sandstone	XXXX	Materials that break down into smaller particles and achieve pHs in the range of 5.5-6.5 are very good. Sandstones that are hard (durable) and do not form soil materials and/or alkaline (maintain pH's > 7) should be avoided unless no better materials are available.
Unweathered Siltstone and Shale.	XXX	Usually a poor choice when used alone; can be mixed with unweathered or weathered sandstones to form good-to-excellent reforestation materials.
Rocks from directly above or below the coal seam	X	Generally high in soluble salts and a poor choice for reforestation, even when mixed in significant ratios with more favorable materials. Black shales and siltstones especially poor for reforestation.
Rocks containing pyrites or high levels of metals	X	Any material that stabilizes at pH<4.5 should be avoided. pHs of > 5.5 but < 7.0 are preferred.

Note: the term "mixed" as used above refers to the intermingling of rock materials that occurs routinely during operations such as blasting, loading, hauling, and dumping. These are general guidelines that can be applied with overburdens typical of southwestern Virginia's coalfield. On some mining operations, specific overburden materials may have properties that are not well suited for these general guidelines.

Placing and Grading Mine Soil Material

Reclaimed mine soils must be left loose and uncompacted to ensure successful establishment and long-term growth of trees. Prior to seeding ground covers, reclaimed sites are often cleared of large boulders, gullies are filled, and the surface is graded smooth and "tracked in" with bulldozers to create a seedbed for ground covers. Smooth-graded, tracked-in spoils are very undesirable for tree establishment and long-term forest growth. Powell River Project research shows that mine soil compaction is the single factor most limiting to reforestation success on older mine sites in central Appalachia. When soils are excessively graded and tracked in, trees are often not planted deeply enough because of the physical effort required to open a suitable planting hole. This results in poor survival and permanently reduces the mine soil quality. Compacted mine soils reduce water infiltration, reduce plant available water, increase sheet erosion, and restrict root growth.

When forest land is the post-mining land use, grading should be limited to the extent needed to shape the final landform and ensure the stability of slopes. On level and gently sloping areas, spoil placement should be planned so that once a pile is dumped in place, no more equipment passes over it except for a final, light grading with a small dozer. Mine soil compaction can be minimized by grading when mine soil materials are dry and using small dozers with low ground pressures. Natural forest land in the Appalachians is usually rougher than pastureland. Reclaimed forestland with boulders and uneven surfaces will not adversely affect forest management activities. When "topsoil" from the pre-mining forest is available for use in preparing the final surface, leaving any stumps, logs, or other woody debris that is in that topsoil on the final land surface will aid reforestation.

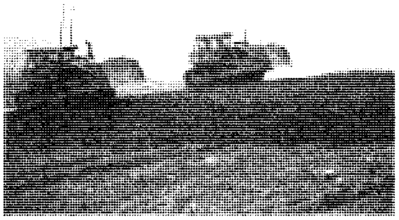

Photo 6. Typical grading and tracking-in operations for non-forest post-mining land uses.

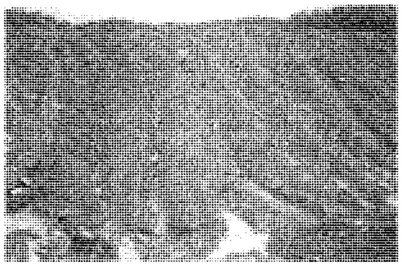

Photo 7. Example of uncompacted, roughly graded surface ideal for tree planting.

Using Tree Compatible Groundcovers While Controlling Erosion

Grass and legume ground covers are typically seeded with fertilizer and mulch hydromixes. Even though trees are being planted, these herbs are sometimes needed to reduce erosion and stabilize sloping terrain. Commonly-used agricultural grasses and legumes are not natural components of forest ecosystems in this area. Trees planted in aggressive, tall, heavily-fertilized ground covers usually fail because they are overcome by the ground cover. When forestland is the intended land use, reforestation requires a carefully-planned balance between ground cover for erosion control and the trees' requirements for light, moisture, and space. Forage species commonly used to create hayland or pasture such as K-31 tall fescue and red or sweet clover are not compatible with trees; they grow too tall and too dense for trees to emerge.

A tree-compatible ground cover mix should include annual and perennial grasses and legumes (Table 3) and should be used only as needed to control erosion at acceptable levels. Because soil conditions typically differ across the site, species adapted to a variety of site conditions should be included within the mix.

Table 3. Recommended groundcover seeding and fertilizer application rates for reforestation of reclaimed lands.[a]

Species/Fertilizer	**Rate (lbs/acre)**
Grasses:	
foxtail millet (spring seeding only)	5
annual ryegrass (fall seeding only)	10
timothy	5
perennial ryegrass	10
orchard grass (steep slopes only)	5
Legumes:	
birdsfoot trefoil	5
ladino or white clover	3
Fertilizer[b]*:*	
nitrogen	50 to 75
Phosphorus (as P)	80 to 100
(as P_2O_5)	180 to 230

[a] For further detail, see VCE Publication 460-124.

[b] Can be achieved by applying 400 lb./acre di-ammonium phosphate, by blending 200 lbs/acre concentrated superphosphate with 300 lbs/acre 19-19-19 fertilizer, or with other fertilizer blends.

Annual grasses such as foxtail millet (*Setaria italica*), and annual ryegrass (*Lolium multiflorum* Lam.) provide quick, initial protection to the surface by reducing the impact of raindrops and minimizing soil movement. Foxtail millet is the preferred annual grass to use for spring or summer seeding; annual ryegrass should be used for fall seeding. These grasses germinate quickly and provide good cover during the first year. Since most annual grasses are tall, they must not be so dense as to adversely block light from tree seedlings. The limited shade and protection from wind provided by these annual grasses reduce seedling moisture stress. Rye grain and wheat grain should not be used in groundcover mixes for hardwood plantings. Their grain production attracts rodents that chew the bark of seedlings thus killing them. If a heavier-than-normal groundcover is desired for reforestation due to a localized circumstance, the annual ryegrass seeding rate can be increased up to 20 lbs./acre, although the 10 lb/acre rate of Table 2 should be adequate to control erosion on most Virginia mine sites when the surface soils are left in a loose condition as is recommended for reforestation.

After the first growing season, slower-growing perennial grasses and legumes should satisfy ground cover requirements. They should be adapted to low pH and fertility levels, and most grasses should be cool-season species to reduce competition with trees for moisture during mid summer. Perennial ground cover species should not grow so tall or dense that the establishment of trees is hindered. Perennial ryegrass (*Lolium perenne*) and timothy (*Phleum pratense*) are low-statured grasses that become established on relatively acid, infertile soils. They are quickly established and decline after several years, providing space for developing legumes.

On long steep slopes, orchardgrass (*Dactylis glomerata*) can be included to provide additional protection against erosion. Kentucky-31 tall fescue (*Festuca arundinacea*, 'K-31') should not be used with trees. Kentucky-31 tall fescue competes excessively for light and moisture, it produces allelopathic substances (phytotoxic chemicals) that retard tree growth, and it attracts rodents that chew on the stems of trees.

Weeping lovegrass (*Eragrostis curvula*) is tolerant of very acid spoil and germinates within a few days, thus contributing to early erosion control. Where pockets of acidic spoils (pH < 4.5) are present, weeping lovegrass can be added to the reforestation ground cover seeding mix at low seeding rates (~2 lbs/acre).

A leguminous ground cover can enhance soil nitrogen (N) levels by as much as 50 lbs/acre/year. Legumes, in conjunction with *Rhizobium* bacteria, enhance the nitrogen status of the soil by fixing atmospheric nitrogen. Nitrogen released by decomposition of legume foliage and sloughed roots quickly becomes available to trees. Birdsfoot trefoil (*Lotus corniculatus*) is a perennial legume that has performed well in numerous research studies and on operational sites on mine soils in Virginia. The `Fergus' variety of birdsfoot trefoil is better adapted to Virginia than most of the northern varieties. Birdsfoot trefoil and white clover are a good combination since they are cool-season plants and are tolerant of moderately acid soils. This combination provides an actively-growing ground cover from spring through the fall season. Kobe lespedeza (*Lespedeza striata var. Kobe*) is a low-statured annual legume that can be added to the reforestation seeding mix at low rates (3-5 lbs. per acre) if a heavier-than-normal groundcover is desired for reforestation due to a localized circumstance, although it is not a necessary or desirable addition to the above seeding mix for reforestation on most Virginia mine sites. Serecia lespedeza (*Lespedeza cuneata*), formerly widely used in reclamation, is not an acceptable legume for use in reforestation; it is too tall and competitive, and it has become an invasive weed throughout the coalfields.

As a group, the clovers are less suitable for reforestation ground covers. Most clovers require soil pH and fertility levels that are higher than needed for trees, and most clover species are too aggressive during the first year to be used with trees. An exception is white or ladino clover (*Trifolium repens*); it is tolerant of acidic mine soils and produces a short cover that does not excessively compete with tree seedlings. It produces good cover for the first two years and then yields to the birdsfoot trefoil.

Photo 8. Example of non-competitive, tree-compatible ground cover.

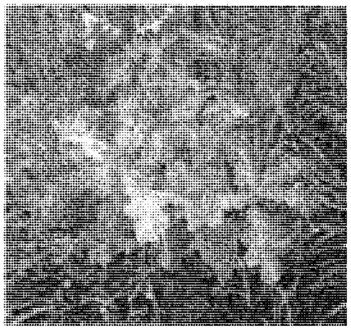

Photo 9. Example of competitive ground cover compromising the survival of trees.

Importance of Using Tree-Compatible Ground Covers

Unlike standard hayland and pasture forages that are lush during the first year and gradually decline without additional fertilizer, tree-compatible covers are designed to be sparse during the first year and become increasingly dense by the second and third years. This allows tree seedlings to emerge above the ground cover and aids their survival.

Despite relatively-low recommended seeding rates, sufficient ground cover can be achieved for partial bond reduction during the first year. Most of the first-year cover results from the annual grasses, while the legumes dominate after several years. Birdsfoot trefoil and white clover emerge slowly by producing only a few plants per square foot, and these plants are generally less than six inches tall after the first season. By the third season, however, they develop into a complete cover replacing the grass and filling in under emerging trees. These legumes persist beneath the trees, increasing organic matter and nitrogen levels for several years until they are eventually shaded out by trees.

Another purpose of low ground cover seeding rates is to allow the invasion of native plant species such as yellow poplar, red maple, birch and other light-seeded trees. Dense ground covers prevent the natural "seeding-in" of native plants. An additional benefit of a tree-compatible cover is that some tree and shrub species can be established by direct seeding. When conventional ground covers are used, direct-seeded trees will not emerge and survive due to dense shading.

For further information on reforestation groundcovers, see Powell River Project / VCE Publication 460-124, "Establishing Ground Cover for Forested Post-Mining Land Uses."

Tree Species Selection

A sufficient number of desirable trees must be established during reclamation in order to achieve multiple uses from a developing and mature forest. Two categories of tree species are recommended:

1. "Crop" trees: commercially-valuable, native, "timber crop" species, and
2. Nurse trees/wildlife trees: Trees and shrubs that fix nitrogen and/or attract wildlife, including birds.

Crop trees are long-lived species that offer value to landowners as saleable forest products.. Yellow-poplar (*Liriodendron tulipifera*), oaks (*Quercus* spp.), ash (*Fraxinus* spp.), maple (*Acer* spp.) and other hardwood species are commonly planted as crop trees on mining operations that are reclaimed using the Forestry Reclamation Approach. Nurse trees are planted to assist the crop trees by enhancing the organic matter and nitrogen status of the soil and improving soil physical properties, and by attracting seed-carrying wildlife such as birds on to the site. Nurse trees will die or can be cut out after 15 to 20 years when crop trees need additional growing space. Nurse trees help achieve the minimum number of stems and ground cover required for bond release, and they provide food and cover for wildlife. Recommended nurse species are flowering dogwood (*Cornus florida*) redbud (*Cercis canadensis*), blackhaw (*Viburnum prunifolium*), native crabapple or hawthorn (*Rosacea* species) shagbark hickory (*Carya ovata*), and white pine (*Pinus strobus*). Black locust (*Robinia psuedoacacia*) and autumn olive (*Elaeagnus umbellata*) were commonly used in the past, but are not recommended today. Autumn olive, Russian olive (*Elaeagnus angustifolia* L.) and related species, and bicolor lespedeza (*Lespedeza bicolor*), are non-native species that are listed as invasive in Virginia and neighboring states (Miller and other 2008) and should be avoided.

Crop Tree Selection

Hardwoods: On well-constructed mine soils, most native hardwood species grow well. The critical factors that affect survival and growth of trees are spoil type, compaction, slope aspect and position, and competition from ground cover grasses and legumes. Ideally, these factors should be optimized during the reclamation process as described above. Most reclaimed sites, however, contain a variety of soil conditions. A key to successful reforestation with hardwoods is tailoring the species to mine soil conditions. Tree species can and should be selected to "fit" the final combination of conditions found on a reclaimed site. For example, hardwoods recommended for good sites are red, white, and black oak, tulip-poplar, sugar maple, black cherry, and white ash. When available, blight-resistant American chestnut hybrids are also recommended as part of the native hardwood species mix. Sycamore, green ash, and red maple are more tolerant of sites that are compacted, poorly drained, or have minesoils primarily derived from siltstones or shales (Figure 3).

Photo 10. Northern red oak crop trees on mined land after 55 years.

Slope aspect and position (Figure 4) influence water availability through the growing season. The best sites for the most water-demanding trees and the most valuable species are slopes with a north and east aspect and a position toward the toe of the slope. Red oak, sugar maple, and tulip poplar are examples of species that should be planted on such sites. Southwest aspects toward the tops of slopes are the driest; therefore, drought-tolerant hardwoods such as scarlet and chestnut oaks should be planted in these positions. Good tree planting contractors can do site-specific tree selection and planting. Site-specific planting should be specified and described in mining permits and tree planting contracts.

Competition control of ground covers is also critical for reforestation success regardless of other conditions. Spot or row spraying with herbicides must be done when ground cover grasses are aggressive and competitive.

Many minesoils are excessively wet during much of the growing season because of poor internal drainage or because of compacted layers that perch water. Most high-value crop trees are intolerant of wet soils; however, sycamore (*Platanus occidentalis*), eastern cottonwood (*Populus deltoides*), and black alder can tolerate wet sites and should be used under these conditions.

On very low-quality sites, with limitations due to compaction, acidity, or high soluble salt levels, the concept of selecting a long-term "crop tree" should be abandoned. Emphasis should be placed on stabilizing the site with trees and shrubs that are commonly used as nurse trees. As already mentioned, sycamore, green ash, and black alder are suitable for wet sites. Black alder and bristly locust are both tolerant of very acid sites.

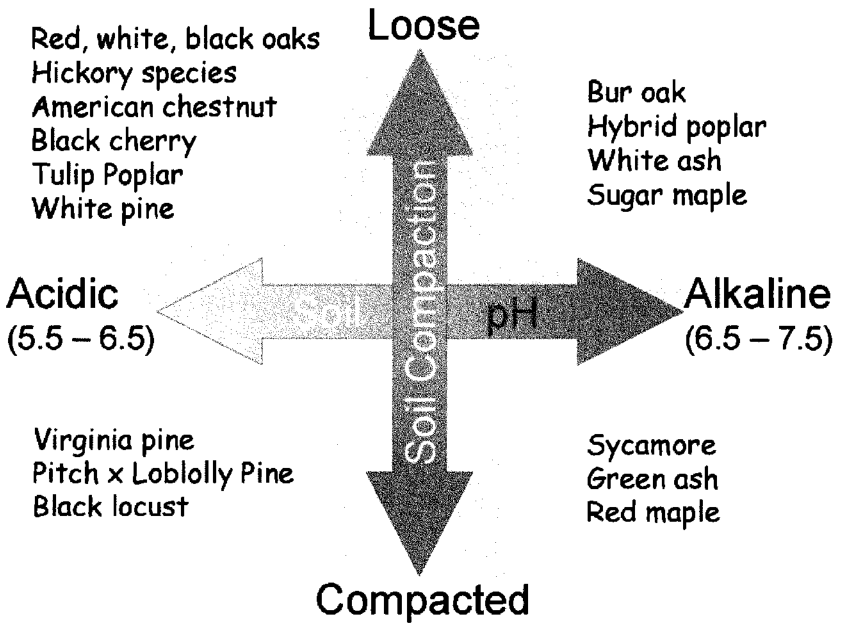

Figure 3. Tree species recommended for different spoil types and levels of compaction.

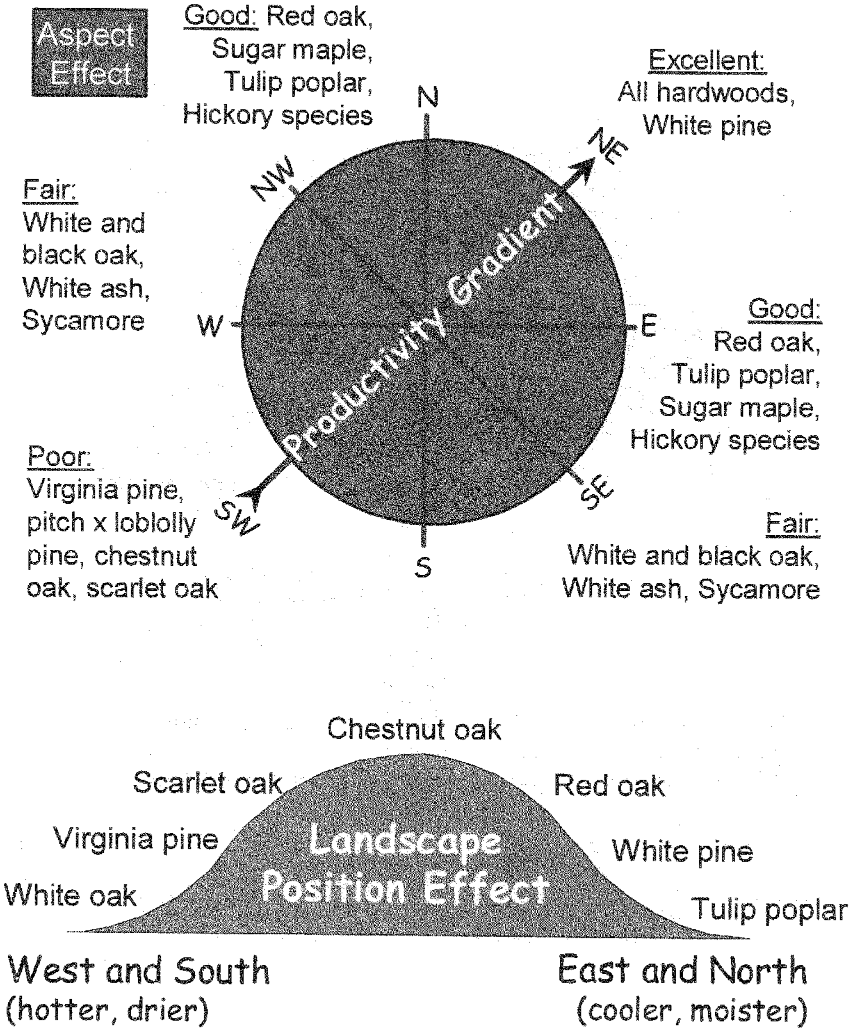

Figure 4. Tree species recommended for different slope aspects (above) and positions (below).

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Pines: On good sites, white pine can produce more merchantable volume than any other native species. White pine on a 12 x 12 to 15 x 15 foot spacing (200-300 trees/acre) can produce merchantable timber in 30 to 40 years (Balmer and Williston, 1983). However, white pine requires higher-quality sites than other pines. White pine should be planted in areas that have at least four feet of uncompacted soil. It does best on deep, brown, well-drained, sandy mine soils.

On sites that are unsuitable for white pine or quality hardwood growth due to depth, acidity, salinity, or drainage, other pine species can be planted. On shallow sites, or sites with a large amount of coal refuse, Virginia pine (*Pinus virginiana*) and loblolly pine *(P. taeda*) are good choices for crop trees. Both species are more drought-tolerant than white pine. Virginia pine is an excellent pulpwood species that is native to the region and is adapted to harsh sites. It has a shallow root system, which makes it a suitable species for shallow soils. It is also tolerant of acid mine soils with pH levels as low as 4.0. Loblolly pine is not native to the mountainous regions of Virginia, but it has been successfully planted and grown on many reclaimed sites. Some winter damage has been reported in the northern part of Virginia's coal mining region, but the problem seems to be no more severe than in the northern Piedmont of Virginia where loblolly pine is grown commercially. Good stands can produce pulpwood and sawtimber-sized trees in 20 to 40 years. Pitch x loblolly pine hybrid (*P. rigida x taeda*) may be the best commercially valuable pine species for planting on dry mine soils because of its tolerance to a variety of soil and site conditions and because of its rapid growth. It is a cross between loblolly and pitch pine, which is native to the region. It has the rapid growth rate and good form of loblolly pine, and the coldhardiness and strength of pitch pine. Loblolly pine, pitch x loblolly, and Virginia pine are more susceptible to damage by the southern pine beetle than white pine.

Wildlife/Nurse Tree Selection

The nurse tree and nurse shrub species recommended for reclamation planting are N-fixing plants that benefit crop trees and provide food and cover for wildlife. Nurse trees contribute to ground cover requirements and help stabilize the site. Recommended species include flowering dogwood (*Cornus florida*) redbud (*Cercis canadensis*), blackhaw (*Viburnum prunifolium*), native crabapple or hawthorn (*Rosacea* species) shagbark hickory (*Carya ovata*), and white pine (*Pinus strobus*). Dogwood, redbud, blackhaw and hawthorn produce soft fruits for wildlife, shagbark hickory provides nesting habitat for the endangered Indiana bat, and with pine provides winter cover for a variety of wildlife. Historically, black locust was the most commonly planted nurse tree species in Virginia. Black locust is easily established and grows rapidly; unfortunately, it is very competitive and should not be planted with crop trees in a commercial forest mix. Black locust is too aggressive and the thorns on its branches can damage the branches and terminal leaders of adjacent trees. European black alder (*Alnus glutinosa*) is non-native, but it fixes nitrogen and tolerates salty, acidic sites. It grows nearly as rapidly as black locust but is less competitive and has no thorns. It is very susceptible to sooty mold and anthracnose fungi and usually succumbs to these pests by age 10 in most areas of the Appalachian coalfields.

Establishing Trees

Planting Contractors

The successful establishment of trees is highly dependent on selecting good nursery stock, proper handling before planting, and proper procedures during planting. In most cases, tree planting is best left to a professional tree planting crew that guarantees their work in a written contract. With proper, long-range planning, a good professional tree planter will arrange for seedling production at nurseries, plant at the appropriate time, and do follow-up inspections to ensure survival.

Photo 11. A professional tree planting crew in action on a mine site.

Seedling Procurement

Most states in the Appalachian coalfield maintain state nurseries that grow and can supply seedlings for a variety of tree species in large quantities at reasonable prices. A number of commercial outlets for tree seedlings are also available. For best results, seedlings should be obtained from a grower within the general area (i.e. within the state or an adjacent state) and with climatic conditions similar to the planting site. Companies knowing in advance that they will require large numbers of seedlings can work with state nurseries or commercial suppliers a year or more in advance to assure that the seedlings of desired species are available when needed. Most commercial tree planters will also procure and provide the seedlings, if that service is included in the tree-planting contract. Working with the tree-planting contractor to procure the seedlings has the advantage of placing full responsibility for successful planting with the tree planter.

Virginia residents can purchase a variety of tree species from the Virginia Department of Forestry (VDOF). Many species from the state nursery are grown from genetically superior seed and should perform better than other seed sources on Virginia mine soils. If planting is managed directly by coal companies, supervisors should work carefully with their local VDOF forester in ordering and picking up seedlings.

A common reason for poor seedling survival is that planting crews pick up more seedlings than they can reasonably plant within a short period of time. If planting crews cannot keep seedlings in cold storage until planting, they should arrange with the supplier to pick up smaller numbers of seedlings on a more frequent basis.

Use Healthy Seedlings

Seedlings should be graded prior to planting so that only healthy seedlings are used. Healthy pine seedlings should have a root collar diameter of 4/32 to 9/32 inches. Very small pine seedlings (under 4/32 inches diameter) and very large seedlings (over 10/32 inches in diameter) do not survive well. Very large seedlings are difficult to plant correctly. Root pruning is not recommended; there is a tendency to chop off too much of the root system. With root pruning now being done in the nursery beds, none is needed at the planting site. Overall survival is better when no root pruning is done by tree planters. Seedlings should not be planted if the roots are dry. Air-dried roots have less growth potential than roots that remain moist.

Seedling Storage

Proper seedling storage and handling before planting is critical to ensure good survival and growth. Seedlings must not be allowed to get hot or dry. If planting is delayed, the bags of seedlings should be wetted and roots dipped in a moisture-retaining gel specifically designed to keep roots from drying. The seedlings should then be rebundled and placed in cold storage (32-36° F) for no more than four weeks. If cold storage is not possible, they should be stored in a cool damp basement for no more than a week. At temperatures over 40°F, mold develops and seedlings are killed. Without cold storage, it becomes more important to dampen the roots as soon as they are delivered.

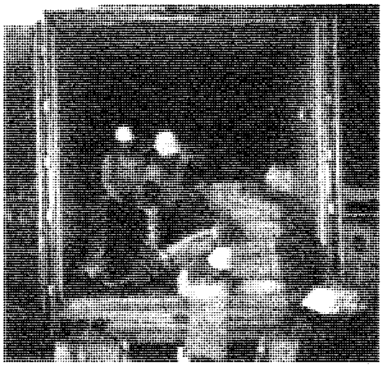

Photo 12. Proper storage and handling of seedlings is critical to reforestation success.

Photo 13. Roots of seedlings must be kept moist prior to planting.

Tree Planting

Seedlings should be planted as soon as possible in late winter or early spring (February-April) after the ground has thawed. Early planting is preferred because the soil is usually wetter and more conducive to root growth. Root growth decreases during periods of rapid shoot elongation; therefore, it is important that the seedlings be planted early in the season so roots can become established before the weather turns warm enough for shoot growth to begin. During planting, crew leaders need to make certain that planters do not expose roots to the air by carrying seedlings in their hand. Seedlings should be carried in a planting bag and not removed until the planting hole is opened. Planting holes must be opened deeply enough so that the roots can be evenly spread in the hole. Seedlings should be planted about one inch deeper than grown in the nursery. Finally, the planting hole must be completely closed since any air spaces around the roots will cause those roots to die.

Mine operators are advised to plant enough trees to assure survival that is adequate to achieve bond release. When a competent tree planting contractor plants healthy seedlings on a site that has been prepared properly for reforestation and summer conditions are not excessively dry, survival rates of >70% should be achieved. If 650 trees per acre are planted and achieve 70% survival, the 455 surviving trees per acre will easily meet bond release requirements for forest land. Planting on an 8 foot x 8 foot spacing will require 650 trees per acre.

Photo 14. Seedlings must be planted properly in order to survive.

Supervision

Planting crews should be given instructions on proper techniques prior to planting, and crew leaders should start quality checks immediately so that needed corrections can be made before much of the area is planted. In Virginia, the VDOF will do planting-quality checks for landowners or operators who want to verify and/or improve seedling survival. This involves careful lifting of planted seedlings on random plots to check on seedling health, tightness, depth of planting, straightness, spacing, and density. Seedlings are carefully replaced after each one is inspected.

Establishing Trees When Dense Ground Cover Is Present

Sometimes it is necessary to establish trees in an existing cover of dense grasses or legumes such as K-31 tall fescue or Serecia lespedeza. In order to ensure survival and good growth, herbicides and slow-release fertilizer pellets are highly recommended. Chemical weed control (herbicides applied via backpack sprayer) helps maintain the seedlings free of overtopping competition. By controlling dense vegetation with herbicides, seedlings will receive adequate sunlight and more soil water to ensure their survival. In conjunction with weed control, slow-release fertilizer pellets can speed growth during the first few years to help the trees grow above surrounding grasses. Fertilizer pellets should be placed in the closing hole about two inches from the roots during planting. Fertilizer pellets slowly decompose and release nutrients needed by the trees. By using pellets it is possible to selectively fertilize seedlings without fertilizing surrounding grasses. Although fertilizer pellets are usually not available locally in the coalfields, they can be obtained from regional or national forestry-product supply companies that can be located through the internet; these companies routinely ship products to purchasers throughout the country.

Herbicide technology changes rapidly. New chemicals appear on the market annually and herbicide labels and regulations change almost as quickly. For these reasons, a timely discussion of best herbicide treatments is not possible. Contact your local county extension agent, or local VDOF forester in Virginia, for current recommendations of specific herbicide products and application rates.

Hydroseeding Trees

Some nurse species can be hydroseeded with the ground cover provided an appropriate ground cover mix is used. Many direct-seeding efforts have failed in the past because the accompanying ground cover was too tall and dense for tree germinants to become established. Black locust is most easily and inexpensively established by direct seeding. If black locust is seeded as a nurse tree, the seeding rate should be no more than 1/2 ounce per acre. A disadvantage of hydroseeding nurse trees is the loss of control with respect to tree number and spacing. Too many nurse trees can reduce the amount of growing space for crop trees, and wind-blown locust branches can damage the tops of trees growing in close proximity. Therefore, hydroseeding trees is not recommended for most mine land reclamation.

Economic Considerations

Costs of Reforestation

The cost of reclaiming mined land with trees using the methods recommended in this publication ("Forestry Reclamation Approach") can be comparable to or less expensive than reclamation for hayland/pasture, and less expensive than reforestation using conventional reclamation methods . Table 4 shows that the use of these suggested guidelines for forest land can save several hundred dollars per acre compared to reclamation for hayland/pasture. The greatest cost savings occurs due to reduced grading. Our discussions with mine operators indicate that, on average, about 2 to 4 hours of bulldozer work per acre can be saved by leaving level areas and short slopes in a rough-graded condition and not tracking-in the surface (the cost of a D-9 bulldozer with operator was estimated to be $200/hr).

Coal companies doing reforestation should be able to realize additional costs savings on regrading and reseeding costs since groundcover and gully elimination requirements for forest land are not as strict as for hayland/pasture; we have estimated that savings at about $125 per acre. Seed and fertilizer for the tree-compatible ground cover (Table 3) costs less than hayland/pasture seed mixtures with high rates of K-31, clovers and other species; in Table 4, we have estimated that cost difference at $75 per acre.

Forest land reclamation does involve tree planting costs. Planting 650 trees/acre will affect reclamation cost for reforestation. We have estimated this cost at $250/acre for the conventional reclamation, because the low-value species that have the best chance of survival on such sites will also be less expensive to purchase as seedlings than the native hardwoods, such as the oaks, that can be planted and survive if the Forestry Reclamation Approach is used. We have estimated the cost of planting a site with high-quality hardwoods at $500/acre.

If compaction has been avoided by reduced grading, and a tree-compatible ground cover is used (FRA reclamation), a sufficient number of trees will become established through the combination of planting and natural invasion to satisfy bond release requirements and result in a well-stocked forest without any replanting of trees. If FRA reclamation is not used, traditional reclamation approaches that emphasize smooth grading and thick grass cover will have a negative effect on tree survival and replanting may be required even with the lower-value and more easily established species that are commonly use in those approaches; we have estimated the cost of re-planting non-FRA areas at $200 per acre.

Another significant cost savings using FRA reclamation is associated with sediment pond clean-out. Our discussions with mining operators indicate that less sediment moves off the site when loose grading practices are used, because loose spoils allow rainwater to infiltrate while tightly-graded spoils cause more rainwater to run off the surface. Because less rainwater runs off the surface of loosely graded spoils, less soil is eroded and carried to the sediment pond. Based on our discussions with coal operators, FRA prepared land can eliminate the need for sediment pond cleanout. Cleanout costs range from $10,000 to $50,000 depending on the size and complexity of the sediment pond, and cleaning without FRA site preparation may be required two or more times during the bond period. Cost savings associated with reduced sediment pond cleaning is very mine site specific and hard to estimate, but, on average, is very significant.

Table 4. Relative costs of two common reclamation methods, compared to quality reforestation with native hardwoods using the Forestry Reclamation Approach (FRA): Hayland/pasture reclamation, and reforestation using methods that were commonly employed prior to the Forestry Reclamation Approach using heavy surface grading and thick grass cover (pre-FRA). Costs are illustrative, based on discussions with mining firms, and meant to be typical as of mid-to-late 2000s.

Operation	Hayland/Pasture	Pre-FRA Reforestation	FRA Reforestation[a]
Grading cost difference	+400 to 800	+400 to 800	-
Seed and fertilizer cost difference	+75	+75	-
Gully repair	+ 125	-	-
Tree planting	- 500	- 250	-
Re-planting trees due to poor survival	-	+100	-
Increased cost for sediment pond cleanout	+?	+?	-
Total	+100 to 5000	+ 300 to 700	-

[a] Baseline or reference; Hayland/Pasture and Pre-FRA Reforestation costs are estimated as differences, relative to FRA Reforestation.

Benefits of Quality Reforestation

Numerous benefits are created when coal mining firms establish productive forests on land that has been mined for coal (see Table 5). One way to describe that outcome is to say that the opportunity for quality reforestation is a "win – win – win" situation: the mining firm wins because quality reforestation is cost effective and helps to achieve prompt regulatory compliance; the surface owner wins because the land created through use of these reclamation methods is more productive, and more valuable than the coal-mined land that is produced using traditional reclamation methods; and the general public wins because of the economic and environmental benefits that result from quality reforestation – in addition to enjoying the benefits of cost-effective coal-generated electric power . VCE Publication 460-138 describes the post-mining land value that is created through quality reforestation.

Photo 15. A mine site reclaimed using the guidelines in this publication at age 7. As the native trees pictured in this photo grow and mature, the vegetation will become more like the native forests that occupy most of the umined landscape in the coalfield region, and the area will become less visible as a former coal mine.

SMCRA requires that mine reclamation operations "restore the land affected to a condition capable of supporting the uses which it was capable of supporting prior to any mining, or higher or better uses of which there is reasonable likelihood." Numerous Appalachian coal mines have been reclaimed to support improved post-mining land uses such as pasture land for grazing, development for housing, commercial activity, or industry, and public purposes such as recreation. However, the majority of coal-mining sites become forested after mining; such lands can be reclaimed using the procedures described in this publication to create the economic and environmental benefits summarized by Table 5.

Table 5: Summary of benefits that occur when mining firms restore high-quality forests when reclaiming mine sites.

Beneficiary	Nature of Benefit	Further details
Mine Operator	**Cost-effective Reclamation** and prompt bond release.	As described in this publication (see Table 4).
Landowner	**Post-mining Economic Value:** Trees growing on sites reforested using FRA reclamation practices will produce thousands of dollars per acre in economic value for the landowner.	See VCE Publication 460-138.
Coal Industry	**Positive Public Perceptions:** Mine sites are visible elements of the landscape, from the ground and from the air.	Public concern with environmental impacts of coal mining is increasing. Mines that demonstrate environmental stewardship help the industry
Coal Purchasers	**Positive Public Perceptions:** Electric utilities can inform the public that they purchase coal from mines that reclaim the land effectively.	Public concern with environmental impacts of electric power generation is increasing; that concern extends to energy and fuel sources.
General Public	**Economic Impacts**: Wood products from reclaimed mines generate economic impacts when harvested.	See VCE Publication 460-138.
	Environmental Impacts: Productive forests, when growing on mine sites or on natural soils, provide numerous *ecosystem services* that benefit people who reside in coal mining areas and beyond.	*Examples* (partial listing): Serve as wildlife habitat. Hold soil, prevent soil erosion. Maintain clean water quality. Protect the watershed by enhancing groundwater recharge and reducing peak stormflows to help prevent flooding. Store carbon so as to aid in mitigating climate change. Maintain landscape aesthetics

Summary

The purpose of this publication is to provide practical, cost-effective guidelines for reclaiming surface-mined land to forests using the principles of reforestation silviculture. These guidelines should benefit coal mine operators by helping ensure timely release of reclamation performance bonds. The guidelines also include procedures that help improve the quality of mine soils and sites for timber production and other forest values.

Reclamation procedures for forest land differ in several important ways from procedures for hayland/pasture or other post-mining land uses. The key principles for timely and successful reforestation of mined land are summarized below.

Selecting, Placing, and Grading Mine Soil Material

Spoil selection: Four feet or more good-quality mine spoil and/or topsoil should be placed at the surface to accommodate the need of deeply rooted trees. Mine spoils with low to moderate levels of soluble salts, an equilibrium pH of 5.5 to 6.5, and a sandy loam texture are preferred. A mixture of two parts of brown, oxidized sandstone, and one part siltstone or shale found near the surface in most areas of Virginia's coal fields weathers quickly into a good soil medium for trees. If native topsoil is available, mixing even small amounts of fresh soil into the surface will increase volunteer establishment and seedling survival.

Loose Grading: Minimizing soil compaction is extremely important. Compaction on level areas can be minimized by end dumping spoil piles and waiting until all piles are in place before lightly leveling them, using a small bulldozer if possible. Restrict traffic on leveled areas to specific, designated roads and parking areas. Do not track-in or compact surface soils unless compaction is necessary for stability. Forest land surfaces are naturally rough; rough grading and grading for slope stability are usually adequate.

Selecting and Establishing Ground Cover Vegetation

Tree-compatible groundcover: Reforestation requires a carefully-planned balance between ground cover for erosion control and trees' requirements for light, water and space. Ground covers that include grass and legume species that are slow-growing, have a sprawling growth form, and are tolerant of acid, infertile mine soils should be used for reforestation when required to control erosion at acceptable levels. Fast-growing grasses and legumes, such as K-31 tall fescue and most clover species (except white and ladino) should be avoided.

Selecting Tree Species and Establishing Trees

Tree species selection: When mined land is reclaimed according to these guidelines, a variety of hardwood and softwood species can be planted and established successfully. When reestablishing native forest for reclamation, the tree species mix should be approximately 80% "crop trees" and 20% "nurse and wildlife" trees. The crop trees are commercially values species such as the oaks. Wildlife/nurse trees are of pioneer species such as nitrogen-fixing trees and shrubs are easily established by planting seedlings. Additional hardwood species from the native forest will eventually seed in and flourish when proper groundcovers and woody species are planted during reclamation. For good forest stand development, 600 to 700 trees per acre should be established by a combination of planting, seeding, and natural invasion.

Seedling handling and planting techniques: Poor tree survival and early growth are usually due to improper seedling handling or planting. Trees must be kept dormant until planted; they should never be allowed to dry out; they should be planted in late winter to early spring; and they should be planted deeply and firmly enough to ensure survival. Only reputable and experienced tree planting crews should be used for tree planting.

Establishing trees in dense ground cover: Herbicide should be sprayed in spots or strips (along the contour) in order to ensure seedling survival and emergence above established ground covers. Fertilizer pellets can be placed in the planting bar closing hole next to the tree (never in the planting hole) to speed early growth and emergence above ground covers. On newly reclaimed sites, it is preferable to use tree-compatible groundcovers which allow planted seedlings to survive without using herbicides.

Costs and Benefits of Quality Reforestation

Costs: Quality reforestation can be less expensive than reclamation for hayland/pasture use because forest land reclamation requires less grading, less repair work, and less seed and fertilizer for ground covers. Extensive grading compacts mine soils which decreases tree survival and growth. Rougher ground surfaces and less aggressive ground covers are consistent with forest land uses.

Benefits: Use of quality reforestation procedures in reclamation creates a "win – win – win" situation: The mine operator benefits because of prompt bond release and cost-effective reclamation procedures; the landowner benefits from the resulting increase in post-mining land capability and value; and the public benefits from the environmental services that reforested mined landscapes can provide. Use of quality reforestation by mining firms creates benefits for the coal industry through positive impacts on public perceptions of coal and coal mining.

Bottom Line

Coal mines can be reclaimed to create productive, high quality forests. Such practices are cost effective and can achieve regulatory compliance. The practices outlined in this publication are intended to achieve that goal. Coal mining firms can execute the practices most effectively when reclamation personnel are aware of basic reforestation principles, and of how reclamation practices are affecting the chemistry, physical properties, and biology of the mining site. When mine soils are capable of producing high growth rates, other forest values such as wildlife habitat, water quality, and recreational opportunities are also maximized.

Restoring economically-viable post-mining forests requires little or no additional effort or expense compared to other land uses. Use of the reclamation procedures outlined in this publication will help create highly-productive forests in a timely manner so that the mine operator, the landowner, and local communities will benefit.

Acknowledgements and Photo Credits

Photos 3 and 5 by John Torbert; photos 6, 9, 11, 12, 13, and 14 by Rick Williams; all other photos by Jim Burger.

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Forest Reclamation Advisory No. 4: Loosening Compacted Soils on Mined Sites.

Forest Reclamation Advisory No. 5. Mine Reclamation Practices to Enhance Forest Development Through Natural Succession

Virginia Department of Mines, Minerals and Energy

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RULES
OF
TENNESSEE DEPARTMENT OF CONSERVATION
DIVISION OF SURFACE MINING

CHAPTER 0400-3-7
COAL

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0400-3-7-.01 INTRODUCTION. In addition to fulfilling all the requirements of Sections 58-1540-58-1564, T.C.A. and all requirements in Chapters 0400-3-1-0400-3-6, the following special provisions contained in Chapter 0400-3-7 are to be adhered to by all operators of surface coal mines.

Authority:** T.C.A. Section 58-1543.* ***Administrative History. *Original Rule certified May 24, 1974. Amended, filed November 12, 1975, effective December 12, 1975.*

0400-3-7-.02 ACCESS ROADS.

(1) Definition. -"Haulageway or access road" shall mean any road constructed, improved or used by the operator (except public roads) which ends at the pit or bench and which is located within the permitted area. A bench may serve as a haulageway, but a haulageway cannot serve as a bench.

(2) Location.

(a) The location of the proposed haulageway shall be identified on the site by visible markings at the time the reclamation and mining plan is pre-inspected and prior to commencement of construction.

(b) No road shall be constructed in a stream or drainage channel proper or so close to its bank that material will spill into the channel during construction, use, or maintenance.

(3) Grading.

(a) Maximum Grades-New access roads shall be located and constructed so that:

1. No sustained grade shall exceed 10%.

2. The maximum grade shall not exceed 15% for 300 feet.

3. There shall not be more than 300 feet of maximum grade for each 1,000 feet of road constructed.

4. The surface shall be insloped toward the ditch line at the minimum rate of 1/2 inch per foot of surface width.

5. The grade on switchback curves must be reduced to less than the approach grade and shall not be greater than 10%

6. The grade on temporary roads on or between benches, which will be destroyed within three (3) months by the mining or reclamation process shall not exceed 20%.

(b) Cut Slopes-Cut slopes shall not be more than 45 degrees, or 1.0 horizontal to 1.0 vertical, except in stable rock.

(4) Drainage.

(a) Stream or Drainage Crossings. -Drainage structures shall be required in order to cross a stream or drainage channel. They shall be such so as not to affect the normal flow of the stream. Consideration will be given to the time of year the stream is crossed and the length of time the stream channel is used, but in no event, and under no condition, will the normal flow of the stream be affected or the sediment load of the stream be significantly increased during construction and/or use.

(b) Ditches. -A ditch shall be provided on both sides of a through-cut and on the inside shoulder of a cut-fill section, with ditch relief cross-drains being spaced according to grade. Water shall be intercepted before reaching a switchback or large fill and led off. Water on a fill or switchback shall be released below, not over, the fill.

(c) Culverts. - Ditch relief culverts shall be installed as needed to insure adequate drainage as determined by the Commissioner.

1. The suggested spacing of culverts is as follows:

Road Grade in Percent	Spacing of Culverts in Feet
2-5	300 800
6-10	200 300
11-15	100 200

In determining culvert spacing, consideration shall be given to the area drained, and its slope, shape, cover and runoff characteristics.

2. The inlet end shall be protected by a headwall of suitable material and the outlet end shall have an apron of suitable material provided for the outflow to spill on. No water shall be allowed to flow across loose spoil. Ditches in these areas shall be lined with rock.

3. The culvert shall be covered by compact fill to a depth of one foot or half the culvert diameter, whichever is greater.

4. Culvert openings installed on access roads should not be less than one hundred (100) square inches in area, but, in any event, all culvert openings shall be adequate to carry normal runoff and shall receive necessary maintenance to function properly at all times.

(d) Removal of Drainage Structures.-No bridges, culverts, stream crossings, etc., necessary to provide access to the operation, may be removed until reclamation is completed and approved by the Commissioner. The same precautions as to water quality are to be taken during removal of drainage structures as those taken during construction and use.

(5) Construction and Maintenance.

(a) Surfacing - Access roads must be surfaced with an approved, non-erodible material, but shall not be surfaced with coal refuse or any acid-producing or toxic material. Approved materials include crushed stone, gavel, "red dog," crushed slag, and chert.

(b) Seeding of Slopes - All f fill and cut slopes which will be left after mining shall be seeded immediately after the construction of the road in order to control erosion in accordance with Rule 0400-3-7-.04(4).

(c) Surface Drainage - No berm produced during construction, grading, or maintenance of the road shall be left on the ditch side.

(6) Abandonment of Access Road.

(Rule 0400-3-7-.02, continued)

(a) When an access road is to be abandoned and shall no longer be used as a road by the operator, the landowners, or the State or National Forest Services, vegetative cover and surface drainage to minimize erosion shall be provided. Regardless of the future use of the road, adequate surface drainage shall be provided. "Abandoned" means that the operator has ceased to use the road and has not turned the road over to another party for his use. When the road is abandoned and proper vegetative cover is provided, the bond on the road shall be released. If the road is not to be abandoned, but turned over to another party for his use, and adequate surface drainage and surfacing have been provided, the bond on the road shall be released.

(b) When the access road is to be abandoned, culverts shall be removed and replaced by water bars of the earth or rock type, open-top log culverts, or similar structures. They shall be installed according to the following table of maximum spacings:

Grade (Percent)	Maximum Spacing (Feet)
2	250
5	135
10	80
15	60

(7) Special Circumstances. Should the Division determine that modifications to this Chapter are necessary because of topography or particular watershed situations, the Commissioner may, in his discretion, make such modifications.

Authority: *T.C.A. Section 58-1543.* ***Administrative History.*** *Original Rule was certified May 24, 1974. (5)-Amended: Filed May 17, 1974; Effective June 17, 1974.*

0400-3-7-.03 BACKFILLING AND GRADING.

(1) General Provisions.

(a) Application. -The following provisions shall apply to all coal mining operations, in addition to other specific provisions applying to particular types of mining.

(b) Handling of Toxic Materials.-All toxic or acid-producing materials shall be properly handled and segregated within the pit. After removal of the coal, the faces of coal seams, the bottom of the pit, and all toxic materials, waste coal, metal, lumber, and other mining refuse shall be covered with spoil to a compacted depth of at least four (4) feet. However, the coal seam may, instead, be covered by a permanent water impoundment if the impoundment is part of the mining and reclamation plan approved by the Commissioner. This work is to be completed as soon as possible, but not later than the time specified in this regulation.

(c) Breakthrough to Underground.-Any breakthrough to an underground mine must be reported. If any water drains from the underground mine, the Water Quality Control Division of the Department of Public Health and the Knoxville Office of the Surface Mining Division or the Inspector shall be notified as soon as possible, but at least within twenty-four (24) hours, and temporary corrective measures started immediately. Plans for permanent control of drainage must be submitted to the Knoxville Office within five (5) days, and the work shall be completed within thirty (30) days of approval. If no water drains from the breakthrough, the Knoxville Office shall be notified in writing within five (5) days. If the operator is in doubt as to whether the underground mine is wet or dry, the breakthrough shall be reported as soon as possible, but at least within twenty-four (24) hours.

(d) Protection of Streams.-No mining, placement of spoil, or associated activity will be permitted within one hundred (100) feet horizontal distance of any stream, except that roads may be constructed within one hundred (100) feet of a stream where such roads are part of the approved mining and reclamation plan and in special circumstances, such as where head-of-hollow fill plans have been approved by the Commissioner,

(e) Water Control.

1. The water flow from the mine area and haul roads shall be controlled to mini. mize soil, erosion, damage to other lands, and pollution of streams or other waters. This may include construction of checks, impoundments, silt-trap dams, and water bars in conjunction with other control measures as required. All sediment control structures shall be constructed according to criteria contained in the Drainage Handbook for Surface Mining provided by the Department of Conservation.

2. The Tennessee Water Quality Control Act of 1970, TCA 70-324 et seq., requires that all runoff or pumped discharges must be covered by a discharge permit from the Division of Water Quality Control if the quality of the water is or may be altered in any way. All discharges or runoff must meet the water quality standards promulgated by the Water Quality Control Division.

(f) Special Conditions. -When special unusual conditions at the site make the application of these regulations unwise, unnecessary, or impossible, deviations may be allowed with written approval of the Commissioner as long as the effects do not violate the intent of the Law.

(2) Contour Mining.

(a) Application.- These regulations shall apply in areas where the slope of the original ground covering the coal seam or lying below the coal seam exceeds 15 degrees.

(b) Spoil Handling- Landslides.

1. The mining plan shall be devised and the mining operation conducted so as to minimize erosion and prevent all landslides. A landslide is defined as any uncontrolled earth movement which carries spoil outside the approved limits.

2. If a landslide occurs, all mining at the affected mine shall cease immediately and shall not resume until written permission is obtained from the Division. Permission to resume mining shall not be granted until (i) the slide is stabilized and graded or the material is recovered and replaced on the bench or other designated area, and (ii) the mining plan has been re-examined and amended, if necessary in the opinion of the Division to prevent further slides.

(c) Fill Bench Limitation

1. (i) If the natural slope of the land for a distance of one-hundred (100) feet downslope from the coal seam outcrop is greater than 28 degrees from the horizontal, no spoil shall be placed downslope from the outcrop, temporarily or permanently. Therefore, no fill bench is permitted on slopes over 28 degrees, and no exception can be granted.

2. The slope below the coal seam means the average or mean slope of the ground. between the cropline and one-hundred (100) feet downslope. Before surface disturbance, the slope will be determined by making readings on the ground at intervals no greater than one-hundred (100) feet along -the cropline.

   (iii) Where the slope of the land below the coal seam is less than 28 degrees, the upgraded spoil must be placed in such a way that the spoil toe will not extend more than fifty (50) feet downslope from the cropline, measured along the ground perpendicular to the contour line. This shall be the "ungraded spoil limit line", which is the maximum distance downslope that spoil may be placed during the initial mining phase, that is prior to final grading.

2. If any spoil crosses the spoil limit line, all mining shall cease immediately and shall not be resumed until proposed corrective actions are completed to the satisfaction of the inspector.

3. Prior to placing any spoil downslope from the cropline, where the slope is less than 28 degrees, tree vegetation must be cleared and grubbed (scalped) No tree vegetation shall be left to project from any spoil. This tree vegetation must be windrowed to produce a brush barrier. The brush barrier must be constructed so that the major limbs and tree trunks shall lay approximately parallel with the contour. The total disturbed area from the cropline to the downslope side of the windrowed brush barrier must not exceed one-hundred twenty-five (125) feet measured downslope from the cropline perpendicular to the contour line. The clearing and grubbing (scalping) shall not extend more than 500 feet along the cropline ahead of the active pit. In the case of multiple seam mining, this shall mean ahead of the active pit of the lowest seam. See Figure 1Virgin cut before final grading.

4. When the approved mining and reclamation plan calls for the use of mining methods such as, but not limited to, the modified -block cut, head-of-hollow fill, or offsite storage, deviations from the above limits shall be allowed for the purpose of temporary or permanent storage of spoil on a limited, designated area downslope from the cropline if the operator submits a plan which will prevent landslides and minimize erosion and it is approved by the Division.

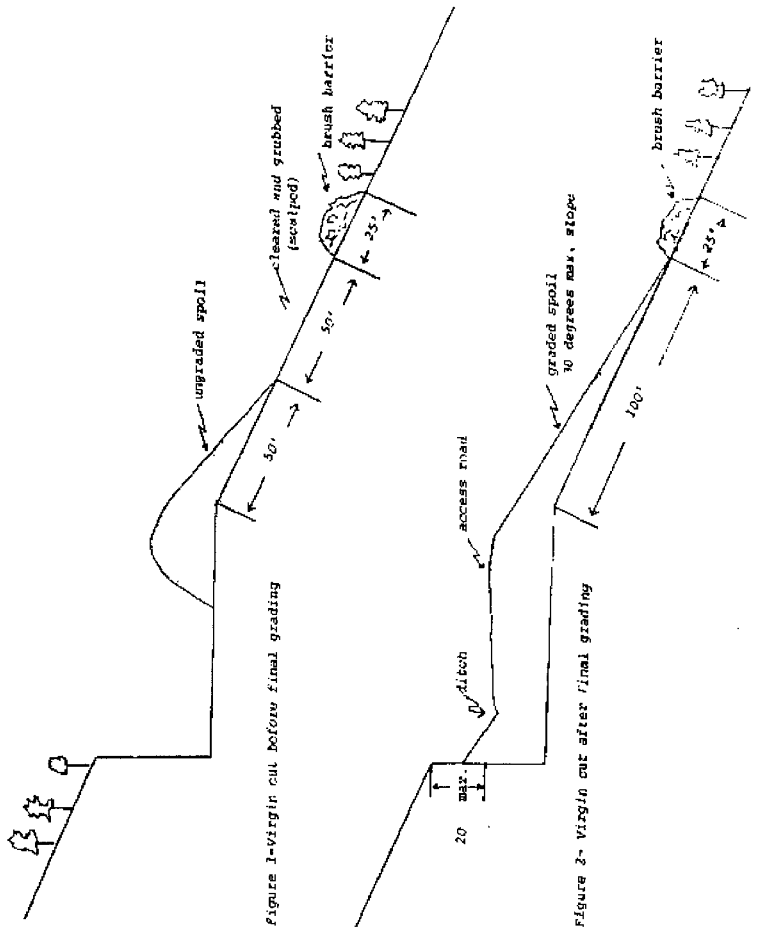

Figure 1-Virgin cut before final grading

Figure 2- Virgin cut after final grading

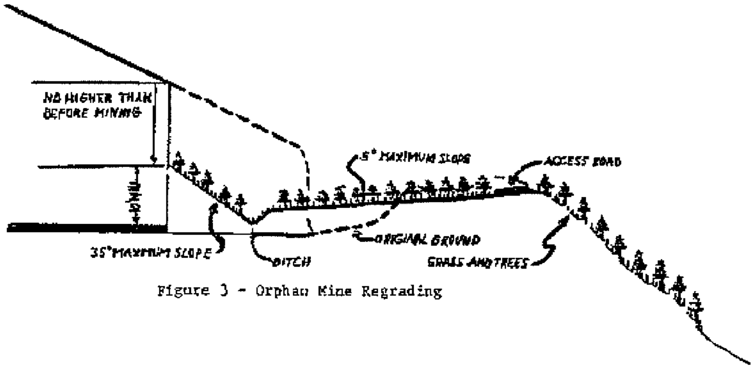

Figure 3 - Orphan Mine Regrading

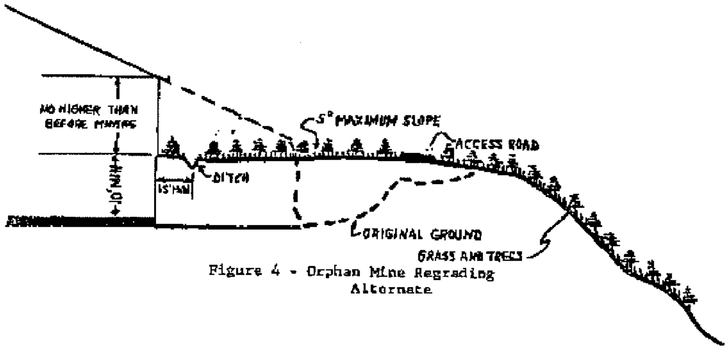

Figure 4 - Orphan Mine Regrading
Alternate

5. When the approved mining and reclamation plan calls for the use of mining methods such as, but not limited to, the modified block cut, head-of-hollow fill, or off-site storage, deviations from the above limits shall be allowed for the purpose of temporary or permanent storage of spoil on a limited, designated area downslope from the cropline if the operator submits a plan which will prevent landslides and minimize erosion and it is approved by the Division.

(d) Final Grading.

1. (i) The upgraded spoil shall be graded against the highwall and downward to roll gently over the outslope to blend smoothly with the surrounding land. During the final grading process, part of the ungraded spoil may be graded to a maximum distance of one-hundred (100) feet downslope from the cropline, measured along a perpendicular to the contour. The final graded outslope shall not be steeper than thirty (30) degrees from the horizontal, or that slope steepness which is accessable with earth grading equipment, whichever is less.

(ii) Spoil shall be placed against the highwall to eliminate or reduce its final height. A minimum terrace width of fifteen (15) feet shall be constructed to provide for an access road. A ditch shall be graded along the inside edge of the access road to conduct surface drainage from the fill bench to designated drainways. Such ditch shall be constructed to eliminate depressions in which water could accumulate pools. To insure proper drainage, the minimum grade of the ditch bottom shall be 1%. At least four (4) feet of compacted spoil shall be placed over the floor of the pit at all points including the bottom of all drainage ditches. The graded spoil from the terrace ditch to the highwall shall not be steeper than 30 degrees. No more than 20 feet of highwall may be left at points where no highwall existed before current mining. See Figure 2-Virgin cut after final grading.

2. When the mining operation is a second or subsequent cut on an orphan or otherwise previously mined area, the total elimination of the highwall shall not be required. All overburden not necessary to cover the floor of the pit shall be placed against the highwall so that the remaining highwall is no higher than that existing prior to the cur- mining. The entire bench area, including spoil piles from previous operations which have not naturally reverberated to current coverage standards, shall be graded to slope toward the highwall at a slope not to exceed 5 degrees. At least four (4) feet of compacted spoil shall be placed over the floor of the pit. A ditch shall be placed along the bench at the toe of the sloping spoil, as shown in Figure 3. Other or it a configurations meeting the highwall and slope limitations, such as that in Figure 4, shall also be allowed.

3. No slope, except stable rock highwall as provided for in subsection (2), shall exceed thirty (30) degrees. All rock and boulders rolling off the permitted area shall be removed to some approved locations within the permitted area, or the permitted area shall be enlarged to include the area where they are left. Large rocks shall be buried or placed in constructed drainways as lining or in an approved manner as water-retarding structures.

(e) Natural Drainways.-Natural drainways, where water flows occasionally in a well-defined channel, but less often than six months per year, shall be identified prior to mining and skipped. No mining will be allowed within twenty-five (25) feet of the centerline of a natural drain which crosses the contour. Fill or spoil placement and construction of access roads across natural drainways shall be conducted so as not to affect the normal flow of the drainway or materially increase the sediment load in the drainway. This may be accomplished by conveying the water in an adequate enclosed watertight conduit beneath the access road, or by spanning the natural drainway with a bridge, The conduit will be placed on the original drainway bed and will extend to a point ten (10) feet beyond the toe of the overburden or access road embankment.

(f) Multiple Seam Mining. When two or more seams are to be mined under any given permit, when the seams are not on the same highwall, the mining and reclamation plans will be treated as special cases and judged on their own merits. The following general guidelines shall be followed:

1. Mining Sequence The lower seam shall be mined in advance of the seam above.

2. Overburden-Overburden from the seam being mined shall not extend beyond the solid bench of the seam below.

3. No ungraded spoil shall be allowed to extend, more than fifty (50) feet downslope from a cropline of any seam. If the distance between the cropline of the upper seam and the top of highwall of the next lower seam is greater than one-hundred (100) feet, spoil shall not be pushed across the intervening area to reach the lower bench, but must be hauled to the lower bench.

4. All requirements which apply to a single-seam mining shall apply to multiple seam mining unless the mining and reclamation plan proposes an acceptable variation and is approved in writing by the Commissioner.

(g) Highwall Access.-At least one access to the lands above the highwall, suitable for passage by a four-wheel drive vehicle, shall be provided every mile along the bench, at locations approved by the inspector.

(h) Keeping Operation Current.

1. All coal shall be picked up within thirty (30) days following removal of the overburden. (for the purpose of this provision, overburden shall be considered removed when less than four (4) feet remains above the coal.)

2. If the operation includes only stripping (no augering), the grading and backfilling shall follow the coal removal by not more than fifteen (15) days, but in no instance shall an area be left ungraded more than 1,500 feet behind the removal of the coal.

3. If the operation includes stripping and augering, the augering shall follow the stripping by not more than sixty (60) days or 2,500 feet, and the grading and backfilling shall follow the augering by not more than fifteen (15) days, but in no instance shall an area be left ungraded more than 1,500 feet behind the augering.

4. If the operation includes only augering, the grading and backfilling shall follow the augering by not more than fifteen (15) days, but in no instance shall an area be left ungraded more than 1,500 feet behind the augering.

5. All backfilling and necessary grading and drainage work on a given area shall be completed within one hundred eighty (180) days after the initiation of sod disturbance on that area.

6. Modifications of these requirements may be made by the Commissioner if heavy rains or wet conditions make backfilling and/or grading impractical.

(i) Augering.

1. Augering is prohibited where the coal seam rises away from the outcrop at a slope greater than 1/2 degree, except where the coal seam is below drainage.

2. "Below drainage" is defined as being below the established water table, or below the elevation of all streams or other water bodies in the vicinity of the permitted area.

3. Auger holes shall be plugged by forcing spoil into the openings by machine immediately after augering.

4. The exposed face of the coal seam at the highwall shall be covered with backbone material and compacted to at least ten (10) feet above the top of the auger holes. Backfiring and grading shall follow the angering by not more than fifteen (15) days or 1,500 feet along the bench.

5. Restored areas shall be graded so there will be no depressions to accumulate water and to facilitate rapid runoff of surface drainage from the auger area.

6. A twenty-five (25) foot barrier of coal shall be left between any underground mine and the completed auger hole. Test listings may be necessary to determine the solid depth of outcrop so as not to penetrate the underground mine.

7. Any breakthrough to an underground mine must be reported. If any water drains from the underground mine, the Knoxville office or the inspector shall be notified as soon as possible, but at least within twenty-four (24) hours, and temporary corrective measures started immediately. Plans for permanent control of drainage must be submitted to the Knoxville office within five (5) days, and the work shall be completed within thirty (30) days of approval. If no water drains from the breakthrough, the Knoxville office shall be notified in writing within five (5) days. If the operator is in doubt as to whether the underground mine is wet or dry, the breakthrough should be reported as soon as possible, but at least within twenty-four (24) hours.

(j) Head-of-Hollow Fills.

1. Head-of-hollow fills shall be allowed for off-site permanent storage of excess spoil material only if the operator submits an acceptable engineered plan which is approved in writing by the Commissioner.

2. Construction of such fills shall not violate the terms of a water quality discharge permit.

3. Unless excepted by the Commissioner, plans for head-of-hollow fills shall provide for:

(i) A five-foot (5) thick drainage blanket of large rocks or boulders, extending from the toe of the fill up the hollow to the upper surface of the flu.

(ii) Spoil placement in horizontal layers above the drainage blanket, compacted to a maximum thickness of six (6) feet per layer.

(iii) Filling of the hollow from one side completely to the other, and from the downstream face to the head.

(iv) No slope of more than 30 degrees on the downstream face, with the sloping sections interspersed by terraces draining to the side for every twenty-five (25) foot difference in elevation.

(v) Crowning of the final upper surface so that no water drains over the downstream face.

(vi) Adequate surface drainage so that water will flow around the fill and not over it, with water carried in graded ditches. Ditches on slopes over 5 degrees shall be rock-lined or rock-filled.

(3) Area Mining.

(a) Application.- These regulations shall apply in areas where the slope of the original ground covering the coal seam is 15 degrees or less.

(b) Site Preparation. -Topsoil and other soil suitable for supporting vegetation shall be separated and removed to an approved storage area for stockpiling during the mining operation. Following mining and initial grading, the topsoil and other soil suitable for supporting vegetation shall be replaced over the area affected.

(c) Final Grading.

1. Complete backfilling to approximately the original contour or rolling topography shall be required, beginning at or beyond the top of the highway and sloped to the toe of the spoil bank at a maximum angle not to exceed the approximate contour of the land with no depressions to accumulate water, and all highwalls and spoil piles shall be eliminated.

2. Lands shall be deemed to have been completely backfilled and graded to their approximate original contour when the contour of the land conforms approximately to the contour of the original ground, but the final surface of the restored area need not necessarily have the exact elevations of the original ground surface. However, where a flat surface or a surface with less slope than the original ground surface is desired, such surface shall be deemed to comply with backfilling and grading to the approximate original contour. In addition, when a very flat surface is mined, the land may be restored to gently rolling terrain to enhance drainage.

(d) Blending With Adjacent Lands.-Spoil abutting onto unstrapped land shall be graded so as to blend into the adjoining stripped lands. In order to prevent excessive disturbance of the adjoining unstripped lands through the placing of spoil onto already vegetated areas, spoil will be considered as blending into the unstripped lands if the angle between the spoil and the unstripped lands is twelve (12) degrees or less, except that the slope created shall not be greater than twenty-five (25) degrees.

(e) Water Diversion Ditches.-Water diversion ditches or terraces shall be constructed in the final grading to control water runoff and erosion on long uninterrupted slopes and to remove surface water runoff to a safe outlet. For the purpose of this regulation, a diversion ditch shall be a channel constructed on a continuous grade of one to two percent (1%-2%) across the slope, with a supporting ridge on the lower side and the entire ditch seeded to an adaptable grass or grass-legume mixture. The depth and width of the diversion ditch may vary depending on the length and degree of slope.

(f) Water Impoundments.

1. Water impoundments, as an alternative to backfilling the final pit, are encouraged and will be allowed if they are part of the approved mining and reclamation plan and if they meet -the following minimum criteria:

   (i) Adequate sources of water must be available to maintain the water level at least four (4) feet above the top of the coal seam at all times.

   (ii) Proper measures must be taken to prevent undesirable seepage.

   (iii) Adequate spillways or other measures necessary to control overflow must be provided.

   (iv) Adequate means of access to the water impoundment must be left or provided.

   (v) The highwall or low wall must be reduced to a slope fifteen (15) degrees or less, sloping to the water's edge.

2. All impoundments must be designed in conformance with the criteria included in the Drainage Handbook for Surface Mining provided by the Department of Conservation.

(Rule 0400-3-7-.03, continued)

(g) Keeping Operation Current.-The grading and backfilling shall not be more than two (2) spoil ridges behind the pit being worked, the spoil from this pit being considered the first ridge. All backfilling and grading shall be completed within ninety (90) days after the completion of an operation or a prolonged suspension of work in the area and within one hundred eighty (180) days of initial disturbance. Modifications to these requirements may be made by the Commissioner in connection with the backfilling of the final pit.

Authority: *T.C.A. Section 58-1543.* ***Administrative History.*** *Original Rule certified May 24, 1974. (1)(c), (2)(b), (2)(c), (2)(d), (2)(e), (2)(f), (2)(i), (2)(j), (3)(b), Figure 1, Figure 2, Figure 3, and Figure 4-Amended: Filed May 17, 1974; Effective June 17, 1974. (1)(c), (2)(c), (2)(d), (2)(f), (3)(f); Figure 1, Figure 2, Figure 3, Figure 4-Amended: Filed November 12, 1975; to be effective December 12, 1975. Rules 0400-3-7-.03(c) and 0400-3-7-.03(d) Suspended December 11, 1975 until June 30, 1976.*

0400-3-7-.04 VEGETATION.

(1) Objective in Revegetation. The objective of revegetation is to provide a self-regenerating cover on the disturbed area as soon as possible and to minimize erosion.

(2) General Rules Governing Seeding or Planting.

(a) Seasonal Feasibility.-Immediately after grading, appropriate vegetation shall be planted and seeded in the proper season in accordance with accepted agricultural and reforestation practices.

(b) Plant Selection.

1. Plants that give a quick, permanent, protective cover shall be used. Select plants to use after evaluating both their potential for stabilization and their use in terms of forest products, wildlife habitat, and agricultural benefits.

2. Adapted plant species and mixtures are listed in 0400-3-7-.04(5)j-m.

(c) Direct Seeding.

1. Direct seeding of trees and shrubs is encouraged on all disturbed areas to supplement planted trees.

2. Some Species Adapted to Direct Seeding:

(i) Black (Sweet) Birch (ii) Virginia Pine (iii) Pitch Pine (iv) Red Maple (v) European Black Alder (vi) Autumn Olive

3. Species that can be direct seeded are not limited to the above list.

(3) Contour Mining.

(a) Application.- These regulations shall apply in areas where the slope of the original ground covering the coal seam or lying below the coal seam exceeds 15 degrees.

(b) Area to be Revegetated.-The entire disturbed area shall be fertilized and vegetated with adapted legumes and/or perennial grasses, and adapted trees and/or adapted shrubs, except as hereinafter provided. Adapted species and mixtures are listed in 0400-3-7-.04(5)j-m.

(c) Access Roads.-Roadbeds shall be seeded to adapted legumes and perennial grasses only, no trees being required. This vegetative requirement for roads may be modified if, in the opinion of the Commissioner, the roadway will not contribute offsite damage to the public or adjacent property owners.

(d) Shrubs for Wildlife. -Shrubs for wildlife may be planted to include border plantings, clump plantings, intervening strips, or area planting.

(4) Area Mining.

(a) Application. These provisions shall apply where regrading to original contour as defined in 0400-7-03(3)(c) is used.

(b) Area to be Revegetated.-The entire disturbed area shall be fertilized and vegetated with adapted legumes and/or perennial grasses, and adapted trees and/or adapted shrubs, except as hereinafter provided. If future use of area will be agricultural grassland or crops, trees and/or shrubs may be omitted. Adapted species and mixtures are listed in 0400-3-7-.04(5)j-m.

(c) Shrubs for Wildlife.-Shrubs for wildlife may be planted to include border plantings, clump plantings, intervening strips. or area plantings.

(5) Mixture and Seed Requirements

(a) Seed Inoculation.-All legume seed, except black locust, shall be inoculated.

(b) Scarifying.- All black locust and sericea lespedeza seed dull be scarified, except when used in fall and winter seeding.

(c) Preparation of Soil. -Preparation of the seed bed by harrowing, discing, or other approved methods, prior to seeding is required, except on slopes greater thin fifteen (IS) degrees.

(d) Seeding Dates and Rates.-Dates of seeding and rates of seed used shall be in accord with the requirements of the adapted species selected and elevation of the site.

(e) Livestock Grazing.-Protection of seeded area from grazing by livestock is required during the first two growing seasons

(f) Fertilizer.-Fertilizer shall be applied at a minimum rate of 100 pounds each of Nitrogen (N), Phosphate (P205) and Potash (K20) per acre. Agricultural lime shall be applied at a minimum of eight thousand (8,000) pounds per acre.

(g) Mulch.

1. All disturbed areas shall be mulched. The approved mulch and rates are:

2. Dry Wheat Straw or Hay at a rate of four thousand (4,000) pounds, approximately 80 bales per acre.

3. Wood Fiber Mulch at a rate of one thousand five hundred (1,500) pounds per acre, but not in the months of November. December, January and February.

4 Dry Wheat Straw and hay must be anchored by asphalt emulsion or by discing the straw or hay on contour in mines soil.

(h) Planting.

1. Tree species - Planting of a single species, or of two or more species, in pure blocks or strips at least thirty (30) feet wide, over the entire area, or of a single species in a block or a contour strip is required

(i) Preferred tree species are.

Virginia pine
Shortleaf pine (on light (sandy) soils only)
Black locust

(ii) Other species that may be used are:

European black alder
Red maple
Loblolly pine (below,, 000 ft. elevation)
Pitch pine
White pine

2. Tree seedlings shall be planted at a 6'x 7'spacing.

3. Seedlings should be planted between November I and May 1.

(i) Wildlife Planting.

1. Plantings for wildlife food and cover &hall consist of one or mom of the following:

(i) Shrub Lespedeza:
Lespedeza bicolor
Lespedeza japonica

(ii) Bush Honeysuckle:
Amur - Lonicera maackii (Fall fruiting)
Tatarian - Lonicera tataric (Summer fruiting)
Autumn Olive - Elaeagnus umbellata (Fail fruiting)

2. The following type of plantings may be made:

(i) Intervening contour strips and borders. Contour strips or borders of wildlife food and cover may be substituted for the appropriate number of trees to provide space for planting one or more of the following shrub species:

(I) Bush honeysuckle - I to 3 rows - 6' x 6' spacing - Feb. 1 to April IS

(II) Autumn olive - I to 3 rows - 6'x 6' spacing - Feb. I to April 15

(III) Shrub lespedeza plants - 5 rows - 2'x 2'spacing - Feb. I to April 15

(IV) Shrub lespedeza seeded - 12 to 15 feet width - 20 lbs./ac. scarified seed March I to June 15.

(ii) Clumps - Clump plantings numbering not more than 2 per acre may be substituted for trees to provide space for one or more of the following shrub species

(I) Bush honeysuckle - 25 plants - 6' x 6' spacing - Feb. I to April 15

(II) Autumn olive - 25 plants - 6'x 6'spacing - Feb. I to April 15

(III) Shrub lespedeza plants - 700 plants - 2' x :' spacing - Feb. I to April 15

(IV) Shruh lespedeza - I lb. scarified seed 50'x 50' area - March I to June 15.

(iii) Rocky and Stony Areas.

(I) Shrub lespedeza may be substituted for tree species using the following mixture for rocky and stony sites where planting of tree seedlings is not possible:

(II) Plant the mixture from Dec. I to April 1 S.

<u>SPECIES</u>	<u>AMOUNT PER ACRE</u>
Tall fescue	20 pounds
Shrub lespedeza (scarified seed)	10 pounds

(j) Legumes, Perennial Grasses, and Annual Grains. One of the following mixtures shall be sown on the entire disturbed area, unless an alternative mixture is proposed in the Revegetation Plan and approved by the Commissioner.

1. Mixture One: February-April Per Acre

(i) Sericea Lespedeza (scarified)	25 pounds
(ii) Ky-31 Tall Fescue	25 pounds
(iii) Weeping Lovegrass,	10 pounds
(iv) Kobe or Korean Lespedeza ,	10 pounds
(v) Bicolor Lespedeza	5 pounds
(vi) Millett or Sudangrass 10 pounds	

2. Mixture Two: May-July

(i) Sericea Lespedeza (scarified)	35 pounds
(ii)Ky-31 Tall Fescue	25 pounds
(iii) Weeping Lovegrass	10 pounds
(iv) Bicolor Lespedeza	5 pounds
(v) Millett or Sudangrass	10 pounds

3. Mixture Three: August-October

(i) Sericea Lespedeza (Unscarified)	45 pounds
(ii) Ky-31 Tall Fescue	9-5 pounds
(iii) Weeping Lovegrass	5 pounds
(iv) Bicolor Lespedeza	5 pounds
(v) Balboa or English Rve	15 pounds

4. Mixture Four: November-January

(i) Sericea Lespedeza (unscarified)	2 0 pounds
(ii) Ky-31 Tall Fescue	40 pounds
(iii) Weeping Lovegrass *	5 pounds,
(iv) Bicolor Lespedeza	5 pounds
(v) Balboa or English Rye	15 pounds

(k) Evaluation of Vegetation Survival. Inspection and evaluation of' vegetation for cover and survival shall be made as soon as it is possible to determine if a satisfactory stand has been established. In no instance shall this vegetative cover check be made until twelve (12) months following the planting of trees or shrubs. A revegetation evaluation report shall be prepared and filed by the inspector.

(l) Standards for Perennials. Standards for legumes and perennial grasses shall require at least an eighty percent (80%) ground cover. Bare areas shall not exceed one-fourth (1/4) acre (100 feet by 100 feet) in size, nor total more than twenty percent (20%) of the area seeded unless such areas are too stony to support vegetation.

(m) Standards for Woody Plants with Perennials. Standards for woody plants with legumes and perennial grasses overseeded shall require an eighty percent (80%) establishment of ground cover of legumes and perennial grasses and six hundred (600) trees or woody plants per acre distributed more or less uniformly over the area. No fifty-foot by fifty-foot (50' x 50') area shall contain fewer than seventeen (17) surviving trees or woody plants.

(n) Performance Bond Release. After the vegetative cover has been inspected and approved, the operator shall submit his final report to the Commissioner and request release of the remaining portion of the performance bond still in force. No revegetation performance bonds will be released until the approved revegetation plan has been carried out unless the Commissioner determines that further efforts toward revegetation are impractical. No revegetation plans will be considered to have been carried out until satisfactory coverage and survival have been obtained.

Authority: *T.C.A. Section 58-1543.* ***Administrative History****. Original Rule certified May 24, 1974. (2)(b), (2)(c), (3)(a), (3)(b), (3)(d), (4)(b), (5)(g), (5)(h), (5)(j) and (5)(m)-Amended: Filed May 17, 1974; Effective June 17, 1974. (2)(c), (5)(f), (5)(g), (5)(j)-Amended: Filed November 12, 1975; Effective December 12, 1975.*

HOUSE BILL 455

By McDonald

AN ACT to amend Tennessee Code Annotated, Title 59 and Title 69, Chapter 3, relative to water quality control and mining.

WHEREAS, unsound surface coal mining practices permanently degrade the waters of Tennessee; and

WHEREAS, clean water is an increasingly valuable resource throughout Tennessee and the Southeast; and

WHEREAS, Tennessee's mountains are a permanent source of wealth and clean water for all Tennesseans; and

WHEREAS, unsound surface mining practices trade permanent wealth and water for all, for the short-term gain of a few; and

WHEREAS, Tennessee needs adequate scientific information to protect the environment and water quality around surface coal mining operations; and

WHEREAS, surface coal mining operations must be restricted to limit impact on water and scenic vistas; and

WHEREAS, surface coal mining results in discharges to navigable waters and applicants for federal surface mining permits are therefore required under Section 401 of the Federal Water Pollution Control Act, commonly known as the Clean Water Act, to obtain a certification from Tennessee that such discharges will not violate water quality standards or other appropriate requirements of Tennessee law and Tennessee may either deny such certification or impose conditions in the certification which then become part of the federal surface mining permit; and

WHEREAS, the Tennessee Wildlife Resources Agency has stated that mountain top removal and cross-ridge surface coal mining operations "invariably result in the loss of fish and aquatic life, aquatic habitat destruction and serious water pollution"; and

WHEREAS, Tennessee would benefit from updated scientific data and analysis when making Section 401 certification determinations for federal surface mining permits. Completing a new or supplemental Programmatic Environmental Impact Statement for the Tennessee program, addressing direct and indirect site specific and cumulative impacts in cooperation with the state using the best available scientific methods and research and publishing a record of decision in the Federal Register would provide this updated data and analysis; now; therefore,

BE IT ENACTED BY THE GENERAL ASSEMBLY OF THE STATE OF TENNESSEE:

SECTION 1. Tennessee Code Annotated, Section 69-3-108, is amended by adding the following language as a new, appropriately designated subsection:

(__)(1) Under no circumstances shall the commissioner issue or renew a permit, certification, or variance that would allow:

(A) Surface coal operations, or resulting waste, fill or in-stream treatment within one hundred feet (100') of any waters of the state; provided, however, that a permit, certification, or variance may be issued or renewed for operations to improve the quality of streams previously disturbed by mining; or

(B) Surface coal mining operations to alter or disturb any ridge line that is above two thousand feet (2,000') elevation above sea level, such elevation being determined using the most current edition of the United States forest service's publication, Ecological Subregions of the United States. This subsection does not prohibit any otherwise allowable surface coal mining above two thousand feet (2,000') elevation above sea level that does not alter or disturb a ridgeline;

(2) The requirements of this subsection do not apply to surface coal mining activities that are only incidental to underground mining if the commissioner determines that surface disturbance and effect is limited to that required to conduct legal underground mining;

SECTION 2. The provisions of this act are declared to be remedial in nature and the provisions of this act shall be liberally construed to effectuate its purposes.

SECTION 3. If any provision of this act or the application thereof to any person or circumstance is held invalid, such invalidity or affect shall not affect other provisions or applications of the act which can be given effect without the invalid provision or application, and to that end the provisions of this act are declared to be severable.

SECTION 4. This act shall take effect upon becoming law, the public welfare requiring it.

ENGROSSED

Senate Bill No. 1011

(By Senators Tomblin (Mr. President) and Caruth,

By Request of the Executive)

[Introduced May 31, 2009; referred to the Committee on Economic Development.]

A BILL to amend and reenact §5B-2A-3, §5B-2A-5, §5B-2A-6 and §5B-2A-9 of the Code of West Virginia, 1931, as amended; and to amend and reenact §22-3-10 of said code, all relating to ensuring the post-mine development of reclaimed surface mine property; defining certain terms; requiring certain counties to develop master land use plans for post-mine development; clarifying procedures relating to master land use plans and community impact statements; enhancing certain powers and responsibilities of the Office of Coalfield Community Development and the Department of Environmental Protection with respect to master land use plans; requiring surface mine reclamation plans to comport with approved master land use plans; and authorizing surface mine reclamation plans to contain alternative, noncomporting post-mining land uses under certain circumstances.

Be it enacted by the Legislature of West Virginia:
That §5B-2A-3, §5B-2A-5, §5B-2A-6 and §5B-2A-9 of the Code of West Virginia, 1931, as amended, be amended and reenacted; and that §22-3-10 of said code be amended and reenacted, all to read as follows:

CHAPTER 5B. ECONOMIC DEVELOPMENT ACT OF 1985.

ARTICLE 2A. OFFICE OF COAL FIELD COMMUNITY DEVELOPMENT.

§5B-2A-3. Definitions.

(a) For the purpose of this article, the following terms have the meanings ascribed to them:

(1) "Department" means the Department of Environmental Protection established in article one, chapter twenty-two of this code;

(2) "Master land use plan" means a plan as defined in 145 CSR 8;

~~(2)~~ (3) "Office" means the Office of Coalfield Community Development;

~~(3)~~ (4) "Operator" means the definition in section three, article three, chapter twenty-two of this code; and

~~(4)~~ (5) "Renewable and alternative energy" means energy produced or generated from natural or replenishable resources other than traditional fossil fuels or nuclear resources and includes, without limitation, solar energy, wind power, hydropower, geothermal energy, biomass energy, biologically derived fuels, energy produced with advanced coal technologies, coalbed methane, fuel produced by a coal gasification or liquefaction facility, synthetic gas, waste coal, tire-derived fuel, pumped storage hydroelectric power or similar energy sources.

(b) Unless used in a context that clearly requires a different meaning or as otherwise defined herein, terms used in this article shall have the definitions set forth in this section.

§5B-2A-5. Powers and duties.

The office has and may exercise the following duties, powers and responsibilities:

(1) To establish a procedure for developing a community impact statement as provided in section six of this article and to administer the procedure so established;

(2) To establish a procedure for determining the assets that could be developed in and maintained by the community to foster its long-term viability as provided in section eight of this article and to administer the procedure so established;

(3) To establish a procedure for determining the land and infrastructure needs in the general area of the surface mining operations as provided in section nine of this article and to administer the procedure so established;

(4) To establish a procedure to develop action reports and annual updates as provided in section ten of this article and to administer the procedure so established;

(5) To determine the need for meetings to be held among the various interested parties in the communities impacted by surface mining operations and, when appropriate, to facilitate the meetings;

(6) To establish a procedure to assist property owners in the sale of their property as provided in section eleven of this article and to administer the procedure so established;

(7) In conjunction with the department, to maintain and operate a system to receive and address questions, concerns and complaints relating to surface mining; and

(8) On its own initiative or at the request of a community in close proximity to a mining operation, or a mining operation, offer assistance to facilitate the development of economic or community assets. Such assistance ~~may~~ shall include the preparation of a master land use plan pursuant to the provisions of section nine of this article.

§5B-2A-6. Community impact statement.

(a)(1) The operator shall develop a community impact statement, as described in this section, which shall be submitted to the office within sixty days of the filing of a surface mining application pursuant to the provisions of article three, chapter twenty-two of this code. Failure to submit a community impact statement to the office shall be considered a violation under the provisions of section seventeen of said article; and

(2) The operator shall provide copies of the community impact statement to the

~~division's~~ department's office of mining reclamation and office of explosives and blasting and to the county commissions, county clerks' offices and local, county or regional ~~economic~~ development or redevelopment authorities of the areas to be affected by the surface mining operations.

(b) The community impact statement, where practicable, shall not be a highly technical or legalistic document, but shall be written in a clear and concise manner understandable to all citizens. The community impact statement shall include the following:

(1) The amount and location of land to be mined or used in the actual mining operations;

(2) The expected duration of the mining operations in each area of the community;

(3) The extent of anticipated mining-related property acquisitions, to the extent that such acquisitions are known or knowable;

(4) The intentions of the surface and mineral owners relative to the acquired property, to the extent that such intentions are known or knowable;

(5) A statement of the post-mining land use for all land within the permit boundary;

(6) The intended blasting plan and the expected time and duration it will affect each community;

(7) Information concerning the extent and nature of valley fills and the watersheds to be affected; ~~and~~

(8) Economic information, such as the number of jobs created and annual coal production resulting from the surface mining operation, the anticipated life of the mining operation and such other information as may be deemed appropriate; and

(9) An acknowledgment of the recommendations of any approved master land use plan that pertains to the land proposed to be mined, including an acknowledgment of the infrastructure components needed to accomplish the designated post-mine land use required by the plan.

(c) Where the operator makes any significant revision to the permit application under section eighteen, article three, chapter twenty-two of this code, which revision substantially affects any of the information provided in subsection (b) of this section, the operator shall revise the affected provisions of its community impact statement and shall submit such revisions as set forth in subsection (a) of this section.

(d) Within thirty days of receipt of a community impact statement pursuant to subdivision (2), subsection (a) of this section or a revised community impact statement pursuant to subsection (c) of this section, the local, county or regional development or redevelopment authorities of the areas to be affected by the surface mining operations shall provide a written acknowledgment of the receipt of this community impact statement or revised community impact statement to the department's Division of Mining Reclamation, to the county commission or county commissions and to the office.

~~(d)~~ (e) The provisions of this section shall apply as follows:

(1) To all surface mining permits granted after ~~the effective date of this article~~ June 11, 1999; and

(2) At the first renewal date of all previously issued permits: *Provided,* That the permittee shall be afforded ninety days from said date to comply with the provisions of this section.

§5B-2A-9. Securing developable land and infrastructure.

(a) The office shall determine the land and infrastructure needs in the general area of the surface mining operations.

(b) For the purposes of this section, the term "general area" shall mean the county or counties in which the mining operations are being conducted or any adjacent county.

(c) To assist the office the operator shall be required to prepare and submit to the office the information set forth in this subsection as follows:

(1) A map of the area for which a permit under article three, chapter twenty-two of this code is being sought or has been obtained;

(2) The names of the surface and mineral owners of the property to be mined pursuant to the permit; and

(3) A statement of the post-mining land use for all land which may be affected by the mining operations.

(d) In making a determination of the land and infrastructure needs in the general area of the mining operations, the office shall consider at least the following:

(1) The availability of developable land in the general area;

(2) The needs of the general area for developable land;

(3) The availability of infrastructure, including, but not limited to, access roads, water service, wastewater service and other utilities;

(4) The amount of land to be mined and the amount of valley to be filled;

(5) The amount, nature and cost to develop and maintain the community assets identified in section eight of this article; and

(6) The availability of federal, state and local grants and low-interest loans to finance all or a portion of the acquisition and construction of the identified land and infrastructure needs of the general area.

(e) In making a determination of the land and infrastructure needs in the general area of the surface mining operations, the office shall give significant weight to developable land on or near existing or planned multilane highways.

(f) The office may secure developable land and infrastructure for a development office or county through the preparation of a master land use plan for inclusion into a reclamation plan prepared pursuant to the provisions of section ten, article three, chapter twenty-two of this code. No provision of this section may be construed to modify requirements of article three of said chapter. ~~Participation in a master land use plan is voluntary~~

(1) ~~State, local, county or regional development or redevelopment authorities may~~ The county commission or other governing body for each county in which there are surface mining operations that are subject to this article shall determine land and infrastructure needs within their jurisdictions through the development of a master land use plan which incorporates post-mining land use needs ~~that include~~ , including, but not limited to, renewable and alternative energy uses, residential uses, highway uses, industrial uses, commercial uses, agricultural uses, public facility uses or recreational facility uses. A county commission or

other governing body of a county may designate a local, county, or regional development or redevelopment authority to assist in the preparation of a master land use plan. A county commission or other governing body of a county may adopt a master land use plan developed after July 1, 2009, only after a reasonable public comment period;

~~(2) A master land use plan must be reviewed by the office of coalfield community development and approved by the Division of Environmental Protection pursuant to section ten, article three, chapter twenty-two of this code before the master land use plan can be implemented.~~

(2) Upon the request of a county or designated development or redevelopment authority, the office shall assist the county or development or redevelopment authority with the development of a master land use plan;

(3)(A) The Department of Environmental Protection and the Office of Coalfield Community Development shall review master land use plans existing as of July 1, 2009. If the office determines that a master land use plan complies with the requirements of this article and the rules promulgated pursuant to this article, the office shall approve the plan on or before July 1, 2010;

(B) Master land use plans developed after July 1, 2009, shall be submitted to the department and the office for review. The office shall determine whether to approve a master land use plan submitted pursuant to this subdivision within three months of submission. The office shall approve the plan if it complies with the requirements of this article and the rules promulgated pursuant to this article;

(C) The office shall review a master land use plan approved under this section every three years. No later than six months before the review of a master land use plan, the county or designated development or redevelopment authority shall submit an updated master land use plan to the department and the office for review. The county may submit its updated master land use plan only after a reasonable public comment period. The office shall approve the master land use plan if the updated plan complies with the requirements of this article and the rules promulgated pursuant to this article;

(D) If the office does not approve a master land use plan, the county or designated development or redevelopment authority shall submit a supplemental master land use plan to the office for approval;

~~(3)~~ (4) The required infrastructure component standards needed to accomplish the designated post-mining land uses identified in ~~subdivision (1) of this subsection~~ a master land use plan shall be developed by the ~~relevant state, local,~~ county or ~~regional~~ its designated development or redevelopment authority. These standards must be in place before the respective ~~state, local,~~ county or ~~regional~~ development or redevelopment authority can accept ownership of property donated pursuant to a master land use plan. Acceptance of ownership of such property by a ~~state, local,~~ county or ~~regional~~ development or redevelopment authority may not occur unless it is determined that: ~~(a)~~ (i) The property use is compatible with adjacent land uses; ~~(b)~~ (ii) the use satisfies the relevant county or development or redevelopment authority's anticipated need and market use; ~~(c)~~ (iii) the property has in place necessary infrastructure components needed to achieve the anticipated use; ~~(d)~~ (iv) the use is supported by all other appropriate public agencies; ~~(e)~~ (v) the property is eligible for bond release in accordance with section twenty-three, article three, chapter twenty-two of this code; and ~~(f)~~ (vi) the use is feasible. Required infrastructure component standards require approval of the relevant county commission ~~or~~, commissions or other county governing body before such standards are accepted. County commission or other county governing body approval may be rendered only after a reasonable public comment period;

~~(4)~~ (5) The provisions of this subsection shall not take effect until legislative rules are promulgated pursuant to paragraph (C), subdivision (1), subsection (c), section twenty-three, article three, chapter twenty-two of this code governing bond releases which assure sound future maintenance by the local or regional economic development, redevelopment or planning agencies.

CHAPTER 22. ENVIRONMENTAL RESOURCES.

ARTICLE 3. SURFACE COAL MINING AND RECLAMATION ACT.

§22-3-10. Reclamation plan requirements.

(a) Each reclamation plan submitted as part of a surface mining permit application shall include, in the degree of detail necessary to demonstrate that reclamation required by this article can be accomplished, a statement of:

(1) The identification of the lands subject to surface mining over the estimated life of these operations and the size, sequence and timing of the operations for which it is anticipated that individual permits for mining will be sought;

(2) The condition of the land to be covered by the permit prior to any mining, including: (A) The uses existing at the time of the application and, if the land has a history of previous mining, the uses which preceded any mining; (B) the capability of the land prior to any mining to support a variety of uses, giving consideration to soil and foundation characteristics, topography and vegetation cover and, if applicable, a soil survey prepared pursuant to subdivision (15), subsection (a), section nine of this article; and (C) the best information available on the productivity of the land prior to mining, including appropriate classification as prime farmlands and the average yield of food, fiber, forage or wood products from the lands obtained under high levels of management;

(3) The use which is proposed to be made of the land following reclamation, including a discussion of the utility and capacity of the reclaimed land to support a variety of alternative uses, including, but not limited to, renewable and alternative energy uses, residential uses, highway uses, industrial uses, commercial uses, agricultural uses, public facility uses or recreational facility uses, and the relationship of the use to existing land use policies and plans and the comments of any owner of the surface, other state agencies and local governments which would have to initiate, implement, approve or authorize the proposed use of the land following reclamation;

~~The plan may include a master plan as provided in section nine, article two-a, chapter five-b of this code which included a post-mining land use consistent with the reclamation and post-mining land use requirements of this article;~~

(A) The post-mining land use proposed in any reclamation plan for lands proposed to be mined by surface mining methods shall comport with the land use that is specified in the approved master land use plan for the area as provided in section nine, article two-a, chapter five-b of this code: *Provided,* That the secretary may approve an alternative post-mining land use where the applicant demonstrates that:

(i) The proposed post-mining land use is a higher and better use than the land use specified in the approved master land use plan;

(ii) Site-specific conditions make attainment of a post-mining land use which comports with the land use that is specified in the approved master land use plan for the area impractical; or

(iii) The post-mining land use specified in the approved master land use plan would substantially interfere with the future extraction of mineable coal, as that term is defined in 110 CSR 1 or a successor rule, from the land to be mined.

(B) Existing permits with approved reclamation plans may be modified by the operator through an appropriate permit revision to include a post-mining land use which comports with the land use that is specified in the approved master land use plan for the area as provided in section nine, article two-a, chapter five-b of this code;

(C) By complying with a master land use plan that has been approved in accordance with article two-a, chapter five-b of this code, a post-mining land use satisfies the requirements for an alternative post-mining land use and satisfies the variance requirements set forth in subsection (c), section thirteen, article three, chapter twenty-two of this code if applicable to the proposed use;

(4) A detailed description of how the proposed post-mining land use is to be achieved and the necessary support activities which may be needed to achieve the proposed land use;

(5) The engineering techniques proposed to be used in mining and reclamation and a description of the major equipment; a plan for the control of surface water drainage and of water accumulation; a plan, where appropriate, for backfilling, soil stabilization and compacting, grading, revegetation and a plan for soil reconstruction, replacement and stabilization pursuant to the performance standards in subdivision (7), subsection (b), section thirteen of this article for those food, forage and forest lands identified therein; and a statement as to how the operator plans to comply with each of the applicable requirements set out in section thirteen or fourteen of this article;

(6) A detailed estimated timetable for the accomplishment of each major step in the reclamation plan;

(7) The consideration which has been given to conducting surface mining operations in a manner consistent with surface owner plans and applicable state and local land use plans and programs;

(8) The steps to be taken to comply with applicable air and water quality laws and rules and any applicable health and safety standards;

(9) The consideration which has been given to developing the reclamation plan in a manner consistent with local physical environmental and climatological conditions;

(10) All lands, interests in lands or options on the interests held by the applicant or pending bids on interests in lands by the applicant, which lands are contiguous

to the area to be covered by the permit;

(11) A detailed description of the measures to be taken during the surface mining and reclamation process to assure the protection of:

(A) The quality of surface and groundwater systems, both on and off site, from adverse effects of the surface mining operation;

(B) The rights of present users to the water; and

(C) The quantity of surface and groundwater systems, both on and off site, from adverse effects of the surface mining operation or to provide alternative sources of water where the protection of quantity cannot be assured;

(12) The results of tests borings which the applicant has made at the area to be covered by the permit or other equivalent information and data in a form satisfactory to the director, including the location of subsurface water and an analysis of the chemical properties, including acid-forming properties of the mineral and overburden: *Provided,* That information which pertains only to the analysis of the chemical and physical properties of the coal, except information regarding the mineral or elemental contents which are potentially toxic in the environment, shall be kept confidential and not made a matter of public record;

(13) The consideration which has been given to maximize the utilization and conservation of the solid fuel resource being recovered so that reaffecting the land in the future can be minimized; and

(14) Any other requirements as the director may prescribe by rule.

(b) ~~Any surface mining permit application filed after the effective date of this subsection may contain, in addition to the requirements of subsection (a) of this section, a master land use plan, prepared in accordance with article two-a, chapter five-b of this code, as to the post-mining land use.~~ A reclamation plan ~~approved but not implemented or~~ pending approval as of the effective date of this section may be amended by the operator to provide for a ~~revised reclamation plan consistent~~ post-mining land use that comports with ~~the provisions of this subsection~~ a master land use plan that has been approved in accordance with article two-a, chapter five-b of this code.

(c) The reclamation plan shall be available to the public for review except for those portions thereof specifically exempted in subsection (a) of this section.

(d) The amendments to this section by the first extraordinary session of the Legislature in 2009 are effective upon the approval of the corresponding amendments to West Virginia's state program, as that term is defined in the federal Surface Mining Control and Reclamation Act of 1977, 30 U. S. C. §1291, by the federal Office of Surface Mining Reclamation and Enforcement.

SENATE RESOLUTION NO. 50

(By Senators Tomblin (Mr. President), Boley, Bowman, Browning, Caruth, Chafin, Deem, Edgell, D. Facemire, K. Facemyer, Foster, Green, Guills, Hall, Helmick, Jenkins, Kessler, Laird, McCabe, Minard, Oliverio, Palumbo, Plymale, Prezioso, Snyder, Stollings, Sypolt, Wells, Williams, Yost and Fanning)

Recognizing the importance of the coal mining industry in West Virginia and requesting West Virginia's congressional delegation to support the coal industry.

Whereas, The Legislature works tirelessly to improve the quality of life for the citizens of the Mountain State; and

Whereas, Coal mining has been, and continues to be, one of the primary industries responsible for the economic success of West Virginia and its citizens; and

Whereas, Before the national economic downturn, severance tax collections from coal were at record levels, contributing to a budget surplus at the state and county levels; and

Whereas, All 55 counties continue to receive a local share of coal severance dollars to support county, local and municipal budgets; and

Whereas, County governments and county school systems throughout the state rely on the taxes from coal companies and coal miners to fund many valuable programs, including public education, ambulance services and law enforcement; and

Whereas, Thousands of West Virginians are employed, either directly or indirectly, by the coal mining industry which generates payrolls totaling over $2 billion; and

Whereas, The loss of any of West Virginia's coal mines and the loss of any mining-related employment ultimately results in significant harm to all West Virginians; and

Whereas, Surface coal mining, including the practice of mountaintop removal, currently represents forty-two percent of the total coal production in West Virginia; and

Whereas, Engrossed Senate Bill No. 375 provides for master land use plans to be developed in all counties where surface mining takes place, with greater focus provided by the Coalfield Economic Development Office on renewable and alternative fuel sources, highways and residential areas; and

Whereas, Actions and inactions by federal regulatory agencies which have had the effect of closing surface coal mines are more frequent and result in the loss of hundreds of mining and other jobs in West Virginia; therefore, be it

Resolved by the Senate:

That the Senate hereby recognizes the importance of the coal mining industry in West Virginia and requests West Virginia's congressional delegation to support the coal industry; and, be it

Further Resolved, That the Senate supports the continued mining of coal in West Virginia, including surface mining by all methods recognized by state and federal law, and is prepared to cooperate with all federal agencies in an effort to resolve quickly any outstanding issues which are preventing the mining of coal and which are contributing to the loss of jobs in West Virginia; and, be it

Further Resolved, That the Senate requests West Virginia's congressional delegation to make every effort possible to assist in securing the needed cooperation from federal agencies to allow the continuation of the mining of coal and to protect the jobs of coal miners and others who derive their employment from the coal industry; and, be it

Further Resolved, That the Clerk is hereby directed to forward a copy of this resolution to the West Virginia Coal Association and West Virginia's congressional delegation.

Resolution regarding Permit SMA#S-3002-07 and NPDES#WV1022202

Whereas tourism is the fastest growing industry in Fayette County and the economic engine of our County; and

Whereas the Midland Trail Scenic Highway, Hawks Nest State Park, the Gauley River National Recreation and the New River Gorge Bridge are central to that tourism; and

Whereas the mining described in the above-referenced permits would be visible from or impact these essential tourism areas; and

Whereas our rivers and wetlands are home to an abundance of wildlife, including trout and rare Peregrine Falcons, which would be negatively impacted by this mining; and

Whereas the federally endangered *Lampacilus abrupta* -- Pink Mucket Pearly mussel -- lives in the Kanawha River in Fayette County and is especially susceptible to changes caused by mining and acid mine drainage; and

Whereas the permit area's geology has very high levels of potentially deadly selenium and silica which would be released to the air and water if mining activities take place; and

Whereas citizens in Ansted have grave concerns over the process DEP following in granting the NPDES permit; and

NOW Be it Therefore RESOLVED that:

We, the Commissioners of Fayette County, do hereby go on record in opposition to Permits SMA#S-3002-07 and NPDES#WV1022202 and strongly urge the Appeal Board of the WV Department of Environmental Protection to rescind same.

Resolved this 12th day of February, 2008.

Kenneth L. Eskew, President

John H. Lopez

John H. Lopez, Commissioner

Matthew D. Wender, Commissioner

The Eighteenth Decennial Census of the United States

Census of Population: 1960

Volume I

CHARACTERISTICS OF THE POPULATION

Number of Inhabitants, General Population Characteristics,
General Social and Economic Characteristics,
and Detailed Characteristics

Part 50

WEST VIRGINIA

Prepared under the supervision of
Howard G. Brunsman
Chief, Population Division

U.S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

BUREAU OF THE CENSUS
Richard M. Scammon, *Director* (from May 1, 1961)
Robert W. Burgess, *Director* (to March 3, 1961)

Table 36.—SUMMARY OF ECONOMIC CHARACTERISTICS, BY COUNTIES: 1960

[See text for source of data. Percent not shown where less than 0.1; percent, median, and ratio not shown where base is less than 200]

COUNTY	NON-WORKER-WORKER RATIO[1]	PERCENT IN LABOR FORCE					CIVILIAN LABOR FORCE	EMPLOYED PERSONS		WORKERS DURING CENSUS WEEK[3]		PERSONS WHO WORKED IN 1959	FAMILIES		
		FEMALE, 14 YEARS OLD AND OVER	MARRIED WOMEN, HUSBAND PRESENT		MALE		PERCENT UNEMPLOYED	PERCENT IN MANUFACTURING INDUSTRIES	PERCENT IN WHITE-COLLAR OCCUPATIONS[2]	PERCENT WORKING OUTSIDE COUNTY OF RESIDENCE	PERCENT USING PUBLIC TRANSPORTATION	PERCENT WORKED 50 TO 52 WEEKS	MEDIAN INCOME (DOLLARS)	PERCENT WITH INCOMES OF--	
			TOTAL	WITH OWN CHILDREN UNDER 6	18 TO 24 YEARS OLD	65 YEARS OLD AND OVER								UNDER $3,000	$10,000 AND OVER
THE STATE	2.16	24.3	21.0	12.5	66.0	22.9	8.3	23.4	36.4	13.1	6.4	50.8	4 572	32.6	8.4
BARBOUR	2.54	19.1	16.3	8.5	62.5	22.3	11.4	8.7	31.5	15.3	1.2	37.5	2 807	52.8	2.1
BERKELEY	1.63	34.9	32.6	26.3	86.4	20.7	8.3	31.5	33.8	9.9	0.8	55.1	4 725	26.0	7.4
BOONE	3.02	14.1	14.0	8.0	56.3	12.6	10.4	7.5	27.1	17.9	1.1	45.7	4 139	39.8	5.2
BRAXTON	2.97	13.5	13.4	7.0	61.2	27.5	13.7	10.7	29.4	16.0	0.5	34.6	2 610	55.0	4.8
BROOKE	1.79	26.1	17.5	10.4	70.3	21.7	4.8	51.1	32.6	44.9	11.4	48.4	5 984	13.5	12.6
CABELL	1.71	31.0	26.6	16.5	67.7	28.5	6.6	24.7	45.7	8.0	10.7	53.7	5 278	24.3	12.9
CALHOUN	2.36	23.7	22.1	15.2	74.3	27.2	12.7	18.1	24.5	13.8	0.9	35.0	2 635	55.5	2.9
CLAY	3.78	12.7	13.5	12.5	51.4	20.1	10.8	19.6	28.0	22.6	6.5	37.4	2 614	55.1	1.5
DODDRIDGE	2.43	21.2	17.1	12.1	65.0	19.4	7.4	16.7	24.8	28.3	0.5	40.1	3 041	49.5	2.1
FAYETTE	2.89	18.4	16.9	9.2	48.7	15.8	12.9	16.0	33.3	13.7	5.0	46.3	3 862	41.0	6.0
GILMER	2.59	17.6	17.9	12.0	49.7	24.8	4.6	8.7	32.0	18.5	0.4	35.4	2 719	54.7	3.0
GRANT	2.18	19.0	14.4	7.1	80.1	36.4	8.5	14.9	24.7	12.7	0.3	44.9	2 437	64.0	3.0
GREENBRIER	2.14	23.6	20.3	11.2	76.0	28.7	8.1	10.9	33.1	11.4	0.6	43.2	3 426	43.7	5.5
HAMPSHIRE	2.08	21.8	20.1	12.1	78.0	29.9	7.7	15.4	27.9	20.1	0.4	41.0	2 925	51.2	3.2
HANCOCK	1.76	25.2	19.6	9.7	80.4	25.3	3.1	61.0	26.2	14.1	21.0	60.4	6 912	9.6	18.0
HARDY	2.11	20.3	19.3	7.4	76.9	35.2	5.8	22.6	23.3	12.9	0.6	46.2	2 795	53.9	3.4
HARRISON	1.82	28.0	23.0	15.2	70.7	23.4	8.5	25.2	38.6	5.7	8.9	55.7	4 969	26.6	8.0
JACKSON	2.31	17.1	15.1	8.7	82.6	25.6	8.6	35.1	29.1	10.8	0.8	47.0	4 707	35.0	7.6
JEFFERSON	1.65	31.9	31.6	28.2	71.0	30.3	6.6	19.5	32.6	22.1	1.7	46.5	4 201	32.6	7.6
KANAWHA	1.85	28.6	23.2	13.5	76.2	26.2	6.1	27.4	44.4	4.4	10.2	60.0	5 862	21.4	14.3
LEWIS	2.25	24.9	25.3	19.0	66.2	20.6	3.9	17.7	32.5	7.1	0.6	54.7	3 503	43.2	5.2
LINCOLN	3.78	12.9	12.7	9.8	48.2	18.0	12.0	19.7	25.9	36.8	1.4	36.9	2 659	54.9	2.5
LOGAN	2.95	18.7	17.4	7.8	59.4	17.7	11.6	5.8	33.1	5.0	1.8	52.2	4 876	32.6	7.2
MC DOWELL	3.17	15.9	14.6	6.9	58.8	12.4	10.8	3.4	29.2	4.3	2.9	39.3	3 932	41.4	5.8
MARION	1.62	27.9	24.0	16.5	62.9	19.8	6.7	23.2	33.6	5.9	5.6	55.5	5 153	25.3	10.2
MARSHALL	1.94	26.8	22.2	12.1	55.7	23.2	11.0	39.5	30.0	22.8	7.2	46.5	5 157	19.8	7.8
MASON	2.18	21.1	18.1	10.6	80.1	24.2	11.3	26.5	30.4	22.1	1.0	48.7	4 418	34.1	7.4
MERCER	2.26	24.8	21.6	16.4	61.2	20.5	9.4	12.6	41.7	16.4	9.7	49.2	4 073	36.8	6.3
MINERAL	2.12	21.9	18.5	10.7	56.6	20.2	6.8	29.9	30.4	36.0	1.8	50.0	4 491	30.6	6.3
MINGO	3.63	14.6	14.4	9.9	58.4	12.4	13.3	5.8	34.3	15.7	1.7	46.2	3 410	46.1	4.4
MONONGALIA	1.67	29.3	26.1	16.7	47.5	23.5	8.9	16.7	41.1	8.2	6.8	43.6	4 515	29.6	8.7
MONROE	2.22	19.8	22.7	17.9	73.4	26.4	6.0	26.1	22.1	33.3	0.4	45.9	2 597	56.6	2.7
MORGAN	1.81	29.8	30.2	22.3	77.9	34.0	14.8	19.9	25.6	19.8	1.5	45.2	3 608	41.0	3.6
NICHOLAS	2.73	16.5	14.8	6.8	65.2	22.0	8.1	15.6	28.3	12.1	1.2	37.5	3 507	43.3	4.0
OHIO	1.54	33.2	24.7	12.7	71.0	33.1	7.3	25.7	45.1	13.4	16.9	55.2	5 428	20.6	13.3
PENDLETON	2.22	18.2	17.9	12.5	68.8	34.5	11.9	12.4	18.1	7.3	1.0	42.8	2 490	60.3	2.8
PLEASANTS	2.04	26.4	22.5	10.7	74.2	27.8	7.4	30.9	34.7	20.6	0.2	51.8	4 664	31.3	5.6
POCAHONTAS	2.31	18.0	16.6	4.9	57.9	32.7	8.3	23.6	31.6	5.7	1.2	47.7	3 160	47.0	2.9
PRESTON	2.43	19.0	16.2	8.9	75.7	24.0	8.5	13.3	25.9	12.0	1.1	42.6	3 214	46.4	3.6
PUTNAM	2.42	15.9	13.3	6.9	70.6	21.7	7.6	40.4	26.3	48.6	2.3	53.7	4 779	30.4	6.8
RALEIGH	2.58	22.6	20.8	13.1	64.4	13.9	14.0	9.5	38.5	11.0	4.0	47.3	3 845	39.9	5.4
RANDOLPH	2.26	24.4	20.4	9.3	53.8	24.0	8.8	20.4	33.3	5.1	0.9	44.8	3 547	41.9	4.9
RITCHIE	2.23	19.7	19.5	11.2	71.4	27.4	8.2	21.2	27.2	19.8	0.5	46.5	3 355	45.2	3.7
ROANE	2.46	21.4	21.2	13.1	69.5	21.6	10.5	21.6	28.1	16.6	0.8	45.7	3 098	48.6	3.5
SUMMERS	2.85	16.5	15.8	9.4	54.3	32.0	13.1	10.4	34.5	13.9	3.0	40.4	2 698	54.4	3.8
TAYLOR	2.43	20.9	18.1	11.5	71.7	12.8	10.7	12.8	34.8	23.0	1.2	47.8	3 425	44.7	2.8
TUCKER	2.40	21.5	19.2	9.8	73.5	17.5	8.6	27.1	32.2	10.2	1.5	42.0	2 887	52.1	4.2
TYLER	2.35	19.2	16.9	7.9	81.1	19.7	6.7	36.7	28.2	35.7	0.4	50.9	3 903	40.9	6.0
UPSHUR	2.42	21.1	19.3	11.6	49.1	19.6	6.9	10.8	33.7	13.7	1.9	37.5	3 256	46.7	4.6
WAYNE	2.46	22.5	21.5	12.7	60.5	17.3	11.2	27.1	36.8	46.1	6.5	47.5	4 110	37.8	5.7
WEBSTER	3.22	15.5	15.7	10.2	51.6	21.0	17.1	12.4	30.8	19.6	0.7	35.8	2 476	57.7	2.5
WETZEL	2.27	19.6	17.5	7.0	70.4	16.9	8.5	38.4	37.0	33.9	0.9	58.2	5 249	29.1	9.5
WIRT	2.14	19.4	18.0	11.9	74.1	32.2	13.1	24.9	28.1	31.7	1.6	39.6	3 058	49.3	3.0
WOOD	1.74	30.8	26.0	14.7	84.6	25.5	5.0	37.5	40.1	10.4	5.1	58.8	5 499	20.1	10.3
WYOMING	3.17	13.6	13.0	7.9	56.3	16.1	8.4	5.4	27.2	7.0	0.9	47.0	4 740	33.6	5.2

[1] RATIO OF PERSONS NOT IN THE LABOR FORCE (INCLUDING CHILDREN UNDER 14) TO LABOR FORCE.
[2] PROFESSIONAL, MANAGERIAL (EXCEPT FARM), CLERICAL, AND SALES.
[3] INCLUDES MEMBERS OF THE ARMED FORCES.

1970
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volume I	CHARACTERISTICS OF THE POPULATION
part 50	West Virginia

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U. S. DEPARTMENT OF COMMERCE
Peter G. Peterson, Secretary
James T. Lynn, Under Secretary
Harold C. Passer, Assistant Secretary for Economic Affairs
and Administrator,
Social and Economic Statistics Administration

BUREAU OF THE CENSUS
George Hay Brown, Director

Table 43. Summary of Social Characteristics by Counties: 1970—Continued

[Data based on sample, see text. For minimum base for derived figures (percent, median, etc.) and meaning of symbols, see text]

Counties	Total population			Native population—Percent residing in State of birth	Persons 5 years and over—Percent migrant	Children in elementary school—Percent in private school	Persons 14 to 17 years—Percent in school	Persons 25 years and over—Median school years completed	Married couples—Percent without own household	Families—Percent with own children under 6 years	Persons under 18 years—Percent living with both parents	Women 35 to 44 years—Cumulative fertility rate[1]
	Number	Percent foreign born	Percent native of foreign or mixed parentage									
Preston	25 455	0.7	2.3	85.5	7.8	0.1	93.0	9.1	2.2	25.2	83.6	3 172
Putnam	27 625	0.4	1.0	89.4	20.3	-	87.5	10.5	0.8	25.8	87.0	3 098
Raleigh	70 080	0.8	2.4	82.8	11.4	1.7	83.1	9.8	2.6	22.3	79.5	3 199
Randolph	24 596	0.3	2.2	85.8	14.2	3.1	80.5	10.0	2.8	24.0	81.7	3 195
Ritchie	10 145	0.1	0.9	91.9	10.9	0.5	90.4	9.0	2.1	23.0	84.4	3 436
Roane	14 111	0.2	0.5	93.4	13.2	0.2	87.1	8.7	1.2	20.3	83.5	3 355
Summers	13 213	0.1	0.5	90.7	9.8	-	90.6	8.9	2.7	19.6	77.6	3 291
Taylor	13 878	0.6	2.5	89.3	15.1	3.9	90.2	10.2	2.8	22.8	78.3	3 071
Tucker	7 447	1.0	4.9	86.7	15.5	-	89.4	9.6	0.9	24.4	82.3	3 362
Tyler	9 929	0.5	2.1	84.9	16.3	0.4	86.8	11.0	0.8	29.3	84.2	3 117
Upshur	19 092	0.5	1.9	81.8	20.1	0.4	90.0	10.0	1.2	24.4	85.8	3 015
Wayne	37 581	0.3	0.7	80.6	12.9	1.3	83.8	10.0	2.0	26.1	83.6	3 031
Webster	9 809	0.3	1.0	92.1	8.3	0.4	72.7	8.5	3.6	25.7	76.7	3 634
Wetzel	20 314	0.5	2.1	85.1	12.9	2.4	88.5	11.5	1.3	28.1	85.8	3 184
Wirt	4 154	0.1	1.0	91.0	16.9	-	82.9	9.0	1.6	26.6	81.5	3 170
Wood	86 818	0.6	1.7	82.0	12.7	3.0	91.7	12.0	1.1	27.2	86.0	2 973
Wyoming	30 094	0.3	0.9	83.0	12.1	0.4	86.7	8.9	2.0	28.0	84.9	3 370

[1] Children ever born per 1,000 women of all marital classes.

Table 44. Summary of Economic Characteristics by Counties: 1970

[Data based on sample, see text. For minimum base for derived figures (percent, median, etc.) and meaning of symbols, see text]

Counties	Nonworker-worker ratio	Percent in labor force					Civilian labor force—Percent unemployed	Employed persons			Worked during census week—Percent working outside county of residence	Persons who worked in 1969—Percent worked 50 to 52 weeks	Families		
		Female, 16 years and over	Married women, husband present		Male			Percent in manufacturing industries	Percent in white-collar occupations	Percent government workers			Median income (dollars)	Percent with income of—	
			Total	With own children under 6 years	18 to 24 years	65 years and over								Less than poverty level	$15,000 or more
The State	**1.98**	**29.4**	**27.5**	**17.9**	**64.0**	**16.7**	**5.1**	**23.2**	**40.4**	**16.5**	**17.3**	**58.3**	**7 415**	**18.0**	**9.6**
Barbour	2.13	28.1	25.6	21.2	54.1	15.6	7.0	11.7	31.8	12.7	28.4	49.9	5 324	25.9	4.8
Berkeley	1.55	40.1	39.1	30.7	83.5	18.1	4.0	32.3	36.7	16.1	15.5	62.2	8 001	11.9	10.5
Boone	2.72	19.9	19.8	13.4	67.9	13.1	7.8	7.4	30.7	16.1	23.6	59.8	6 100	26.1	5.7
Braxton	2.99	19.4	19.0	14.8	64.4	7.8	10.6	14.6	37.7	24.9	13.3	47.8	4 502	37.1	3.9
Brooke	1.67	30.9	26.9	14.6	75.8	17.3	3.4	46.0	34.5	10.1	44.0	61.0	9 296	8.6	12.9
Cabell	1.66	33.9	32.4	22.5	66.0	17.6	4.9	26.0	49.3	15.1	10.5	58.4	8 109	13.1	13.6
Calhoun	2.75	22.5	23.9	22.8	60.7	7.4	10.1	28.8	34.7	34.9	24.7	50.3	4 504	37.1	5.9
Clay	3.73	14.0	10.8	3.3	63.3	5.7	15.4	20.3	27.1	21.0	42.8	49.2	4 179	39.6	2.7
Doddridge	2.34	24.2	23.3	27.5	61.8	14.0	6.9	22.1	23.6	17.6	33.2	58.7	5 896	23.4	4.5
Fayette	2.91	20.3	19.4	11.8	48.4	11.5	5.8	15.2	38.0	18.9	20.8	52.6	6 034	23.6	6.1
Gilmer	2.29	28.8	27.0	19.0	48.9	11.6	7.3	15.6	38.2	42.7	20.5	35.1	4 485	36.8	4.1
Grant	1.91	29.4	27.8	24.2	68.4	28.7	5.7	29.3	26.9	12.5	22.4	50.9	5 320	28.0	5.8
Greenbrier	2.00	28.2	27.3	19.9	67.0	25.5	6.2	13.6	36.9	16.3	13.2	54.0	6 016	21.1	6.5
Hampshire	1.72	34.7	32.4	22.8	76.9	24.0	7.1	24.2	30.3	20.2	24.1	47.7	6 119	20.6	5.0
Hancock	1.70	30.8	25.1	14.7	76.0	18.4	2.7	55.0	33.0	8.4	26.1	62.7	10 380	5.9	17.9
Hardy	1.76	29.6	32.0	26.3	76.0	21.9	6.3	30.5	23.3	15.4	26.6	53.8	5 300	26.9	6.7
Harrison	1.80	30.1	27.1	17.8	66.3	17.4	4.8	23.4	42.5	11.1	7.5	64.6	7 717	13.2	8.8
Jackson	2.06	25.6	25.9	13.5	69.5	22.4	7.9	38.4	37.4	16.6	20.7	60.0	7 959	17.0	8.0
Jefferson	1.50	37.8	35.4	22.4	74.7	25.9	3.0	20.1	39.3	20.2	27.9	59.4	7 721	13.4	11.4
Kanawha	1.65	34.3	32.1	19.4	69.6	22.2	4.1	19.1	52.0	16.0	4.6	64.3	8 669	13.0	15.3
Lewis	2.22	29.4	32.3	22.6	69.0	12.6	5.0	22.1	32.8	24.8	10.2	60.8	5 919	22.4	5.2
Lincoln	3.13	19.8	18.4	16.3	59.5	10.1	9.3	22.6	28.6	16.9	43.5	48.1	5 058	38.0	4.4
Logan	2.77	23.1	21.7	13.4	62.4	14.2	4.7	7.1	40.3	15.4	5.8	60.7	7 077	23.0	7.9
McDowell	3.20	19.1	18.6	9.0	58.0	11.3	7.4	4.2	32.9	16.3	9.3	58.5	5 868	29.3	4.6
Marion	1.77	31.8	29.5	19.8	61.5	13.0	3.7	26.6	34.5	13.1	8.0	59.3	7 807	12.6	8.7
Marshall	1.69	33.0	30.5	17.8	70.1	18.9	4.8	36.8	30.7	10.2	28.0	57.1	8 492	10.5	10.7
Mason	2.18	24.1	21.7	14.5	74.1	13.0	6.6	28.1	31.0	16.0	29.2	53.5	6 768	23.1	4.9
Mercer	1.95	30.4	28.5	20.8	65.5	13.7	5.0	14.4	43.4	18.3	16.9	57.1	6 945	18.0	8.5
Mineral	1.93	28.5	25.3	15.3	52.7	20.7	5.6	32.8	32.9	14.9	50.7	60.9	7 548	16.2	6.2
Mingo	3.42	19.3	18.8	12.8	61.3	12.7	5.3	6.7	38.5	17.8	21.9	52.5	5 127	36.5	4.5
Monongalia	1.75	34.5	33.5	20.1	39.1	19.7	4.2	11.9	49.3	37.5	9.1	46.5	7 758	13.1	12.1
Monroe	2.25	23.9	31.0	24.6	63.2	18.3	9.1	30.6	27.2	21.8	44.6	56.6	5 516	29.2	4.9
Morgan	1.84	31.2	32.4	20.8	71.9	18.7	6.1	26.8	29.1	16.4	37.9	55.8	6 897	15.0	6.5
Nicholas	2.42	24.3	22.6	16.2	64.7	11.8	8.0	12.9	30.4	14.1	11.4	58.2	6 623	25.2	5.3
Ohio	1.52	36.7	30.3	17.4	63.2	23.7	3.7	21.0	47.6	12.2	17.8	55.3	8 770	10.3	14.3
Pendleton	2.17	25.3	24.9	22.4	69.7	23.8	5.2	27.2	27.5	24.1	12.1	52.2	5 358	28.7	5.7
Pleasants	2.12	30.1	29.7	18.1	54.9	19.9	5.4	33.1	38.9	27.2	28.3	65.3	8 235	14.9	12.1
Pocahontas	2.45	21.1	19.7	8.8	63.4	11.5	8.9	23.8	31.1	34.7	10.2	50.5	5 089	27.2	5.0
Preston	2.19	27.2	27.2	18.5	71.0	11.7	4.8	23.7	27.7	19.8	27.6	56.4	5 626	26.8	4.8
Putnam	2.04	23.4	21.7	12.4	73.9	12.1	3.8	31.8	33.5	14.6	56.2	61.6	8 156	13.7	8.1
Raleigh	2.41	25.2	23.4	14.0	66.3	12.2	5.8	7.3	40.3	15.5	11.3	57.9	6 737	19.6	7.2
Randolph	2.00	30.6	30.5	23.1	56.8	19.6	5.6	18.4	40.9	17.1	7.2	56.0	5 870	24.0	5.8
Ritchie	2.17	27.3	27.8	17.5	67.2	14.0	13.4	36.3	24.9	12.9	30.1	53.1	5 681	25.0	2.7
Roane	2.58	24.4	27.1	23.4	60.5	13.0	8.6	24.9	37.2	22.7	16.1	52.2	5 517	27.1	4.3
Summers	2.76	20.3	18.8	10.0	66.4	17.9	11.7	8.1	37.1	19.6	15.1	51.1	5 130	33.7	4.3
Taylor	2.00	30.5	29.2	27.5	77.3	9.0	6.1	21.6	34.7	17.3	26.5	56.7	6 644	18.9	5.1
Tucker	2.05	28.7	31.1	22.9	57.7	17.8	4.2	31.0	33.9	28.2	12.7	58.3	5 243	24.9	5.4
Tyler	2.25	23.3	22.2	7.6	83.4	20.0	2.7	44.4	29.9	15.2	38.3	66.5	7 362	18.5	6.8
Upshur	2.06	29.1	29.1	21.2	49.7	15.8	5.8	21.4	40.5	16.3	13.1	50.1	6 228	23.8	6.3
Wayne	2.13	27.2	24.8	14.9	72.1	13.1	5.5	31.1	37.1	15.0	58.3	56.7	7 033	21.1	7.4
Webster	3.09	18.8	17.6	11.9	58.6	8.3	9.3	18.2	29.0	23.6	18.8	49.4	4 288	39.1	3.6
Wetzel	2.15	23.6	21.3	7.9	84.4	14.1	6.4	43.5	32.4	11.5	41.7	61.9	8 185	16.9	11.6
Wirt	2.22	24.1	23.3	16.9	80.1	18.2	6.6	41.4	31.3	19.7	48.9	46.0	5 688	28.9	6.8
Wood	1.61	36.0	33.4	22.7	79.1	21.9	4.4	37.0	43.6	13.6	11.9	64.2	8 766	9.7	13.3
Wyoming	2.83	16.0	15.7	6.5	69.4	11.0	4.1	7.3	28.0	14.6	10.1	59.6	7 284	21.9	5.2

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1980 Census of Population

VOLUME 1
CHARACTERISTICS OF THE POPULATION

CHAPTER C

General Social and Economic Characteristics

PART 50

WEST VIRGINIA

PC80-1-C50

Issued August 1983

U.S. Department of Commerce
Malcolm Baldrige, Secretary
Robert G. Dederick,
Under Secretary for
Economic Affairs

BUREAU OF THE CENSUS
Bruce Chapman, Director

Table 176. Labor Force Characteristics for Counties: 1980

[Data are estimates based on a sample, see Introduction. For meaning of symbols, see Introduction. For definitions of terms, see appendixes A and B]

Counties	Barbour	Berkeley	Boone	Braxton	Brooke	Cabell	Calhoun	Clay	Doddridge	Fayette	Gilmer
LABOR FORCE STATUS											
Persons 16 years and over	12 431	34 620	21 515	10 390	23 709	82 895	6 155	7 789	5 437	42 837	6 339
Labor force	5 918	21 001	9 865	4 458	12 584	44 435	2 825	3 001	2 594	18 260	2 997
Percent of persons 16 years and over	47.6	60.7	45.9	42.9	53.1	53.6	45.9	38.5	47.7	42.6	47.3
Armed Forces	5	66	19	35	7	98	–	–	–	37	5
Civilian labor force	5 913	20 935	9 846	4 423	12 577	44 337	2 825	3 001	2 594	18 223	2 992
Employed	5 330	19 333	9 151	3 814	11 818	41 224	2 423	2 599	2 294	15 858	2 752
Unemployed	583	1 602	695	609	759	3 113	402	402	300	2 365	240
Percent of civilian labor force	9.9	7.7	7.1	13.8	6.0	7.0	14.2	13.4	11.6	13.0	8.0
Not in labor force	6 513	13 619	11 650	5 932	11 125	38 460	3 330	4 788	2 843	24 577	3 342
Inmate of institution	80	982	37	22	121	1 114	3	13	12	282	–
Female, 16 years and over	6 536	17 770	10 943	5 319	12 368	44 950	3 106	3 922	2 727	22 437	3 229
Labor force	2 096	8 733	2 552	1 504	4 361	17 977	984	726	886	6 062	1 225
Percent of female, 16 years and over	32.1	49.1	23.3	28.3	35.3	40.0	31.7	18.5	32.5	27.0	37.9
Armed Forces	2	–	–	–	–	17	–	–	–	2	–
Civilian labor force	2 094	8 733	2 552	1 504	4 361	17 960	984	726	886	6 060	1 225
Employed	1 960	7 966	2 339	1 328	4 047	16 799	895	646	822	5 481	1 137
Unemployed	134	767	213	176	314	1 161	89	80	64	579	88
Percent of civilian labor force	6.4	8.8	8.3	11.7	7.2	6.5	9.0	11.0	7.2	9.6	7.2
Not in labor force	4 440	9 037	8 391	3 815	8 007	26 973	2 122	3 196	1 841	16 375	2 004
Inmate of institution	30	132	–	14	69	601	–	3	12	140	–
Male, 16 to 19 years	648	1 598	991	495	1 250	3 737	306	393	314	2 332	447
Employed	161	733	244	133	353	1 467	115	114	84	535	142
Unemployed	74	185	84	32	110	311	27	58	61	257	36
Not in labor force	413	680	663	309	787	1 947	164	221	169	1 536	269
Male, 20 to 24 years	700	1 770	1 329	518	1 436	4 949	318	415	270	2 694	470
Employed	429	1 460	1 036	310	945	3 283	180	208	162	1 471	240
Unemployed	138	162	133	89	157	528	115	92	32	449	14
Not in labor force	133	142	160	119	327	1 126	23	115	76	766	216
Male, 25 to 54 years	2 771	8 721	5 646	2 414	5 611	18 733	1 457	1 974	1 247	9 237	1 265
Employed	2 270	7 528	4 730	1 745	5 178	15 883	1 026	1 367	973	7 006	996
Unemployed	206	422	246	278	147	854	154	172	133	975	75
Not in labor force	292	711	651	377	286	1 945	277	435	141	1 233	189
Male, 55 to 64 years	756	2 527	1 330	652	1 622	5 180	380	457	347	2 941	361
Employed	382	1 345	706	242	1 161	3 063	175	220	192	1 180	183
Unemployed	20	41	19	30	12	207	17	–	8	83	7
Not in labor force	354	1 141	605	380	449	1 904	188	237	147	1 678	171
Male, 65 years and over	1 020	2 234	1 276	992	1 422	5 346	588	628	532	3 196	567
Employed	128	301	96	56	134	729	32	44	61	185	54
Unemployed	11	25	–	4	19	52	–	–	2	22	20
Not in labor force	881	1 908	1 180	932	1 269	4 565	556	584	469	2 989	493
Female, 16 to 19 years	674	1 500	944	426	1 192	3 859	279	385	231	2 053	386
Employed	151	510	96	69	398	1 098	78	36	55	314	112
Unemployed	41	118	54	7	39	202	2	12	1	100	10
Not in labor force	482	872	794	350	755	2 559	199	337	175	1 639	264
Female, 20 to 24 years	814	1 942	1 334	499	1 456	5 442	307	436	266	2 355	464
Employed	346	1 216	340	198	683	2 806	127	77	107	963	227
Unemployed	9	154	56	43	70	312	13	12	19	93	34
Not in labor force	459	572	938	258	703	2 313	167	347	140	1 297	203
Female, 25 to 54 years	2 867	8 940	5 564	2 467	5 829	19 904	1 442	1 870	1 240	10 012	1 309
Employed	1 150	5 080	1 534	885	2 374	10 107	596	454	528	3 401	622
Unemployed	73	422	95	122	187	551	49	53	26	341	44
Not in labor force	1 642	3 438	3 935	1 460	3 268	9 246	797	1 363	686	6 270	643
Female, 55 to 64 years	849	2 318	1 450	735	1 803	6 497	410	530	376	3 346	414
Employed	236	893	286	143	451	2 249	59	75	95	603	138
Unemployed	11	67	8	2	18	71	17	3	18	45	–
Not in labor force	602	1 358	1 156	590	1 334	4 171	334	452	263	2 698	276
Female, 65 years and over	1 332	3 070	1 651	1 192	2 088	9 248	668	701	614	4 671	656
Employed	77	267	83	33	141	539	35	4	37	200	38
Unemployed	–	6	–	2	–	25	8	–	–	–	–
Not in labor force	1 255	2 797	1 568	1 157	1 947	8 684	625	697	577	4 471	618
MARITAL STATUS AND PRESENCE OF OWN CHILDREN											
Female, 16 years and over	6 536	17 770	10 943	5 319	12 368	44 950	3 106	3 922	2 727	22 437	3 229
With own children under 6 years	971	2 992	2 388	842	1 921	5 841	475	867	422	3 825	477
In labor force	253	1 460	404	241	488	2 275	198	108	112	913	221
With own children 6 to 17 years only	1 261	3 705	2 307	1 060	2 389	8 056	604	782	500	4 295	594
In labor force	563	2 268	667	416	961	4 274	282	207	213	1 502	255
Married women 16 years and over, husband present	3 817	10 737	7 354	3 195	7 526	24 355	1 959	2 594	1 641	13 096	1 881
In labor force	1 243	5 388	1 628	981	2 429	9 800	708	481	566	3 596	783
With own children under 6 years	915	2 601	2 226	731	1 758	4 964	437	743	395	3 299	440
In labor force	233	1 186	349	203	434	1 828	189	67	110	732	193
With own children 6 to 17 years only	1 084	3 172	1 963	910	2 033	6 491	513	705	426	3 562	503
In labor force	468	1 869	520	334	726	3 152	229	172	183	1 127	211
CLASS OF WORKER											
Employed persons 16 years and over	5 330	19 333	9 151	3 814	11 818	41 224	2 423	2 599	2 294	15 858	2 752
Private wage and salary workers	3 987	14 011	7 300	2 377	9 949	31 537	1 473	1 733	1 487	11 466	1 528
Employees of own corporation	99	233	163	87	140	914	13	47	3	200	40
Federal government workers	100	1 833	243	165	88	1 390	99	91	74	685	99
State government workers	395	899	490	524	517	3 246	292	308	243	1 263	568
Local government workers	407	1 214	630	371	885	3 141	228	294	235	1 401	272
Self-employed workers	413	1 271	453	353	329	1 732	267	156	219	936	244
In agriculture	99	226	6	36	30	73	46	–	65	19	45
Unpaid family workers	28	105	35	24	50	178	64	17	36	107	41
In agriculture	16	18	–	–	–	11	26	13	25	9	13
Employed females 16 years and over	1 960	7 966	2 339	1 328	4 047	16 799	895	646	822	5 481	1 137
Private wage and salary workers	1 389	5 518	1 378	732	3 035	11 929	471	281	464	3 454	540
Employees of own corporation	14	83	70	23	16	213	2	7	–	38	14
Federal government workers	50	847	130	57	33	594	65	35	40	353	77
State government workers	174	526	291	229	326	1 920	117	129	127	572	279
Local government workers	236	733	354	203	512	1 768	130	162	118	787	167
Self-employed workers	101	267	161	89	91	458	69	29	49	267	66
Unpaid family workers	10	75	25	18	50	130	43	10	24	48	8

Table 176. Labor Force Characteristics for Counties: 1980—Con.

[Data are estimates based on a sample, see Introduction. For meaning of symbols, see Introduction. For definitions of terms, see appendixes A and B]

Counties	Grant	Greenbrier	Hampshire	Hancock	Hardy	Harrison	Jackson	Jefferson	Kanawha	Lewis	Lincoln
LABOR FORCE STATUS											
Persons 16 years and over	7 501	28 496	10 925	30 713	7 644	59 193	19 009	22 486	178 699	14 291	16 727
Labor force	3 928	14 539	5 982	17 107	4 236	30 419	10 174	13 311	104 354	7 081	6 877
Percent of persons 16 years and over	52.4	51.0	54.8	55.7	55.4	51.4	53.5	59.2	58.4	49.5	41.1
Armed Forces	-	5	8	22	9	28	-	12	178	8	16
Civilian labor force	3 928	14 534	5 974	17 085	4 227	30 391	10 174	13 299	104 176	7 073	6 861
Employed	3 599	13 019	5 627	15 876	3 963	28 187	9 058	12 297	97 593	6 664	5 988
Unemployed	329	1 515	347	1 209	264	2 204	1 116	1 002	6 583	409	873
Percent of civilian labor force	8.4	10.4	5.8	7.1	6.2	7.3	11.0	7.5	6.3	5.8	12.7
Not in labor force	3 573	13 957	4 943	13 606	3 408	28 774	8 835	9 175	74 345	7 210	9 850
Inmate of institution	5	401	122	170	16	403	148	245	947	653	18
Female, 16 years and over	3 838	14 921	5 636	16 078	3 879	31 777	9 719	11 482	95 537	7 556	8 517
Labor force	1 396	5 398	2 346	6 055	1 663	11 706	3 324	5 400	42 676	2 802	1 897
Percent of female, 16 years and over	36.4	36.2	41.6	37.7	42.9	36.8	34.2	47.0	44.7	37.1	22.3
Armed Forces	-	-	-	-	9	-	-	-	19	-	-
Civilian labor force	1 396	5 398	2 346	6 055	1 654	11 706	3 324	5 400	42 657	2 802	1 897
Employed	1 282	4 832	2 190	5 540	1 548	10 968	3 022	4 887	40 815	2 647	1 706
Unemployed	114	566	156	515	106	738	302	513	1 842	155	191
Percent of civilian labor force	8.2	10.5	6.6	8.5	6.4	6.3	9.1	9.5	4.3	5.5	10.1
Not in labor force	2 442	9 523	3 290	10 023	2 216	20 071	6 395	6 082	52 861	4 754	6 620
Inmate of institution	-	195	45	126	11	244	123	167	475	274	15
Male, 16 to 19 years	364	1 304	591	1 433	376	2 597	1 005	1 284	7 606	646	934
Employed	106	481	203	571	161	789	285	412	2 769	211	171
Unemployed	46	104	30	202	22	232	137	117	682	79	108
Not in labor force	212	719	358	660	193	1 576	583	755	4 155	356	655
Male, 20 to 24 years	351	1 522	487	1 673	398	3 046	1 058	1 371	9 520	650	897
Employed	269	1 010	360	1 301	302	2 101	674	987	7 032	495	479
Unemployed	45	197	48	224	30	342	238	64	1 069	44	224
Not in labor force	37	315	79	130	66	594	146	318	1 372	103	187
Male, 25 to 54 years	1 915	6 689	2 603	7 598	1 792	13 291	4 935	5 575	43 449	3 326	4 176
Employed	1 619	5 355	2 254	7 009	1 539	11 250	4 286	4 963	37 584	2 653	3 121
Unemployed	93	593	92	220	77	794	375	260	2 586	119	328
Not in labor force	203	736	249	365	176	1 228	374	342	3 173	554	718
Male, 55 to 64 years	484	1 774	774	2 000	558	3 991	1 128	1 403	11 732	890	1 030
Employed	239	1 034	462	1 228	309	2 423	661	780	7 809	521	387
Unemployed	23	49	19	28	24	78	64	25	308	12	17
Not in labor force	222	691	293	744	225	1 490	403	598	3 609	357	626
Male, 65 years and over	549	2 286	834	1 931	641	4 491	1 164	1 371	10 855	1 223	1 173
Employed	84	307	158	227	104	656	130	268	1 584	137	124
Unemployed	8	6	2	20	5	20	-	23	96	-	5
Not in labor force	457	1 973	674	1 684	532	3 815	1 034	1 080	9 175	1 086	1 044
Female, 16 to 19 years	341	1 341	562	1 491	355	2 678	950	1 194	7 649	579	889
Employed	58	263	118	373	129	662	218	421	2 756	161	135
Unemployed	30	106	9	85	6	116	55	94	320	17	8
Not in labor force	253	972	435	1 033	220	1 900	677	679	4 573	401	746
Female, 20 to 24 years	391	1 471	536	1 766	385	3 117	1 029	1 420	10 492	704	968
Employed	181	662	286	890	232	1 491	469	823	6 365	334	220
Unemployed	23	130	39	163	24	181	101	128	485	52	43
Not in labor force	187	679	211	713	129	1 445	459	469	3 635	318	705
Female, 25 to 54 years	1 915	7 024	2 802	7 816	1 851	14 316	5 131	5 511	46 834	3 338	4 157
Employed	848	3 308	1 392	3 399	953	6 910	1 995	3 005	25 481	1 672	1 147
Unemployed	57	289	65	235	56	376	139	234	850	57	134
Not in labor force	1 010	3 427	1 345	4 182	833	7 030	2 997	2 272	20 491	1 609	2 876
Female, 55 to 64 years	514	1 857	729	2 412	545	4 857	1 120	1 658	13 796	1 098	1 132
Employed	145	430	303	733	209	1 526	293	525	5 016	395	177
Unemployed	2	31	33	23	20	33	7	43	107	29	-
Not in labor force	367	1 396	393	1 656	316	3 298	820	1 090	8 673	674	955
Female, 65 years and over	677	3 228	1 007	2 593	743	6 809	1 489	1 699	16 766	1 837	1 371
Employed	50	169	91	145	25	379	47	113	1 197	85	27
Unemployed	2	10	10	9	-	32	-	14	80	-	6
Not in labor force	625	3 049	906	2 439	718	6 398	1 442	1 572	15 489	1 752	1 338
MARITAL STATUS AND PRESENCE OF OWN CHILDREN											
Female, 16 years and over	3 838	14 921	5 636	16 078	3 879	31 777	9 719	11 482	95 537	7 556	8 517
With own children under 6 years	698	2 320	890	2 409	600	4 924	1 672	1 844	14 332	1 111	1 664
In labor force	188	813	382	766	294	1 608	389	895	5 543	472	249
With own children 6 to 17 years only	835	2 810	1 209	3 189	851	5 798	2 288	2 168	17 274	1 358	1 931
In labor force	381	1 458	655	1 387	485	2 958	1 039	1 257	9 306	710	592
Married women 16 years and over, husband present	2 540	8 815	3 525	10 004	2 440	18 621	6 591	6 677	53 439	4 166	5 528
In labor force	935	3 272	1 547	3 341	1 121	6 819	2 230	3 072	23 913	1 668	1 135
With own children under 6 years	621	2 090	792	2 185	526	4 320	1 586	1 615	12 599	970	1 494
In labor force	159	696	330	618	245	1 320	356	719	4 495	378	204
With own children 6 to 17 years only	766	2 364	1 044	2 736	728	4 879	2 043	1 815	14 313	1 085	1 679
In labor force	354	1 130	561	1 082	393	2 358	876	993	7 144	535	456
CLASS OF WORKER											
Employed persons 16 years and over	3 599	13 019	5 627	15 876	3 963	28 187	9 058	12 297	97 593	6 664	5 988
Private wage and salary workers	2 442	9 413	3 655	13 704	2 746	22 027	6 960	7 901	73 913	4 318	4 212
Employees of own corporation	58	173	90	144	39	575	121	196	1 725	134	22
Federal government workers	97	523	202	106	66	1 051	214	1 334	2 818	197	195
State government workers	241	968	578	364	275	1 458	609	925	9 635	1 235	528
Local government workers	431	904	456	1 069	312	1 976	688	1 074	6 958	385	643
Self-employed workers	375	1 086	666	578	501	1 524	510	1 030	3 917	493	351
In agriculture	142	213	210	54	239	93	60	358	101	86	34
Unpaid family workers	13	125	70	55	63	151	77	33	352	36	59
In agriculture	5	53	24	10	54	5	13	17	-	11	25
Employed females 16 years and over	1 282	4 832	2 190	5 540	1 548	10 968	3 022	4 887	40 815	2 647	1 706
Private wage and salary workers	813	3 370	1 332	4 448	1 143	8 222	2 002	3 051	28 675	1 505	902
Employees of own corporation	21	47	7	34	15	132	31	57	382	24	2
Federal government workers	56	208	100	22	38	472	102	521	1 131	100	94
State government workers	78	490	293	225	102	667	297	529	5 708	699	231
Local government workers	278	512	303	648	194	1 115	408	544	4 090	209	411
Self-employed workers	46	174	133	155	71	388	166	222	956	102	61
Unpaid family workers	11	78	29	42	-	104	47	20	255	32	7

Table 176. **Labor Force Characteristics for Counties: 1980**—Con.

[Data are estimates based on a sample; see Introduction. For meaning of symbols, see Introduction. For definitions of terms, see appendixes A and B]

Counties	Logan	McDowell	Marion	Marshall	Mason	Mercer	Mineral	Mingo	Monongalia	Monroe	Morgan
LABOR FORCE STATUS											
Persons 16 years and over	**35 818**	**34 659**	**50 454**	**31 001**	**20 181**	**55 545**	**20 092**	**25 543**	**60 345**	**9 632**	**8 005**
Labor force	16 424	13 763	25 728	16 757	10 927	27 815	10 374	10 428	32 445	4 829	4 587
Percent of persons 16 years and over	45.9	39.7	51.0	54.1	54.1	50.1	51.6	40.8	53.8	50.1	57.3
Armed Forces	3	16	20	9	26	43	30	6	59	14	8
Civilian labor force	16 421	13 747	25 708	16 748	10 901	27 772	10 344	10 422	32 386	4 815	4 579
Employed	14 442	12 072	23 677	14 798	9 741	25 411	9 466	9 362	30 479	4 354	4 231
Unemployed	1 979	1 675	2 031	1 950	1 160	2 361	878	1 060	1 907	461	348
Percent of civilian labor force	12.1	12.2	7.9	11.6	10.6	8.5	8.5	10.2	5.9	9.6	7.6
Not in labor force	19 394	20 896	24 726	14 244	9 254	27 730	9 718	15 115	27 900	4 803	3 418
Inmate of institution	49	78	327	743	243	220	130	26	373	176	151
Female, 16 years and over	**18 500**	**18 210**	**27 201**	**16 028**	**10 304**	**29 782**	**10 527**	**13 132**	**30 572**	**4 962**	**4 122**
Labor force	5 212	4 119	9 986	6 092	3 684	10 582	3 538	3 037	13 638	1 787	1 764
Percent of female, 16 years and over	28.2	22.6	36.7	38.0	35.8	35.5	33.6	23.1	44.6	36.0	42.8
Armed Forces	3	6	–	–	7	5	7	–	6	6	–
Civilian labor force	5 209	4 113	9 986	6 092	3 677	10 577	3 531	3 037	13 632	1 781	1 764
Employed	4 660	3 649	9 270	5 399	3 333	9 759	3 201	2 737	13 008	1 582	1 615
Unemployed	549	464	716	693	344	818	330	300	624	199	149
Percent of civilian labor force	10.5	11.3	7.2	11.4	9.4	7.7	9.3	9.9	4.6	11.2	8.4
Not in labor force	13 288	14 091	17 215	9 936	6 620	19 200	6 989	10 095	16 934	3 175	2 358
Inmate of institution	–	17	193	104	129	128	98	6	224	116	125
Male, 16 to 19 years	**1 736**	**1 885**	**2 154**	**1 267**	**1 086**	**2 648**	**1 071**	**1 373**	**3 918**	**502**	**342**
Employed	426	385	741	315	334	912	322	306	1 160	164	144
Unemployed	168	156	171	125	152	196	88	113	160	55	28
Not in labor force	1 142	1 344	1 233	822	600	1 540	661	954	2 598	283	170
Male, 20 to 24 years	**2 216**	**2 101**	**2 831**	**1 688**	**1 107**	**3 019**	**955**	**1 685**	**7 210**	**459**	**432**
Employed	1 446	1 318	1 916	1 024	778	2 111	633	1 173	3 259	365	327
Unemployed	459	290	325	352	216	362	160	167	363	37	36
Not in labor force	311	493	590	312	113	540	157	345	3 588	57	69
Male, 25 to 54 years	**9 029**	**8 041**	**11 191**	**7 995**	**5 128**	**12 675**	**5 066**	**6 542**	**13 191**	**2 235**	**1 974**
Employed	6 890	5 577	9 416	6 471	4 350	10 321	4 468	4 560	10 998	1 814	1 717
Unemployed	724	700	722	629	406	877	277	440	667	153	89
Not in labor force	1 415	1 754	1 042	891	353	1 448	303	1 536	1 479	260	160
Male, 55 to 64 years	**2 233**	**2 232**	**3 366**	**2 008**	**1 201**	**3 729**	**1 144**	**1 419**	**2 760**	**651**	**539**
Employed	814	938	1 972	1 298	771	1 930	741	467	1 724	345	310
Unemployed	67	45	66	149	33	80	18	38	86	17	35
Not in labor force	1 352	1 249	1 328	561	397	1 719	385	914	950	289	194
Male, 65 years and over	**2 104**	**2 190**	**3 711**	**2 015**	**1 355**	**3 692**	**1 329**	**1 392**	**2 694**	**823**	**596**
Employed	206	205	362	291	175	378	101	119	330	84	118
Unemployed	12	20	31	2	9	28	5	2	7	–	11
Not in labor force	1 886	1 965	3 318	1 722	1 171	3 283	1 223	1 271	2 351	739	467
Female, 16 to 19 years	**1 728**	**1 818**	**2 368**	**1 380**	**982**	**2 556**	**994**	**1 283**	**3 610**	**440**	**314**
Employed	301	184	647	368	286	716	187	139	1 061	61	126
Unemployed	113	84	148	82	58	143	79	81	130	38	19
Not in labor force	1 314	1 550	1 573	930	638	1 697	728	1 063	2 419	341	169
Female, 20 to 24 years	**2 290**	**2 190**	**2 905**	**1 632**	**1 140**	**3 389**	**1 038**	**1 701**	**6 608**	**411**	**375**
Employed	634	497	1 381	808	508	1 667	391	423	3 345	199	174
Unemployed	100	177	128	74	72	164	87	84	183	40	14
Not in labor force	1 553	1 516	1 396	750	560	1 558	560	1 194	3 080	166	187
Female, 25 to 54 years	**9 323**	**8 537**	**12 060**	**7 956**	**5 153**	**13 421**	**5 104**	**6 618**	**12 973**	**2 331**	**2 027**
Employed	3 067	2 342	5 676	3 425	2 153	5 865	2 167	1 816	7 191	1 094	1 049
Unemployed	302	172	371	457	201	459	144	106	257	113	101
Not in labor force	5 954	6 017	6 013	4 074	2 792	7 092	2 786	4 696	5 519	1 124	877
Female, 55 to 64 years	**2 511**	**2 707**	**4 192**	**2 195**	**1 234**	**4 568**	**1 506**	**1 735**	**3 179**	**730**	**571**
Employed	551	544	1 252	650	324	1 161	348	259	1 127	175	215
Unemployed	27	29	57	80	11	39	18	11	43	6	13
Not in labor force	1 933	2 134	2 883	1 465	899	3 368	1 140	1 465	2 009	549	343
Female, 65 years and over	**2 648**	**2 958**	**5 676**	**2 865**	**1 795**	**5 848**	**1 885**	**1 795**	**4 202**	**1 050**	**835**
Employed	107	82	314	148	62	350	108	100	284	53	51
Unemployed	7	2	12	–	2	13	2	18	11	2	2
Not in labor force	2 534	2 874	5 350	2 717	1 731	5 485	1 775	1 677	3 907	995	782
MARITAL STATUS AND PRESENCE OF OWN CHILDREN											
Female, 16 years and over	**18 500**	**18 210**	**27 201**	**16 028**	**10 304**	**29 782**	**10 527**	**13 132**	**30 572**	**4 962**	**4 122**
With own children under 6 years	4 078	3 859	3 869	2 732	1 859	4 838	1 624	2 896	4 058	822	669
In labor force	923	680	1 267	927	494	1 766	485	502	1 520	322	247
With own children 6 to 17 years only	3 751	3 828	4 700	3 185	2 153	5 711	2 391	2 857	4 529	992	787
In labor force	1 256	955	2 257	1 466	1 004	2 592	1 058	730	2 507	499	442
Married women 16 years and over, husband present	**11 894**	**10 906**	**15 280**	**10 266**	**6 762**	**17 554**	**6 559**	**8 074**	**15 218**	**3 121**	**2 669**
In labor force	3 217	2 409	5 396	3 939	2 291	6 232	2 200	1 778	6 768	1 257	1 180
With own children under 6 years	3 596	3 310	3 505	2 538	1 699	4 246	1 444	2 555	3 786	777	620
In labor force	773	516	1 072	836	394	1 485	389	395	1 329	301	221
With own children 6 to 17 years only	3 187	3 152	3 917	2 794	1 886	4 710	2 077	2 318	3 799	845	692
In labor force	967	763	1 713	1 237	822	1 964	869	561	1 964	421	358
CLASS OF WORKER											
Employed persons 16 years and over	**14 442**	**12 072**	**23 677**	**14 798**	**9 741**	**25 411**	**9 466**	**9 362**	**30 479**	**4 354**	**4 231**
Private wage and salary workers	11 856	8 968	18 547	11 924	7 462	19 633	7 169	7 078	17 520	2 724	2 980
Employees of own corporation	242	122	327	189	115	513	41	155	483	54	71
Federal government workers	273	373	470	275	228	662	159	278	1 213	196	171
State government workers	654	950	1 463	730	689	2 000	673	659	8 047	491	321
Local government workers	1 013	1 170	1 864	1 128	776	1 882	799	856	2 047	390	328
Self-employed workers	618	586	1 233	663	537	1 141	618	457	1 518	500	392
In agriculture	12	8	61	130	144	81	65	–	81	143	24
Unpaid family workers	28	25	100	78	49	93	48	34	134	53	39
In agriculture	7	–	7	6	14	25	11	8	7	35	–
Employed females 16 years and over	**4 660**	**3 649**	**9 270**	**5 399**	**3 333**	**9 759**	**3 201**	**2 737**	**13 008**	**1 582**	**1 615**
Private wage and salary workers	3 207	1 910	6 762	4 127	2 311	7 009	2 228	1 601	6 656	888	1 066
Employees of own corporation	41	31	52	35	21	107	7	31	65	8	8
Federal government workers	194	244	205	97	86	227	47	152	395	111	82
State government workers	367	624	759	341	365	944	304	360	4 279	235	184
Local government workers	723	688	1 200	574	405	1 264	398	480	1 158	247	193
Self-employed workers	159	167	276	220	145	271	194	122	449	78	78
Unpaid family workers	10	16	68	40	21	44	30	22	71	23	12

Table 176. **Labor Force Characteristics for Counties: 1980**—Con.

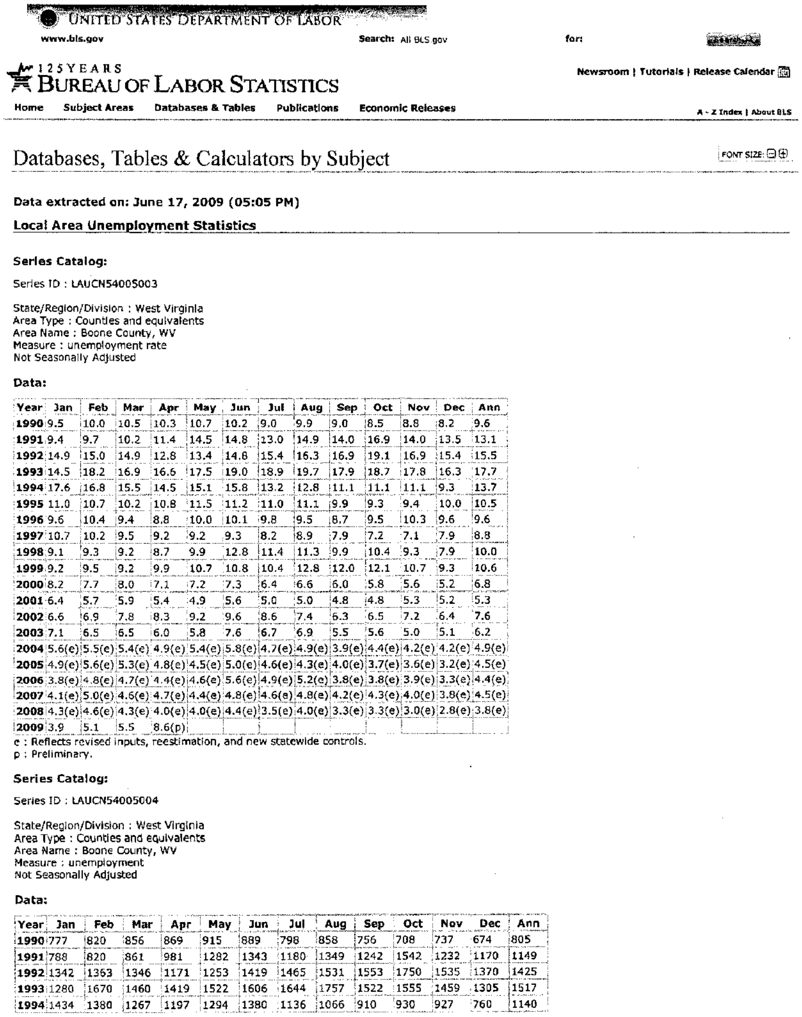
[Data are estimates based on a sample; see Introduction. For meaning of symbols, see Introduction. For definitions of terms, see appendixes A and B]

Counties	Nicholas	Ohio	Pendleton	Pleasants	Pocahontas	Preston	Putnam	Raleigh	Randolph	Ritchie	Roane
LABOR FORCE STATUS											
Persons 16 years and over	**20 183**	**48 681**	**6 009**	**6 048**	**7 487**	**22 083**	**27 970**	**63 649**	**21 757**	**8 531**	**11 999**
Labor force	9 626	26 963	3 207	2 983	3 841	10 891	15 772	30 831	11 343	4 384	5 746
Percent of persons 16 years and over	47.7	55.4	53.4	49.3	51.3	49.3	56.4	48.4	52.1	51.4	47.9
Armed Forces	16	10	168	–	–	13	30	44	2	2	–
Civilian labor force	9 610	26 953	3 039	2 983	3 841	10 878	15 742	30 787	11 341	4 382	5 746
Employed	8 492	25 366	2 843	2 735	3 507	9 896	14 141	27 957	10 404	4 031	5 115
Unemployed	1 118	1 587	196	248	334	982	1 601	2 830	937	351	631
Percent of civilian labor force	11.6	5.9	6.4	8.3	8.7	9.0	10.2	9.2	8.3	8.0	11.0
Not in labor force	10 557	21 718	2 802	3 065	3 646	11 192	12 198	32 818	10 414	4 147	6 253
Inmate of institution	82	463	91	392	167	333	21	737	780	78	432
Female, 16 years and over	**10 353**	**26 557**	**3 066**	**3 116**	**3 810**	**11 347**	**14 284**	**33 574**	**11 101**	**4 366**	**6 205**
Labor force	3 147	11 044	1 169	992	1 423	3 660	5 283	10 732	4 301	1 629	2 117
Percent of female, 16 years and over	30.4	41.6	38.1	31.8	37.3	32.3	37.0	32.0	38.7	37.3	34.1
Armed Forces	–	–	31	–	–	3	–	–	–	2	–
Civilian labor force	3 147	11 044	1 138	992	1 423	3 657	5 283	10 732	4 301	1 627	2 117
Employed	2 874	10 480	1 081	925	1 298	3 396	4 873	10 094	4 040	1 547	1 968
Unemployed	273	564	57	67	125	261	410	638	261	80	149
Percent of civilian labor force	8.7	5.1	5.0	6.8	8.8	7.1	7.8	5.9	6.1	4.9	7.0
Not in labor force	7 206	15 513	1 897	2 124	2 387	7 687	9 001	22 842	6 800	2 737	4 088
Inmate of institution	29	341	68	176	126	215	11	457	182	56	239
Male, 16 to 19 years	**1 018**	**2 224**	**236**	**333**	**329**	**1 037**	**1 320**	**2 785**	**1 162**	**406**	**579**
Employed	283	928	94	70	133	286	477	906	349	135	145
Unemployed	106	150	12	20	12	83	119	275	93	61	93
Not in labor force	629	1 146	124	243	184	668	724	1 604	720	210	341
Male, 20 to 24 years	**1 104**	**2 950**	**354**	**393**	**387**	**1 256**	**1 428**	**3 413**	**1 465**	**442**	**573**
Employed	739	1 999	232	197	269	949	1 039	2 458	836	318	394
Unemployed	185	298	22	81	59	149	262	397	198	89	107
Not in labor force	170	651	49	115	59	158	121	558	429	35	72
Male, 25 to 54 years	**5 094**	**10 334**	**1 459**	**1 451**	**1 705**	**5 432**	**7 870**	**15 739**	**5 164**	**1 945**	**2 847**
Employed	3 901	9 111	1 099	1 224	1 382	4 373	6 738	12 399	4 129	1 610	2 166
Unemployed	513	522	82	74	122	399	684	1 375	366	109	254
Not in labor force	674	699	204	153	201	650	424	1 921	669	226	427
Male, 55 to 64 years	**1 272**	**3 131**	**349**	**362**	**523**	**1 352**	**1 511**	**3 915**	**1 222**	**535**	**793**
Employed	567	2 289	188	252	318	730	861	1 740	785	262	373
Unemployed	38	53	23	6	16	82	104	113	11	10	28
Not in labor force	667	789	132	104	189	540	546	2 062	426	263	392
Male, 65 years and over	**1 342**	**3 485**	**545**	**393**	**733**	**1 659**	**1 557**	**4 223**	**1 643**	**837**	**1 002**
Employed	128	559	149	67	107	162	153	360	265	159	69
Unemployed	3	–	–	–	–	8	22	32	8	2	–
Not in labor force	1 211	2 926	396	326	626	1 489	1 382	3 831	1 370	676	933
Female, 16 to 19 years	**989**	**2 321**	**237**	**300**	**279**	**946**	**1 321**	**2 705**	**1 120**	**292**	**505**
Employed	235	882	63	33	79	258	390	647	365	62	85
Unemployed	28	66	–	8	28	60	74	129	66	2	41
Not in labor force	726	1 373	174	259	172	628	857	1 929	689	228	379
Female, 20 to 24 years	**1 190**	**3 176**	**329**	**366**	**368**	**1 238**	**1 442**	**3 527**	**1 257**	**439**	**641**
Employed	492	1 729	152	93	148	524	636	1 519	631	251	332
Unemployed	74	149	15	19	22	29	71	136	78	35	41
Not in labor force	624	1 298	137	254	198	685	735	1 872	548	153	268
Female, 25 to 54 years	**5 198**	**11 248**	**1 375**	**1 504**	**1 694**	**5 421**	**8 015**	**16 277**	**4 917**	**1 896**	**2 834**
Employed	1 789	6 138	677	645	808	2 140	3 377	6 602	2 435	954	1 240
Unemployed	165	252	31	28	71	151	256	319	105	18	64
Not in labor force	3 244	4 858	661	831	815	3 127	4 382	9 356	2 377	924	1 530
Female, 55 to 64 years	**1 352**	**3 887**	**449**	**423**	**580**	**1 544**	**1 661**	**4 886**	**1 576**	**657**	**960**
Employed	286	1 298	154	129	198	380	382	1 085	446	196	263
Unemployed	6	91	11	9	–	19	9	49	6	17	3
Not in labor force	1 060	2 498	284	285	382	1 145	1 270	3 752	1 124	444	694
Female, 65 years and over	**1 624**	**5 925**	**676**	**523**	**889**	**2 198**	**1 845**	**6 179**	**2 231**	**1 060**	**1 265**
Employed	72	433	35	25	65	94	88	241	163	64	48
Unemployed	–	6	–	3	4	2	–	5	6	8	–
Not in labor force	1 552	5 486	641	495	820	2 102	1 757	5 933	2 062	988	1 217
MARITAL STATUS AND PRESENCE OF OWN CHILDREN											
Female, 16 years and over	**10 353**	**26 557**	**3 066**	**3 116**	**3 810**	**11 347**	**14 284**	**33 574**	**11 101**	**4 366**	**6 205**
With own children under 6 years	2 127	3 196	479	516	632	2 161	2 883	6 193	1 724	690	1 156
In labor force	528	1 089	190	106	270	618	863	1 569	659	233	446
With own children 6 to 17 years only	2 210	4 334	590	609	671	2 301	3 241	6 890	2 146	859	1 131
In labor force	785	2 290	291	322	323	1 002	1 418	2 900	1 093	432	525
Married women 16 years and over, husband present	**6 796**	**13 627**	**1 899**	**1 836**	**2 250**	**7 200**	**10 134**	**20 796**	**6 568**	**2 700**	**3 980**
In labor force	1 958	5 503	808	620	889	2 377	3 610	6 587	2 722	1 030	1 468
With own children under 6 years	1 911	2 751	451	459	577	1 981	2 645	5 567	1 578	604	1 046
In labor force	406	872	176	85	233	546	732	1 284	590	189	372
With own children 6 to 17 years only	1 908	3 405	504	512	577	2 035	2 920	5 811	1 853	724	1 003
In labor force	617	1 703	245	268	267	855	1 229	2 276	911	356	457
CLASS OF WORKER											
Employed persons 16 years and over	**8 492**	**25 366**	**2 843**	**2 735**	**3 507**	**9 896**	**14 141**	**27 957**	**10 404**	**4 031**	**5 115**
Private wage and salary workers	6 573	20 442	1 728	1 784	2 045	6 966	11 123	21 466	7 695	2 881	3 359
Employees of own corporation	210	608	60	37	26	156	237	606	215	63	29
Federal government workers	161	540	189	71	223	276	381	1 240	418	87	136
State government workers	545	1 452	243	506	613	1 063	963	1 742	959	387	795
Local government workers	741	1 750	238	250	297	746	1 047	1 958	495	323	419
Self-employed workers	447	1 085	407	115	287	733	580	1 464	793	318	355
In agriculture	31	43	181	2	85	203	53	45	166	107	66
Unpaid family workers	25	97	38	9	42	112	47	87	44	35	51
In agriculture	7	–	27	–	14	35	12	–	13	22	14
Employed females 16 years and over	**2 874**	**10 480**	**1 081**	**925**	**1 298**	**3 396**	**4 873**	**10 094**	**4 040**	**1 547**	**1 968**
Private wage and salary workers	1 853	8 416	656	402	636	2 004	3 420	6 823	2 947	1 045	1 118
Employees of own corporation	12	102	2	5	9	14	52	125	69	12	–
Federal government workers	84	158	95	38	70	150	127	748	214	62	79
State government workers	294	715	132	315	277	619	512	974	376	178	458
Local government workers	499	841	136	132	208	421	599	1 133	281	173	216
Self-employed workers	124	268	51	31	91	151	187	350	185	74	60
Unpaid family workers	20	82	11	7	16	51	28	66	37	15	37

Table 176. Labor Force Characteristics for Counties: 1980—Con.

[Data are estimates based on a sample; see introduction. For meaning of symbols, see introduction. For definitions of terms, see appendixes A and B]

Counties	Summers	Taylor	Tucker	Tyler	Upshur	Wayne	Webster	Wetzel	Wirt	Wood	Wyoming
LABOR FORCE STATUS											
Persons 16 years and over	**12 125**	**12 320**	**6 527**	**8 277**	**17 565**	**33 581**	**8 712**	**16 024**	**3 653**	**70 174**	**24 900**
Labor force	4 868	6 317	3 182	4 233	8 871	16 273	3 474	8 331	1 763	40 365	10 963
Percent of persons 16 years and over	40.1	51.3	48.8	51.1	50.5	48.5	39.9	52.0	48.3	57.5	44.0
Armed Forces	6	-	-	9	13	21	2	5	-	33	8
Civilian labor force	4 862	6 317	3 182	4 224	8 858	16 252	3 472	8 326	1 763	40 332	10 955
Employed	4 181	5 557	2 887	3 885	8 084	14 632	2 928	7 483	1 596	37 299	9 942
Unemployed	681	760	295	339	774	1 620	544	843	167	3 033	1 013
Percent of civilian labor force	14.0	12.0	9.3	8.0	8.7	10.0	15.7	10.1	9.5	7.5	9.2
Not in labor force	7 257	6 003	3 345	4 044	8 694	17 308	5 238	7 693	1 890	29 809	13 937
Inmate of institution	1 054	195	151	4	110	46	6	56	8	595	3
Female, 16 years and over	**6 885**	**6 416**	**3 342**	**4 274**	**9 236**	**17 361**	**4 425**	**8 325**	**1 857**	**37 552**	**12 693**
Labor force	1 712	2 414	1 170	1 470	3 253	5 576	1 127	2 699	581	15 996	2 838
Percent of female, 16 years and over	24.9	37.6	35.0	34.4	35.2	32.1	25.5	32.4	31.3	42.6	22.4
Armed Forces	-	-	-	-	13	7	-	-	-	-	6
Civilian labor force	1 712	2 414	1 170	1 470	3 240	5 569	1 127	2 699	581	15 996	2 832
Employed	1 528	2 153	1 082	1 382	2 916	5 123	931	2 409	536	14 939	2 576
Unemployed	184	261	88	88	324	446	196	290	45	1 057	256
Percent of civilian labor force	10.7	10.8	7.5	6.0	10.0	8.0	17.4	10.7	7.7	6.6	9.0
Not in labor force	5 173	4 002	2 172	2 804	5 983	11 785	3 298	5 626	1 276	21 556	9 855
Inmate of institution	1 036	52	52	1	75	-	-	25	2	395	-
Male, 16 to 19 years	**495**	**627**	**366**	**436**	**988**	**1 683**	**472**	**747**	**234**	**3 266**	**1 247**
Employed	156	159	109	105	296	342	52	189	56	1 150	384
Unemployed	79	42	32	52	102	150	70	117	7	290	100
Not in labor force	260	426	225	279	590	1 191	350	441	171	1 826	763
Male, 20 to 24 years	**557**	**625**	**304**	**388**	**1 227**	**1 866**	**444**	**832**	**198**	**3 639**	**1 651**
Employed	355	360	208	282	755	1 309	302	571	154	2 512	1 206
Unemployed	111	159	45	61	98	268	93	119	19	686	237
Not in labor force	91	106	51	45	374	289	49	142	25	441	208
Male, 25 to 54 years	**2 482**	**2 979**	**1 546**	**2 029**	**3 889**	**8 505**	**2 119**	**3 999**	**867**	**17 243**	**6 678**
Employed	1 784	2 432	1 239	1 726	3 354	6 725	1 462	3 442	732	15 300	5 133
Unemployed	279	247	111	123	220	640	170	272	83	888	397
Not in labor force	413	300	196	171	315	1 126	485	280	52	1 028	1 146
Male, 55 to 64 years	**819**	**743**	**375**	**504**	**1 025**	**2 040**	**488**	**989**	**197**	**4 133**	**1 428**
Employed	286	381	209	315	594	943	154	711	84	2 764	596
Unemployed	28	51	15	13	18	97	11	22	13	96	15
Not in labor force	505	311	151	176	413	1 000	323	256	100	1 273	817
Male, 65 years and over	**887**	**930**	**594**	**646**	**1 200**	**2 126**	**764**	**1 132**	**300**	**4 341**	**1 203**
Employed	72	72	40	75	169	190	27	161	34	634	47
Unemployed	-	-	4	2	12	19	4	23	-	16	8
Not in labor force	815	858	550	569	1 019	1 917	733	948	266	3 685	1 148
Female, 16 to 19 years	**525**	**522**	**277**	**398**	**1 049**	**1 646**	**359**	**876**	**197**	**3 328**	**1 308**
Employed	65	114	78	88	251	330	39	162	45	1 221	116
Unemployed	51	22	10	18	53	59	26	41	-	206	67
Not in labor force	409	386	189	292	745	1 257	294	673	152	1 901	1 119
Female, 20 to 24 years	**763**	**587**	**307**	**417**	**1 364**	**1 830**	**496**	**770**	**176**	**4 024**	**1 714**
Employed	215	257	141	170	527	761	134	277	73	2 305	414
Unemployed	57	25	8	19	93	121	57	72	27	256	48
Not in labor force	491	305	158	228	744	948	305	421	76	1 463	1 252
Female, 25 to 54 years	**3 507**	**3 005**	**1 543**	**2 043**	**4 084**	**8 871**	**2 107**	**3 995**	**855**	**18 252**	**6 622**
Employed	982	1 442	695	872	1 777	3 366	648	1 549	389	9 170	1 711
Unemployed	69	181	55	51	154	243	103	166	18	524	115
Not in labor force	2 456	1 382	793	1 120	2 140	5 255	1 356	2 280	448	8 558	4 796
Female, 55 to 64 years	**831**	**881**	**441**	**575**	**1 006**	**2 313**	**635**	**1 115**	**272**	**4 954**	**1 596**
Employed	219	279	123	202	264	522	94	318	24	1 743	288
Unemployed	7	33	13	-	6	23	2	5	-	55	19
Not in labor force	605	569	305	373	736	1 768	539	792	248	3 156	1 289
Female, 65 years and over	**1 259**	**1 421**	**774**	**841**	**1 733**	**2 701**	**828**	**1 569**	**357**	**6 994**	**1 453**
Employed	47	61	45	50	97	144	16	103	5	500	47
Unemployed	-	-	2	-	18	-	8	6	-	16	7
Not in labor force	1 212	1 360	727	791	1 618	2 557	804	1 460	352	6 478	1 399
MARITAL STATUS AND PRESENCE OF OWN CHILDREN											
Female, 16 years and over	**6 885**	**6 416**	**3 342**	**4 274**	**9 236**	**17 361**	**4 425**	**8 325**	**1 857**	**37 552**	**12 693**
With own children under 6 years	1 158	1 042	484	678	1 596	2 978	871	1 367	253	5 749	3 070
In labor force	345	386	165	207	389	949	164	371	71	2 283	474
With own children 6 to 17 years only	939	1 304	715	993	1 587	3 894	893	1 759	448	7 742	2 975
In labor force	400	632	345	419	813	1 473	325	758	220	4 018	772
Married women 16 years and over, husband present	**3 338**	**3 971**	**2 042**	**2 604**	**5 615**	**11 345**	**2 799**	**5 167**	**1 225**	**22 863**	**8 848**
In labor force	1 026	1 596	782	951	1 887	3 604	707	1 693	391	9 590	1 946
With own children under 6 years	985	938	449	606	1 482	2 618	765	1 211	242	5 101	2 839
In labor force	249	326	150	179	312	809	130	325	71	1 959	405
With own children 6 to 17 years only	692	1 061	611	893	1 296	3 433	762	1 552	419	6 667	2 650
In labor force	282	480	291	346	610	1 191	261	640	206	3 204	664
CLASS OF WORKER											
Employed persons 16 years and over	**4 181**	**5 557**	**2 887**	**3 885**	**8 084**	**14 632**	**2 928**	**7 483**	**1 596**	**37 299**	**9 942**
Private wage and salary workers	2 705	4 032	2 006	2 712	6 027	11 019	1 984	6 000	1 038	29 060	8 084
Employees of own corporation	85	70	61	12	145	208	32	61	8	455	154
Federal government workers	159	135	92	82	260	668	58	144	117	1 698	176
State government workers	427	518	318	397	509	838	309	348	171	1 930	551
Local government workers	466	552	246	431	581	1 178	360	569	150	2 706	736
Self-employed workers	398	258	199	225	615	838	188	389	113	1 771	347
In agriculture	45	46	26	50	65	33	11	44	18	109	-
Unpaid family workers	26	62	26	38	92	91	29	33	7	134	48
In agriculture	8	9	-	6	26	6	5	5	7	14	-
Employed females 16 years and over	**1 528**	**2 153**	**1 082**	**1 382**	**2 916**	**5 123**	**931**	**2 409**	**536**	**14 939**	**2 576**
Private wage and salary workers	900	1 362	691	700	2 078	3 489	486	1 582	275	10 672	1 538
Employees of own corporation	26	16	6	-	31	31	6	13	-	72	21
Federal government workers	61	73	39	17	102	253	39	90	69	1 056	105
State government workers	231	253	133	279	266	446	182	205	78	985	328
Local government workers	205	354	160	290	304	655	188	380	74	1 608	440
Self-employed workers	113	65	35	64	115	210	26	132	40	508	142
Unpaid family workers	18	46	24	32	51	70	10	20	-	110	23



Databases, Tables & Calculators by Subject

Data extracted on: June 17, 2009 (05:05 PM)

Local Area Unemployment Statistics

Series Catalog:

Series ID : LAUCN54005003

State/Region/Division : West Virginia
Area Type : Counties and equivalents
Area Name : Boone County, WV
Measure : unemployment rate
Not Seasonally Adjusted

Data:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1990	9.5	10.0	10.5	10.3	10.7	10.2	9.0	9.9	9.0	8.5	8.8	8.2	9.6
1991	9.4	9.7	10.2	11.4	14.5	14.8	13.0	14.9	14.0	16.9	14.0	13.5	13.1
1992	14.9	15.0	14.9	12.8	13.4	14.8	15.4	16.3	16.9	19.1	16.9	15.4	15.5
1993	14.5	18.2	16.9	16.6	17.5	19.0	18.9	19.7	17.9	18.7	17.8	16.3	17.7
1994	17.6	16.8	15.5	14.5	15.1	15.8	13.2	12.8	11.1	11.1	11.1	9.3	13.7
1995	11.0	10.7	10.2	10.8	11.5	11.2	11.0	11.1	9.9	9.3	9.4	10.0	10.5
1996	9.6	10.4	9.4	8.8	10.0	10.1	9.8	9.5	8.7	9.5	10.3	9.6	9.6
1997	10.7	10.2	9.5	9.2	9.2	9.3	8.2	8.9	7.9	7.2	7.1	7.9	8.8
1998	9.1	9.3	9.2	8.7	9.9	12.8	11.4	11.3	9.9	10.4	9.3	7.9	10.0
1999	9.2	9.5	9.2	9.9	10.7	10.8	10.4	12.8	12.0	12.1	10.7	9.3	10.6
2000	8.2	7.7	8.0	7.1	7.2	7.3	6.4	6.6	6.0	5.8	5.6	5.2	6.8
2001	6.4	5.7	5.9	5.4	4.9	5.6	5.0	5.0	4.8	4.8	5.3	5.2	5.3
2002	6.6	6.9	7.8	8.3	9.2	9.6	8.6	7.4	6.3	6.5	7.2	6.4	7.6
2003	7.1	6.5	6.5	6.0	5.8	7.6	6.7	6.9	5.5	5.6	5.0	5.1	6.2
2004	5.6(e)	5.5(e)	5.4(e)	4.9(e)	5.4(e)	5.8(e)	4.7(e)	4.9(e)	3.9(e)	4.4(e)	4.2(e)	4.2(e)	4.9(e)
2005	4.9(e)	5.6(e)	5.3(e)	4.8(e)	4.5(e)	5.0(e)	4.6(e)	4.3(e)	4.0(e)	3.7(e)	3.6(e)	3.2(e)	4.5(e)
2006	3.8(e)	4.8(e)	4.7(e)	4.4(e)	4.6(e)	5.6(e)	4.9(e)	5.2(e)	3.8(e)	3.8(e)	3.9(e)	3.3(e)	4.4(e)
2007	4.1(e)	5.0(e)	4.6(e)	4.7(e)	4.4(e)	4.8(e)	4.6(e)	4.8(e)	4.2(e)	4.3(e)	4.0(e)	3.8(e)	4.5(e)
2008	4.3(e)	4.6(e)	4.3(e)	4.0(e)	4.0(e)	4.4(e)	3.5(e)	4.0(e)	3.3(e)	3.3(e)	3.0(e)	2.8(e)	3.8(e)
2009	3.9	5.1	5.5	8.6(p)									

e : Reflects revised inputs, reestimation, and new statewide controls.
p : Preliminary.

Series Catalog:

Series ID : LAUCN54005004

State/Region/Division : West Virginia
Area Type : Counties and equivalents
Area Name : Boone County, WV
Measure : unemployment
Not Seasonally Adjusted

Data:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1990	777	820	856	869	915	889	798	858	756	708	737	674	805
1991	788	820	861	981	1282	1343	1180	1349	1242	1542	1232	1170	1149
1992	1342	1363	1346	1171	1253	1419	1465	1531	1553	1750	1535	1370	1425
1993	1280	1670	1460	1419	1522	1606	1644	1757	1522	1555	1459	1305	1517
1994	1434	1380	1267	1197	1294	1380	1136	1066	910	930	927	760	1140

1993	8814	9169	8624	8544	8713	8452	8713	8902	8507	8320	8199	8015	8581
1994	8155	8207	8165	8244	8590	8755	8579	8360	8177	8341	8344	8143	8338
1995	8263	8303	8312	8494	8643	8607	8656	8631	8415	8346	8295	8210	8431
1996	8294	8445	8334	8481	8650	8660	8479	8491	8434	8320	8184	8202	8415
1997	8148	8198	8413	8397	8425	8526	8504	8474	8238	8165	8337	8064	8324
1998	8053	8132	8151	8048	8276	8511	8688	8509	8290	8098	8202	7951	8242
1999	7976	7931	7819	7941	8107	8315	8344	8395	8331	8083	8222	7846	8109
2000	9819	9806	9805	9848	9712	9983	9933	9876	9735	9724	9725	9724	9808
2001	9715	9633	9614	9559	9541	9735	9826	9595	9546	9530	9551	9492	9611
2002	9481	9556	9634	9803	9834	10115	10184	9823	9690	9659	9672	9550	9751
2003	9341	9336	9312	9390	9419	9727	9739	9610	9385	9382	9349	9313	9442
2004	9204(e)	9245(e)	9244(e)	9302(e)	9394(e)	9601(e)	9549(e)	9436(e)	9282(e)	9324(e)	9284(e)	9250(e)	9343(e)
2005	9188(e)	9286(e)	9277(e)	9336(e)	9378(e)	9599(e)	9629(e)	9479(e)	9393(e)	9384(e)	9296(e)	9277(e)	9377(e)
2006	9133(e)	9234(e)	9270(e)	9397(e)	9510(e)	9808(e)	9754(e)	9686(e)	9500(e)	9488(e)	9473(e)	9415(e)	9473(e)
2007	9238(e)	9326(e)	9347(e)	9428(e)	9499(e)	9715(e)	9744(e)	9617(e)	9514(e)	9499(e)	9425(e)	9355(e)	9475(e)
2008	9350(e)	9309(e)	9312(e)	9461(e)	9441(e)	9673(e)	9658(e)	9523(e)	9381(e)	9338(e)	9221(e)	9111(e)	9398(e)
2009	9032	8986	8941	9321(p)									

e : Reflects revised inputs, reestimation, and new statewide controls.
p : Preliminary.

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Databases, Tables & Calculators by Subject

Data extracted on: June 17, 2009 (05:07 PM)

Local Area Unemployment Statistics

Series Catalog:

Series ID : LAUPA54065003

State/Region/Division : West Virginia
Area Type : Counties and equivalents
Area Name : Fayette County, WV
Measure : unemployment rate
Not Seasonally Adjusted

Data:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1990	12.3	11.6	11.4	11.3	9.8	10.9	9.8	10.5	11.1	12.0	13.0	13.2	11.4
1991	14.7	15.1	14.0	12.0	13.1	13.0	11.6	13.7	13.2	12.8	15.4	14.7	13.6
1992	18.8	16.8	16.2	14.1	14.0	14.0	13.6	14.0	12.4	12.5	15.1	14.7	14.6
1993	16.2	17.1	15.6	14.6	13.8	13.5	13.4	11.9	11.6	11.9	13.4	14.1	13.9
1994	17.3	15.8	15.9	13.5	12.1	11.7	10.9	11.0	9.5	9.8	11.5	11.2	12.5
1995	13.3	14.7	13.7	10.4	9.1	10.0	9.3	9.3	8.3	8.3	11.9	11.5	10.7
1996	13.3	12.3	11.3	9.4	8.3	8.1	7.5	7.8	7.3	7.7	11.2	10.8	9.5
1997	13.2	12.6	11.0	8.9	7.9	8.1	7.0	7.4	6.3	6.8	10.1	10.8	9.1
1998	12.2	12.2	11.6	8.4	7.4	7.8	7.3	7.7	7.0	7.9	10.5	9.5	9.1
1999	11.3	12.0	11.0	10.7	9.7	9.0	9.1	9.1	7.8	7.6	10.7	9.6	9.8
2000	9.6	9.8	8.8	7.2	6.6	6.6	6.1	6.1	5.3	5.6	6.9	6.9	7.1
2001	8.7	8.5	7.8	6.6	5.4	5.7	5.3	5.6	5.0	5.0	6.4	6.6	6.4
2002	8.4	8.5	7.9	7.5	7.2	7.8	6.8	6.6	5.6	5.9	7.7	7.9	7.3
2003	9.5	9.7	8.8	7.6	6.6	7.3	6.6	6.5	5.4	5.8	6.9	6.9	7.3
2004	7.9(e)	7.9(e)	7.3(e)	6.4(e)	5.8(e)	6.0(e)	5.2(e)	5.2(e)	4.2(e)	5.0(e)	6.2(e)	6.1(e)	6.1(e)
2005	7.0(e)	7.8(e)	7.0(e)	5.9(e)	5.0(e)	5.4(e)	4.9(e)	5.0(e)	4.5(e)	4.4(e)	5.4(e)	5.2(e)	5.6(e)
2006	6.2(e)	6.8(e)	6.1(e)	5.4(e)	5.1(e)	5.4(e)	4.9(e)	5.1(e)	4.2(e)	4.1(e)	5.1(e)	5.0(e)	5.3(e)
2007	6.4(e)	7.1(e)	6.0(e)	5.3(e)	4.6(e)	4.8(e)	4.6(e)	4.6(e)	4.0(e)	4.2(e)	5.1(e)	5.3(e)	5.1(e)
2008	5.7(e)	6.1(e)	5.5(e)	4.6(e)	4.3(e)	4.5(e)	3.8(e)	4.0(e)	3.5(e)	3.6(e)	4.2(e)	4.6(e)	4.5(e)
2009	6.5	7.7	8.1	8.2(p)									

e : Reflects revised inputs, reestimation, and new statewide controls.
p : Preliminary.

Series Catalog:

Series ID : LAUPA54065004

State/Region/Division : West Virginia
Area Type : Counties and equivalents
Area Name : Fayette County, WV
Measure : unemployment
Not Seasonally Adjusted

Data:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1990	1972	1814	1795	1916	1677	1873	1700	1793	1905	2062	2181	2185	1906
1991	2406	2490	2326	2028	2255	2263	2057	2397	2307	2233	2617	2466	2320
1992	3191	2758	2708	2400	2464	2482	2449	2452	2169	2201	2552	2452	2523
1993	2662	2833	2609	2507	2462	2448	2474	2180	2081	2157	2343	2433	2432
1994	2963	2659	2694	2372	2202	2167	2010	2009	1737	1797	1995	1892	2208

1993	16425	16600	16686	17178	17785	18132	18530	18286	18013	18095	17490	17243	17538
1994	17092	16807	16989	17614	18202	18515	18415	18187	18273	18252	17358	16819	17710
1995	16808	17150	17417	17683	18073	18754	18714	18552	18490	18260	17558	17218	17890
1996	17054	17245	17226	17857	18598	19036	19207	19046	19107	18835	17852	17481	18212
1997	17537	17409	17470	17811	18390	18913	19079	18829	18723	18563	17546	17266	18128
1998	17263	17287	17391	17675	18459	18304	18832	18539	18796	18667	17687	17285	18016
1999	17136	17234	16928	17679	18020	18276	18242	17955	18042	17869	16964	16706	17587
2000	18072	18051	17936	18343	18918	19232	19156	18920	19027	18630	17942	17792	18501
2001	18071	17938	17946	18219	18419	18781	18832	18557	18504	18352	17909	17717	18270
2002	17579	17676	17783	18234	18501	19064	19138	18893	19005	18635	18036	17847	18366
2003	17407	17500	17423	17694	18030	18555	18609	18212	18183	18073	17538	17405	17886
2004	17225(e)	17273(e)	17248(e)	17593(e)	17922(e)	18455(e)	18437(e)	18102(e)	18035(e)	18161(e)	17481(e)	17338(e)	17772(e)
2005	17117(e)	17218(e)	17236(e)	17649(e)	17946(e)	18409(e)	18553(e)	18454(e)	18425(e)	18284(e)	17844(e)	17640(e)	17898(e)
2006	17237(e)	17323(e)	17296(e)	17732(e)	18155(e)	18838(e)	19032(e)	18817(e)	18762(e)	18522(e)	17960(e)	17813(e)	18124(e)
2007	17560(e)	17741(e)	17710(e)	18016(e)	18206(e)	18781(e)	18959(e)	18727(e)	18715(e)	18389(e)	17787(e)	17545(e)	18178(e)
2008	17319(e)	17449(e)	17480(e)	17906(e)	18187(e)	18555(e)	18578(e)	18408(e)	18365(e)	18213(e)	17737(e)	17536(e)	17978(e)
2009	17139	17234	17168	17352(p)									

e : Reflects revised inputs, reestimation, and new statewide controls.
p : Preliminary.

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Databases, Tables & Calculators by Subject

Data extracted on: June 17, 2009 (05:08 PM)

Local Area Unemployment Statistics

Series Catalog:

Series ID : LAUCN54043003

State/Region/Division : West Virginia
Area Type : Counties and equivalents
Area Name : Lincoln County, WV
Measure : unemployment rate
Not Seasonally Adjusted

Data:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1990	15.7	15.0	13.9	13.3	14.0	14.7	13.5	16.0	14.8	14.5	12.7	14.6	14.4
1991	16.7	18.1	16.8	17.0	16.8	16.9	15.1	16.4	14.6	16.2	16.0	16.5	16.4
1992	19.3	19.1	17.9	15.7	14.7	16.4	14.1	15.7	14.0	15.2	15.9	16.5	16.2
1993	17.0	17.1	16.8	15.5	14.8	16.3	15.6	15.0	12.3	12.4	12.7	12.7	14.9
1994	17.7	15.9	15.9	13.2	11.5	13.7	12.6	13.0	10.7	11.0	10.4	11.2	13.0
1995	13.7	14.0	12.8	13.1	12.9	14.0	12.7	13.3	12.2	11.5	13.7	12.6	13.0
1996	17.1	15.7	14.4	12.3	11.0	11.6	11.7	11.5	9.1	10.3	10.3	10.6	12.1
1997	13.5	14.0	12.7	10.3	10.2	12.1	10.7	10.5	8.9	10.1	9.5	9.8	11.0
1998	13.6	13.2	13.1	10.4	9.9	13.0	10.7	11.0	9.0	10.3	10.3	9.8	11.2
1999	13.2	12.7	12.6	11.6	10.9	11.7	11.3	12.1	10.1	9.4	10.1	9.7	11.3
2000	9.1	9.0	8.3	7.2	7.7	8.0	7.3	7.0	6.3	5.7	6.0	6.0	7.3
2001	8.7	8.5	8.0	7.2	6.0	6.9	6.3	6.7	5.4	5.8	6.3	6.4	6.9
2002	9.1	9.3	9.7	9.1	8.1	8.7	7.9	8.0	6.8	6.7	7.6	7.7	8.2
2003	9.2	9.8	8.9	8.4	7.0	8.5	7.2	7.1	5.9	5.7	6.0	5.5	7.4
2004	7.3(e)	7.6(e)	7.2(e)	6.4(e)	5.9(e)	6.6(e)	5.9(e)	6.2(e)	4.8(e)	5.3(e)	5.3(e)	5.6(e)	6.2(e)
2005	7.1(e)	7.9(e)	7.3(e)	6.3(e)	5.8(e)	6.8(e)	6.1(e)	6.3(e)	5.1(e)	5.1(e)	5.4(e)	5.1(e)	6.2(e)
2006	6.3(e)	6.7(e)	6.2(e)	5.5(e)	5.6(e)	6.6(e)	5.9(e)	6.3(e)	5.1(e)	4.8(e)	4.8(e)	4.6(e)	5.7(e)
2007	5.9(e)	7.1(e)	6.1(e)	5.5(e)	4.9(e)	5.5(e)	5.3(e)	5.3(e)	4.2(e)	4.0(e)	4.0(e)	4.0(e)	5.2(e)
2008	5.1(e)	5.9(e)	5.3(e)	4.8(e)	4.7(e)	5.0(e)	4.3(e)	4.5(e)	3.7(e)	3.8(e)	3.9(e)	4.5(e)	4.6(e)
2009	6.8	8.9	9.5	10.3(p)									

e : Reflects revised inputs, reestimation, and new statewide controls.
p : Preliminary.

Series Catalog:

Series ID : LAUCN54043004

State/Region/Division : West Virginia
Area Type : Counties and equivalents
Area Name : Lincoln County, WV
Measure : unemployment
Not Seasonally Adjusted

Data:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1990	1106	1044	961	921	983	1036	991	1120	998	1004	846	985	1000
1991	1139	1283	1187	1202	1176	1199	1111	1129	1006	1148	1121	1162	1155
1992	1408	1405	1308	1134	1140	1181	1057	1108	977	1089	1132	1181	1177
1993	1198	1218	1193	1085	1053	1187	1145	1031	835	871	905	882	1050
1994	1240	1117	1106	914	868	981	930	921	747	772	776	772	929

1993	7060	7137	7109	6980	7104	7266	7324	6878	6792	7000	7128	6926	7058
1994	7025	7032	6937	6950	7569	7145	7381	7084	6998	6988	7461	6900	7123
1995	6860	6899	6792	6882	6892	7007	7313	6930	6794	6912	7045	6985	6943
1996	7195	7174	7046	7047	7625	7086	7255	6999	6902	7088	7062	6966	7121
1997	7051	7075	6962	6838	6884	7018	7259	6917	6951	6953	6916	6775	6966
1998	7047	7031	7040	6929	7384	7142	7184	7023	6915	6839	6776	6747	7004
1999	6941	6969	6999	7013	6993	7126	7393	7160	7060	6994	6985	6955	7049
2000	8173	8196	8111	8127	8053	8295	8275	8178	8054	8011	8054	8083	8134
2001	8237	8200	8136	8052	7980	8160	8228	8076	7945	7967	7975	7952	8075
2002	8049	8112	8123	8177	8034	8271	8353	8174	8059	8000	8032	8004	8116
2003	7895	7996	7896	7965	7881	8118	8089	7961	7788	7757	7810	7735	7907
2004	7774(e)	7851(e)	7820(e)	7841(e)	7832(e)	8030(e)	8023(e)	7935(e)	7774(e)	7809(e)	7792(e)	7788(e)	7856(e)
2005	7779(e)	7874(e)	7835(e)	7854(e)	7863(e)	8098(e)	8096(e)	8010(e)	7864(e)	7877(e)	7839(e)	7828(e)	7902(e)
2006	7809(e)	7845(e)	7845(e)	7913(e)	7998(e)	8260(e)	8208(e)	8161(e)	8015(e)	7986(e)	7966(e)	7948(e)	7997(e)
2007	7921(e)	8028(e)	7990(e)	7998(e)	8039(e)	8240(e)	8263(e)	8132(e)	8004(e)	7976(e)	7930(e)	7895(e)	8035(e)
2008	7934(e)	7938(e)	7920(e)	8027(e)	8011(e)	8187(e)	8194(e)	8064(e)	7925(e)	7905(e)	7837(e)	7805(e)	7979(e)
2009	7836	7878	7865	7991(p)									

e : Reflects revised inputs, reestimation, and new statewide controls.
p : Preliminary.

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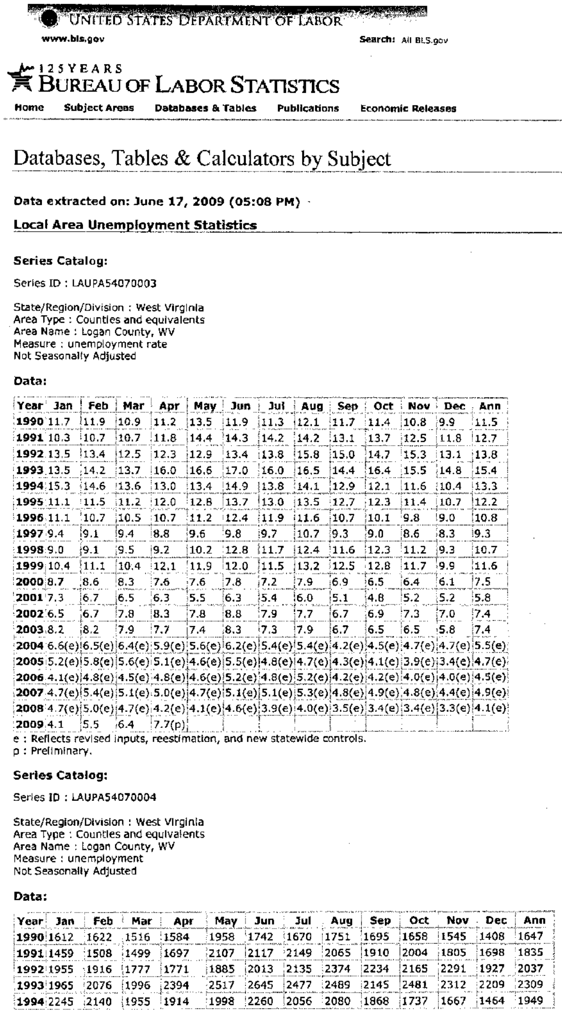

Databases, Tables & Calculators by Subject

Data extracted on: June 17, 2009 (05:08 PM)

Local Area Unemployment Statistics

Series Catalog:

Series ID : LAUPA54070003

State/Region/Division : West Virginia
Area Type : Counties and equivalents
Area Name : Logan County, WV
Measure : unemployment rate
Not Seasonally Adjusted

Data:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1990	11.7	11.9	10.9	11.2	13.5	11.9	11.3	12.1	11.7	11.4	10.8	9.9	11.5
1991	10.3	10.7	10.7	11.8	14.4	14.3	14.2	14.2	13.1	13.7	12.5	11.8	12.7
1992	13.5	13.4	12.5	12.3	12.9	13.4	13.8	15.8	15.0	14.7	15.3	13.1	13.8
1993	13.5	14.2	13.7	16.0	16.6	17.0	16.0	16.5	14.4	16.4	15.5	14.8	15.4
1994	15.3	14.6	13.6	13.0	13.4	14.9	13.8	14.1	12.9	12.1	11.6	10.4	13.3
1995	11.1	11.5	11.2	12.0	12.8	13.7	13.0	13.5	12.7	12.3	11.4	10.7	12.2
1996	11.1	10.7	10.5	10.7	11.2	12.4	11.9	11.6	10.7	10.1	9.8	9.0	10.8
1997	9.4	9.1	9.4	8.8	9.6	9.8	9.7	10.7	9.3	9.0	8.6	8.3	9.3
1998	9.0	9.1	9.5	9.2	10.2	12.8	11.7	12.4	11.6	12.3	11.2	9.3	10.7
1999	10.4	11.1	10.4	12.1	11.9	12.0	11.5	13.2	12.5	12.8	11.7	9.9	11.6
2000	8.7	8.6	8.3	7.6	7.6	7.8	7.2	7.9	6.9	6.5	6.4	6.1	7.5
2001	7.3	6.7	6.5	6.3	5.5	6.3	5.4	6.0	5.1	4.8	5.2	5.2	5.8
2002	6.5	6.7	7.8	8.3	7.8	8.8	7.9	7.7	6.7	6.9	7.3	7.0	7.4
2003	8.2	8.2	7.9	7.7	7.4	8.3	7.3	7.9	6.7	6.5	6.5	5.8	7.4
2004	6.6(e)	6.5(e)	6.4(e)	5.9(e)	5.6(e)	6.2(e)	5.4(e)	5.4(e)	4.2(e)	4.5(e)	4.7(e)	4.7(e)	5.5(e)
2005	5.2(e)	5.8(e)	5.6(e)	5.1(e)	4.6(e)	5.5(e)	4.8(e)	4.7(e)	4.3(e)	4.1(e)	3.9(e)	3.4(e)	4.7(e)
2006	4.1(e)	4.8(e)	4.5(e)	4.8(e)	4.6(e)	5.2(e)	4.8(e)	5.2(e)	4.2(e)	4.2(e)	4.0(e)	4.0(e)	4.5(e)
2007	4.7(e)	5.4(e)	5.1(e)	5.0(e)	4.7(e)	5.1(e)	5.1(e)	5.3(e)	4.8(e)	4.9(e)	4.8(e)	4.4(e)	4.9(e)
2008	4.7(e)	5.0(e)	4.7(e)	4.2(e)	4.1(e)	4.6(e)	3.9(e)	4.0(e)	3.5(e)	3.4(e)	3.4(e)	3.3(e)	4.1(e)
2009	4.1	5.5	6.4	7.7(p)									

e : Reflects revised inputs, reestimation, and new statewide controls.
p : Preliminary.

Series Catalog:

Series ID : LAUPA54070004

State/Region/Division : West Virginia
Area Type : Counties and equivalents
Area Name : Logan County, WV
Measure : unemployment
Not Seasonally Adjusted

Data:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1990	1612	1622	1516	1584	1958	1742	1670	1751	1695	1658	1545	1408	1647
1991	1459	1508	1499	1697	2107	2117	2149	2065	1910	2004	1805	1698	1835
1992	1955	1916	1777	1771	1885	2013	2135	2374	2234	2165	2291	1927	2037
1993	1965	2076	1996	2394	2517	2645	2477	2489	2145	2481	2312	2209	2309
1994	2245	2140	1955	1914	1998	2260	2056	2080	1868	1737	1667	1464	1949

1993	14558	14652	14587	14937	15118	15533	15481	15113	14873	15131	14953	14941	14990
1994	14658	14663	14387	14695	14930	15208	14952	14761	14481	14341	14374	14061	14626
1995	14273	14311	14128	14415	14591	14889	14912	14789	14646	14403	14369	14162	14491
1996	14091	13913	13796	14085	14136	14451	14578	14078	13963	13872	13843	13834	14053
1997	13554	13634	13723	13933	14123	14156	14288	14244	14024	14432	14369	14362	14070
1998	14231	14226	14335	14371	14690	14890	14674	14285	14088	13837	13765	13486	14240
1999	13269	13393	13192	13441	13566	13564	13602	13366	13342	13129	13057	12702	13302
2000	13744	13837	13766	13838	13846	13972	13713	13642	13559	13620	13636	13582	13730
2001	13511	13507	13550	13472	13257	13552	13535	13394	13404	13428	13538	13401	13462
2002	13270	13310	13269	13463	13510	13543	13420	13143	13078	12970	12982	12863	13235
2003	12818	12933	12789	12950	12960	13113	12971	12831	12686	12586	12569	12621	12819
2004	12555(e)	12627(e)	12556(e)	12671(e)	12728(e)	13084(e)	13015(e)	12887(e)	12805(e)	12739(e)	12731(e)	12678(e)	12757(e)
2005	12573(e)	12707(e)	12712(e)	12811(e)	12829(e)	13043(e)	13019(e)	12980(e)	12854(e)	12836(e)	12725(e)	12720(e)	12818(e)
2006	12608(e)	12788(e)	12809(e)	12886(e)	12970(e)	13216(e)	13246(e)	13159(e)	13002(e)	13001(e)	12967(e)	12889(e)	12962(e)
2007	12793(e)	12792(e)	12845(e)	12942(e)	12972(e)	13220(e)	13207(e)	12997(e)	12900(e)	12849(e)	12807(e)	12653(e)	12914(e)
2008	12698(e)	12662(e)	12728(e)	13040(e)	13082(e)	13332(e)	13404(e)	13332(e)	13339(e)	13304(e)	13205(e)	13099(e)	13103(e)
2009	13077	13047	13043	13148(p)									

e : Reflects revised inputs, reestimation, and new statewide controls.
p : Preliminary.

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Databases, Tables & Calculators by Subject

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Data extracted on: June 17, 2009 (05:09 PM)

Local Area Unemployment Statistics

Series Catalog:

Series ID : LAUPA54035003

State/Region/Division : West Virginia
Area Type : Counties and equivalents
Area Name : McDowell County, WV
Measure : unemployment rate
Not Seasonally Adjusted

Data:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1990	11.7	11.5	11.7	13.0	12.6	13.9	14.1	15.5	13.9	13.5	14.5	13.6	13.3
1991	14.0	15.6	15.6	18.7	18.7	20.6	18.5	21.9	19.2	17.0	17.2	16.4	17.9
1992	16.8	15.8	14.4	14.8	15.3	17.8	16.1	17.4	15.7	15.8	16.8	15.0	16.0
1993	14.6	14.5	16.0	15.0	14.3	15.6	15.0	15.5	14.1	13.9	12.7	11.3	14.4
1994	13.4	12.4	12.6	14.5	13.0	15.3	14.3	16.4	14.7	13.5	11.8	11.7	13.7
1995	11.5	11.3	12.0	11.6	11.8	13.3	12.8	14.7	13.3	13.1	12.2	11.4	12.4
1996	11.6	11.3	11.5	11.5	12.0	13.4	14.4	15.1	13.3	12.8	12.3	11.1	12.6
1997	10.5	10.6	10.6	10.1	10.1	12.1	11.7	11.8	9.4	9.6	10.0	10.2	10.6
1998	11.7	11.4	11.9	11.0	11.2	13.2	12.0	12.6	10.2	10.2	11.1	11.6	11.5
1999	12.4	12.1	12.5	15.1	14.3	15.2	14.8	15.5	13.3	13.7	14.2	11.7	13.8
2000	11.5	12.1	11.8	11.1	10.6	11.3	10.8	10.2	8.5	8.7	8.5	8.0	10.3
2001	9.4	8.9	8.8	8.7	7.7	8.9	8.4	8.5	7.1	6.8	7.0	6.9	8.1
2002	8.0	8.6	9.1	9.6	9.7	11.3	10.4	10.1	9.0	9.5	10.7	10.5	9.7
2003	10.7	11.0	10.4	11.1	11.0	12.5	12.9	13.1	11.8	12.3	11.5	11.3	11.6
2004	12.1(e)	12.2(e)	11.6(e)	10.4(e)	9.6(e)	10.5(e)	9.5(e)	9.6(e)	7.5(e)	7.7(e)	7.8(e)	7.7(e)	9.7(e)
2005	8.3(e)	9.1(e)	8.7(e)	8.1(e)	7.7(e)	9.0(e)	8.5(e)	8.7(e)	7.6(e)	7.1(e)	7.0(e)	6.0(e)	8.0(e)
2006	6.5(e)	7.5(e)	7.7(e)	7.2(e)	7.2(e)	8.1(e)	7.9(e)	8.1(e)	6.9(e)	6.6(e)	6.5(e)	5.9(e)	7.2(e)
2007	7.6(e)	7.6(e)	7.4(e)	7.1(e)	6.4(e)	7.7(e)	7.9(e)	7.4(e)	6.6(e)	6.4(e)	6.3(e)	5.9(e)	7.0(e)
2008	6.8(e)	6.8(e)	6.4(e)	5.7(e)	5.8(e)	6.4(e)	6.0(e)	5.8(e)	5.0(e)	5.0(e)	4.8(e)	5.1(e)	5.8(e)
2009	8.1	10.6	9.9	11.0(p)									

e : Reflects revised inputs, reestimation, and new statewide controls.
p : Preliminary.

Series Catalog:

Series ID : LAUPA54035004

State/Region/Division : West Virginia
Area Type : Counties and equivalents
Area Name : McDowell County, WV
Measure : unemployment
Not Seasonally Adjusted

Data:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1990	984	963	985	1135	1128	1249	1307	1405	1252	1182	1268	1172	1169
1991	1184	1341	1342	1671	1664	1922	1731	2050	1740	1502	1494	1394	1586
1992	1445	1350	1216	1276	1358	1612	1512	1534	1355	1359	1451	1266	1395
1993	1224	1209	1364	1240	1190	1337	1317	1318	1186	1160	1049	926	1210
1994	1103	1018	1024	1194	1073	1298	1214	1361	1176	1090	948	908	1117

1993	8402	8345	8507	8280	8324	8563	8787	8491	8405	8332	8262	8171	8406
1994	8248	8204	8153	8215	8266	8467	8488	8294	7992	8051	8035	7752	8180
1995	7947	7995	8174	8151	8215	8400	8465	8366	8147	8006	7899	7811	8132
1996	7845	7892	7867	8035	8300	8387	8479	8315	8108	7910	7826	7752	8060
1997	7646	7690	7661	7648	7681	7841	7930	7782	7577	7486	7476	7531	7662
1998	7599	7533	7627	7509	7696	7716	7854	7630	7458	7300	7417	7332	7556
1999	7354	7363	7393	7590	7571	7770	7935	7740	7521	7447	7461	7235	7532
2000	7108	7139	7059	7065	7286	7283	7136	7076	7022	6982	6974	6938	7089
2001	7039	7038	6951	6902	6885	7038	7024	6963	6897	6963	6979	6975	6972
2002	7052	7141	7089	7051	7092	6983	7022	6862	6840	6899	6935	6832	6984
2003	6795	6891	6817	6891	6907	6991	6938	6820	6673	6765	6731	6676	6825
2004	6590(e)	6582(e)	6498(e)	6491(e)	6509(e)	6666(e)	6489(e)	6397(e)	6273(e)	6252(e)	6272(e)	6262(e)	6440(e)
2005	6259(e)	6351(e)	6246(e)	6294(e)	6341(e)	6521(e)	6446(e)	6465(e)	6513(e)	6495(e)	6549(e)	6676(e)	6429(e)
2006	6805(e)	6814(e)	6821(e)	6884(e)	6930(e)	7158(e)	7132(e)	7115(e)	7084(e)	6996(e)	6997(e)	6898(e)	6969(e)
2007	6978(e)	6887(e)	6876(e)	6912(e)	6926(e)	7067(e)	7035(e)	6960(e)	6946(e)	6951(e)	6929(e)	6933(e)	6950(e)
2008	7059(e)	7027(e)	7089(e)	7191(e)	7231(e)	7411(e)	7295(e)	7260(e)	7229(e)	7269(e)	7207(e)	7184(e)	7205(e)
2009	7365	7419	7330	7435(p)									

e : Reflects revised inputs, reestimation, and new statewide controls.
p : Preliminary.

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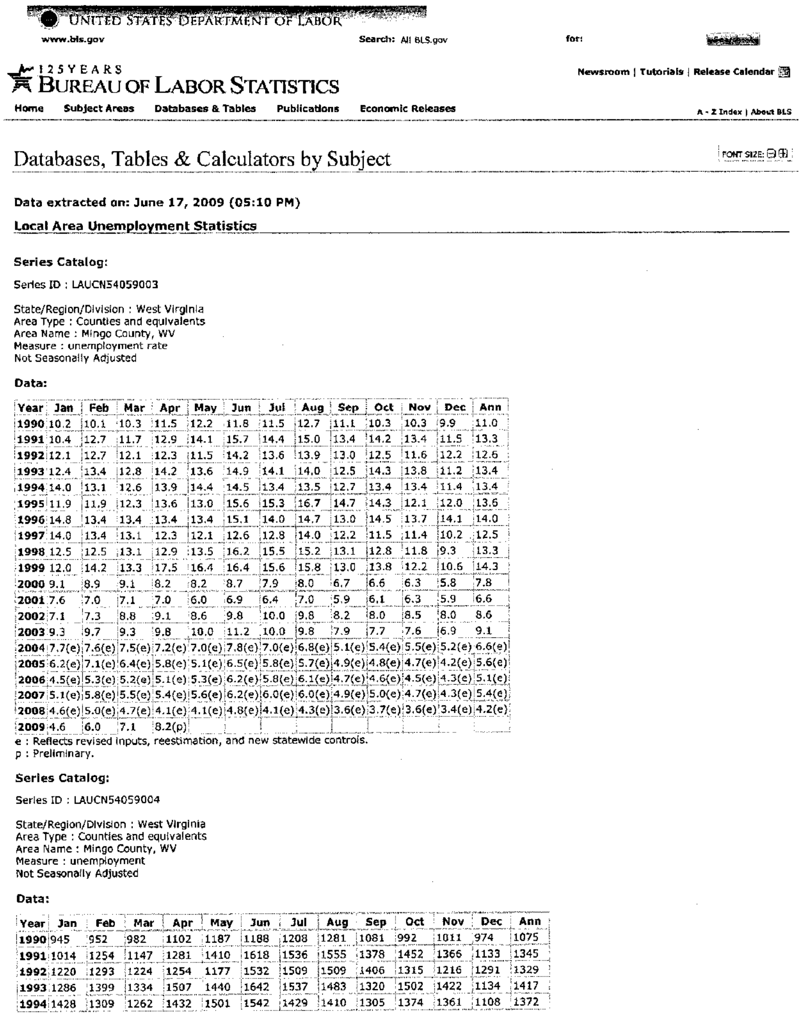

Databases, Tables & Calculators by Subject

Data extracted on: June 17, 2009 (05:10 PM)

Local Area Unemployment Statistics

Series Catalog:

Series ID : LAUCN54059003

State/Region/Division : West Virginia
Area Type : Counties and equivalents
Area Name : Mingo County, WV
Measure : unemployment rate
Not Seasonally Adjusted

Data:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1990	10.2	10.1	10.3	11.5	12.2	11.8	11.5	12.7	11.1	10.3	10.3	9.9	11.0
1991	10.4	12.7	11.7	12.9	14.1	15.7	14.4	15.0	13.4	14.2	13.4	11.5	13.3
1992	12.1	12.7	12.1	12.3	11.5	14.2	13.6	13.9	13.0	12.5	11.6	12.2	12.6
1993	12.4	13.4	12.8	14.2	13.6	14.9	14.1	14.0	12.5	14.3	13.8	11.2	13.4
1994	14.0	13.1	12.6	13.9	14.4	14.5	13.4	13.5	12.7	13.4	13.4	11.4	13.4
1995	11.9	11.9	12.3	13.6	13.0	15.6	15.3	16.7	14.7	14.3	12.1	12.0	13.6
1996	14.8	13.4	13.4	13.4	13.4	15.1	14.0	14.7	13.0	14.5	13.7	14.1	14.0
1997	14.0	13.4	13.1	12.3	12.1	12.6	12.8	14.0	12.2	11.5	11.4	10.2	12.5
1998	12.5	12.5	13.1	12.9	13.5	16.2	15.5	15.2	13.1	12.8	11.8	9.3	13.3
1999	12.0	14.2	13.3	17.5	16.4	16.4	15.6	15.8	13.0	13.8	12.2	10.6	14.3
2000	9.1	8.9	9.1	8.2	8.2	8.7	7.9	8.0	6.7	6.6	6.3	5.8	7.8
2001	7.6	7.0	7.1	7.0	6.0	6.9	6.4	7.0	5.9	6.1	6.3	5.9	6.6
2002	7.1	7.3	8.8	9.1	8.6	9.8	10.0	9.8	8.2	8.0	8.5	8.0	8.6
2003	9.3	9.7	9.3	9.8	10.0	11.2	10.0	9.8	7.9	7.7	7.6	6.9	9.1
2004	7.7(e)	7.6(e)	7.5(e)	7.2(e)	7.0(e)	7.8(e)	7.0(e)	6.8(e)	5.1(e)	5.4(e)	5.5(e)	5.2(e)	6.6(e)
2005	6.2(e)	7.1(e)	6.4(e)	5.8(e)	5.1(e)	6.5(e)	5.8(e)	5.7(e)	4.9(e)	4.8(e)	4.7(e)	4.2(e)	5.6(e)
2006	4.5(e)	5.3(e)	5.2(e)	5.1(e)	5.3(e)	6.2(e)	5.8(e)	6.1(e)	4.7(e)	4.6(e)	4.5(e)	4.3(e)	5.1(e)
2007	5.1(e)	5.8(e)	5.5(e)	5.4(e)	5.6(e)	6.2(e)	6.0(e)	6.0(e)	4.9(e)	5.0(e)	4.7(e)	4.3(e)	5.4(e)
2008	4.6(e)	5.0(e)	4.7(e)	4.1(e)	4.1(e)	4.8(e)	4.1(e)	4.3(e)	3.6(e)	3.7(e)	3.6(e)	3.4(e)	4.2(e)
2009	4.6	6.0	7.1	8.2(p)									

e : Reflects revised inputs, reestimation, and new statewide controls.
p : Preliminary.

Series Catalog:

Series ID : LAUCN54059004

State/Region/Division : West Virginia
Area Type : Counties and equivalents
Area Name : Mingo County, WV
Measure : unemployment
Not Seasonally Adjusted

Data:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1990	945	952	982	1102	1187	1188	1208	1281	1081	992	1011	974	1075
1991	1014	1254	1147	1281	1410	1618	1536	1555	1378	1452	1366	1133	1345
1992	1220	1293	1224	1254	1177	1532	1509	1509	1406	1315	1216	1291	1329
1993	1286	1399	1334	1507	1440	1642	1537	1483	1320	1502	1422	1134	1417
1994	1428	1309	1262	1432	1501	1542	1429	1410	1305	1374	1361	1108	1372

1993	10408	10467	10394	10614	10557	10993	10878	10586	10597	10537	10322	10090	10537
1994	10182	10023	9988	10293	10405	10636	10674	10449	10304	10216	10160	9731	10255
1995	9703	9773	9725	10097	10070	10456	10602	10508	10045	10008	9725	9657	10031
1996	9673	9658	9718	9949	10017	10272	10273	10121	9839	9714	9376	9381	9832
1997	9260	9118	9079	9187	9286	9413	9583	9417	9102	8911	8981	8772	9176
1998	8818	8726	8731	8924	9054	9327	9343	8986	8789	8694	8640	8404	8870
1999	8431	8535	8308	8701	8646	8809	8799	8695	8408	8672	8541	8335	8574
2000	9076	9077	9096	9104	9162	9284	9171	9050	8867	9005	9029	9007	9078
2001	9043	9016	9040	8938	8889	9143	9101	8932	8875	8764	8766	8582	8924
2002	8654	8723	8703	8769	8780	8891	8769	8727	8666	8536	8512	8457	8683
2003	8391	8450	8414	8408	8235	8415	8390	8190	8118	7948	7819	7782	8214
2004	7988(e)	7873(e)	7846(e)	7939(e)	7945(e)	8135(e)	8177(e)	8122(e)	8094(e)	7936(e)	7913(e)	7863(e)	7986(e)
2005	7814(e)	7933(e)	7960(e)	8020(e)	8086(e)	8336(e)	8418(e)	8381(e)	8412(e)	8413(e)	8342(e)	8305(e)	8202(e)
2006	8320(e)	8404(e)	8380(e)	8541(e)	8605(e)	8821(e)	8807(e)	8753(e)	8742(e)	8756(e)	8808(e)	8633(e)	8631(e)
2007	8598(e)	8670(e)	8639(e)	8780(e)	8865(e)	9075(e)	9052(e)	8923(e)	8829(e)	8883(e)	8834(e)	8715(e)	8822(e)
2008	8778(e)	8757(e)	8814(e)	8942(e)	8968(e)	9220(e)	9197(e)	9110(e)	9090(e)	9077(e)	9043(e)	8935(e)	8994(e)
2009	8879	8836	8782	8632(p)									

e : Reflects revised inputs, reestimation, and new statewide controls.
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Local Area Unemployment Statistics

Series Catalog:

Series ID : LAUCN54109003

State/Region/Division : West Virginia
Area Type : Counties and equivalents
Area Name : Wyoming County, WV
Measure : unemployment rate
Not Seasonally Adjusted

Data:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1990	10.8	11.7	11.6	12.7	12.3	12.7	11.9	13.6	13.4	11.3	12.7	12.9	12.3
1991	12.0	12.4	11.0	11.0	12.3	12.9	12.2	14.7	13.3	12.5	14.7	12.3	12.6
1992	14.2	14.2	14.1	13.3	13.6	14.5	18.9	19.8	18.5	17.0	16.5	16.1	15.9
1993	15.5	20.2	17.2	16.3	18.1	18.6	18.8	20.4	17.4	16.5	17.2	15.2	17.7
1994	15.4	14.0	13.5	13.0	12.3	13.6	13.0	12.5	12.3	11.8	10.5	10.0	12.7
1995	11.2	11.2	11.1	11.1	10.6	12.3	11.3	11.4	11.3	9.5	9.4	9.4	10.8
1996	9.5	9.7	9.4	9.2	9.3	10.1	9.9	12.6	12.3	10.8	10.5	9.9	10.3
1997	10.5	9.8	9.3	8.7	8.7	9.3	8.8	9.9	9.0	8.3	8.1	7.7	9.0
1998	8.2	9.1	8.7	7.7	7.5	9.5	10.1	11.2	9.7	10.5	9.2	7.6	9.1
1999	8.8	10.6	9.9	10.4	10.4	10.4	10.9	11.7	10.4	9.7	10.0	8.1	10.1
2000	8.8	9.4	8.8	7.7	7.5	8.0	7.4	7.7	6.8	6.4	6.7	6.5	7.7
2001	7.7	7.1	7.0	6.6	5.8	6.5	6.8	6.8	5.6	5.3	5.0	5.1	6.3
2002	6.4	6.6	7.0	6.9	6.1	7.2	6.5	6.7	6.2	6.3	6.9	6.7	6.6
2003	7.5	7.8	7.2	7.1	6.7	7.7	7.6	8.8	8.4	8.6	6.8	8.2	7.7
2004	8.0(e)	8.7(e)	8.1(e)	6.6(e)	6.2(e)	6.8(e)	5.4(e)	5.6(e)	4.4(e)	4.8(e)	4.9(e)	4.6(e)	6.2(e)
2005	5.2(e)	6.3(e)	5.9(e)	5.5(e)	5.0(e)	5.8(e)	5.1(e)	5.0(e)	4.8(e)	4.6(e)	4.6(e)	4.1(e)	5.2(e)
2006	4.8(e)	5.5(e)	5.4(e)	5.1(e)	5.1(e)	5.8(e)	5.5(e)	5.8(e)	5.1(e)	4.8(e)	4.9(e)	4.7(e)	5.2(e)
2007	6.1(e)	6.6(e)	6.3(e)	6.2(e)	5.7(e)	6.1(e)	6.2(e)	6.2(e)	5.0(e)	5.4(e)	5.2(e)	4.9(e)	5.8(e)
2008	5.4(e)	5.5(e)	5.3(e)	4.6(e)	4.6(e)	5.5(e)	4.9(e)	5.1(e)	3.8(e)	3.7(e)	3.6(e)	3.9(e)	4.7(e)
2009	5.2	8.4	7.4	9.4(p)									

e : Reflects revised inputs, reestimation, and new statewide controls.
p : Preliminary.

Series Catalog:

Series ID : LAUCN54109004

State/Region/Division : West Virginia
Area Type : Counties and equivalents
Area Name : Wyoming County, WV
Measure : unemployment
Not Seasonally Adjusted

Data:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1990	923	1000	980	1088	1133	1125	1021	1130	1104	932	1055	1065	1046
1991	990	1010	892	903	1011	1109	1047	1217	1114	1024	1232	1006	1046
1992	1214	1184	1169	1131	1216	1265	1774	1768	1613	1473	1441	1393	1387
1993	1309	1791	1487	1411	1604	1695	1699	1790	1473	1416	1465	1263	1534
1994	1301	1148	1086	1063	1049	1161	1059	1021	1018	954	891	792	1045

1993	8440	8855	8638	8653	8850	9090	9024	8778	8482	8562	8529	8302	8684
1994	8424	8199	8043	8190	8562	8518	8148	8153	8255	8106	8476	7926	8250
1995	7804	7786	7769	7972	7998	8271	8254	8018	8062	7847	7819	7747	7946
1996	7793	7658	7679	7974	8440	8215	8367	8442	8475	8381	8344	8197	8164
1997	8327	8337	8310	8355	8352	8525	8512	8411	8291	8255	8275	8134	8340
1998	8136	8063	8039	8448	9023	9009	8826	8666	8549	8602	8394	8319	8506
1999	8289	8357	8202	8385	8440	8607	8533	8295	8159	8024	8085	7902	8273
2000	8581	8625	8509	8612	8984	8892	8747	8559	8398	8476	8485	8418	8607
2001	8500	8387	8371	8522	8444	8673	8663	8482	8427	8506	8656	8604	8520
2002	8678	8711	8661	8787	9162	8960	8816	8655	8601	8518	8544	8494	8716
2003	8446	8419	8389	8417	8335	8453	8311	8168	7928	8056	7941	7982	8238
2004	7971(e)	7973(e)	7877(e)	8005(e)	8050(e)	8223(e)	8190(e)	8110(e)	8055(e)	7973(e)	8037(e)	7933(e)	8033(e)
2005	7939(e)	8023(e)	8027(e)	8201(e)	8271(e)	8504(e)	8375(e)	8347(e)	8281(e)	8319(e)	8256(e)	8147(e)	8224(e)
2006	8194(e)	8291(e)	8296(e)	8303(e)	8372(e)	8542(e)	8464(e)	8460(e)	8448(e)	8356(e)	8262(e)	8253(e)	8354(e)
2007	8286(e)	8305(e)	8261(e)	8287(e)	8215(e)	8344(e)	8328(e)	8254(e)	8234(e)	8092(e)	8044(e)	7947(e)	8216(e)
2008	7813(e)	7818(e)	7843(e)	7964(e)	7974(e)	8152(e)	7846(e)	7778(e)	8227(e)	8167(e)	8103(e)	8053(e)	7978(e)
2009	8075	7954	7776	7817(p)									

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United States Department of the Interior
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NEW RIVER GORGE NATIONAL RIVER
GAULEY RIVER NATIONAL RECREATION AREA
BLUESTONE NATIONAL SCENIC RIVER
104 Main Street
P.O. Box 246
Glen Jean, West Virginia 25846

IN REPLY REFER TO

January 22, 2009

N3617(NERI)
xA3815

Ed Wojtowicz
Permit Supervisor
DEP Regional Office
116 Industrial Drive
Oak Hill, WV 25901

RE: Powellton Coal Company, LLC 's application for renewal of Article 3 Permit Number S-3003-01

Dear Mr. Wajtowicz:

Please accept the following comments on the above referenced permit renewal application for the Powellton Coal Company LLC's Bridge Fork West Surface Mine. New River Gorge National River, the Gauley River National Recreation Area and the surrounding environs contain nationally significant aquatic, terrestrial, and recreational resources. The continued operation of Bridge Fork West Surface Mine, and its associated extensive violations for discharge of pollutants into waters of the United States causes us great concern for potential threats to these resources.

Associated with the mining permit is National Pollutant Discharge Elimination System (NPDES) Permit # WV 1019449 for discharging into Softwood Hollow, Grassy Lot Hollow and unnamed tributaries of Bridge Fork at Rich Creek. Rich Creek flows into the Gauley River just downstream of National Park Service administered lands of the Gauley River National Recreation Area (GRNRA).

Performance standards under the Federal Surface Mining Control and Reclamation Act (SMCRA) require that all discharges from permitted mining operations be made in compliance with all applicable State and Federal water quality laws and regulations and with the effluent limitations for coal mining. The West Virginia Surface Mining Rule states a similar standard that "Discharge from mining areas distributed by surface mining shall not violate effluent limitations or cause a violation of applicable water quality standards" 38 C.S.R. 2-14.5.b. According to Powellton's Discharge Monitoring Reports (DMR's) for WV/NPDES Permit WV1019449 including reports through September 2008, Powellton has been exceeding permit limits for discharge for daily and monthly averages at an extremely high frequency, registering a substantial number of violations for multiple parameters including suspended solids, iron, manganese, and aluminum.

These pollutants pose a threat to aquatic life and human welfare. Precipitates of aluminum, iron, and manganese can coat stream bottom substrate limiting the available habitat for aquatic life, suspended solids are also harmful to aquatic life through the erosion of gills, and aluminum is known to be toxic to aquatic life, and has been associated with neurological and bone diseases in humans. The frequency of exceeding permit limits indicates a lack of commitment on the part of the permittee to employ adequate controls that will limit the impacts of this operation on downstream resources. The proximity of these activities and discharges to GRNRA may limit the abundance and productivity of aquatic life in and around GRNRA, particularly mobile species that otherwise might use Rich Creek and its tributaries as refugia, spawning habitat or rearing habitat.

Prior to issuance of the original permit for this mining operation, it is assumed that a Probable Hydrological Consequences (PHC) determination and a Cumulative Hydrological Impact Analysis (CHIA) would have been required by the state. Considering the extent of violations to WV/NPDES Permit WV1019449 through operations of Bridge Fork West Surface Mine under Article 3 Permit Number S-3003-01 any rationale for determining "No Material Damage" to surrounding hydrology would no longer be valid since the determination would be dependent on discharge remaining within permit limits. We request that the PHC and CHIA be reconsidered and evaluated with the actual mine operations and associated discharges utilized instead of projected discharges or other now irrelevant measures.

The National Park Service is concerned about the continued operation of this mine as a stand-alone operation but is even more concerned about the cumulative impacts of this mine in association with other nearby mining operations (some operated by Powellton) within the same and adjacent watersheds. It appears that some of these operations have a propensity to grow beyond their original permit boundaries and/or scope of operations. Individual operations may be located within close proximity to other operations in a manner that they appear to be the same mine with extensive disturbance occurring concurrently within the same watershed. However, the permit process does not address these cumulative effects to the surrounding and downstream resources. When evaluated as a whole, the extensive mining operations in the vicinity of Rich Creek are jeopardizing the health of the watershed and the other values that are dependent upon it.

In consideration of the water quality violations at this site, apparent violations at other mine sites operated by Powellton, and the cumulative impacts to the environment, we request that DEP deny this permit renewal until a full evaluation of cumulative effects can occur with public input. In addition, site conditions, and current violations be fully investigated, and until Powellton can fully demonstrate compliance with all State and Federal standards throughout the site and all mine related activities.

If there are any questions please feel free to contact Scott Stonum, Natural Resource Specialist, at 304-465-6531.

Sincerely,

Don Striker
Superintendent

cc:
Laura Hill, Acting Field Supervisor, U.S. Fish and Wildlife Service, West Virginia Field Office, P.O. Box 1278, Elkins, WV 26241-1278

Ginger Mullins, Chief-Regulatory Branch, U.S. Army Corps of Engineers, Huntington District, 502 Eighth Street, Huntington, WV 25701

CATERPILLAR®

Cat Global Mining
Caterpillar Inc.
300 Hamilton Blvd., Suite 300
Peoria IL USA
Telephone: 309-675-5126
Fax: 309-675-4777

June 29, 2009

The Honorable Benjamin Cardin
Chairman
Water and Wildlife Subcommittee
Environment and Public Works
United States Senate
Washington, DC 20510-6150

The Honorable Mike Crapo
Ranking Member
Water and Wildlife Subcommittee
Environment and Public Works
United States Senate
Washington, DC 20510-6150

Dear Senators Cardin and Crapo:

As a leading supplier to the coal mining industry, I'm writing to express Caterpillar's support for the coal mining industry and surface mining in Appalachia.

For more than 80 years, Caterpillar has been making progress possible on every continent. As the world's leading manufacturer of construction and mining equipment, diesel and natural gas engines, and industrial gas turbines; along with our commitment to providing leading financial, remanufacturing, logistics and rail services, Caterpillar has a keen interest in the hearing you held on June 25, 2009, regarding surface coal mining in Appalachia.

Caterpillar serves the worldwide mining industry through the Cat Global Mining organization, headquartered in Peoria, Illinois, with regional offices around the world. . Cat Global Mining is the single point of contact for global mineral producers and the primary link to Cat's extended mining enterprise.

Caterpillar works with our dealers and customers to develop products, services and solutions that enhance customer value; with a lighter environmental footprint in mining and every industry we serve. We have a long history of serving the coal mining industry. As one of our most important natural resources, coal is a critical part of our nation's energy mix. Coal is abundant within the U.S., has a high-energy intensity, and is cost effective. With roughly half of our electricity currently generated by coal, coal-fired power has and will continue to have a major role in U.S. power generation and steel production. Caterpillar strongly supports the continued use of this important resource.

Surface mine coal seams cannot be mined by underground methods. Therefore the practice of mountaintop mining is the safest and most efficient way to mine this critical resource contained in the multiple steep slope coal seams in central Appalachia. This legal, highly regulated and complex engineered earthmoving process is an environmentally responsible method of surface mining. Depending on the state in this region of the country, this practice can account for a sizable portion of the coal produced, and supports thousands of good paying jobs in the mining industry, and those additional industries that support it.

Caterpillar has a significant presence and involvement in surface mining in Appalachia. Our dealer network, which supports mining customers in the Appalachian areas of West Virginia, Kentucky and Virginia, employ over 3,000 people that depend largely on the coal mining business. These jobs are in addition to the thousands of jobs at Caterpillar facilities in Illinois and other locations designing and manufacturing industry leading mining products.

Mountaintop mining not only supports our nation's energy needs while providing thousands of good jobs, it also is practiced in a responsible way, ensuring that sites are restored through reclamation in accordance with permit requirements. It is important to note that all mountaintop-mining operations must obtain permits and comply with the Clean Water Act (CWA), other water quality standards, and comprehensive mitigation plans.

Caterpillar is committed to sustainable development, and to partnering with our mining customers in Appalachia and around the world to ensure the environmentally responsible extraction and use of our natural resources. Surface mining is no exception.

Providing reliable and efficient energy solutions, promoting responsible use of materials, enabling the mobility of people and goods, and developing quality infrastructure are key societal challenges. They are also the major areas where Caterpillar, our dealers and our customers have been providing solutions for decades. In this regard, we look forward to continuing to work with you on these and other important matters before the Senate Environment and Public Works Committee. I'm pleased to include a copy of a Walker Machinery Company (an independent Caterpillar dealer) brochure that further explains the facts behind mountaintop mining in Appalachia. I welcome your comments.

Sincerely,

Chris Curfman

Chris Curfman

Cc: Environment and Public Works Committee Chairwoman Barbara Boxer
Ranking Member James Inhofe

Acculab Inc.
"The quality you expect, the service you deserve"
#1 Acculab Drive
PO Box 367 Mount Gay, West Virginia 25637
(304) 752-6798 FAX (304) 752-5933

July 2, 2009

The Honorable Mr. Benjamin L. Cardin
The Honorable Mr. Lamar Alexander
U.S. Senate Committee on Environment & Public Works
410 Dirksen Senate Office Bldg
Washington, DC 20510

Dear Senators,

Upon attending the Senate Wildlife Subcommittee of the Environmental and Public Works committee of the U.S. Senate titled "The Impacts of Mountaintop Removal Coal Mining on Water Quality in Appalachia" meeting in Washington, D. C. on June 25, 2009 I am deeply concerned about the future our coal industry faces here in West Virginia.

After hearing testimony given by the panel of experts before the committee I feel as though some opinions presented before the panel are misleading and biased in their attempt to stop mining altogether not just mountaintop removal.

Your proposal would not just affect mountaintop removal operations. Almost all coal mining permits here in Southern West Virginia must utilize some type of valley fill to dispose of the excess spoil that is generate during the mining process. This is just the nature of the geography that exists here in Southern West Virginia which along that of Eastern Kentucky has the most unique challenges of any mining region within the United States. I implore you to examine all the facts before you consider passing legislation that will affect the livelihoods of not just coal miners and their families but entire communities here in West Virginia.

Our business would cease to exist without the contracts that are supplied from the coal industry. I am not biased for the coal industry, my company's involvement is to provide a service that in essence helps to promote and protect cleaner waters for our coalfield communities and its residents. Our support role for the coal industry is to ensure that pollutants are kept within the limits of their NPDES Permits by routine monitoring and reporting to all regulatory agencies.

Testimony was given that basically said that mining completely kills the streams and aquatic life contained within the watershed below valley fills and the stream is no longer able to support a healthy ecosystem. That is an opinion of Dr. Margaret Palmer and not a sound scientific fact. Although, I can not dispute the fact that a specific genus of mayfly may indeed leave the waters of a stream below a valley fill there still exists a hosts of other aquatic species and in fact other mayfly colonies do still exist. More scientific research needs to be done instead of that of a handful of scientists who have published one study.

Our company for the last six years has been compiling data for both water chemistry and macroinvertebrae data for approximately 230 sites across the state of West Virginia to determine the effects that mining has on our streams and their ecosystems.

Mr. Cardin you yourself even wanted to know if in fact the EPA's recommendations were based on a broader base of scientific data to determine the findings published by the Pond and Passmore Study. Such scientific data exists that outlines the aquatic health of an entire watershed. Mr. Cardin one paper is not the answer to the debate. In fact our organization would be glad to assist in continuing this investigation jointly with our scientific colleagues.

At a preliminary glance we reviewed our data and looked at only water chemistry analysis with specific conductance greater than 500 us/cm, which was used as an indicator for the Pond and Passmore Study, to see if there was indeed negative effects on mayfly populations, which are a type of macroinvertebrate that inhabit our states waters.

Our findings suggest that there are such benthic populations that still exist when the specific conductance is at least 500 us/cm or higher but our study only examined to the family classification instead of the more stringent genus level as suggested by the Pond and Passmore Study using a new method.

I am asking you for an extension of the deadline for data submittal so that a formal presentation of our findings may be presented unto the committee. I feel as though all sides to the story have yet to be told.

One would think that each of you on the committee would want to carefully consider all the facts as relating to such a potentially devastating act. Your responsibility as relating to this matter poses the threat of eliminating a way of life for an entire region. Tourism is not completely the answer but I agree that there can be a balance achieved if all sides come to the table to work out their differences. Tourism wages by no means hails in comparison to the wages that accompany the mining industry here in West Virginia. Your proposal would further impoverish our region.

Your prompt attention and consideration for this request would be most appreciated.

Sincerely,

Randall Carpenter
President
Acculab, Inc.

Chris Ellis for Mr. Randall Carpenter

Cc: West Virginia Coal Association
Logan County Coal Vendors

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FRANK PALLONE, JR.
6TH DISTRICT, NEW JERSEY
Congress of the United States
House of Representatives
Washington, DC 20515–3006

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Statement of Rep. Frank Pallone
Senate Subcommittee on Water and Wildlife

Hearing on the Impacts of Mountaintop Removal Coal Mining on Water Quality in Appalachia
Thursday, June 26, 2009

First, I would like to thank Senator Ben Cardin for holding this hearing. I applaud his leadership in introducing the Appalachia Restoration Act (S. 696), the companion bill to the Clean Water Protection Act (H.R. 1310), which I introduced in the House. This bill will protect American waterways by overturning a 2002 Bush Administration rule, which has allowed hundreds of miles of headwater streams to be buried by toxic waste from mountaintop removal sites.

In a typical mountaintop removal operation, hundreds of vertical feet spread over thousands of acres are blasted apart using ammonium nitrate fuel oil. The rubble created by blowing these mountains apart is then dumped directly into the adjacent river valley in what is called a "valleyfill." According to the Environmental Protection Agency's 2003 Environmental Impact Statement, these valleyfills have buried and polluted more than 1,200 miles of streams, depositing heavy metals and chemicals such as arsenic, lead, mercury, and selenium and negatively impacting water quality for those in Appalachia and downstream.

Senator Cardin and Senator Alexander are both from Appalachian coal-producing states and understand that there are better ways to move our economy forward than blowing the tops off of our mountains and destroying our valuable natural resources.

Last week, West Virginia University professor Michael Hendryx released a study titled "Mortality in Appalachian Coal Mining Regions: The Value of Statistical Life Lost." This study proves that current mining practices are not only ruining America's oldest mountains, it is also having a tremendous negative impact on the economy and the public health in communities where it is taking place.

Furthermore, Dr. Hendryx's shows us that while coal mining contributes $8 billion annually to local economies, the cost to the local communities is more than $50 billion. Because of this coal mining, according to Dr. Hendryx, this region of the country loses $42 billion every year. The areas with the highest amount of mining are the areas with the highest unemployment in the region. Much of this is due to the increased use of strip-mining, which costs the region traditional underground mining jobs and employs far fewer people than underground mines would. Coal mining areas fared significantly worse across all socioeconomic and mortality indicators compared with non-mining areas of Appalachia and/or the nation.

That said, we can and must do better. Congress must work to pass the Clean Water Protection Act (HR 1310) and the Appalachia Restoration Act (S 696). These bills will protect the health, economy, mountains, streams, and communities of this great nation.

Stopping mountaintop removal will help protect Appalachia's invaluable natural resources and communities and help us promote economic growth in some of the most impoverished communities in the country.

Again, I appreciate Senator Cardin's attention to this important issue and for holding this critical hearing.

Economic Benefits, Carbon Dioxide (CO_2) Emissions Reductions, and Water Conservation Benefits from 1,000 Megawatts (MW) of New Wind Power in West Virginia

Wind power is one of the fastest-growing forms of new power generation in the United States. Industry growth in 2007 was an astounding 45%. New wind power installations constituted 30% of all new electric power installations. This growth is the result of many drivers, including increased economic competitiveness and favorable state policies such as Renewable Portfolio Standards. However, new wind power installations provide more than cost-competitive electricity. Wind power brings economic development to rural regions, reduces water consumption in the electric power sector, and reduces greenhouse gas production by displacing fossil fuels.

The U.S. Department of Energy's Wind Powering America Program is committed to educating state-level policy makers and other stakeholders about the economic, CO_2 emissions, and water conservation impacts of wind power. This analysis highlights the expected impacts of 1000 MW of wind power in West Virginia. Although construction and operation of 1000 MW of wind power is a significant effort, six states have already reached the 1000-MW mark. We forecast the cumulative economic benefits from 1000 MW of development in West Virginia to be **$1.0 billion**, annual CO_2 reductions are estimated at **3.3 million tons**, and annual water savings are **1,763 million gallons**.

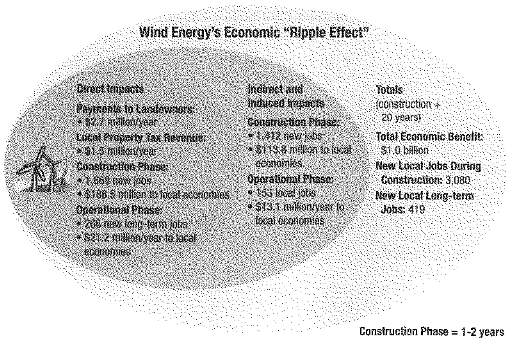
Economic Benefits

Building and operating 1000 MW of wind power requires a significant investment. But this investment will generate substantial direct, indirect, and induced economic benefits for West Virginia. Direct benefits include jobs, land-lease payments, and increased tax revenues. Indirect benefits include benefits to businesses that support the wind farm. Induced benefits result from additional spending on goods and services in the area surrounding the development.

Direct impacts result from investment in the planning, development, and operation of new wind facilities. Beneficiaries include landowners, construction workers, O&M staff, turbine manufacturers, and project managers. Indirect impacts reflect payments made to businesses that support the wind facility and include banks financing the project, component suppliers, and manufacturers of equipment used to install and maintain the facility. Induced benefits result from increased spending by direct and indirect beneficiaries. Examples include increased business to restaurants, retail establishments, and child care providers.

Drivers of economic benefits include the use of local construction companies, the presence of in-state component suppliers, local wage structures, local property tax structures, and operation and maintenance (O&M) expenditures. The projected benefits for West Virginia could be greatly increased by the development of a local wind supply, installation, and maintenance industry within the state.

West Virginia Economic Impacts
from 1,000 MW of New Wind Development



Wind Energy's Economic "Ripple Effect"

Direct Impacts

Payments to Landowners:
- $2.7 million/year

Local Property Tax Revenue:
- $1.5 million/year

Construction Phase:
- 1,668 new jobs
- $188.5 million to local economies

Operational Phase:
- 266 new long-term jobs
- $21.2 million/year to local economies

Indirect and Induced Impacts

Construction Phase:
- 1,412 new jobs
- $113.8 million to local economies

Operational Phase:
- 153 local jobs
- $13.1 million/year to local economies

Totals (construction + 20 years)

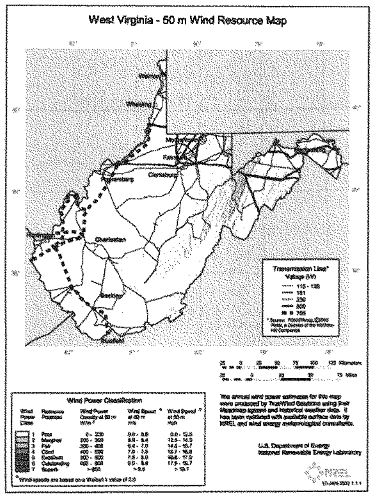
Total Economic Benefit: $1.0 billion

New Local Jobs During Construction: 3,080

New Local Long-term Jobs: 419

Construction Phase = 1-2 years
Operational Phase = 20+ years

Distribution of Wind Resources in West Virginia



Methodology

The data for economic analysis are primarily from interviews with state-specific contacts, including developers, power plant operators, contractors, mining and gas associations, and state property tax assessors or administrators. When interviews were not possible, information was obtained from public Web resources, state tax reports, and federal databases for current power plants. Cumulative impacts are estimated for construction and 20 years of operations. Economic impacts are 2007 constant dollars and estimated by application of NREL's Job and Economic Development Impacts (JEDI) model. Carbon estimates apply 2004 non-baseload CO_2 emissions rates (EPA eGRID2006 Version 2.1, April 2007). Water savings are calculated based on consumption rates for various generating technologies. Consumption rates were compiled by Western Resource Advocates and calculated from EIA form 767 data and EPRI publications. Consumption rates are applied to the NERC region generation mix as determined from EIA form 960/920 (2006).

Data Inputs	
Construction Cost	$1,650/kW
Operations and Maintenance	$24.70/kW/yr
Property Tax	$1,515/MW/year
Landowner Lease Payments	$2,667/MW/year

CO_2 Emissions and Water Conservation Benefits

In 2004, the average West Virginia resident emitted approximately 49.4 tons of CO_2 from electricity consumption. As a state, West Virginia ranked 3rd in per capita electricity sector CO_2 emissions. CO_2 emissions are increasingly important factors as state and federal government consider policies regarding climate change while drought in the Southeast has underscored the relevance of freshwater supply issues outside of the arid and semi-arid regions of the United States.

Developing wind power in West Virginia will result in CO_2 emissions reductions and water savings. Choosing to build wind projects results in CO_2 reductions from decreased natural gas consumption. In addition, both fossil- and nuclear-based electricity generation consume large amounts of water. Wind power reduces our reliance on increasingly vital freshwater resources.

Annual Impacts in West Virginia from 1000 MW of New Wind Power

Water Savings	CO_2 Savings
1,763 million gallons	3.3 million tons

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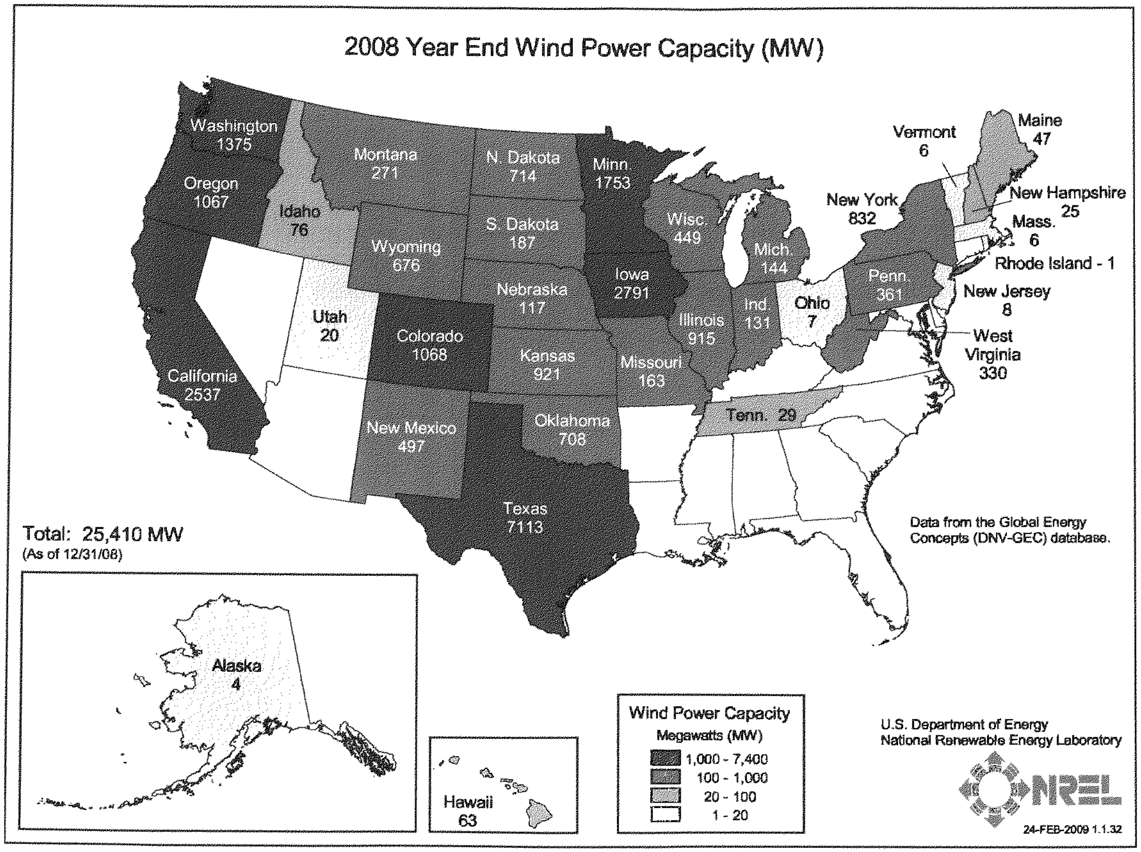

2008 Year End Wind Power Capacity (MW)

WVAHC
West Virginians for Affordable Health Care

Early Deaths:
West Virginians Have Some of the Shortest Life Expectancies in the United States
A Report by West Virginians for Affordable Health Care

Developed under a grant from the Claude Worthington Benedum Foundation.
The West Virginia Council of Churches is the fiscal agent for this grant.

In April 2008 Harvard researchers published a report examining life expectancy in the United States.[1] The report examined life expectancy over a 38-year period by county and by gender. Their basic finding is that counties with high life expectancies continued to improve, while the life expectancy in the worst-off counties was stagnant or actually declined. The result is that the inequity in life expectancy among different counties increased from 1961 to 1999, the last year that data was available.

West Virginians for Affordable Health Care (WVAHC) examined the data used by this report. A summary of the counties with the lowest one percent of life expectancies in the country is attached as Appendix A. States that are most prevalent in this lowest one percent are: South Dakota, Mississippi, West Virginia and Arkansas. Major findings that relate to West Virginia include the following:

- West Virginians have lower life expectancy than the average in the United States.
- Southern West Virginia has some of the lowest life expectancy in the country. McDowell, Logan and Mingo counties were rated among the lowest one percent for shortest life expectancy in the United States.

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[1] M. Ezzati , A. Friedman, S. Kulkarni , C. Murray, "The Reversal of Fortunes: Trends in County Mortality and Cross-County Mortality Disparities in the United States." PLoS Med 5(4): e66. doi:10.1371/journal.pmed.0050066. (2008) Accessed June 2008 at http://medicine.plosjournals.org/perlserv/?request=get document&doi=10.1371/journal.pmed.0050066 .

McDowell County residents were rated 14th out of 3,141 counties in the U.S. Logan County was rated 21st, and Mingo was rated 27th.

- Another three counties -- all in southern West Virginia -- were rated among the lowest ten percent for life expectancy in the U.S. Lincoln County was rated 100th, Wyoming County was rated 145th, and Boone County was rated 224th. Fayette County was only five counties above being in the lowest 10 percent and was rated 319th.

- Only four counties in West Virginia (Pendleton, Grant, Tucker and Monongalia) had life expectancy above the national median.[2]

- West Virginia women relative to other women in the U.S. had even lower life expectancies. Women in three counties (McDowell, Mingo and Logan) were all within the sixteen lowest life expectancy counties in the country. Another 4 counties were in the lowest 10 percent of counties in the country for life expectancy.

County	National Ranking for Both Men & Women	National Ranking for Women Only
McDowell	14	10
Mingo	21	15
Logan	27	16
Lincoln	100	53
Wyoming	145	58
Boone	224	107
Fayette	319	265

- In 1999 not a single county in West Virginia had life expectancy for women at or above the national average. The best county for women in West Virginia (Tucker County) had a life expectancy of 79.5 years, while the national average was 79.6 years.

- If women in McDowell County had life expectancies at the national average, they would live on average an additional 6.1 years. If women in McDowell County had the same life expectancy as women in the county with the highest life expectancy[3], they would live on average an additional 11 years. Women in Logan County would add a decade of life if they had life expectancy equal

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[2] The Harvard researchers provided a national average life expectancy for men in 1999 (74.1 years) and for women (79.6 years), but did not provide an average life expectancy combining both men and women. WVAHC used the median county; that is, the county with 50 percent greater life expectancy and 50 percent lower life expectancy; to determine the average for both men and women.

[3] Stearns County, Minnesota.

to the best in the country, and would live slightly more than five additional years if they had life expectancy at the national average.

- A number of counties in West Virginia experienced a reduction in life expectancy for both men and women, although in only two counties was the reduction in life expectancy more than one year. From 1995 to 1999 the life expectancy in Logan County fell by 1.49 years. In Wyoming County life expectancy fell by 1.31 years between 1992 and 1999.

- For women the reduction in life expectancy was far more pronounced. In ten West Virginia counties (or groups of counties[4]) life expectancy for women was reduced by at least one year. In three counties the reduction was more than two years. In Logan County life expectancy for women dropped by more than 2 ½ years from 1989 to 1999. In Boone County life expectancy fell by almost 2 ¼ years between 1992 and 1999. In Taylor/Barbour counties life expectancy for women fell by 2 ¼ years between 1988 and 1999.

- Other counties that experienced at least a one year drop in life expectancy for women include: McDowell County with a 1.97 years decline between 1993 and 1999; Lincoln County fell by 1.95 years between 1983 and 1999; Wyoming County declined 1.88 years between 1989 and 1999; Gilmer/Lewis counties with a 1 ½ years decrease between 1983 and 1999; Clay/Nicholas Counties dropped by 1.18 years between 1984 and 1999; and Pocahontas/Braxton/Webster counties had a decrease of 1.05 years between 1982 and 1999.

Limitation of the Report: The major limitation of this report is that there is no life expectancy data from 1999 to 2008. It is impossible to determine what has occurred in the intervening 9 years. The West Virginia Vital Statistics has data from 1999 through 2006 on average age at death by counties. While this data is not the same as life expectancy, it can be used as a proxy for life expectancy for the missing data between 1999 and 2008. As the chart below demonstrates the average age of death declined in each of the selected southern West Virginia counties. This is particularly true for both Boone and Wyoming counties which experienced a 3.1 years decline in the average age of death between 1999 and 2006, the last year these statistics are available. Lincoln County had more than a 2 ½ years decline in the average age of death during the 9-year interval.

This data is not reported by gender, so it is impossible to tell if women continued to experience greater reduction in their life span as was reported by the Harvard researchers.

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[4] The Harvard researchers decided that in order "to avoid unstable death rates, smaller counties were merged with adjacent counties to form units with a total population of at least 10,000 males and 10,000 females in 1990." Ibid. at page 0002.

Average Age of Death Selected Counties Between 1999 and 2005[5]

	1999	2000	2002	2003	2004	2005	2006	Difference Between 2006 and 1999
Boone	71.2	71.8	70.0	70.2	68.9	70.2	68.1	-3.1
Fayette	72.9	73.3	72.7	72.7	73.1	72.2	72.5	-0.4
Lincoln	72.7	67.7	69.5	68.4	67.8	68.5	70.1	-2.6
Logan	68.9	69.9	70.1	70.6	69.6	68.6	68.4	-0.5
McDowell	69.1	71.7	67.1	69.4	68.1	68.2	67.3	-1.8
Mingo	68.8	69.3	68.0	70.2	68.3	67.5	67.7	-1.1
Wyoming	70.2	68.1	70.4	67.1	67.7	67.9	67.1	-3.1

Policy Implications:

The first step is to ensure that the data used to draw these conclusions is correct. WVAHC is requesting that the WVU Health Policy Research Institute review the data for its validity from start to the conclusions reached in this report. For example, was the raw data used by the Harvard researchers accurate? Is there something in the way that data is reported by West Virginia to the National Center for Health Statistics or sampling errors by the US Census Bureau that would result in data that underestimates the life expectancy of West Virginians, particularly southern West Virginians? Second, although highly unlikely, is there a flaw in the methodology used by the Harvard researchers? And finally, were there errors by WVAHC in interpreting the data? In short, is the basic data that decisions makers need to make decisions correct?

We should take our time to carefully verify the data, because if this data is accurate, it requires that we -- the Governor, the Legislature, local communities including schools and health care providers, and all West Virginians -- take immediate and meaningful action to reverse the unacceptably short lives that West Virginians are apparently experiencing.

Assuming that the data is accurate, WVAHC is making a series of proposals to decision makers in order to address the shorter life expectancy of West Virginians.

- While efforts should be directed statewide, efforts within southern West Virginia where life expectancy is the shortest should have the highest priority. The "focus area" is defined as Boone, Fayette, Lincoln, Logan, McDowell, Mingo and Wyoming counties.

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[5] West Virginia 2006 Vital Statistics, West Virginia Department of Health and Human Resources, Available at http://www.wvdhhr.org/bph/oehp/hsc/pubs/vital06/index.htm#death . Accessed September 2, 2008.

- **Study**

  One of the first questions most people ask when presented this data is: Why? WVAHC will try to work with Bluefield State College to see if a longitudinal study can be performed to determine the reason for short life expectancy in southern West Virginia, particularly among women.

Public Health Initiative

- The short life expectancy for southern West Virginians is first and foremost a public health issue. Investment in public health can reduce preventable disease by 10 percent according to a 2007 Marshall University report.[6] This report also found that for every dollar invested in public health, West Virginia would reap a $1.69 return on investment.

  Local county health departments do not have the staffing or resources necessary to conduct the extensive public health initiatives necessary to respond to this crisis. WVAHC is recommending that a regional Health Department be established for the focus area. The regional Health Department would be charged with determining the underlying causes of the low life expectancy in the focus area and developing initiatives to combat these causes. In addition, the regional Health Department must be provided the resources necessary to implement these initiatives. Several initiatives should begin immediately. They would include:

Tobacco Usage:

- The Bureau of Public Health within the Department of Health and Human Resources (DHHR) should conduct aggressive smoking prevention and cessation programs within the target area. The Health Departments in each of the target counties should adopt comprehensive indoor smoking ordinances by January 2009. The West Virginia Legislature should consider raising tobacco taxes to the national average during the 2009 Legislative session, with the proceeds directed to tobacco cessation programs and other health promotion programs.[7]

Obesity:

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[6] C. Kent, P. Rutsohn, K. Soward, A. Chandra, "People at Risk: The Financial Crisis in West Virginia Public Health," Marshall University Center for Business and Economic Research (November 2007) Huntington, West Virginia.

[7] The Center for Disease Control and Prevention has issued the *Guide to Community Preventive Services* which systematically reviews the effectiveness of interventions to reduce or prevent tobacco use. They focused on three areas: stop kids from beginning; increase cessation; and reduce exposure to second hand smoke. Details of their recommendations can be found at http://www.thecommunityguide.org/tobacco/default.htm .

- The state Superintendent of Schools should work with each county board of education within the focus area to ensure that no soft drinks are sold within the school day in any school within the target area by January 2009[8]. Additionally, the state Superintendent of Schools should ensure that every student within the target area is receiving the physical activity required by state Board policy, and take steps to restore elementary physical education teachers to schools in the focus area.

- The Secretary of Transportation should conduct an inventory of the county seats and other major municipalities within the focus area to determine whether these municipalities are walkable and bikeable, and make specific recommendations about how these southern West Virginia communities can promote pedestrian and bicycle usage. While this will be difficult given the steep hills and narrow valleys in the focus area, we need to make physical activity a normal part of life in southern West Virginia.

- The County Commissions in the target area shall fund recreational sites that promote physical activity with an emphasis on encouraging children to exercise.

Nutrition:

- The legislature should consider providing a tax incentive to grocery stores that provide fresh fruits and vegetables.

- The WVU Extension Service, in conjunction with the West Virginia Department of Agriculture and the faith-based community, should promote family and community vegetable gardens in the focus area. Additionally, the state Department of Agriculture and the Governor's Office of Economic Opportunity should establish farmers markets in the focus area.

During the 2009 legislative session, the legislature should consider adoption of menu labeling requirements for all franchise restaurants in West Virginia. The menu labeling would require restaurants to make readily available to customers the calories and nutritional content of foods being sold in the restaurants.

Water and Sewage:

- The Governor's Office of Economic and Community Development should conduct an inventory of drinking water supplies and sewage treatment

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[8] In 2007 the Institute of Medicine issued a report calling for the elimination of soft drinks in schools during the school day. They recommended that water, 100 percent juices and low and non-fat milk be sold in schools during the school day. The Executive Summary of the Institute of Medicine's report can be found at http://www.iom.edu/Object.File/Master/42/505/Food%20in%20Schools.pdf.

facilities in the focus area and prioritize areas in the greatest need of safe drinking water and sewage treatment facilities.

Early Childhood Education:

- The State Board of Education, in conjunction with Head start and private child care centers and the Department of Health and Human Resources, shall submit a comprehensive plan for early childhood education that provides for universal pre-school for every child in the target area by school year 2009-2010. Additionally, the State Board of education should promote school-based health clinics for schools throughout the focus area.

Medical Homes:

- The West Virginia Health Improvement Institute should target the focus area for establishment of pilot medical homes. Practice groups in the target area will be encouraged to apply for medical home accreditation through the Institute.

Technology:

- The West Virginia Health Information Network should provide grants and technical assistance in order to ensure that every physician and hospital in the focus area has access to an interoperable electronic health record by January 2010. Additionally, the West Virginia Telemedicine Network should cooperate with hospitals and physicians in the focus area to ensure access to telemedicine.

Domestic Violence

- The Department of Health and Human Resources shall provide greater technical and financial resources to the focus area in order to reduce the level of domestic violence and provide safe alternatives to victims of domestic violence.

The proposals outlined in this report will take a significant investment of resources. However, we owe the citizens of southern West Virginia a concentrated effort to improve their health status and ensure that they have life expectancy equal to the rest of the United States.

Appendix A

Counties in the United States with the Lowest One Percent of Life Expectancy

National Ranking	State	County	Majority Ethnicity
1	SOUTH DAKOTA	JACKSON	51% American Indian
2	SOUTH DAKOTA	WASHABAUGH	Unknown
3	SOUTH DAKOTA	TODD	81% American Indian
4	SOUTH DAKOTA	SHANNON	87% American Indian
5	SOUTH DAKOTA	BENNETT	55% American Indian
6	SOUTH DAKOTA	MELLETTE	54% American Indian
7	*MARYLAND*	*BALTIMORE CITY*	*65% African American*
8	SOUTH CAROLINA	MARLBORO	52% African American
9	*VIRGINIA*	*PETERSBURG*	*78% African American*
10	ARKANSAS	PHILLIPS	61% African American
11	MISSISSIPPI	COAHOMA	73% African American
12	FLORIDA	UNION	74% European American
13	FLORIDA	BAKER	85% European American
14	**WEST VIRGINIA**	**MCDOWELL**	**88% European American**
15	*MISSOURI*	*ST. LOUIS CITY*	*51% African American*
16	MISSOURI	PEMISCOT	73% European American
17	ARKANSAS	CRITTENDEN	50% EA / 49% AA
18	MISSISSIPPI	SUNFLOWER	72% African American
19	*VIRGINIA*	*RICHMOND CITY*	*55% African American*
20	MISSISSIPPI	WASHINGTON	67% African American
21	**WEST VIRGINIA**	**LOGAN**	**96% European American**
22	MISSISSIPPI	TALLAHATCHIE	60% African American
23	MISSISSIPPI	TUNICA	72% African American
24	MISSISSIPPI	QUITMAN	69% African American
25	NORTH CAROLINA	MARTIN	54% European American
26	SOUTH CAROLINA	MARION	55% African American
27	**WEST VIRGINIA**	**MINGO**	**96% European American**
28	NORTH CAROLINA	ROBESON	38% AI/ 36% EA/ 25% AA
29	MISSISSIPPI	BOLIVAR	65% African American
30	ARKANSAS	MISSISSIPPI	64% European American
31	LOUISIANA	WASHINGTON	67% European American

West Virginia counties in bold and urban cities are in italic.

SUMMARY:

5 counties have a majority American Indian population and one has a plurality of American Indians.
14 counties have majority African American population.
10 counties have majority European American population.

Only four counties (italicized) appear to be in urban areas. 27 counties appear to be in rural counties.

Appendix B

West Virginia Rankings of Life Expectancy Among the 3,141 Counties within the United States for Both Men and Women

County	National Ranking	Years
McDowell	14	70.4
Logan	21	71.2
Mingo	27	71.4
Lincoln	100	72.6
Wyoming	145	72.8
Boone	224	73.3
Fayette	319	73.6
Mercer	477	74.2
Mason	543	74.4
Clay	559	74.4
Nicholas	560	74.4
Cabell	582	74.5
Gilmer	589	74.5
Lewis	590	74.5
Kanawha	690	74.8
Raleigh	704	74.8
Harrison	726	74.8
Taylor	780	74.9
Barbour	781	74.9
Pleasants	853	75.1
Ritchie	854	75.1
Doddridge	855	75.1
Mineral	861	75.1
Berkeley	862	75.1
Morgan	863	75.1
Monroe	922	75.3
Summers	923	75.3
Wirt	924	75.3
Calhoun	925	75.3
Roane	926	75.3
Pocahontas	959	75.3
Braxton	960	75.3
Webster	961	75.3
Wayne	980	75.4
Wetzel	987	75.4
Tyler	988	75.4
Randolph	990	75.4

Ohio	1033	75.5
Greenbrier	1034	75.5
Preston	1052	75.5
Jefferson	1053	75.5
Brooke	1137	75.7
Upshur	1214	75.8
Wood	1279	76.0
Hampshire	1291	76.0
Hardy	1292	76.0
Jackson	1356	76.1
Putnam	1366	76.2
Hancock	1406	76.2
Marion	1430	76.3
Marshall	1437	76.3
National Median		**76.5**
Pendleton	1853	76.9
Grant	1854	76.9
Tucker	1855	76.9
Monongalia	2024	77.2
Best in the Country		**81.3**

Appendix C

West Virginia Ranking Among the 3,141 Counties within the United States for Women's Life Expectancy

County	National Ranking	Life Expectancy
McDowell	10	73.5
Mingo	15	74.3
Logan	16	74.4
Lincoln	53	75.6
Wyoming	58	75.7
Boone	107	76.0
Fayette	265	76.8
Taylor	324	77.0
Barbour	325	77.0
Gilmer	384	77.2
Lewis	385	77.2
Mason	418	77.2
Clay	463	77.4
Nicholas	464	77.4
Cabell	488	77.4
Pocahontas	501	77.4
Braxton	502	77.4
Webster	503	77.4
Mercer	511	77.5
Harrison	523	77.5
Kanawha	567	77.6

Appendix D

Rankings of Behavior Risk Factors and Health Conditions within West Virginia for Counties in the Focus Area[9]

County	Fair or Poor Health	No Health Insurance	Obesity	Cigarette Smoking	Diabetes	Hyper-tension	High Cholesterol
Boone and Lincoln	5	10	2	5	5	4	4
Fayette	9	11	6	12	18	26	30
Logan	4	5	1	11	10	3	3
McDowell	1	1	8	6	1	2	1
Mingo	2	2	3	2	4	1	19
Wyoming	3	7	18	1	23	6	7

Note: The West Virginia Health Statistics Center groups 31 counties into 12 groups "in order to obtain adequate sample size for analysis." The best ranking for the state is 36 -- not 55, since these counties are grouped together.

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[9] Source: 2004 - 2005 West Virginia Behavioral Risk Factor Survey Report, West Virginia Department of Health and Human Resources, May 2007. Available at http://www.wvdhhr.org/bph/oehp/hsc/pubs/BRFSS2004and2005/default.htm. Accessed July 31, 2008.

Putnam	587	77.7
Jefferson	608	77.7
Randolph	612	77.7
Preston	628	77.8
Mineral	705	77.9
Raleigh	724	77.9
Pleasants	745	78.0
Ritchie	746	78.0
Doddridge	747	78.0
Greenbrier	768	78.0
Ohio	772	78.0
Jackson	897	78.2
Wood	941	78.3
Wirt	960	78.4
Calhoun	961	78.4
Roane	962	78.4
Brooke	974	78.4
Wayne	1119	78.6
Monroe	1122	78.6
Summers	1123	78.6
Berkeley	1144	78.7
Morgan	1145	78.7
Marshall	1274	78.9
Upshur	1336	79.0
Marion	1337	79.0
Hancock	1377	79.0
Hampshire	1388	79.1
Hardy	1389	79.1
Wetzel	1445	79.1
Tyler	1446	79.1
Monongalia	1561	79.3
Pendleton	1655	79.5
Grant	1656	79.5
Tucker	1657	79.5
National Average		**79.6**
Best in the Country		**84.5**

SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
SUBCOMMITTEE ON WATER AND WILDLIFE
"THE IMPACTS OF MOUNTAINTOP REMOVAL COAL MINING ON WATER QUALITY IN APPALACHIA"
THURSDAY, JUNE 25, 2009

Written Statement of the National Mining Association

Mountaintop Mining in the United States

Mountaintop mining (MTM) is a surface mining method confined to areas with relatively steep terrain and multiple coal seams that are located near the land surface. Typically, MTM operations are in Appalachia. MTM operations are important to the states and local communities where they exist and to the nation as a whole. Depending on the state, mountaintop operations mine 38-66 percent of the coal produced in West Virginia, Kentucky, Tennessee, Virginia and parts of Ohio, and the value of those shipments exceeds $5 billion. Nationwide, these operations contribute 10-11 percent of U.S. coal production—sufficient to provide electricity for 77 million households.

MTM is the safest and most efficient method for mining coal near the surface in steep terrain. The earth and rock overlaying the coal seams are shot (blasted) and removed to expose coal seams for recovery. The excess soil (overburden) is either returned to its original location or, where slope instability prohibits safe replacement of overburden on the top of the mined site, placed in designed fill areas. The mine site, including fills, is restored through reclamation in accordance with permit requirements.

After the coal is removed, the entire site is restored through mine land reclamation as required in permit specifications. In accordance with landowner needs (many sites are leased) and in consultation with community and state environmental and/or economic development officials, MTM sites are restored for other beneficial uses. These uses can include forest land and wildlife habitat or much needed commercial development that can take advantage of a more level landscape that is more affordably created after MTM ceases.

Mountaintop mining was specifically authorized by Congress when it enacted the Surface Mining Control and Reclamation Act (SMCRA) in 1977. Section 515(c) provides an exception for restoring the site's approximate original contour under certain conditions, and Section515 (b)(22) allows excess rock and dirt to be placed in streams (valley fills) so long as lateral drains and under drains are constructed to avoid water filtration through the fill material. All mining operations must obtain permits and comply with regulations of the Clean Water Act (CWA) to avoid degradation of streams. Operations also must comply with state water quality standards. Under Section 404 of the CWA, the Army Corps of Engineers issues permits for the discharge of dredged or fill material into "navigable waters" provided effects on the aquatic ecosystem as a whole are acceptable. A complete mitigation plan is required, and there is opportunity for public review and comment in the case of individual permit authorizations.

Recent Attacks on Surface Coal Mining are Not Limited to MTM

Proposals from Congress and the administration that effectively ban surface mining under the guise of protecting the environment are short-sighted and ill-informed. First, proponents of such legislation suggest the intent is limited to stopping MTM practices and not meant to put the coal industry out of business. Second, these proposals cite no valid environmental reason for adopting such a drastic approach.

Prior to passage of the Surface Mining Control and Reclamation Act (SMCRA) in 1977 many historic mining practices left a legacy of water quality problems, unreclaimed high walls and mine scarred lands. This is no longer allowed, and a modern mining industry has evolved in its place. Today's high-tech, high paying, highly regulated mining industry can make a significant contribution to rebuilding the nation's economy as well as restoring the environment.

Mining's Untold Story

Over the past thirty years, environmental regulation of coal mining has evolved and improved. With the exception of Tennessee, which operates under the federal SMCRA, each coal mining state implements and enforces its own state program that must be at least as stringent as the federal program. Similarly, most of the states that authorize coal mining projects do so under their own state run water quality programs. This is consistent with Congress' intent that decisions about coal mining projects should be locally made allowing for public input where these projects are located and pursuant to a strong federal program.

Both federal and state regulation and enforcement of mining has become increasingly stringent. For example, a rough survey of the mining programs shows that since 1998, a number of more stringent environmental protection requirements for surface coal mining operations within the Eastern coal mining states have been put into place. In addition, the federal regulatory agencies, the Corps, Environmental Protection Agency (EPA) and the Office of Surface Mining (OSM) have revised regulations, making them increasingly stringent over this same time period. The following provides a summary of those requirements that have been included in surface coal regulatory programs over the last ten years.

State Actions

- Presumption that any mining operation that proposes to discharge fill in waters of the United States draining a watershed of 250 acres or more would have more than minimal adverse effects and shall require an individual Clean Water Act section 404 permit- West Virginia only.
- In West Virginia, all individual section 404 permits are subject to an inter-agency process governed by a Memorandum of Understanding (MOU) between EPA, the Corps, OSM, Fish and Wildlife Service (FWS) and the West Virginia Department of Environmental Protection (WVDEP). The goal is to coordinate review and issuance or denial of the CWA section 404 permit issued by the Corps, a CWA section 401 certification issued by WVDEP, a CWA section 402 (NPDES) permit by WVDEP, and a surface mining and reclamation permit issued by WVDEP. Other states have adopted similar coordinated procedures.
- Ensures location of ponds are as close as practicable to the toes of fills.
- Requires a separate hydrologic reclamation plan that addresses requirements found in state regulations and a new hydrologic reclamation policy document.
- New regulations pertaining to variance requirements for restoration to approximate original contour.
- Revisions to contemporaneous reclamation regulations to make reclamation more contemporaneous with mining.
- Approximate Original Contour definition revised for the purpose of optimizing spoil placement for valley fills –Approximate Original Contour (AOC) Plus policy – EPA approved.
- New regulations on post mine land uses, homesteading and bond release.

Federal Actions:

- Preparation of agency-wide Environmental Impact Statement (EIS) evaluating MTM practices and regulation.
- Department of the Interior (DOI) EIS accompanying promulgation of Stream Buffer Zone rule.
- EPA and Corps joint mitigation rule - Increases mitigation and monitoring requirements, discretion to require conservation easements, bonds, etc., for ensuring mitigation success, mitigation requirements become enforceable terms and conditions of the 404 permit.
- NWP 21 Requirements – Requires written approval by Corps before going forward with projects, increases mitigation and success monitoring requirements.
- Stream Buffer Zone Requirements – Requires spoil and fill minimization, ensures spoil placement alternatives are analyzed, analysis of impacts on perennial and intermittent streams.

Current Water Quality Concerns Are Unverified

Overburden from mining operations is often deposited in valleys that typically contain ephemeral or intermittent stream systems. To control potential excess sedimentation, sediment ponds are often constructed downstream of the overburden fills. Some argue that the valley fill is detrimental to the stream ecosystem. In fact, the administration's announcement early this year that the EPA would re-review hundreds of mining permits that have been pending for up to two years, and its subsequent announcement that it would suspend the use of the coal mining general permit is driven by one study done by EPA scientists, Gregory Pond and Margaret Passmore, Pond et al. (2008) (Pond/Passmore Study). A critique of that study and its findings is attached to this statement and draws considerable question as to the soundness of the study approach and conclusions. In sum, several outside experts have concluded that there are a number of other factors that could account for the "impairment" reported in Pond/Passmore. Yet, without any public review or debate, and based on the findings of one study, EPA and the administration have interrupted the issuance of coal mining permits, creating an enhanced review process that takes coal permit decisions out of the hands of both the Corps and the states, where Congress and, just this week, the Supreme Court said the primary authority resides. See *Coeur Alaska, Inc. v. Southeast Alaska Conservation Council et al.*

A survey of the state mining programs shows that much can be done with the states in the lead to enlist the modern mining industry in accomplishing the state environmental goals. In Virginia, for example, the Division of Mined Land Reclamation (DMLR) encourages industry to use Abandoned Mine Land (AML) no-cost agreements to reclaim abandoned mine land. No-cost agreements allow mining companies to use excess spoil from permitted mining operations to eliminate abandoned mine highwalls that normally would not be reclaimed. In addition to reclaiming abandoned mine land highwalls, the practice also minimizes the development of new valley and hollow fills and reduces impacts to coalfield streams. In addition, Virginia DMLR finds opportunities for providing offset credits in the Total Maximum Daily Load (TMDL) allocation context for removal and reclamation of AML refuse piles and reduction of perpetual sediment loads in TMDL watersheds. Without a modern mining industry in these coal mining states, these water quality improvements either would not be accomplished or would be left for the state to complete within already constrained budgets.

Many of the Eastern coal states have addressed water quality problems through permitting coal industry projects for the purpose of re-mining and reclamation of historic sites. In so doing, the environmental and water quality problems are addressed, and the site is reclaimed under modern mining laws resulting in an efficient way to restore the state's watersheds and eliminate perpetual water quality problems that would continue to burden the states. Remining operations provide income through coal production, create jobs and environmental enhancements.

The Environmental Protection Agency recognized in 2002, when promulgating amendments to the remining effluent guidelines, that one of the most successful means for improvement of abandoned mine land is for coal mining companies to remine abandoned areas and extract the coal reserves that remain. See 67 Fed. Reg. at 3375 (Jan. 23, 2002). EPA also recognized that if abandoned mine lands are ignored during mining of adjacent areas, a time-critical opportunity for reclaiming the abandoned mine land is lost. "Once coal mining operations have ceased on the adjacent areas, there is little incentive for operators to return." Id. Legislation and administrative policies that would eliminate or transfer the coal mining industry away from these states overlooks the value states place on the partnerships created between them and coal companies to improve the quality of the environment in the states where they are located.

Post-Mined Land Promotes Economic Diversity and Tourism

Reclaimed mine sites provide opportunities for economic development in mining communities. Particularly in steep sloped areas, mining companies partner with the local community to incorporate post-mining land uses into future redevelopment plans. In this way, much needed public infrastructure such as schools, roads, highways, airports, and recreational facilities are built and new businesses and industries are attracted where they would not otherwise find lands suitable for such development. See Testimony of Mike Whitt, Executive Director Mingo County Redevelopment Authority, Williamson, West Virginia, attached.

Some have argued that prohibitions on mining will benefit state economies by opening them for increased tourist-related commerce. This claim is unsupported. In fact, studies show that in those areas of the coal region where tourist activities are present, mining and tourism seem to coexist with little difficulty and in the remainder of the region there is little or nothing to attract tourists. See Joint Statement of Mark L. Burton and Michael J. Hicks, Center for Business and Economic Research Marshall University, June 6, 2002.

Congress and the Administration Should Support Coal Mining Jobs

More than 90 percent of the coal mined in the U.S. is used to generate electricity. Coal is the nation's most abundant and affordable domestic energy resource.

There are more than 14,000 surface coal miners in Appalachia, and for every mining job an additional 3.5 jobs are created through the economic activity generated by mining for a total of more than 60,000 jobs. The average mining wage is more than $66,000/year, excluding overtime—57 percent higher than the average for industrial jobs.

For additional information, see http://www.nma.org/pdf/fact_sheets/mtm.pdf.

Geotechnical
Water Resources
Environmental and
Ecological Services

GEI Consultants

Technical Memorandum

Identification of Issues in Regard to the "Pond et al. Study" on Effects of Mountaintop Mining and Valley Fill on Benthic Invertebrate Communities

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1.0 Background

Mountaintop mining and valley fill is a mining technique used presently and historically in coal mining in the central Appalachian region of the eastern United States. Excess overburden from the mining operations is deposited in valleys which usually contain ephemeral or intermittent stream systems. To control potential excess sedimentation, sediment ponds are often constructed downstream of the overburden fills. Pond et al. (2008) (Pond/Passmore Study) indicated that mountaintop mining with valley fill techniques are detrimental to the stream ecosystems, as measured with bioassessment of benthic invertebrate communities. This technical memorandum identifies several areas of concern that should be further investigated in order to validate or qualify the findings of the Pond/Passmore Study.

2.0 Issues Raised by the Study

2.1 Multimetric Indices Used

The Pond/Passmore Study was intended to contrast two multimetric invertebrate indexes that have been developed for use in West Virginia. The first is the WVSCI, a family-level index developed several years ago, which according to the original publication apparently did a good job of discriminating between reference and impacted streams (Tetra Tech 2000). The other is GLIMPSS, a draft, unpublished genus-level index recently developed by several scientists who are also co-authors of the Pond/Passmore Study (Pond et al. unpublished draft report). The Pond/Passmore Study concluded that the WVSCI underestimated impairment to West Virginia streams and concluded that the GLIMPSS index did a superior job of discriminating between reference and impacted streams.

2.2 Conductivity as the Controlling Factor?

The Pond/Passmore Study relied heavily on conductivity measures to corroborate their findings of "stream impairment" using the GLIMPSS index. Conductivity is often used as a surrogate measure of other, often complex, water chemistry parameters, and is influenced by numerous organic and inorganic compounds.

The surrogate use of conductivity measurements in the Pond/Passmore Study is possibly inappropriate. For example, Armstead (2006) cited several cases of high invertebrate metric scores (WVSCI) even with high conductivity, as well as high invertebrate metric scores in the presence of variable conductivity. These case studies included streams within the West Virginia coal mining belt. Because conductivity is only a surrogate for other water chemistry variables, findings associated with conductivity should be investigated further to determine which specific compounds may be responsible for changes in conductivity, as it may not be possible to identify which compounds those are – or if the specific compounds vary with location. Furthermore, the arbitrary division of low (<500 µS/cm), medium (500 – 1000 µS/cm), and high (>1000 µS/cm) conductivity in the Pond/Passmore

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Study should also be investigated to determine if these cutoff values represent streams that are actually behaving similarly within the individual groupings.

2.3 Other Possible Reasons for Patterns Observed

There are a number of confounding factors related to valley fill conditions and the patterns observed by Pond/Passmore that may be unrelated to conductivity. For example, the relations between the settling ponds associated with valley fill and resultant stream chemistry, water quality, food quality, and invertebrate community composition could be an important causal agent for the changes in invertebrate community structure. On p. 718 (2nd full paragraph), Pond et al. (2008) stated that there are sediment control structures and ponds associated with mountaintop mining and valley fill and indicate that fine sediments may still bypass those controls. However, they did not state if sediment control structures were in place for all or part of the mining sites used in their analysis.

In fact, the presence of sediment ponds (and not any "elevated conductivity" below the valley fill itself) may be, in part, responsible for any observed changes in invertebrate community composition downstream of those ponds.

2.3.1 Hydrologic Modification?

Armstead (2006) suggested that the valley fill and the sediment control ponds may retain water and release it more slowly to the stream channels than normal surface flows. This may result in the streams behaving more like a perennial spring system than an intermittent/ephemeral stream system – i.e., systems with more constant flows for longer time periods (including year-round). Water chemistry and even biological communities in such perennial "spring-like" systems are often vastly different from those of intermittent/ephemeral and even more variable downstream systems (Williams 1987).

This aspect of the stream hydrologic change should be investigated for these study streams, perhaps by comparing a range of stream conditions similar to those found in the Pond/Passmore Study streams to natural spring systems. This comparison could evaluate the potential influence that conversion of the ephemeral/intermittent stream system to a perennial spring-type system might have to alter the community composition in the streams.

2.3.2 Changes in Food Resources?

Armstead (2006) cited several publications regarding increases in the "collector" functional feeding groups (especially filter feeding hydropsychid caddisflies) below impoundments. Past research indicated shifts in community structure within the hydropsychid community downstream of impoundments, suggesting that changes to the entire community might not be unexpected. It is possible that food resources discharged from the surface release of the settling ponds are rich in components fed on by hydropsychid caddisflies and other filter-feeding organisms, increasing their densities and competitively displacing other organisms, such as mayflies (which tend to be scrapers and collector-gatherers). This shift in community composition may be a natural occurrence below impoundments (and is observed below lakes) and deserves further investigation.

2.4 Trophic Function Maintained?

Although taxonomic changes in the community are evident, a more detailed examination of the results of the Pond/Passmore Study demonstrate that the functional structure of the community (both in terms of functional feeding groups and invertebrate "habits" – which are both used in development of multimetric indices) are actually relatively similar between mined and unmined streams. This suggests that the overall function of the benthic invertebrate communities remained relatively unchanged even though the taxonomic composition did change (Tables 1 and 2).

Table 1: Proportional abundance of functional feeding groups in the Pond/Passmore Study.

Functional Feeding Group	Unmined Sites	Low Mining Activity	Moderate Mining Activity	High Mining Activity
Gather-collector	29%	23%	24%	24%
Scraper	14%	17%	4%	8%
Filter-collector	12%	20%	24%	24%
Predator	21%	26%	20%	28%
Shredder	21%	14%	28%	12%
Piercer	2%	0%	0%	4%

Table 2: Proportional abundance of habit groups in the Pond/Passmore Study.

Habit Group	Unmined Sites	Low Mining Activity	Moderate Mining Activity	High Mining Activity
Swimmer	14%	17%	16%	12%
Clinger	62%	71%	68%	80%
Burrower	5%	0%	0%	0%
Sprawler	17%	11%	16%	8%
Climber	2%	0%	0%	0%

2.5 Basis for GLIMPSS Index?

The Pond/Passmore Study also relied heavily on the results from the recently developed and still unpublished GLIMPSS multi-metric invertebrate index. The Pond/Passmore Study indicated that the GLIMPSS index "performed better" than the previously established WVSCI index. However, there are several aspects of the development and use of the GLIMPSS index that should be investigated further.

Hundreds of metrics are available for use in developing a multimetric index (this fact is admitted in the GLIMPSS document), but development of the GLIMPSS index started with only 36 metrics, which was reduced to 9 metrics for the final index. The choice of metrics was based on the following: 1) sufficient metrics were chosen to span the metric categories of richness, composition, tolerance, and function; 2) some metrics had been used in the WVSCI and other national and regional biomonitoring programs; and 3) some metrics were excluded for biological reasons (e.g., Odonata metrics were not included because odonates are usually rare in riffle habitat – *although we note they are present in most of the sites in the Pond/Passmore study*). These are generally appropriate reasons for including or excluding some metrics from analysis. However, given the computing power available today, the original 36 metrics remains a small, somewhat arbitrary list of metrics to use as the initial list for development of a comprehensive, general-purpose, regional multimetric index. Furthermore, the initial list especially appeared to be lacking in diverse habit metrics (using clingers only) and few tolerance value-based metrics (using "sensitive" taxa with tolerance values <3 or <4 only). Exclusion of the other available metrics that would identify tolerant taxa could have resulted in an overemphasis in the GLIMPSS development on the intolerant taxa and, thus, an overestimation of "impairment".

The EPT Orders were separated for individual analysis instead of applying the commonly used EPT index (in which they are summed), due to the apparent *a priori* bias of the authors regarding the potential influence of "tolerant" hydropsychid taxa on the EPT index (p. 728). This may have resulted in the elimination of Trichoptera metrics from the final index and perhaps caused an overemphasis on Ephemeroptera metrics.

The draft GLIMPSS document stated the criteria used to identify sites as attaining reference ("least disturbed") site condition, particularly emphasizing water quality parameters, habitat parameters, and lack of any evidence of anthropogenic disturbance. There was no identification of discrimination within potential disturbances to the "stressed" sites used in development and calibration of the GLIMPSS index. This leads to the natural dichotomy of "least disturbed" or "stressed", with no middle category wherein there may be influences on the metrics, but they are insufficient to cause significant changes to the community structure and function.

The development of a general-use multimetric index, such as GLIMPSS is purported to be, requires that the "stressed" sites be representative of the spectrum of anthropogenic influences. However, if one particular anthropogenic influence is heavily represented in the development of the multimetric index, then that index will necessarily be useful primarily for the identification of that particular anthropogenic influence. Figure 3 of the GLIMPSS document shows that a large portion of the sites used for both metric development and validation of the Central Appalachian Region index metrics were located in the Coal and Guyandotte watersheds, where many of the sites in the Pond/Passmore Study were also located. This would suggest that it is possible that many of the "stressed" sites used in development and validation of the GLIMPSS index were mine-related sites. Therefore, the identification of "impaired" sites by GLIMPSS techniques in the Pond/Passmore Study being related to valley-fill mines might be expected, since the index may be inadvertently geared toward identification of mined sites rather than general disturbances. The selection of sites for the development and validation of the GLIMPSS index should be investigated to determine if they do reflect the spectrum of anthropogenic influences or are overly represented by mined sites.

The GLIMPSS document indicated (p. 47) that it does not perform well in streams with significant limestone geology and associated groundwater discharges (high alkalinity and low temperatures leading to low invertebrate diversity). An investigation should be undertaken to determine if the sites examined in the Pond/Passmore Study are limestone dominated, a fact which might indicate that GLIMPSS was inappropriate for use.

Additionally, there may be possible changes to the nature of the affected streams as described above, in which the streams behave more like a perennial, spring-fed stream than an intermittent/ephemeral stream system – an overall stream condition influence that may not be accounted for in the GLIMPSS development.

3.0 Summary

In summary, while the findings of the Pond/Passmore Study appear on the surface to strongly indicate a causal agent of conductivity to "impairment" of invertebrate communities, as related to variable valley-fill mine influence, our preliminary review indicates that there are a number of other factors which could account for those patterns. It is clear that additional study of these patterns should be conducted to determine if conductivity is potentially providing a "false signal" and if, in fact, there are other reasons for the observed changes in invertebrate community structure.

4.0 References

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NMA
THE AMERICAN RESOURCE

SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
SUBCOMMITTEE ON WATER AND WILDLIFE
"THE IMPACTS OF MOUNTAINTOP REMOVAL COAL MINING ON WATER QUALITY IN APPALACHIA"
THURSDAY, JUNE 25, 2009

MINING COMMUNITY GRASSROOTS COMMUNICATION SUMMARY

In advance of the June 25 hearing by the subcommittee, the National Mining Association (NMA) encouraged its community of online grassroots supporters to write their senators and express their support for mountaintop mining (MTM) and detail the numerous economic and energy benefits made possible by MTM operations.

A total of 2,090 electronic letters were delivered to 44 Senate offices by mining community supporters regarding the importance of MTM operations.

Below is a summary showing the number of letters delivered to Senate offices, as well as a sample letter sent by a mining community supporter.

Senate Summary

Sen. Robert Byrd (D-W.Va.)	431
Sen. John Rockefeller (D-W.Va.)	431
Sen. Jim Bunning (R-Ky.)	213
Sen. Mitch McConnell (R-Ky.)	213
Sen. Mark Warner (D-Va.)	106
Sen. Jim Webb (D-Va.)	106
Sen. Robert Casey (D-Pa.)	81
Sen. Arlen Specter (D-Pa.)	81
Sen. Sherrod Brown (D-Ohio)	50
Sen. George Voinovich (R-Ohio)	50
Sen. Roland Burris (D-Ill.)	32
Sen. Richard Durbin (D-Ill.)	32
Sen. Evan Bayh (D-Ind.)	30
Sen. Richard Lugar (R-Ind.)	30
Sen. Christopher Bond (R-Mo.)	28
Sen. Claire McCaskill (D-Mo.)	28
Sen. Lamar Alexander (R-Tenn.)	18
Sen. Robert Corker (R-Tenn.)	18

Sen. Max Baucus (D-Mont.)	16
Sen. Jon Tester (D-Mont.)	16
Sen. Mike Crapo (R-Idaho)	7
Sen. Jim Risch (R-Idaho)	7
Sen. Jim DeMint (R-S.C.)	6
Sen. Lindsay Graham (R-S.C.)	6
Sen. Benjamin Cardin (D-Md.)	5
Sen. Barbara Mikulski (D-Md.)	5
Sen. Robert Bennett (R-Utah)	4
Sen. Orrin Hatch (R-Utah)	4
Sen. John Barrasso (R-Wyo.)	3
Sen. Michael Enzi (R-Wyo.)	3
Sen. Richard Burr (R-N.C.)	3
Sen. Kay Hagan (D-N.C.)	3
Sen. Mel Martinez (R-Fla.)	3
Sen. Bill Nelson (D-Fla.)	3
Sen. Mark Udall (D-Colo.)	3
Sen. Mark Begich (D-Alaska)	2
Sen. Lisa Murkowski (R-Alaska)	2
Sen. Kent Conrad (D-N.D.)	1
Sen. Byron Dorgan (D-N.D.)	1
Sen. Saxby Chambliss (R-S.C.)	1
Sen. Dianne Feinstein (D-Calif.)	1
Sen. Barbara Boxer (D-Calif.)	1
Sen. Kay Bailey Hutchinson (R-Texas)	1
Sen. John Cornyn (R-Texas)	1

SAMPLE LETTER

James Charles
1148 Long Fork Road
Kimper, KY 41539-5936

June 23, 2009

300 S. Main Street
Suite 310
London, KY 40741

Dear Sen. McConnell:

Support American coal mining jobs. Oppose S. 696!

Legislation that threatens to inflict massive economic damage on America's mining community will be the subject of a June 25 Senate Water and Wildlife Subcommittee hearing. I am writing to urge you to protect thousands of coal mining jobs oppose the so-called "Appalachian Restoration Act" (S. 696).

S. 696 unnecessarily restricts the availability of vital Clean Water Act permits by introducing a new, poorly conceived definition of the term "fill material." The bill would overturn an existing regulatory definition developed by the U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers and ignores 30 years of effective regulatory practice, serving only to further burden an already suffering economy.

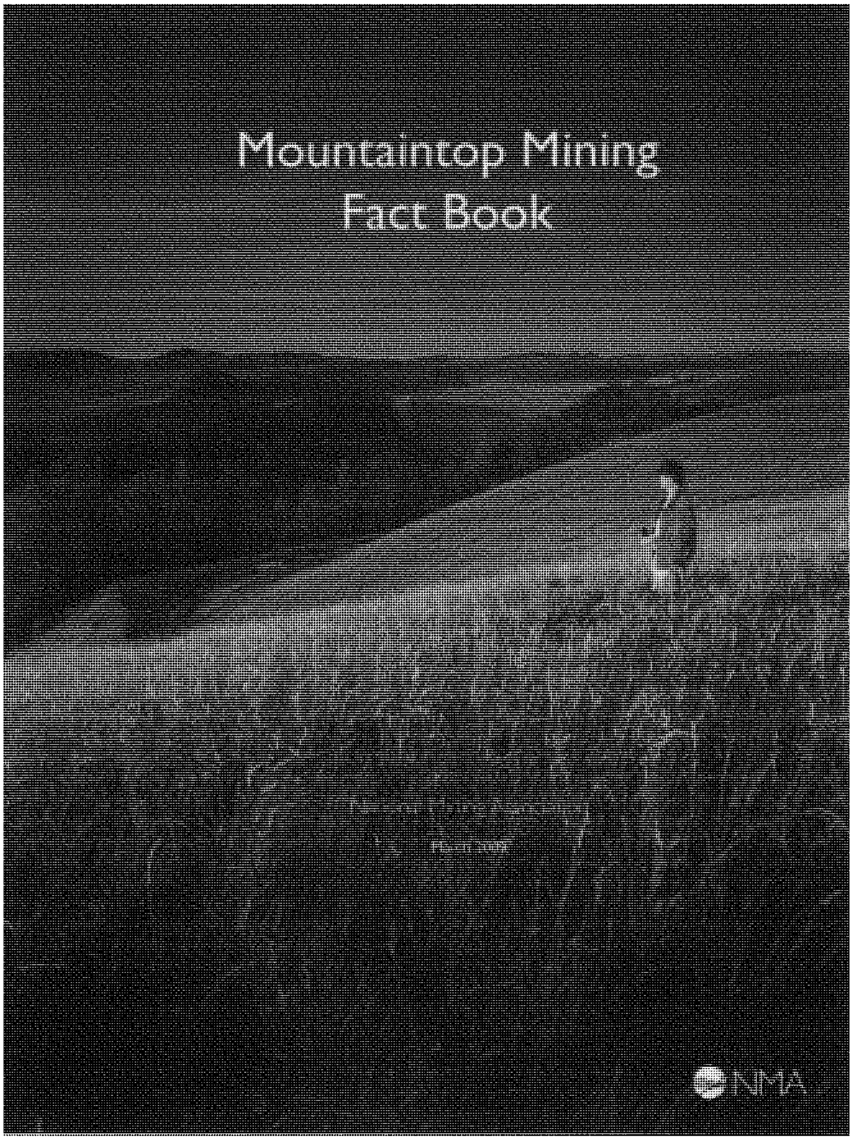
By limiting the availability of Clean Water Act permits, S. 673 would wipe out up to 375,000 high-paying mining jobs and over 1 million jobs dependent upon the economic output generated by mining operations.

Mining operations already comply with stringent state and federal environmental regulations, making the prohibitive new permitting rules in S. 696 wholly unnecessary.

For these reasons, I urge you to support high-wage American jobs and American mining and oppose S. 696.

Sincerely,

James Charles
606-835-2233



Mountaintop Mining Fact Book

National Mining Association

March 2007

OVERVIEW

Mountaintop mining (MTM) is a surface mining technique that is used to safely and efficiently extract coal reserves near the surface in the steep terrain conditions characteristic of Central Appalachia. During MTM, multiple coal seams are uncovered by removing the overburden and interburden (the rock situated above and between seams), which are then placed on previously mined areas or within engineered fill areas.

After the coal is removed, the entire site is restored through mine land reclamation as required in permit specifications. Each MTM site is uniquely designed, engineered, permitted, operated and reclaimed in accordance with standards that are defined and regulated under local, state, and federal laws and regulations, including the 1977 Surface Mining Control and Reclamation Act (SMCRA), which requires final reclamation of the site to create "a level plateau or gently rolling contour with no highwalls remaining."

MTM Economic Impact: *At a glance*	
Jobs	
Direct	14,000
Indirect	60,000
Average Salary	$66,000
Compared to Average Industrial Salary	57% higher
Value of Economic Activity	
Direct	$5 billion
Indirect	$7.5 billion

MTM is frequently applied to areas where previous mining activities took place using methods that achieved only partial recovery of the coal reserves. MTM can mitigate previous environmental problems associated with past mining such as acidic drainage and un-reclaimed highwalls that were created prior to implementation of today's more stringent mining and environmental regulations.

Mountaintop mining generally references all types of surface mining in the Appalachian region, including mountaintop removal, contour mining and area mining. Accordingly, this document will refer to "mountaintop mining" as including all of the types of surface mining in this region.

Nonetheless, the economics of MTM and underground mining are inter-related, and one mining technique cannot replace the other. A study conducted by Marshall University in West Virginia found that "... there are linkages between surface quantities and the cost of underground mining. These linkages are attributable to several factors... Thus [a decision to end MTM] will almost certainly affect both surface and underground production..." One cannot simply assume that a property that is well suited to MTM can be designed and developed using alternative production methods. Other mining methods may or may not be technically and/or economically feasible. Mines and mining properties are unique, and the viability of any mine or reserve can only be determined based on site-specific geological models and engineered mining plans. The only certainty of alternative methods is that overall coal reserve recovery will be lower than with MTM methods, thus permanently sterilizing coal that could have been mined.

Coal produced from the Appalachian region has a significant impact on our nation's economy and social well being. The Appalachian region contains more than 50 billion tons of coal reserves. Mountaintop mining operations alone produce more than 126 million tons of coal per year, providing enough energy to power more than 25 million American homes.

Economic Impact

Mountaintop mining operations produce desirable, high-wage jobs that are the economic engine of local communities, states and the region in which they operate. The average mining wage is more than $66,000/year, excluding overtime – 57 percent higher than the average for industrial jobs. Mountaintop mining accounts for approximately 45 percent of the entire state's coal production in West Virginia.

There are more than 14,000 surface coal miners in the Appalachian region, and for every mining job an additional 3.5 jobs are created through mining services, sales, and other related business. Accordingly, mountaintop mining provides almost 60,000 jobs in Appalachia.

Eliminating MTM will have a devastating economic impact on the communities where these mines are located. A 2004 study conducted by the Center for Business and Economic Research found that that "the impact on State and local tax revenues will be precipitous" if MTM is eliminated. The authors concluded that placing serious restrictions on this efficient mining technique would result in a loss equaling "nearly nine percent" of West Virginia's tax revenue impacting a variety of state services including K-12 education.

Value of Shipments

Investment in these projects creates production value of more than $5 billion from the value of the coal alone. In addition, such operations pump billions of dollars more into the local economy through the purchase of equipment and supplies, payments for transportation on railroads and barges, hiring consultants and engineers, and payment of taxes. Mountaintop mining is also a source of American exports. In 2007, the U.S. exported more than 13 million tons of surface-mined coal from the region, worth almost $1 billion.

The U.S. annually mines more than 1 billion tons of coal. About 90 percent of this output is the fuel source for more than half of our nation's electricity generation. The remaining 100 million tons of U.S. production is utilized for coke-making, industrial uses or sold in the export market. About 70 percent of U.S. coal production is mined using surface mining methods, including MTM. Underground mining methods account for the remaining coal output.

The Department of Energy predicts that coal use will steadily grow over the next 20 years because it is the nation's most abundant and affordable energy resource. There are nearly 125,000 coal miners in the United States today.

GENERAL BACKGROUND

MTM site in southern W.Va., before and after reclamation.

MTM is confined to those areas with relatively steep terrain and multiple seams that are located above natural drainage formations that intermittently carry water or serve as ephemeral streams. The earth and rock overlying the coal seams are shot (blasted) and removed to expose coal seams for recovery. The overburden is either returned to its original location or placed in designed fill areas. The site is reclaimed in accordance with permit requirements.

During the mining process, the general appearance of MTM sites is comparable to other big civil projects in this region that involve moving substantial volumes of material and large earth-moving equipment. Because MTM mining is conducted in rugged terrain where slope instability generally prohibits replacing all of the excavated rock back onto the mountaintop for safety reasons, excess rock in a MTM operation is placed in a designated valley fill area that is engineered to meet regulatory compliance and ensure slope stability. Upon completion of final placement of rock onto previously mined areas and valley fill areas, the area is rough graded and shaped. A final layer of topsoil (growth medium) is placed onto the reclaimed area as part of the final grading application. The affected areas are then re-seeded with vegetation conducive to the surrounding environment and wildlife, planted with seedlings for reforestation, used as farmland, or prepared for development, depending on the final land use requirements as described in the permit.

This entire process is regulated and bonded to ensure compliance. Final reclamation as required by regulation is monitored by federal and state agencies. Release of the reclamation bonds takes place only after these agencies have been satisfied that final reclamation requirements have been met.

photo by Dan Crank, Ky. Dept. of Fish & Wildlife Resources

MINE LAND RESTORATION

Reclaimed MTM site.

SMCRA not only regulates the mining process, it also requires that before mining ever begins the mine operator must submit and regulators must approve a comprehensive mine land restoration and reclamation plan. To develop the plan the mining company, in consultation with landowners and regulators, will design a plan for the mine site that requires the company to restore the land to support an approved "post-mining land use," that will restore the land to a valuable use or purpose after mining. Examples of this could include reclaiming the land to support forests, pastureland, cropland, or an economic use for the public such as a golf course, an airport or industrial park, or a wind farm. In addition to the legal requirements to restore the land, financial bonds are required by federal law as an insurance policy to ensure the land will be fully reclaimed according to the reclamation plan, regardless of the financial condition of the company after mining operations are complete.

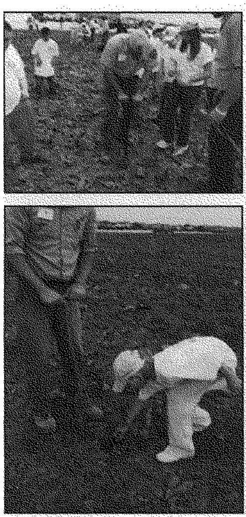
Post Mine Land Use Projects
Mingo County, W.Va.

Project Description	Number of Jobs
Mingo County Fish Hatchery	2
Twisted Gun Golf Course	15
McCoy Hatfield Trails	30
Unilin Flooring	275
Quality Metal Roof Manufacturing	25
Weatherford Fracturing Technology	40
Air Transportation Park	25
4H Youth Camp	15
Total Jobs	**427**

source: Mingo County, W.Va., Redevelopment Authority

Wildlife Habitat and Reforestation

Mining companies have a unique opportunity to tailor their post mining land uses to accomplish a variety of environmental and economic objectives through the reclamation process. For example, mining operations, in conjunction with state government partners and the Rocky Mountain Elk Foundation, reintroduced a total of 1,500 elk in eastern Kentucky between 1997 and 2002. According to the Rocky Mountain Elk Foundation, when mines are properly reclaimed according to government standards, the elk actually prefer such sites to other areas. In 90 percent of the cases where the animals are radio tracked, the elk are living in and around reclaimed surface mines. The elk herd in Kentucky has flourished and now numbers over 10,000 animals, which represents more than a 600 percent increase in the size of the herd.



Demonstrating the correct way to plant American Chestnut seedlings; Photos by Paul Rothman of Kentucky DNR

In addition, research conducted by Virginia Polytechnic and State University and the University of Kentucky has demonstrated that forest communities can be successfully re-established on reclaimed mine sites. This success is promoted through efforts such as the Appalachian Regional Reforestation Initiative (ARRI), a partnership of federal and state regulators, private industry and conservation groups dedicated to promoting and encouraging the restoration of high-value, hardwood forests on coal mined lands in Appalachia using the forestry reclamation approach. The forestry reclamation approach requires using advanced techniques to ensure availability and depth of proper topsoil, avoiding compaction of the soil, using the appropriate groundcover and tree species selections, and applying the correct tree planting techniques. Using this approach, mountaintop mining operations can successfully replant and restore the forest after mining operations are complete.

Mountaintop mines also can improve the environment through reintroduction of plant species. For example, the American chestnut tree was largely eliminated from eastern forests of the United States several decades ago by a blight that destroyed almost the entire species. Through a partnership with the American Chestnut Foundation (TACF), mining companies are planting a blight-resistant version of the chestnut across 1.2 million acres in Kentucky. These plantings are part of the Appalachian Regional Reforestation Initiative mentioned above, which promotes the reforestation of coal-mined lands using high-value, native hardwood trees, includ-

Twisted Gun Golf Course in Mingo County, W.Va., was built on a MTM site.

ing the American chestnut. In addition the ARRI has joined with the United Nations Environment Programme (UNEP) Seven Billion Tree Campaign and has pledged to plant 38 million trees over three years. Reforesting the land with trees, especially fast-growing hardwoods like the American chestnut, on reclaimed mines will also benefit landowners by providing them with a tree crop that can be periodically harvested.

Mixed-use development in W.Va. on a former mine site.

Commercial Development

Mountaintop mining operations can sometimes be designed to create significant commercial development opportunities in steep-sloped areas of Appalachia. These areas are naturally unsuitable for large-scale development due to the rough topography, but mining operations provide an opportunity to create economically valuable level land for such projects following the completion of the mining and reclamation operations.

Working with state regulators and local groups such as the Mingo County Redevelopment Authority in Mingo County, West Virginia, mining companies have integrated the costs of making a site suitable for development as part of their planning and execution of mine land reclamation, creating attractive investment opportunities that have led to a wide variety of sustainable economic development projects. These projects provide permanent jobs and services for residents in local communities and have included a wood products industrial park, an agricultural demonstration project, an 18-hole championship golf course, and an airport facility.

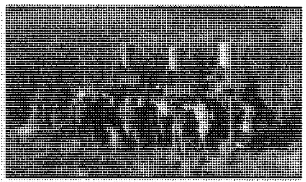
COMMUNITY INVOLVEMENT

Students at a W.Va. elementary school are rewarded by a local coal company for good performance.

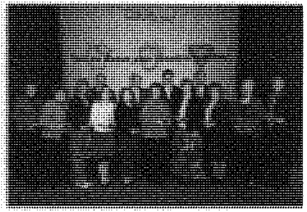
Coal companies and their employees play an important role in improving the life of communities where they operate and where their heir families live. Whether providing a grant to the local youth organization, gathering employees to help build a playground or serving as members of the volunteer fire department, they recognize the importance of being active participants in the social fabric of the communities in which they operate. Recent activities in Appalachia include:

- providing equipment and supplies to rebuild infrastructure services for local communities;
- establishing and underwrite family wellness centers;
- funding scholarships to bring quality medical providers to remote communities;
- partnering to provide volunteers and financial assistance to primary and secondary schools;
- providing scholarships and recognition programs for outstanding teachers;
- funding and assist in constructing playgrounds for school children;
- participating and provide resources for local volunteer fire departments; and
- supporting holiday events for underprivileged children.

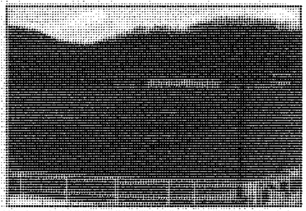
Such activities are annually recognized by the Office of Surface Mining's "Good Neighbor Awards" and other state and local programs. These awards annually recognize mine operators for successfully working with surrounding land owners and the community.



Boy Scout Troop constructing and installing duck nest boxes on a reclaimed mine site in [illegible], Ky.



Arch Coal Teacher Recognition Awards



Ball field constructed by mining company for the residents of Chapmanville, W.Va.

TRANSPARENCY AND PUBLIC PARTICIPATION

SMCRA contains numerous protections to ensure transparency and public involvement to ensure that the performance standards and other requirements of the statute and regulations are being met. The law requires at least one complete inspection of the actual mine site every quarter and one partial inspection each month. SMCRA requires mine operators to notify the public of the proposed surface coal mining operation and provides the public a right to file written objections with the regulator regarding any mining company permit applications with which they disagree. In addition, any person can request an inspection of an operation where they believe is not complying with the law. SMCRA also provides for citizens to file a lawsuit against the federal or state government if they believe that there has been a violation of SMCRA or any of its implementing regulations that the government has not adequately addressed. Compliance with environmental standards is assured through diligent oversight by state and federal regulators in conjunction with significant opportunities for public involvement.

LAWS & REGULATIONS

Mining is carefully regulated throughout the United States. There are several laws that specifically regulate mining, and many other general laws are applicable to mining operations. Some of the most significant federal laws include the Surface Mining Control and Reclamation Act (SMCRA), the Clean Water Act (CWA), the Clean Air Act, the Endangered Species Act (ESA), and the Federal Mine Safety and Health Act. This document will focus primarily on the first two statutes, SMCRA and the CWA. It should be noted, however, that in addition to these, there are also thousands of pages of federal and state regulations providing environmental protection, protection of public health and safety, as well as opportunity for public input during permitting activities.

Mountaintop mining was specifically authorized by Congress when it enacted SMCRA in 1977. Section 515(c) provides an exception for restoring the approximate original contour requirements for mountaintop removal operations under certain conditions, and section 515(b)(22) allows excess rock and dirt to be placed in streams so long as lateral drains and under drains are constructed to avoid water filtration through the fill material. These provisions are further reinforced by the courts, which have ruled that: "SMCRA does not prohibit the discharge of surface coal mining excess spoil [dirt and rock] in waters of the United States…it is beyond dispute that SMCRA recognized the possibility of placing excess spoil material [dirt and rock] in waters of the United States..." See Kentuckians for the Commonwealth v. Rivernburgh, 317 F. 3d 425, 442-443 (4th Cir. 2003).

Most recently, the Office of Surface Mining and Reclamation (OSM) added new regulations that provide additional protections to streams and the environment by requiring companies to minimize the amount of excess "spoil" material (dirt and rock) generated at mountaintop mining and other mine sites. The new regulations require mining companies to demonstrate that the operation has been designed to minimize the volume of excess dirt and rock and ensure that as much of this material is returned to the mountain as possible. Mines must avoid placing such material in perennial or intermittent streams to the extent possible. They must also perform an "alternatives analysis" to consider options for fill placement that take into account different numbers, sizes, locations and configurations to minimize the impact on fish, wildlife and related environmental values.

The Surface Mining Control and Reclamation Act (SMCRA)

The Surface Mining Control and Reclamation Act ("SMCRA") is a comprehensive federal environmental statute for regulating surface coal mining operations. Under this legislation, Congress created the Office of Surface Mining Reclamation and Enforcement (OSM) in 1977 and charged the agency with establishing a nationwide program to protect society from the adverse effects of surface coal mining, yet striking a balance between environmental protection and the nation's need for coal as an essential source of energy.

Performance Standards: SMCRA established comprehensive environmental performance standards for coal mining operations. These standards reflect Congress's understanding that there is a balance to be struck between environmental protection and meeting the nation's energy needs through coal production. All coal mining, including mountaintop mining, must be done consistent with these environmental performance standards. These standards are comprehensive in nature and provide "cradle to grave" coverage throughout the life-cycle of a surface coal mining operation – from the earliest aspects of exploration and planning of the operation, throughout all of the "active" mining operations, and concluding with reclamation of the project.

To accomplish this, SMCRA requires all mining operations to comply with dozens of specific performance standards to protect the environment. Examples of these standards include requirements for companies to maximize and conserve the coal resource, stabilize and protect surface areas to control erosion and water pollution, conserve topsoil for use after mining, and minimize the disturbance to waters. Miners must also minimize impacts of their operations on fish, wildlife, and related environmental values and enhance such resources when practicable. SMCRA and its implementing regulations address every aspect of the mining operation, including regulation of air and water quality, blasting, soil preservation and handling, protection of fish and wildlife, and re-vegetation requirements.

Permits: No mining activity may occur without first obtaining a permit. Mining companies must submit a comprehensive and detailed permit application containing information about the company and the proposed mining operation, including a detailed environmental analysis of how the mining will be conducted to ensure compliance with all of the required environmental standards. Mining companies must also include detailed information about their operations and whether they have any outstanding environmental violations. Companies that have an outstanding environmental violation are prohibited by law from receiving new mining permits. In addition, no mining company may receive a permit until they have provided a bond to ensure that sufficient funds are available to assure the completion of the reclamation plan if the work had to be performed by the government.

Safety: Although safety of miners is primarily regulated through the Federal Mine Safety and Health Act of 1977, SMCRA also requires stability and engineering controls to ensure not only environmental protection, but safety of the miners and the public. Mountaintop mining operations engineer and construct valley fills to contain the excess dirt and rock generated from mountaintop mining operations. Federal regulations require careful planning, placement and construction of these structures to ensure their long-term stability and safety.

The Clean Water Act (CWA)

All mining operations, including mountaintop mines, must obtain permits and comply with regulations under the CWA designed to avoid degradation of streams and other waters from impacts associated with mining activities. The states also have an oversight role through certifying that no mining activity authorized by a federally issued permit will violate state water quality standards.

Section 401: Under CWA Section 401, no Federal permit or license may be issued that may result in a discharge to waters of the United States, unless the authorized Tribe or state where the discharge would occur has certified that the permit or license is consistent with water quality objectives or has waived certification. Among factors a state or authorized Tribe considers are whether the discharge would be consistent with applicable water quality standards, effluent limitations, new source performance standards, toxic pollutant control requirements and relevant requirements of Tribal and state law. The 401 certification may, and most often does, include conditions, that must become an enforceable term or condition of the permit.

Section 402: The National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Most states have primacy "permitting" authority within their borders. The U.S. Environmental Protection Agency (EPA) issues permits where states have not obtained primacy. Under this program, mining operations must obtain permits for all discharges directly to waters and for all discharges associated with stormwater runoff from the mining site. A few minor exceptions exist for stormwater runoff that does not come into contact with the active mining areas.

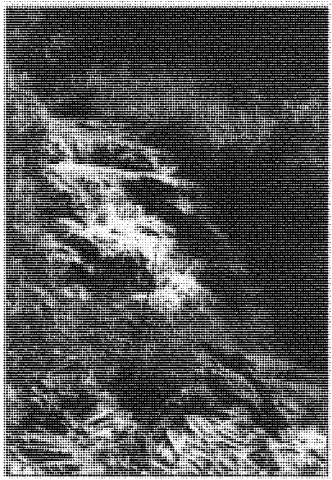
Thus, in addition to SMCRA protections explained above, the CWA provides another layer of environmental protections for streams and other waters by making it an enforceable violation of a CWA permit should any water quality standard be violated.

Section 404: The Section 404 permit program, administered by the Army Corps of Engineers (the Corps), provides that a permit may be issued for the discharge of dredged or fill material into the navigable waters. The Section 404 program is administered through a set of guidelines promulgated by EPA, and EPA participates as a commenting agency in the permitting process. EPA may prohibit issuance of a 404 permit where it determines the impacts will have an unacceptable effect on municipal water supplies, fish and wildlife or recreational areas.

In making determinations about whether to issue a 404 permit, the Corps requires the applicant to submit data and information illustrating the effects of the project on the aquatic ecosystem as a whole, as well as an evaluation of alternatives to the discharge and measures that were taken to avoid, minimize and mitigate or compensate for unavoidable adverse effects. A complete mitigation plan is required along with an opportunity for public review and comment in the case of individual permit authorizations.

The Corps typically requires mitigation at a 1:1 ratio, and in the case of mining permits, the ratio is often higher. This means that any segments of streams impacted by mining activities are mitigated by replacing the stream, creating new streams in other locations or improving other degraded streams. In addition, the Corps has authority to require, and often does require, conservation easements to preserve the mitigation for perpetuity. Mitigation bonds may also be required on a case-by-case basis. All mitigation requirements are incorporated as enforceable conditions on the 404 permit and additional monitoring and reporting requirements attach for a minimum period of five years.

STUDIES OF MOUNTAINTOP MINING



Restored contour at a MTM site

There have been several reports and environmental impact statements on the practice of mountaintop mining over the past 30 years. The most comprehensive of these was a programmatic environmental impact statement co-sponsored by the Environmental Protection Agency, the Fish & Wildlife Service, the Office of Surface Mining, the U.S. Army Corps of Engineers, and the State of West Virginia. This 5,000 page report includes 30 studies on all different aspects of mountaintop mining. Mountaintop Mining/Valley Fills in Appalachia, Draft Programmatic Environmental Impact Statement (June 2003).

According to this study, surface mining has disturbed only about 3 percent of the land in the study area over the past 10 years. The EIS study area (which includes parts of Virginia, West Virginia, Kentucky and Tennessee) accounts for about 25 percent of the nation's coal production.

Mountaintop Mining and Streams: During the ten-year period examined in the June 2003 study, mountaintop mining was viewed as impacting only 2 percent of the streams in the study area, which does not take into account avoidance, minimization and mitigation requirements imposed under regulations of the Clean Water Act. The statistics on impacts to streams include not only bodies of flowing water but also on intermittent streams that contain flowing water for only part of the year and ephemeral streams which contain no water at all except as a result of rain or runoff events.

To learn more about mountaintop mining visit the National Mining Association web site, www.nma.org, or contact Carol Raulston at (202) 463-2600.

TENNESSEE MINING ASSOCIATION

June 25, 2009

Tennessee, like the rest of Appalachia, has been mining coal since before the Civil War. A strong and proud tradition throughout the region, coal mining represents a steady supply of energy and employment. However, mining's legacy has not always been positive.

Prior to 1977 and the passage of the Surface Mining and Reclamation Control Act, coal mining in Tennessee was conducted without regard for environmental consequences. These actions left 1,000 miles of abandoned highwalls that have scarred Tennessee's mountains and left a legacy of water pollution. However, over the past 30 years, the process of coal mining has drastically changed.

Today's coal mining operators provide domestic energy and excellent jobs while also working to protect the environment. Since 2004, Tennessee's coal miners have restored 125 miles of abandoned highwalls and returned many of the states' mountains to their original grandeur. Through their work with various agencies and institutions, Tennessee's coal mine operators have also reintroduced native vegetation, including the American Chestnut tree, to our mountains. Wildlife species have also benefitted from reclamation activities. Tennessee is now home to approximately 250 elk, which reside in the reclaimed Royal Blue Wildlife Management Area.

In addition, the re-mining and reclamation of these abandoned sites has significantly improved impaired watersheds around the mines. According to the Tennessee Department of Environment and Conservation's 2008 303(d) list of impaired waters and streams, 14 percent of the state's water pollution is mining-related. However, only 1.6 percent of this pollution is caused by active mining, leaving 13.4 percent caused by orphaned mines. The most efficient and economical way to restore the pollution from abandoned mines is to continue re-mining with today's modern mining methods. In fact, in 2008, TDEC cited land reclamation as a contributing factor in the removal of Tackett Creek, a current and historic mining watershed, from the list.

Tennessee's coal mining industry also provides much needed jobs in some of the state's most rural and economically-depressed counties. For the 1,000 direct coal mining employees, their salaries are 38 percent higher than the state average and include full health and retirement benefits. Each direct job supports 3.5 more indirect jobs within the state.

Within Tennessee, local counties benefit tremendously from the coal mining industry. Not only does the industry work diligently to be good corporate citizens, they also pay a severance tax directly to each county that is used to support the local schools and roads. Just this year, Tennessee's coal mining industry passed a bill that will incrementally increase the coal severance tax from $0.20 per ton to $1.00

per ton over the next six years. By 2015, this increase will translate into $2 million per year for coal mining counties.

The Tennessee Mining Association is proud to represent today's coal miners and those that support them. Our members take pride in being able to supply our state with abundant and affordable energy while also employing 4,500 Tennesseans. TMA looks forward to continuing mining's strong tradition within Tennessee, throughout Appalachia and across the country.

TESTIMONY OF MIKE WHITT EXECUTIVE DIRECTOR MINGO COUNTY REDEVELOPMENT AUTHORITY OF WILLIAMSON, WEST VIRGINIA

Presented to:
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
Subcommittee on Clean Air, Wetlands, and Climate Change

Hearing on
Thursday, June 6, 2002

Chairman Lieberman, Ranking Member Voinovich, and members of the subcommittee, thank you for inviting me to testify. I commend you for your willingness to hear from the Mingo County Redevelopment Authority.

With mining, Mingo County is diversifying the economy. We are creating good paying jobs with benefits for our citizens, and the opportunities for economic development are better than they have been in a long, long time.

Our Mission..."The Mingo County Redevelopment Authority is a public organization, established to promote and encourage the economic and civic welfare of Mingo County, and for the development, attraction and retention of business, industries, and commerce within the county, thus creating employment opportunities and increasing the area's tax base."

Because of mining and development sites created by mining, we have been able to create good jobs in the industries of wood, aquaculture, agriculture and recreation. The Mingo County Board of Education has established a Horticultural Curriculum through the use of our agriculture demonstration project. By growing excellent Artic Charr from mine water we have created a new industry in southern West Virginia. We anticipate the county school system will add an Aquaculture Curriculum as a result of our fish hatchery, grow-out facilities and proposed fish processing facility. Without mining these new jobs and economic opportunities would never have been possible in southern West Virginia!

Our challenge is to achieve our mission to create new jobs, improve the quality of life for our citizens, and increase our tax base throughout the next generation for the future of our children and grandchildren. We cannot meet this challenge unless reclaimed mine sites are provided to us for the purpose of creating economic development.

Diversifying the Mingo County economy through support of the mining industry is an important part of our future. Realizing this, the Mingo County Redevelopment Authority brought together a diverse group of citizens to develop the Mingo County Land Use Master Plan (Plan). The Plan was presented to the citizens of Mingo County at a public hearing, where public suggestions were incorporated into the Plan. The Plan has been approved by the Mingo County Commission. For the first time in history, Mingo County has a Plan that provides a road map to achieve economic development opportunities. Any coal company who volunteers up front and before mining commences to use our Plan will be provided with our proposed post mine land use for the property. After mining the property will be 1) returned in a manner consistent to our Plan; 2) adequately supplied with infrastructure; and 3) used for the economic development purposes as stated in the post mine land use. Prior to our Plan Mingo County lost many economic development opportunities because most of the property mined was put back to its Approximate Original Contour (AOC); leaving no land suitable for economic development. Our Plan affords opportunities to change that.

Through the leadership of the Mingo County Redevelopment Authority, we have developed an excellent partnership with the private and public sectors. Mike Callaghan, Director of DEP, and Governor Bob Wise have been very instrumental in our efforts to encourage post mine land use development sites for proposed and ongoing surface mine activities. We have listened to Mingo Countians. The Land Use Master Plan is a grass root Plan of what we need to stop the downward economic spiral that we have been faced with. There is one thing that EVERYONE agrees on and it is the fact that Mingo County must diversify.

We must stop the cycle of schools being closed, good teachers leaving and major industry jobs vanishing. Our county population has dropped from 37,000 in 1980 to 28,000 in 2000. One of our schools has 95% of our kids who qualify for the free lunch program…as a best-case scenario; we have nearly half our kids on the free lunch program at Williamson High School, which is located within our county seat.

Before 1989 when the Mingo County Redevelopment Authority was formed, local economic development agencies did not exist in any of the southern West Virginia counties. Since our establishment, we have worked hard to form a team relationship between our private and public sectors, and with the dedication of our board of directors we have achieved an excellent display of teamwork within our county. Everyone has come together to help save our county from economic devastation. We cannot wait to diversify our economy after the coal is depleted…we must diversify in conjunction with the ongoing and future mining activities, and our efforts must continue.

Here are some of the projects that the Mingo County Redevelopment Authority has accomplished by utilizing opportunities created by the mining industry…

- The Mingo County Wood Products Industrial Park **(Exhibit A)**
  - Located on a reclaimed surface mine site
  - $28 million total project cost
  - Includes a centralized lumber storage area, lumber processing facility, lumber pre-drier, a battery of dry kilns, boiler and silo. The first shell building (82,000 sq. ft.) houses a hardwood flooring manufacturing facility.
  - Presently 90 employees
  - 100 new jobs by the end of 2002 (estimate)

- The Mingo County Agriculture Demonstration Project **(Exhibit B)**
  - Located on a reclaimed surface mine site
  - Enabled the Mingo County Board of Education to provide a Horticultural Curriculum
  - Operated and maintained by the students through the new horticultural program

- The Fish Hatchery **(Exhibit C)**
  - Utilizing underground mine water to hatch and raise Artic Charr fingerlings
  - Created a new industry in southern West Virginia
  - Will provide for an Aquaculture Curriculum to be available to the students through the Mingo County School system

- The Grow-out Facility for Artic Charr **(Exhibit C)**
  - Utilizing underground mine water to grow Artic Charr fingerlings to market size (2lbs)
  - $3.5 million private investment
  - Pro-fish is the distributor of Artic Charr into the Washington, DC area.

- Twisted Gun Golf Course **(Exhibit D)**
  - The coal industry has already constructed an 18-hole golf course, with a breathtaking view of the natural surroundings. This project will enhance the recreational opportunities in Mingo County.

Here are some of our potential projects that, in conjunction with ongoing mining, will help diversify and enhance the quality of life for Mingo County citizens...

- King Coal Highway / I 73-74 **(Exhibit E)**
  - In cooperation with the Department of Highway and the Department of Environmental Protection, the coal industry plans to construct (to rough grade) 5 miles of the new King Coal Highway/ I 73-74, with 2 connectors...saving the taxpayers an estimated $90 million dollars

- Airport **(Exhibit F)**
  - In cooperation with the Mingo County Airport Authority, the coal industry will construct (to rough grade) an area to provide the county with an airport runway of 6,000 – 10,000 feet, with sufficient acreage for ancillary future development... saving the taxpayers approximately $30 million dollars.

- Fish Processing Plant
  - The coal industry has provided site preparation as an in-kind contribution toward the construction of a fish processing facility, which will handle all the fish that is hatched and raised in southern West Virginia

As you can see, the mining industry and our efforts to diversify the economy in southern West Virginia are connected in a substantial manner. However, to continue to advance our plans...

- The mining industry <u>must continue</u>...
- Our partnership with the private/public sectors <u>must continue</u>...
- Post mining land use creating developable property for future jobs <u>must continue</u>...
- Our diversification efforts <u>must continue</u>...

I am not a lawyer and I am not a chemist. I'm just a local citizen who loves my county and its citizens. We care about whether our kids and grandkids will be able to work and provide for their families in Mingo County. We want a county that will allow people who have been forced to move away to come back home. We care about all these issues. We care about our schools and the opportunities provided to our kids. We're working hard to make southern West Virginia economically viable.

We have gone to great strides to achieve a better economy in Mingo County. We want to continue, and we will if the mining continues. The mining is necessary, and the valley fills are needed for the continuation of surface and underground mining.

Again, without diversification during the mining of coal, there will be no opportunity for diversification after coal mining. We have found a solution to stop our downward plunge and it's not just a "fleeting vision"...it's reality! It's attainable! It works! And we want it to continue.

Now you have a better understanding of our situation and can see the importance of diversification during the mining process in southern West Virginia. If there's anything I can do to help ensure that our progress is not hindered, please feel free to contact me. Better yet, I would like to invite each of you to come to Mingo County. I'll personally take you around our county and show you first hand what progressive steps are being taken by Mingo County.

Some people see things as they are and ask why...But I dream of things that never were and ask why not.
Quote...John Kennedy

Thank you very much.
Mike Whitt

THE APPALACHIAN REGIONAL REFORESTATION INITIATIVE

FOREST RECLAMATION ADVISORY

Forest Reclamation Advisory No. 1 December 2005

THE APPALACHIAN REGIONAL REFORESTATION INITIATIVE

Patrick Angel[1], Vic Davis[2], Jim Burger[3], Don Graves[4], Carl Zipper[5]

The Appalachian Regional Reforestation Initiative (ARRI) is a cooperative effort by the States of the Appalachian Region with the Office of Surface Mining to encourage restoration of high quality forests on reclaimed coal mines in the eastern USA. ARRI's goals are to communicate and encourage mine reforestation practices that 1) plant more high-value hardwood trees on reclaimed coal mined lands in Appalachia; 2) increase the survival rates and growth rates of planted trees; and 3) expedite the establishment of forest habitat through natural succession. These goals can be achieved when mines are reclaimed using the Forestry Reclamation Approach (FRA).

The FRA is a method for reclaiming coal-mined land under the Surface Mining Control and Reclamation Act (SMCRA) to forest, and is based on knowledge gained from both scientific research and experience (Burger and others, 2005). The FRA is considered by state mining agencies and US Office of Surface Mining to be an appropriate and desirable method for reclaiming coal-mined land to support forested land uses (See References).

When mining and reclamation operations are conducted using the FRA, results can include both cost-effective regulatory compliance by the coal operator and productive postmining forests. Productive forests generate value for their owners and provide watershed protection, wildlife habitat, and other environmental services (photo 1).

Why is the ARRI needed?

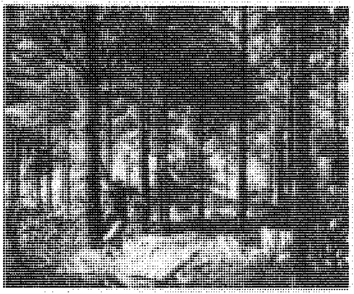
SMCRA improved the surface-mine landforms by increasing stability, improving water quality, and enhancing human safety in the Appalachian region, compared to the results of pre-SMCRA mining. However, SMCRA's implementation has not been accompanied by widespread replacement of forests disturbed by mining. Many mined lands were restored as grasslands but are not currently used for hay or pasture by their owners. Native forests will eventually be restored on such areas by natural succession, but this process is slow and centuries may be required.

Following SMCRA's implementation, regulators focused on stability of landforms created by mining at the expense of restoring forest land capability. This approach was caused by a desire to solve the problems such as severe erosion, sedimentation, landslides, and mass instability caused by pre-SMCRA surface mining. As a result, excessive soil compaction was common on surface mines, and aggressive ground covers were generally planted. Furthermore, both regulators and mine operators were challenged by the technical complexities of implementing SMCRA in the years following its passage. As a result, reforestation took a back seat. Lastly, some early efforts by mine operators to reforest under SMCRA proved problematic, in part because these efforts were conducted without the benefit of scientific knowledge that is available today; as a result, mine operators and regulators came to believe that postmining land uses such as hay and pasture land were easier and cheaper to achieve than forests. These factors and others contributed to a significant loss of forests due to mining across Appalachia. The current reforestation initiative is an effort to increase knowledge and change attitudes about planting trees on surface mines.

Forests have been the traditional land use and support an established industry throughout the eastern coalfields; in recent years, resurgence in the hardwood timber and wood-using industries has occurred throughout the region. Furniture, flooring, and paneling are made from many fine hardwood species, while softer woods are used for plywood, oriented-strandboard, and wood pulp. "Soft hardwoods" such as tulip poplar, red maple, sycamore, green ash and bigtooth aspen, all of which have good potential as reclamation species, are being sought by industrial wood-users along with the traditionally-valuable species such as the oaks. Furthermore, forests provide many benefits such as wildlife habitat, watershed control, carbon sequestration, and recreation. Owners of mined lands, who were once content to have their land reclaimed to grassland and shrubland, are becoming more interested in reforestation with commercially-valuable hardwoods.

A goal of mined land reclamation under SMCRA is to create land with equal or better postmining land use potential than the land was prior to mining. Scientific research has demonstrated that

Photo 1. Thinning and pruning a 17-year old white pine stand established by an active coal mining operation in Virginia using procedures similar to the Forestry Reclamation Approach. Scientific studies demonstrated that this site's productivity is comparable to that of the area's native forests (Rodrigue and Burger, 2004), and that the stand's response to management has created additional economic value for the timber owner (Burger and others, 2003).



reforestation using the FRA is capable of achieving this goal. Many grassland areas created after SMCRA, have soil properties less favorable to forests than on the lands that preceded mining. The role of ARRI is to coordinate and improve dissemination of information, while promoting further research across all the Appalachian States.

What is a Forest Reclamation Advisory?

Reforestation researchers and experts from universities throughout the region have joined forces with Federal and State regulators to form the ARRI. One goal of the ARRI's Academic Team is to generate a series of guidance documents called Forest Reclamation Advisories which will describe state-of-the-science procedures for coal-mine operators and other mine reforestation practitioners, agency personnel, and mined land owners. This introductory publication is the first in the series intended to cover a variety of topics related to reforestation of mined lands. Future publications may address emerging issues as well as current knowledge. Revisions will be published as new information becomes available.

For access to future Forest Reclamation Advisories as they are published, or for a complete list of ARRI Team members, see the ARRI web site at http://arri.osmre.gov/

Faculty and researchers from the following universities and organizations contributed to this Forest Reclamation Advisory: Ohio State University, Pennsylvania State University, Purdue University, Southern Illinois University, University of Kentucky, University of Maryland, University of Tennessee, Virginia Polytechnic Institute and State University, West Virginia University, and United States Forest Service (retiree).

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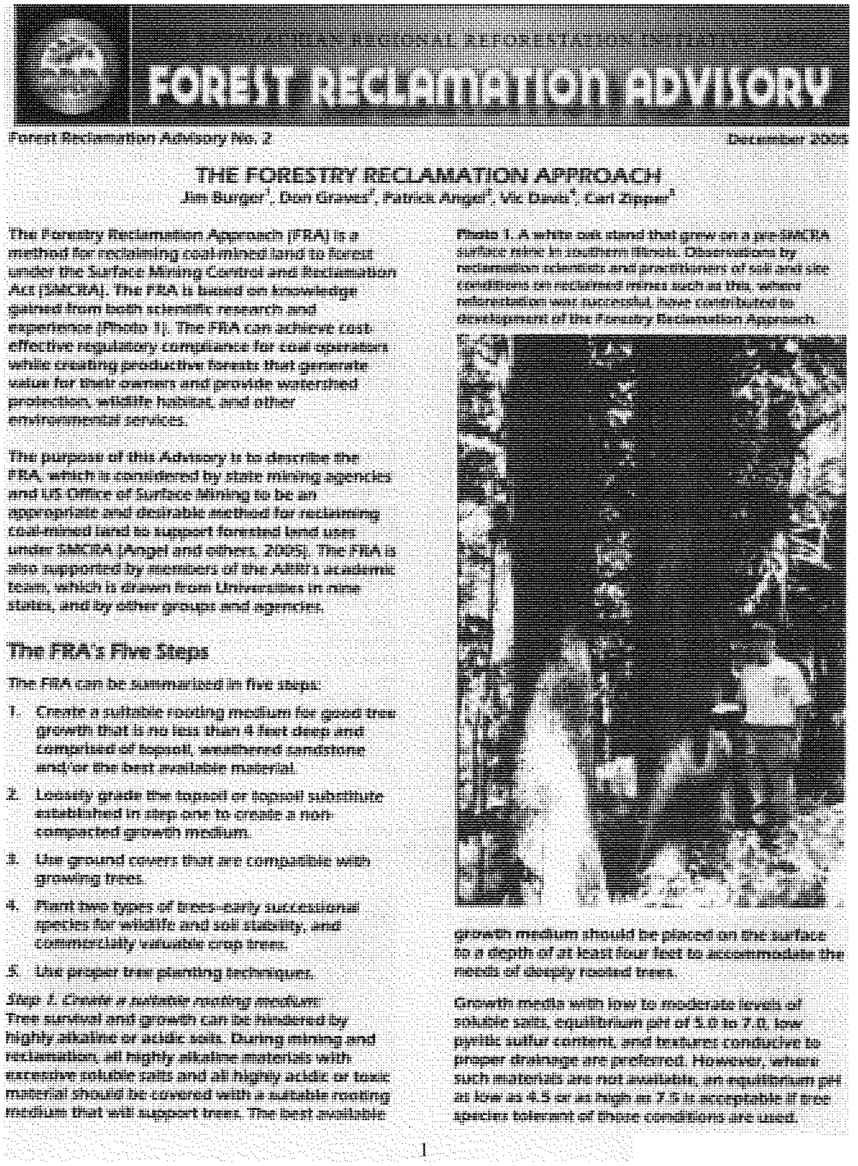


FOREST RECLAMATION ADVISORY

Forest Reclamation Advisory No. 2 December 2005

THE FORESTRY RECLAMATION APPROACH

Jim Burger[1], Don Graves[2], Patrick Angel[3], Vic Davis[3], Carl Zipper[1]

The Forestry Reclamation Approach (FRA) is a method for reclaiming coal-mined land to forest under the Surface Mining Control and Reclamation Act (SMCRA). The FRA is based on knowledge gained from both scientific research and experience (Photo 1). The FRA can achieve cost-effective regulatory compliance for coal operators while creating productive forests that generate value for their owners and provide watershed protection, wildlife habitat, and other environmental services.

The purpose of this Advisory is to describe the FRA, which is considered by state mining agencies and US Office of Surface Mining to be an appropriate and desirable method for reclaiming coal-mined land to support forested land uses under SMCRA (Angel and others, 2005). The FRA is also supported by members of the ARRI's academic team, which is drawn from Universities in nine states, and by other groups and agencies.

The FRA's Five Steps

The FRA can be summarized in five steps:

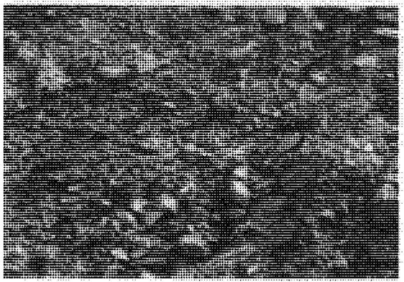
1. Create a suitable rooting medium for good tree growth that is no less than 4 feet deep and comprised of topsoil, weathered sandstone and/or the best available material.
2. Loosely grade the topsoil or topsoil substitute established in step one to create a non-compacted growth medium.
3. Use ground covers that are compatible with growing trees.
4. Plant two types of trees--early successional species for wildlife and soil stability, and commercially valuable crop trees.
5. Use proper tree planting techniques.

Step 1. Create a suitable rooting medium: Tree survival and growth can be hindered by highly alkaline or acidic soils. During mining and reclamation, all highly alkaline materials with excessive soluble salts and all highly acidic or toxic material should be covered with a suitable rooting medium that will support trees. The best available growth medium should be placed on the surface to a depth of at least four feet to accommodate the needs of deeply rooted trees.

Photo 1. A white oak stand that grew on a pre-SMCRA surface mine in southern Illinois. Observations by reclamation scientists and practitioners of soil and site conditions on reclaimed mines such as this, where reforestation was successful, have contributed to development of the Forestry Reclamation Approach.

Growth media with low to moderate levels of soluble salts, equilibrium pH of 5.0 to 7.0, low pyritic sulfur content, and textures conducive to proper drainage are preferred. However, where such materials are not available, an equilibrium pH as low as 4.5 or as high as 7.5 is acceptable if tree species tolerant of those conditions are used.

Photo 2. A mixture of brown weathered and gray sandstones, loosely graded to form a soil medium suitable for trees in West Virginia.



Native hardwood diversity and productivity will be best on soils where the pH is between 5 and 7, and such trees generally grow best in soils with loamy textures, especially sandy loams. Such soils can be formed from overburden materials comprised predominantly of weathered brown and/or unweathered gray sandstones, especially if these materials are mixed with natural soils (Photo 2). Use of materials with soluble salt levels lower than 1.0 mmhos/cm on the surface is preferred when such materials are available.

Step 2. Loosely grade the topsoil or topsoil substitutes.

Excessive soil compaction can have a major negative effect on survival and growth of trees. (Photo 3). Even if a soil's chemical properties are ideal, excessive compaction will create a soil that is poorly suited for trees. The majority of the backfill should be placed and compacted using standard engineering practices – but not the final surface. That surface layer, which will form the postmining forest's soil, should be at least four feet deep and only lightly graded. Surface grading on longer and steeper slopes should be minimized, provided that doing so does not jeopardize stability.

To re-establish a healthy and productive forest after mining, final grading must minimize surface compaction. This can be achieved by:

- dumping and leveling in separate operations,
- leveling with the lightest equipment available, using the fewest passes possible, and during dry conditions, and
- permanently removing all equipment from an area after leveling.

"Tracking in" operations (Photo 4) compact the soil and hinder tree-growth, and should be avoided unless necessary for slope stability. Rubber tired equipment should not be used in final grading.

Step 3. Use ground covers that are compatible with growing trees.

Ground-cover vegetation used in reforestation requires a balance between erosion control and competition for the light, water and space required by trees. Ground covers should include grasses and legumes that are slow-growing, have sprawling growth forms, and are tolerant of a wide range of soil conditions. Fast growing and competitive grasses such as Kentucky-31 tall fescue and aggressive legumes such as sericea lespedeza and crown vetch should not be used where trees will be planted. Slower-growing grasses such as red top and perennial ryegrass, and legumes such as birdsfoot trefoil and white clover, when used in a mix with other appropriate species will increase seedling survival while controlling erosion over the longer term as the trees and accompanying vegetation mature to form a forest. Fertilizer rates should be low in nitrogen, relative to rates commonly used to establish pastures, so as to discourage heavy ground cover growth while applying sufficient rates of phosphorus and potassium for optimal tree growth.

Photo 3. Mine soil properties can have a dramatic effect on tree growth. The Eastern white pines in both photos were the same age (8 years old) when the photos were taken; the pines in the left-hand photo grew on a compacted alkaline shales, while those on the right grew on a moderately acid sandstone.

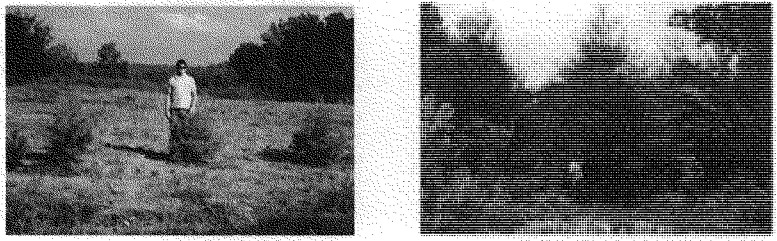
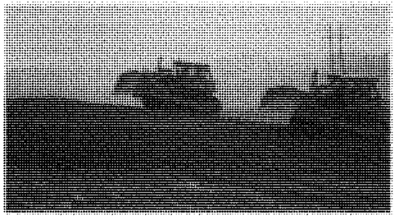


Photo 4. Soil compaction due to equipment operation on mine soils hinders survival and growth of planted trees. "Tracking in" operations, such as those shown in the photo, are NOT recommended for mine sites on which trees will be planted, unless required to stabilize steep slopes.



Step 4. Plant the right mix of tree species
To produce a valuable forest that supports multiple uses, plant a mix of native timber species as crop trees. Such species include those that are compatible with the landowner's postmining forest-management goals, have the potential to grow into healthy trees where they are planted, and are found in the local area's mature forests. Depending on local conditions, such species can include the oaks, black cherry, sugar maple, white ash, and/or other species. Reforestation experts recommend that about 1/5 of the seedlings planted should be a mix of species able to survive in the open conditions commonly found on newly reclaimed sites and that support wildlife and soil improvement. Such species might include bristly locust, redbud, dogwood and crab apple, again depending on which are known to do well under local conditions. The species selected should be mixed as they are planted over the site, not planted separately as single-species blocks. When all FRA steps are used, additional native species with seeds that can be carried by wildlife or wind will volunteer and establish on their own, leading to a species mix similar to the surrounding native forests. Mine operators should work with the State Regulatory Authority to develop reforestation plans that meet State requirements.

Step 5. Use proper tree planting techniques:
Poor tree survival is often due to improper seedling handling or planting. Tree seedlings should never be allowed to dry out during storage and handling prior to planting, and should be kept dormant until planted. Seedlings should be kept cool, but should not be allowed to freeze, and should be protected from direct sunlight and high temperatures prior to planting. The seedlings should be planted in late winter to early spring at the proper depth and firmly enough to ensure survival (Photo 5). Reputable and experienced crews are recommended for broad-scale, operational tree planting.

These five steps have been studied and field tested by ARRI Academic Team members from several of the universities contributing to this advisory (Photo 6), and plantings on active mine sites by coal mining firms using these techniques have been successful. ARRI members have determined that these steps can be implemented under current Federal and State regulations. We expect to provide additional information on each of these 5 steps in future Forest Reclamation Advisories.

The FRA is intended to be compatible with the mine-operator goal of cost-effective regulatory compliance. Avoidance of soil compaction requires that leveling and grading operations be minimized, which helps the operator control equipment operation costs. The species recommended for forest-compatible ground covers are widely available for reasonable costs, and are best seeded with fertilization rates lower than those used commonly for grassland establishment.

Selection of surface materials with chemical and physical properties suitable for trees and successful establishment of less-competitive groundcovers will increase survival of planted seedlings while allowing for invasion by native tree species from the surrounding forest. Avoidance of soil compaction will make it easier for tree planters to plant seedlings firmly and at the proper depth, thereby increasing survival rates.

Photo 5. Planting a seedling at the White Oak reforestation project in Tennessee. Because the soil has not been compacted, a planting hole of the correct depth for the seedling can be opened easily. The seedling is being planted while still dormant, during the late winter season.

Photo 6. An emerging hardwood forest established on an active mine in Virginia as a demonstration of the Forestry Reclamation Approach.

How Does the FRA Improve Value, Diversity, and Succession of Reclaimed Forests?

The FRA is designed to restore forest land capability. When these five steps are followed, forest land productivity equal to or better than that which preceded mining can be restored. Furthermore, the FRA accelerates the natural process of forest development by creating conditions similar to those of natural soils where native forests thrive. By limiting compaction during reclamation, the growth medium becomes deep and loose, similar to the best forest soils. Temporary erosion-control ground covers are selected to allow native herbaceous and woody plants to seed-in, emerge, and grow. The ground cover species are meant to be sparse and slow growing in the months after seeding, after which they will yield to a more diverse species mix that will control erosion and will be self-sustaining as required by SMCRA. Over the longer term, the herbaceous groundcover will yield to native forest through the process of natural succession.

Natural succession is further accelerated by planting late-successional, heavy-seeded species such as the oaks, which are not dispersed from the native forest easily by wind and wildlife. Planting these heavy-seeded species puts them on site right away, allowing them to emerge with other species that can seed in on their own (Photo 7). When a good growth medium is established, as outlined in Steps 1 and 2 of the FRA, late-successional plants will thrive, especially when native soil is used or mixed with the suitable overburden materials. When native forest soils are used as a part of the growth medium, native vegetation establishment will be accelerated due to vegetation that sprouts from those seeds of forest understory and tree species that remain viable. Overall, such reclamation practices create a diverse and valuable forest of native trees that produces wood products and habitat for wildlife.

The FRA does not preclude mine operators from establishing tree crops such as biomass plantations, Christmas trees, or nut orchards, if such reclamation satisfies permit requirements and meets landowner goals. In such cases, all of the above steps apply except that a tree crop is planted instead of a native hardwood mix. Tree crops will benefit from FRA reclamation.

Faculty and researchers from the following universities and organizations contributed to this publication: Ohio State University, Pennsylvania State University, Purdue University, Southern Illinois University, University of Kentucky, University of Maryland, University of Tennessee, Virginia Polytechnic Institute and State University, West Virginia University, and United States Forest Service (retiree).

Photo 7. Red oaks established on the Starfire mine in eastern Kentucky using the Forestry Reclamation Approach.

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Coalition for
Mountaintop Mining

URL: www.mtmcoalition.com "A Voice of Reason" Ph. 304.342.4153

July 3, 2009

The Honorable Mr. Benjamin L. Cardin
The Honorable Mr. Lamar Alexander
U.S. Senate Committee on Environment & Public Works
410 Dirksen Senate Office Bldg
Washington, DC 20510

Dear Senators Cardin and Alexander:

Attached please find a copy of our prepared remarks to be included in the official record for the hearing conducted last week before the U.S. Senate's Wildlife Subcommittee of the Environment and Public Works Committee on "The Impacts of Mountaintop Removal Coal Mining on Water Quality in Appalachia."

We would have presented these remarks at the hearing last week had we been afforded the opportunity to do so.

We also request that you extend the hearing comment period for a period of two weeks so we might prepare adequate responses to the lengthy and technical testimony given by EPA and other witnesses.

We also enclose for the record a copy of a PowerPoint presentation and white paper on mountaintop mining in Appalachia to give additional insight into this form of mining and its importance to West Virginia, Virginia, and Kentucky. Also included is a copy of West Virginia Senate Resolution 50 and SB 1011 dealing with post-mine land use. SB 1011 was recently enacted by our State Legislature to provide for a higher and better post-mine land development.

We encourage you and your colleagues to visit an active mine site in West Virginia or in one of the other states impacted by S-696 before advancing it further along the legislative process. After such a tour, we believe you would have a different perspective that the one you espoused during last week's hearing.

If we can be of assistance in any way, please do not hesitate to call upon us.

Sincerely,

Chris Hamilton, Co-Chairman

Roger Horton, Co-Chairmain

CC: Members of the US Senate Water and Wildlife Subcommittee
Members of the US Senate Environment and Public Works Committee
Senator Robert C. Byrd
Senator John D. Rockefeller
Congressman Alan B. Mollohan
Congresswoman Shelly Moore Capito
Congressman Nick J. Rahall
Governor Joe Manchin
WV Senate President Earl Ray Tomblin
WV House Speaker Richard Thompson

Comments of Chris Hamilton, Chairman, Coalition on Mountaintop Mining to S-696 – "The Appalachian Restoration Act -- before the U.S. Senate's Wildlife and Water Subcommittee of the Environment and Public Works Committee. June 25, 2009 Public Hearing on "The Impacts of Mountaintop Removal Coal Mining on Water Quality in Appalachia."

Good afternoon. Mr. Chairman, Committee Members, my name is Chris Hamilton, Chair, Coalition on Mountaintop Mining. We sincerely appreciate the opportunity to be here today to address your Committee. The Coalition is comprised of coal producing companies, working miners, mine managers, elected office holders, mine vendors equipment companies, land companies and citizens for coal. We are headquartered in Charleston WV and represent a three (3) state region including WV, KY, & VA.

Joining me today are Roger Horton (UMW member/Citizens for Coal), and a contingent of working miners along with their families who made the journey from West Virginia to be present during today's hearing. We are here on behalf of the men and woman who have devoted a career, some a lifetime, towards providing this region, our country and world with low coast reliable (24/7) household and industrial energy. Energy -- that has enabled us to be the greatest, most powerful country in the world with the highest of quality of life of any other land or destination.

We are here today to oppose S-696 and to encourage you not to enact legislation that will have a detrimental effect on our state and its workers – workers who are highly skilled, educated and who work within the coal mining industry daily to provide for their families. They are masterful at what they do and do it with great pride and sophistication.

These are hardhat jobs – brawn & brains! On average, our miners make upwards of $50 - $60k a year. That's buying and household spending power in our communities. Responsible for cars, homes, utilities, groceries and college tuitions.

Our country is struggling economically and all states are feeling the pain. We're all searching for economic stimulus and ways to grow our job base. It is inconceivable to us why any person or legislative body would want to take another's job. Especially good-paying industrial jobs.

As I'm sure you're aware, coal mining and the production of energy are major economic drivers behind our state. Collectively, they are responsible for thousands of good paying jobs, more than 70 percent of all business taxes and a secure revenue stream for all fifty-five counties and local governments. These dollars support educational and much-needed government programs for seniors and the less fortunate.

On a statewide basis, surface mining and mountaintop mining methods account for over 40 percent of our state's total tonnage produced on an annual basis, but in several regions or counties, it represents over 75% of all mining and thus, all revenues generated from mining activity. So, it is clear that surface mining and mountain top mining are extremely important to our energy portfolio and states financial stability.

On the surface, S-696 appears to be aimed at "mountaintop mining", an objective we would strongly argue and method of mining we would defend on its own merits (again, it represents a large segment of our industry and state's economy).

Additionally, you simply cannot single out one form of mining without having severe unintentional (or maybe "intentional" consequences). As written, S-696 includes all forms of mining which have "valley fills". By definition, that accounts for every form of mining in our state, and well as in KY and VA. including underground mines.

Plainly and simply put, S-696 completely removes coal (from all forms of mining) from your energy mix. It would be like enacting a law in WV or in some other state that would preclude the purchase of finished furniture (in our state) of oak or cherry or any other trees that comes from the ground or native soil.

You simply cannot disturb the geology within our steep slope or mountainous region without valley fills. The same is true for any type of major development or construction including road construction within this same region.

Valley fills involve placing natural rock and dirt in ravines or dry ditches (natural crevices) that only pass water during some form of a precipitation event.

A valley fill is a carefully engineered structure. It is designed to secure natural material in the earth's natural formation. Their construction is safe, environmentally sound and secure. The material placed in the fill is the same material that was there prior to mining i.e. natural rock & dirt. The water continues to trickle through fill construction just as it did before mining – through the same material through the same location.

When adversaries of mining, or uninformed journalists, criticize this method of mining, they frequently limit their characterization to the initial impacts of the extractive phase i.e. blasting or some other earth moving activity. They seldom mention the restoration phase of mining or the post mining development that sequentially follows the extractive process.

These mischaracterizations no only cast a negative light on an important segment of our State's industrial base but also serve as an affront to every working miner, their families and to all West Virginians.

We often use a new housing development as analogous to mining i.e. during the actual mining or coal removal phase, it is not always "pretty" just as a new housing site with partially completed roads, exposed infrastructure and houses in various state of construction. However, when you examine the same site several months later when the roads and landscaping are finished, it's a different visual altogether. Undoubtedly, the finished job is more esthetically pleasing.

Most of the mine sites are returned to a higher and better use or at a minimum to their original approximate contour. (Yes, we rebuild mountains in West Virginia.) Many of the former mine sites are reforested with wildlife habitat incorporated into the final plan and a number of the former mine sites are reconfigured by active mining operations to accommodate residential, industrial or recreational uses.

With proper planning which incorporates layout and design of our mining operations, we are able to create usable parcels of land for future development while minimizing the front end cost of earth removal and site preparation.

In West Virginia, we have example after example of housing developments, shopping centers, high schools, correctional facilities and even nationally acclaimed golf courses in place today where mining once took place. As they say – "a picture paints a thousand words", so I'm attaching to my testimony a few pictorial examples of finished land restoration sites and a number of the aforementioned recreational or public use sites.

West Virginia is a shining example of how we can have a viable energy industrial base which employs upwards of 50,000 West Virginians and is responsible for a large percentage of the State's Gross Product and tax base but also a thriving tourism business where people come from all over the world to take advantage of our hiking, canoeing, white watering, camping due to our natural beauty and post mine land development.

The truth of matter is that our mine managers, miners take great pride in their work and devote great attention to environmental stewardship and accomplishment. They not only work the land but they also hunt and enjoy the land.

I've also attached with my testimony some additional facts on mining in West Virginia. For these reasons I would urge you to stop further consideration of S- 696. I'll close by inviting you to invite others to come to West Virginia to tour our natural beauty and coal mining industry and to visit the men and woman who provide the state, country and world with low-cost, household energy.

Thank You.

Coalition for
Mountaintop Mining

MOUNTAINTOP MINING:

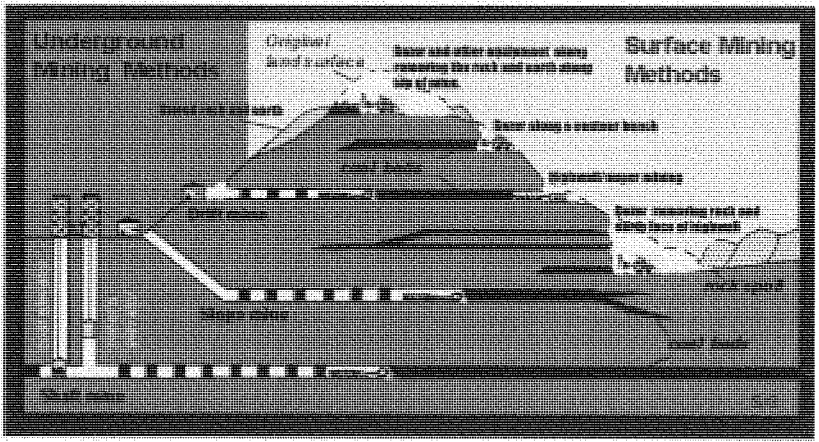
ESSENTIAL TO OUR FUTURE

WEST VIRGINIA COAL ASSOCIATION
KENTUCKY COAL ASSOCIATION
VIRGINIA MINING ASSOCIATION
JANUARY 2009

I. EXECUTIVE SUMMARY

MOUNTAINTOP MINING is simply coal mining that occurs at or near the topmost portion of a mountain.

We at the Mountaintop Mining Coalition believe the practice of surface mining in general and mountaintop mining, in particular, play an essential role in keeping Appalachian coal competitive in the global marketplace. By extension, surface mining and mountaintop mining play an essential role in maintaining coal production at levels required to continue providing the foundation of the area's economy.



Production from surface mining operations constitutes approximately 40 percent of the total production of West Virginia's coal mines (115 million tons of a total of 161 million tons). In Virginia, surface mining operations account for about 42 percent of the state's total production. Surface mining is responsible for about 40 percent of total production in Kentucky as well.

In some individual counties, such as Clay County in West Virginia, mountaintop mining provides almost all of the county's revenues. Clay County gets fully 95 percent of its annual budget from the four million tons of production it turns out annually.

In fact, in West Virginia at least 12 of the state's 55 counties get more than 40 percent of their annual budget from mountaintop mining occurring in those counties. Clearly, mountaintop mining plays a central role in filling West Virginia's budget.

Opponents of mountaintop mining argue that the coal can be produced by underground methods, but this is absolutely wrong. Most of the seams mined using the mountaintop mining method simply can't be mined in any other way. They are too narrow and would be too dangerous to mine using underground methods.

If not for mountaintop mining this is production that would be lost. It would be dollars lost to the budget and jobs lost to working West Virginians.

We at the Mountaintop Mining Coalition call for state and federal government agencies to clarify existing rules and regulations at the various levels of government to make it more difficult for anti-coal extremists to disrupt production through the filing of seemingly endless lawsuits and protests.

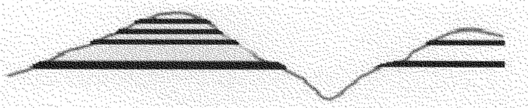
We also call upon the governors of the states and their legislatures to support the industry to their fullest and to join with the industry to market our most plentiful and valuable resource throughout the United States and the world.

II. WHAT IS MOUNTAINTOP MINING

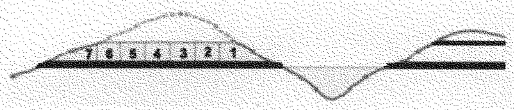
MOUNTAINTOP MINING is simply coal mining that occurs at or near the topmost portion of a mountain.

A Diagrammatic Overview of the Process:

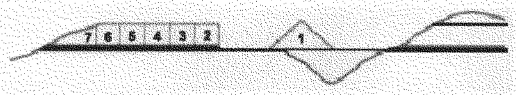
Courtesy of the Environmental Protection Agency.
www.epa.gov/region3/mtntop/process.html.



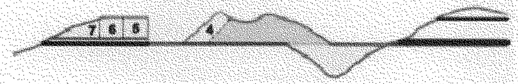
Step 1. Layers of rock and dirt above the coal (called overburden) are removed



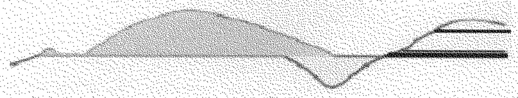
Step 2. The upper seams of coal are removed with spoils placed in an adjacent valley



Step 3. Draglines excavate lower layers of coal with spoils placed in spoil piles



Step 4. Regrading begins as coal excavation continues



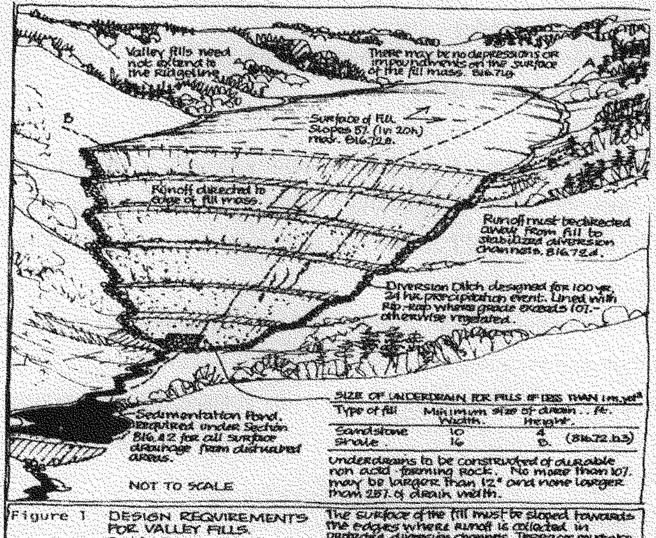
Step 5. Once coal removal is complete, final regrading takes place and the area is revegetated

Surface mining methods are essentially the same as highway construction

Valley fills are areas where the rock and dirt from mining excavation is placed according to a plan designed by engineers and approved by government agencies. The fills usually occur in dry stream beds of what are known as ephemeral or intermittent streams – streams that flow only when it rains.

"Valley fills are areas where the rock and dirt from mining excavation is placed according to a plan designed by engineers and approved by government agencies. The fills usually occur in dry stream beds of what are known as ephemeral or intermittent streams – streams that flow only when it rains."

Contrary to what is portrayed in the press, the amount of actual stream loss from fills is minimal. In other words, where most valley fills are placed, there is no actual stream.



SIZE OF UNDERDRAIN FOR FILLS OF LESS THAN 1 m.yd³

Type of fill	Minimum size of drain . . ft. Width.	Height.	
Sandstone	10	4	
Shale	16	8.	(816.72.b3)

Underdrains to be constructed of durable non acid-forming rock. No more than 10% may be larger than 12" and none larger than 25% of drain width.

Figure 1 DESIGN REQUIREMENTS FOR VALLEY FILLS. Section 816.72.

The surface of the fill must be sloped towards the edges where runoff is collected in protected diversion channels. Terraces must also direct water off the fill to these channels.

Mountaintop mining has also created numerous sites for new schools, hospitals, shopping centers, parks, golf courses, housing, airports, industry, agriculture and timber – providing southern West Virginia valuable sites for sustainable economic development.

In addition, mining operations have actually helped improve habitat for wildlife in Appalachia. Today, we are once again seeing elk and wild horses on former mountaintop mining sites.

We at the Mountaintop Mining Coalition believe the practice of surface mining in general and mountaintop mining, in particular, play an essential role in keeping Appalachian coal competitive in the global marketplace.

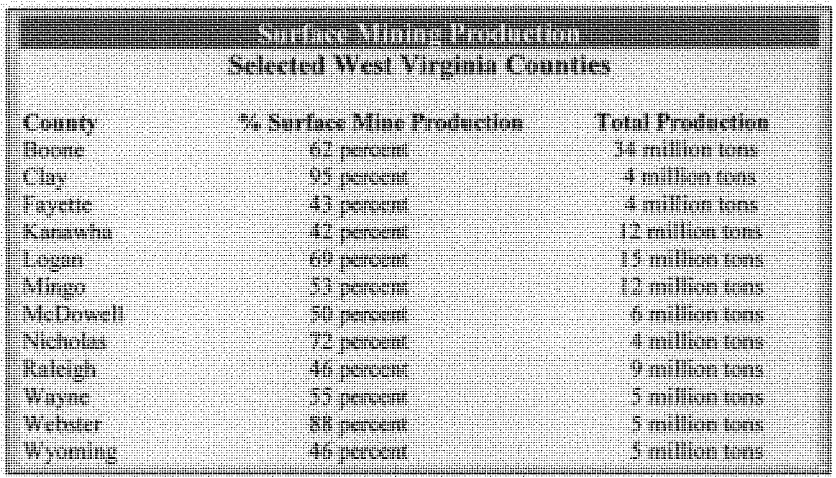
Here are a few facts:

- Surface mining and mountaintop mining play an essential role in maintaining coal production at levels required to continue providing the foundation of the area's economy.
- Production from surface mining operations constitutes approximately 40 percent of the total production of area's total production.
- This represents approximately $600 million in coal severance money across the three states.
- Mountaintop mining is also responsible for approximately 5-7 percent of the West Virginia budget.

In some individual counties, such as Clay County in West Virginia, mountaintop mining provides almost all of the county's revenues. Clay County gets fully 95 percent of its annual budget from the four million tons of production it turns out annually.

In fact, in West Virginia at least 12 of the state's 55 counties get more than 40 percent of their annual budget from surface mining occurring in those counties. Clearly, mountaintop mining plays a central role in filling the state budget.

Opponents of mountaintop mining argue that the coal can be produced by underground methods, but this is absolutely wrong. Most of the seams mined using the mountaintop mining method simply can't be mined in any other way. They are too narrow and would be too dangerous to mine using underground methods.



Surface Mining Production
Selected West Virginia Counties

County	% Surface Mine Production	Total Production
Boone	62 percent	34 million tons
Clay	95 percent	4 million tons
Fayette	43 percent	4 million tons
Kanawha	42 percent	12 million tons
Logan	69 percent	15 million tons
Mingo	53 percent	12 million tons
McDowell	50 percent	6 million tons
Nicholas	72 percent	4 million tons
Raleigh	46 percent	9 million tons
Wayne	55 percent	5 million tons
Webster	88 percent	5 million tons
Wyoming	46 percent	5 million tons

If not for mountaintop mining this is production that would be lost. It would be dollars lost to the budget and jobs lost for residents of the three states.

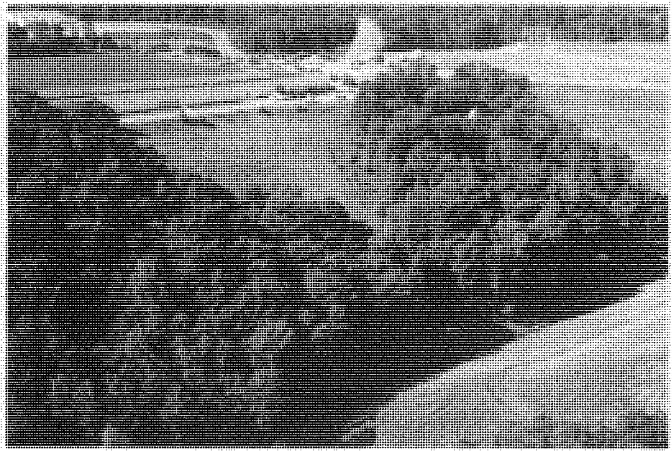
We at the Mountaintop Mining Coalition call upon federal and state agencies to adopt a set of rules and regulations that clarify existing rules and regulations at the various levels of government to make it more difficult for the anti-coal extremists to disrupt production through the filing of seemingly endless lawsuits and protests.

We also call upon the governors of the states and the legislatures to support the industry to their fullest and to join with the industry to market our most plentiful and valuable resource throughout the United States and the world.

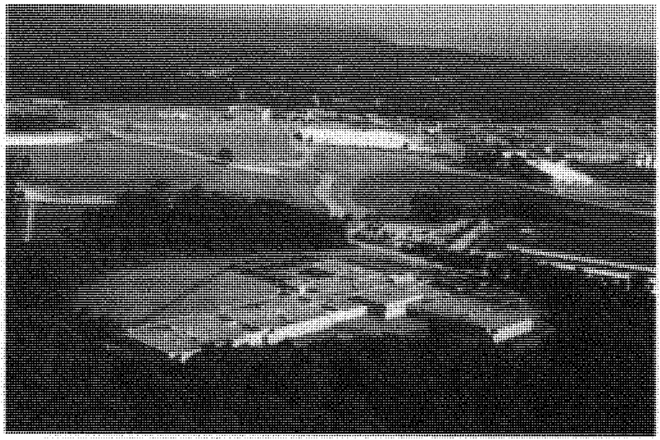
ECONOMIC DIVERSITY IN THE COALFIELDS

The future of Appalachia has to be tied to **ECONOMIC DIVERSITY**. A single-industry economy is not healthy for the long-term viability of a region. Ideally, jobs that pay industrial wages are the goal. Higher wages insure that every household can sustain a decent standard of living. Tourism has been touted by many as a viable alternative.

A recent editorial by Bill Bishop with the *Lexington Herald-Leader* argued that tourism is principally built on minimum wage jobs and that tourism alone is no bargain for a region.



One major drawback facing the region is the availability of level land out of the floodplain---something people in much of the rest of the country take for granted. The residents of the southern coalfields are often faced with either living and building businesses on the floodplain, on the unimproved mountaintops or on slopes often approaching 45 degrees.



Mountaintop mine sites can be left with literally acres of flat to gently sloping land, easily improved access roads, utilities and multi-purpose buildings. These sites have been utilized for everything from golf courses to industrial parks, schools and communities.

> *Properly planned, mountaintop mining can truly be said to be "building a future for Appalachia."*

For an individual to create level land in mountainous terrain, this task is difficult and financially almost impossible. The responsible use of **MOUNTAINTOP MINING** creates level land, land that has the potential for many other uses. Properly planned, mountaintop mining can truly be said to be "building a new West Virginia."

List of developed sites:

1. **West Virginia:**
    a. Pete Dye golf course
    b. Mount View High School built in 1980
    c. New Hope Village - homes for 70 families
    d. Knights of Columbus Community Park built in the 1980's by Buffalo Coal Co

- e. Davis Cemetery
- f. Robert Byrd High School built in the 1970's
- g. Logan County Airport
- h. Weirton housing development and hospital
- i. Anker Sports Complex
- j. Twisted Gun Golf course
- k. Hilltop hunting preserve
- l. Beckley Soccer Complex;
- m. Hatfield-McCoy Trail will have 3,000 center

2. In Kentucky: (A partial list)

- a. Big Sandy Regional Airport
- b. Carroll Airport; Ford Airport
- c. Ohio County Airport
- d. Correctional facilities –
  - i. Federal Correctional Institute
  - ii. East Kentucky Correctional Complex
  - iii. Medium Security Prison Knot County
  - iv. Otter Creek Correctional Center
  - v. Juvenile Boot Camp
- e. Government facilities –
  - i. Clements Job Corps Center
  - ii. Army National Guard Training Center
  - iii. Six solid waste landfills
  - iv. Hazard Amory; jail and state police barracks
- f. Farms –
  - i. Mapco/Morehead Agriculture Center
  - ii. Martin County Coal Corp. Farm
  - iii. DNR Brangus Farm
  - iv. Hawk Farm
- g. Industrial/commercial –
  - i. Clay Industrial Park
  - ii. Coalfields Industrial Park

These are all sites and facilities that would likely have been impossible to build were it not for the availability of mountaintop mine lands.

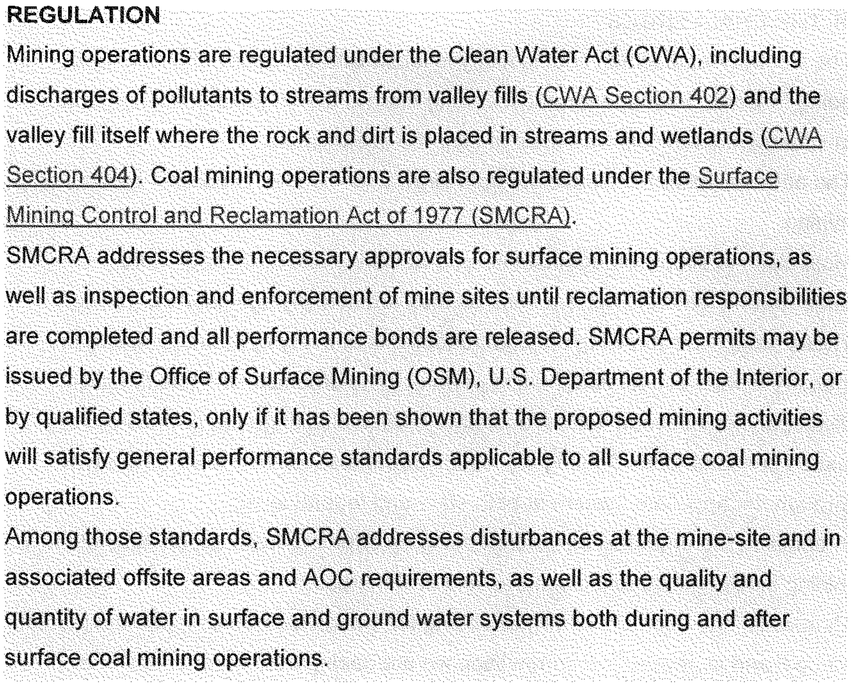
RESTORATION EFFORTS

For those locations where flat land is not needed or wanted, the coal industry does an excellent job of **RESTORATION** – bring the land back to approximate its original appearance. The people who work for coal companies live in the same area and have a great deal of pride in their company's reclamation efforts.

One of the favorite reclamation uses today, one that has been strongly encouraged by fish and wildlife governmental agencies and environmental groups, is leaving the land in a condition that will enhance use by fish and wildlife.

We've seen a resurgence of wildlife at **reclaimed** mine sites across the region because of leaving open spaces, trees and shrubs that provide nourishment for wildlife and ponds that contain water year round.

There is more wildlife than ever, in part because of **reclaimed** coal lands. It was on **reclaimed** land where over 150 mountain elk were released recently in Kentucky, and wild horses have been seen in Logan County. As a practical matter, this could not have occurred other than on a **reclaimed** coal mine site.



REGULATION

Mining operations are regulated under the Clean Water Act (CWA), including discharges of pollutants to streams from valley fills (CWA Section 402) and the valley fill itself where the rock and dirt is placed in streams and wetlands (CWA Section 404). Coal mining operations are also regulated under the Surface Mining Control and Reclamation Act of 1977 (SMCRA).

SMCRA addresses the necessary approvals for surface mining operations, as well as inspection and enforcement of mine sites until reclamation responsibilities are completed and all performance bonds are released. SMCRA permits may be issued by the Office of Surface Mining (OSM), U.S. Department of the Interior, or by qualified states, only if it has been shown that the proposed mining activities will satisfy general performance standards applicable to all surface coal mining operations.

Among those standards, SMCRA addresses disturbances at the mine-site and in associated offsite areas and AOC requirements, as well as the quality and quantity of water in surface and ground water systems both during and after surface coal mining operations.

III. THE CHALLENGES

The Central Appalachian coal industry is faced with a number of challenges going forward. First and foremost among them is the ongoing challenge from environmental radicals who want to stop the use of coal.

The anti-coal extremists have set up a straw man for their criticism – mountaintop mining.

Most claim to simply be against this type of mining and in favor of more underground mining. This is a feint, as they are actually against **ALL** mining.

These groups are throwing up legal roadblocks at every opportunity, suing the industry to stop almost **ALL** mining permits. The organizations use the slight discrepancies between federal and state laws to challenge the permits as they issued in courts, often fighting the issues through several appeals all the way through the appellate system at both state and federal level.

In addition, the organizations are stepping up efforts to force action against the mining industry in state legislatures and in Congress.

Meanwhile, the economic downturn being felt worldwide has softened the market for coal and increased the competition we are seeing from other states and countries, such as the western states of the Powder River Basin and Australia. In both cases, thick coal seams sometimes just inches under the ground. Our primary advantage in competition with these sources is our proximity to major markets and transportation hubs. Despite this, competing sources of coal have recently begun to penetrate our primary markets.

Another challenge is the increasing difficulty of mining in Appalachia. In some areas of the state the seams available for mining are increasingly thinner and with less stable underground geology. As a result, in many areas, mountaintop mining techniques and their use are responsible for continued production and competitiveness in the marketplace.

For example, in Boone County – the largest producing county in the three state region – surface mining accounts for 21 million tons of production, while underground mining accounts for just 13 million tons.

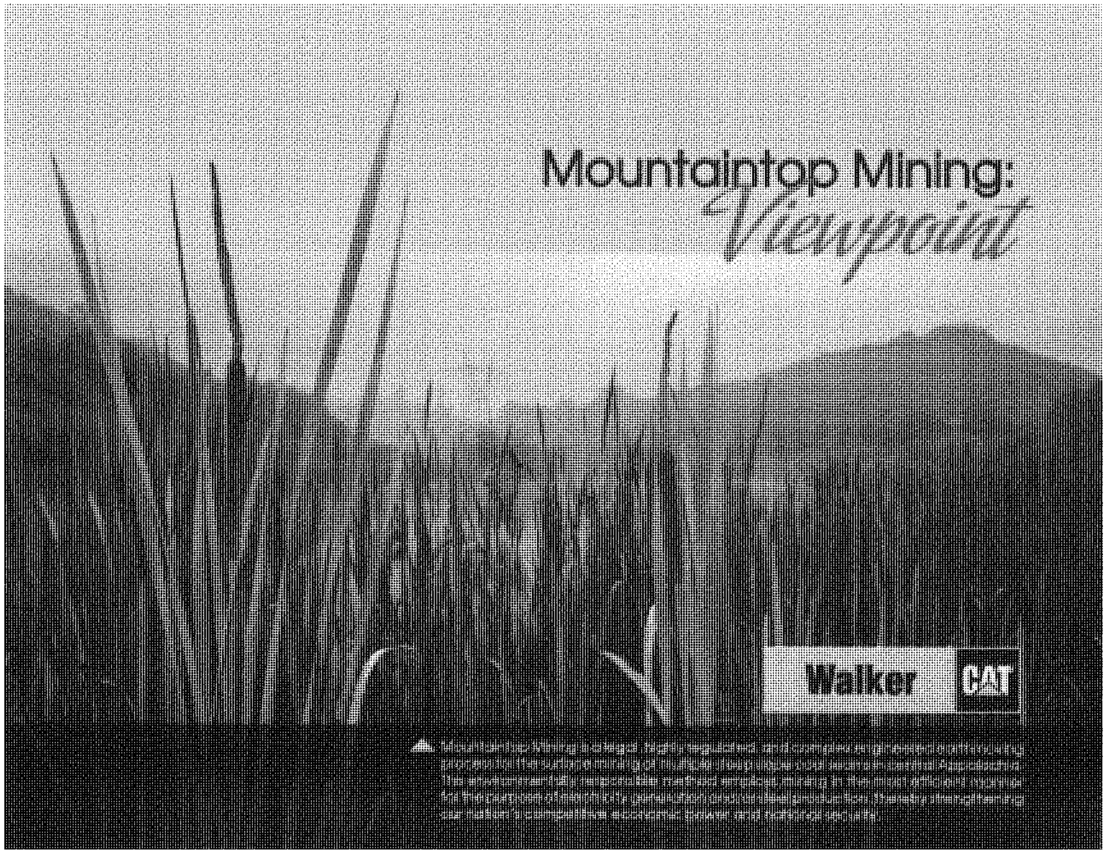
It is important to note that while the anti-coal extremists portray their opposition as only against mountaintop mining and the use of valley fills. There are no significant differences between mountaintop mining and other forms of surface mining, and **ALL FORMS OF MINING REQUIRE THE USE OF VALLEY FILLS.** In other words, banning the use of mountaintop mining and valley fills would effectively end mining across Appalachia.

This is something the area clearly cannot afford. For example, if mining ended in West Virginia, it would almost immediately remove 12-15 percent of the state's tax revenues and with it approximately 50,000 jobs. If mining ends and opponents of coal-fired electrical generation are successful in shutting down these plants and mining operations, it would mean the state would lose 60 percent of its tax revenues and more than 70,000 jobs.

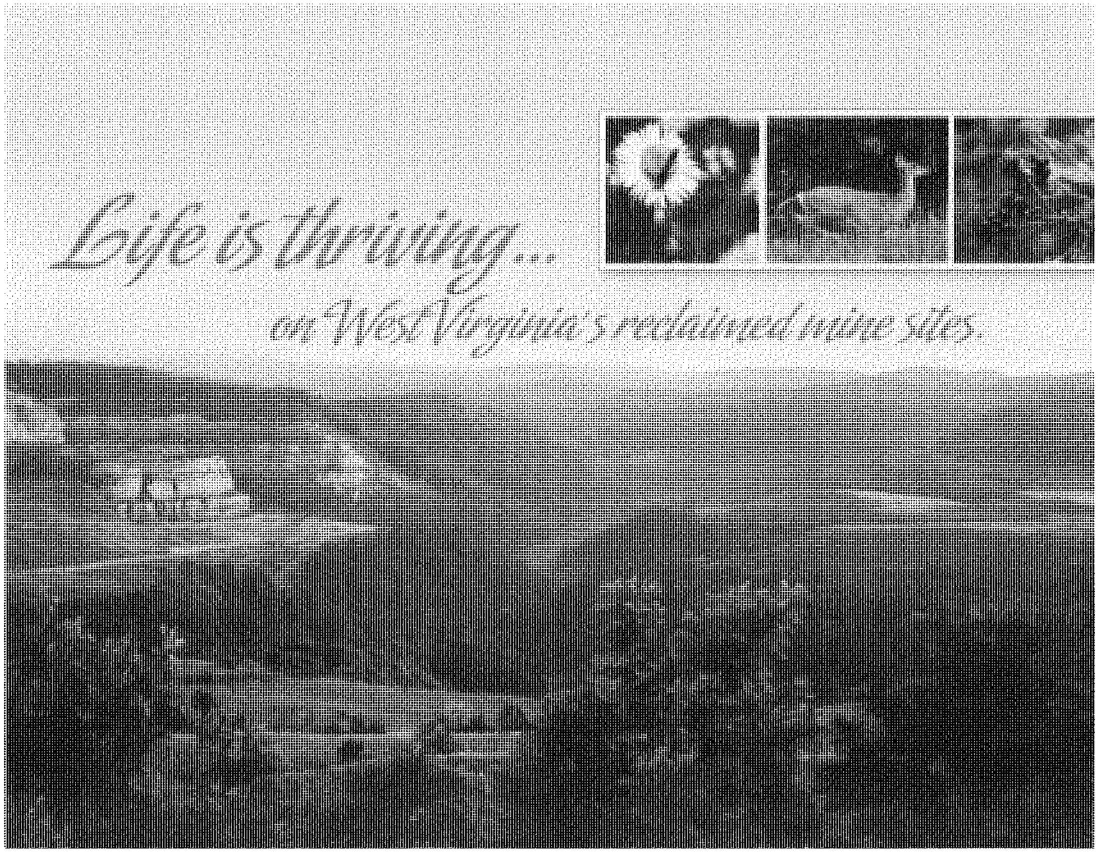
IV. RECOMMENDATIONS

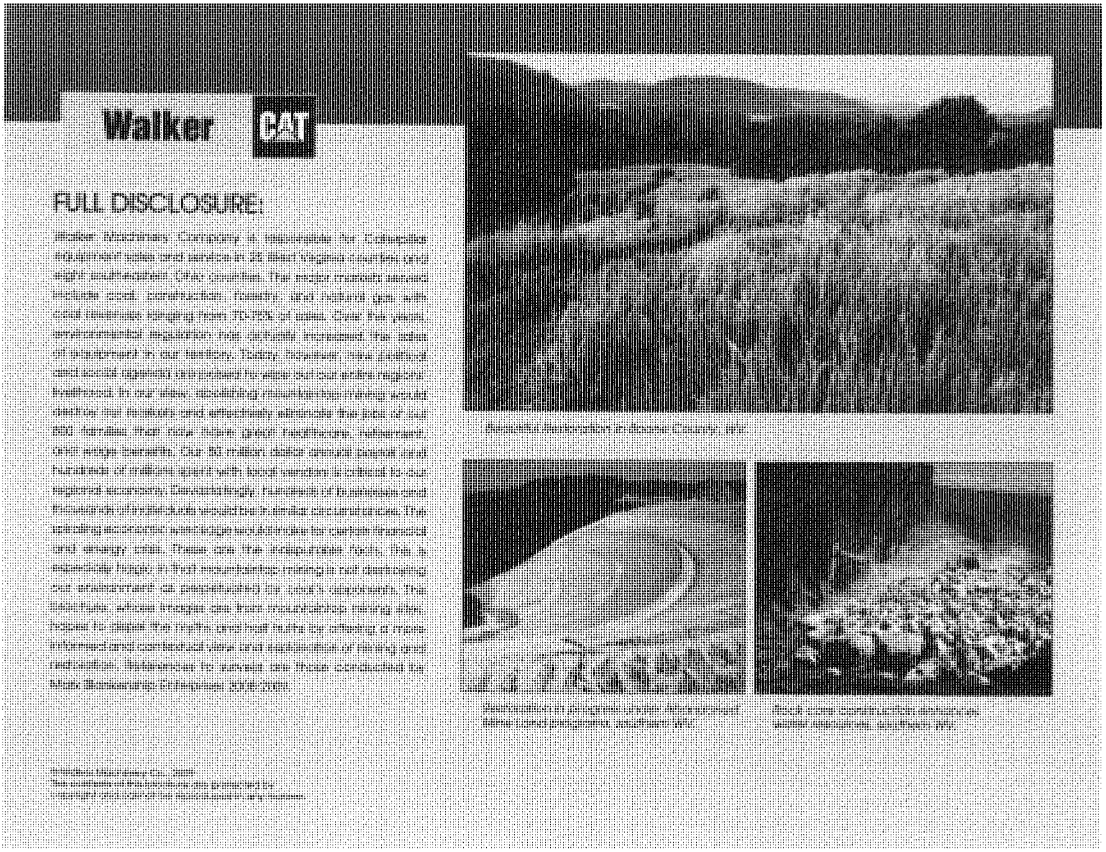
The future of the coal industry in Appalachia depends on the continued use of surface mining and the construction of valley fills. Mountaintop mining is an essential component of our extraction effort, providing us the ability to compete against increasing competition from western and foreign coal production. Banning mountaintop mining and/or the construction of valley fills would effectively destroy our ability to compete in the international marketplace and ultimately bring an end to mining in the state.

We at the Mountaintop Mining Coalition call upon the members of the legislature and the governor, as well as our congressional representation to adopt a set of rules and regulations that clarify existing rules and regulations at the various levels of government to make it more difficult for the radical environmentalists to disrupt production through the filing of seemingly endless lawsuits and protests. We also call upon the governors of the states and the legislatures to support the industry to their fullest and to join with the industry to market our most plentiful and valuable resource throughout the United States and the world.



Mountaintop Mining is a legal, highly regulated, and complex engineered earthmoving process for the surface mining of multiple deep-lying coal seams in central Appalachia. This environmentally responsible method employs mining in the most efficient manner for the purpose of electricity generation and steel production, thereby strengthening our nation's competitive economic power and national security.


Life is thriving...
on West Virginia's reclaimed mine sites.



Walker CAT

FULL DISCLOSURE:

Walker Machinery Company is responsible for Caterpillar equipment sales and service in 26 West Virginia counties and eight southeastern Ohio counties. The major markets served include coal, construction, forestry and natural gas with coal revenues ranging from 70-75% of sales. Over the years, environmental regulation has actually increased the sales of equipment in our territory. Today, however, new political and social agendas are poised to wipe out our entire regional livelihood. In our view, abolishing mountaintop mining would destroy our markets and effectively eliminate the jobs of our 850 families that now have great healthcare, retirement and wage benefits. Our 80 million dollar annual payroll and hundreds of millions spent with local vendors is critical to our regional economy. Devastatingly, hundreds of businesses and thousands of individuals would be in similar circumstances. The spiraling economic wreckage would make for certain financial and energy crisis. These are the indisputable facts. This is especially tragic in that mountaintop mining is not destroying our environment as propagandized by coal's opponents. This brochure, whose images are from mountaintop mining sites, hopes to dispel the myths and half truths by offering a more informed and contextual view and explanation of mining and reclamation. References to surveys are those conducted by Mark Blankenship Enterprises 2008-2009.

Beautiful Reclamation in Boone County, WV

Reclamation in progress under Alternative Mine Land program, southern WV

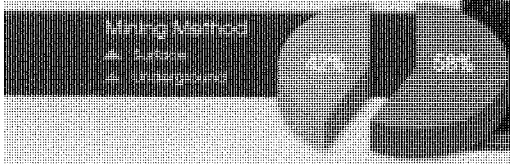
Rock core construction along new water drainage, southern WV

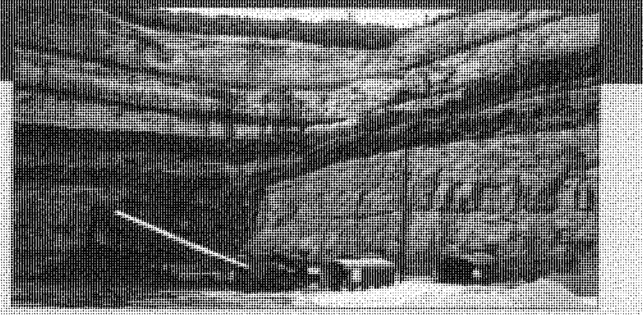
There are two methods to mine coal…underground and surface.

The preference to do one over the other is dictated by geology and economics. Coal that is suitable for surface mining generally cannot be mined economically by underground methods. Typically this is because the seams are not thick enough to use underground equipment and often the rock strata are not stable enough to prevent roof falls which jeopardize miner safety. Coal within 300-800 feet of the surface can be mined safer, faster, with less waste, and lower cost using surface mining methods. It's just that simple.

West Virginia's coal production is approximately 58% underground mining and 42% surface mining. Surface mining can take three forms in West Virginia: (1) Contour mining, (2) Area mining, and (3) Mountaintop mining. All surface mining in WV today is generally referred to as "mountaintop mining."

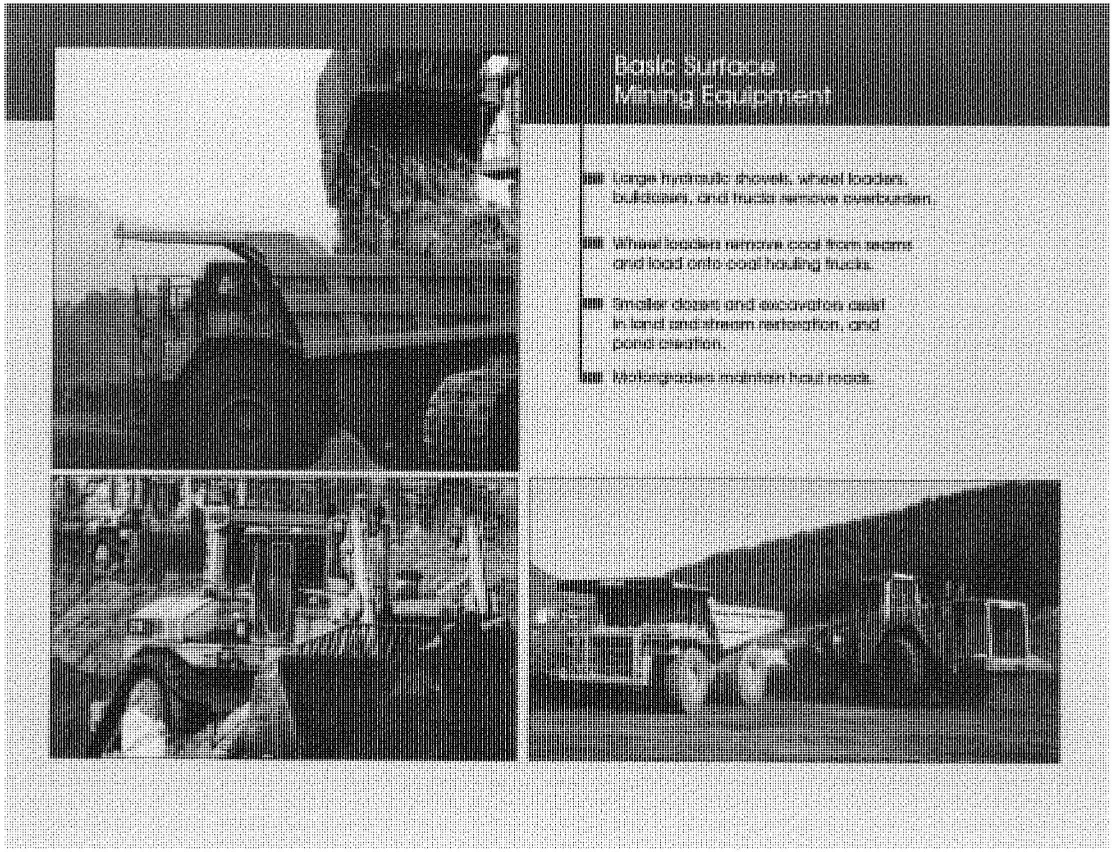
It is interesting to note that reduced surface mining will in fact reduce underground mining. Coal companies utilize the roads, utilities, coal handling infrastructure, railways, and lower cost economics of surface mining to get to the more expensive underground coal. Additionally, the necessity to blend surface coal with underground coal allows electric utilities to create coal with specific qualities that produce more complete combustion with electricity generation. This reduces air pollutants and carbon dioxide emissions as power plant efficiency increases.





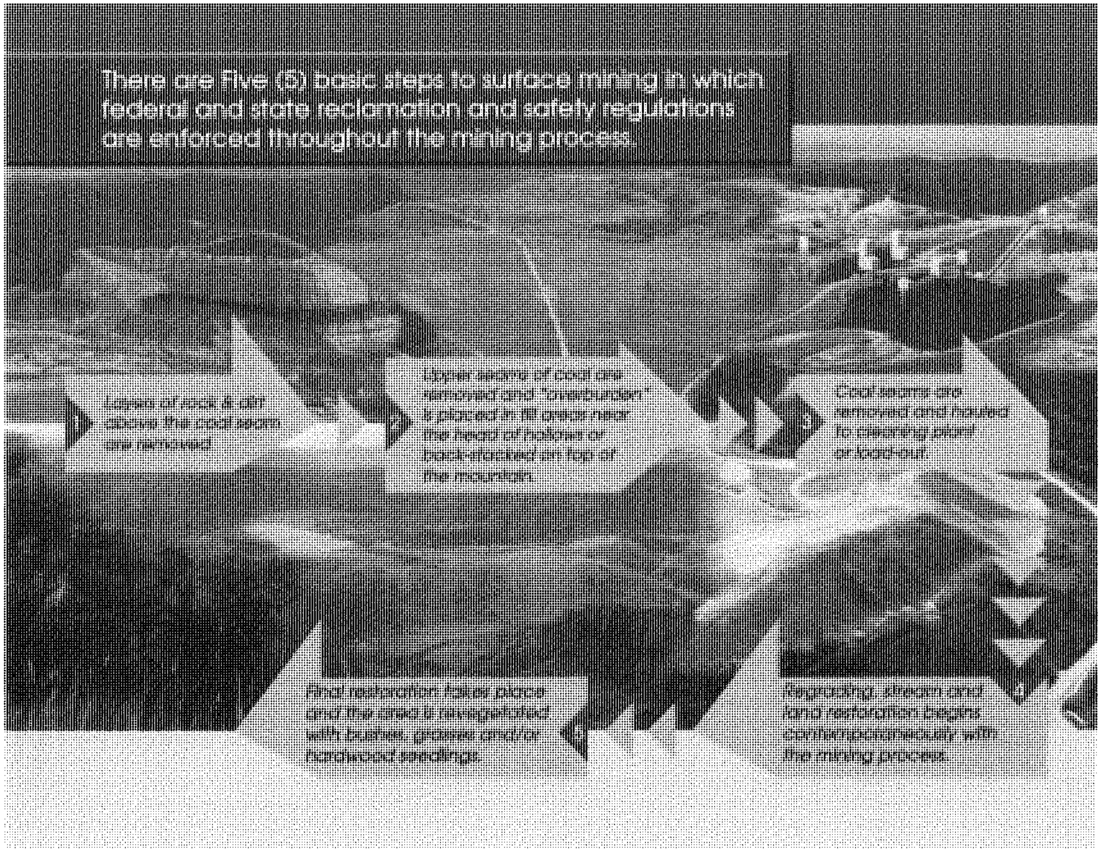
13 coal seams exist above this mine portal. ▲

Surface mine coal seams cannot be mined by underground methods.



Basic Surface Mining Equipment

- Large hydraulic shovels, wheel loaders, bulldozers, and trucks remove overburden.
- Wheel loaders remove coal from seams and load onto coal-hauling trucks.
- Smaller dozers and excavators assist in land and stream restoration, and pond creation.
- Motorgrades maintain haul roads.



There are Five (5) basic steps to surface mining in which federal and state reclamation and safety regulations are enforced throughout the mining process.

1 Layers of rock & dirt above the coal seam are removed.

2 Upper seams of coal are removed and "overburden" is placed in fill areas near the head of hollows or back-stacked on top of the mountain.

3 Coal seams are removed and hauled to cleaning plant or load-out.

4 Regrading, stream and land restoration begins contemporaneously with the mining process.

5 Final restoration takes place and the area is revegetated with bushes, grasses and/or hardwood seedlings.

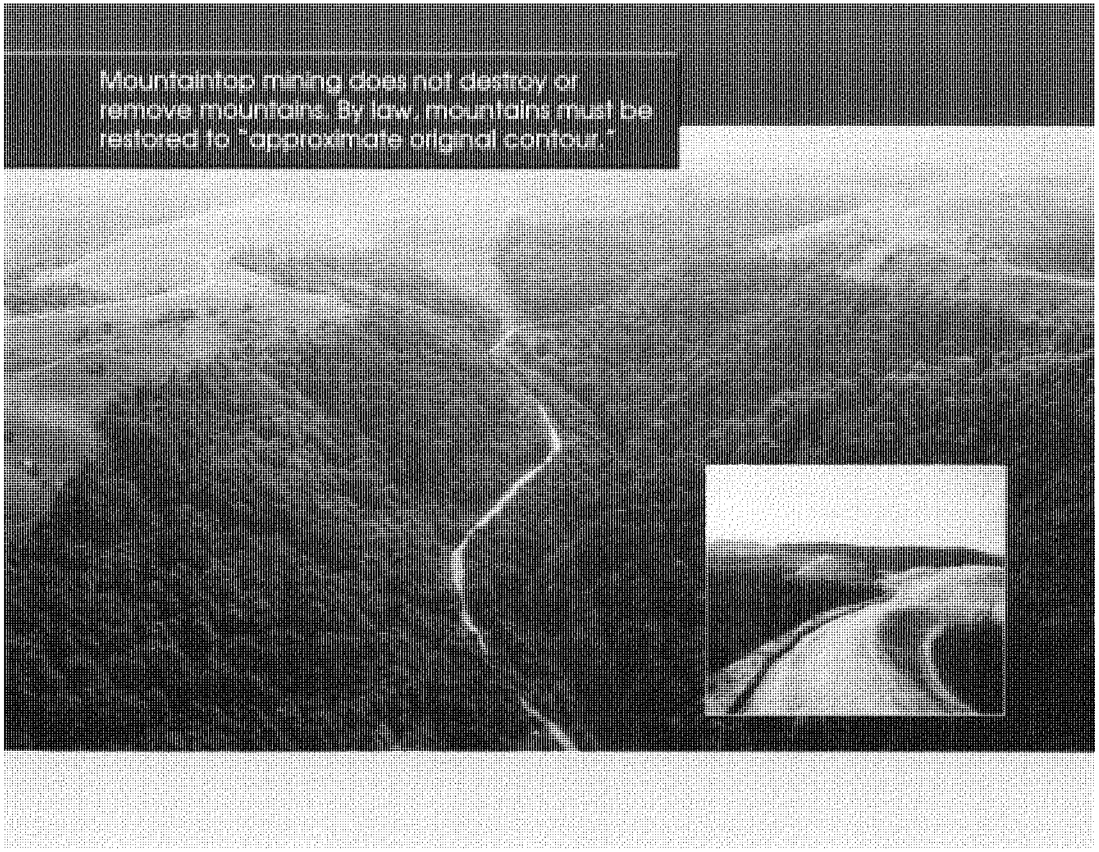
Mountaintop mining is the most efficient and environmentally responsible type of surface mining over the long term.

"Contour mining," more prominent in the '70's and '80's, takes place around a ridgetop in which a two or three hundred foot strip of earth and rock are removed to expose the outer reaches of a coal seam. Contour mining leaves large blocks of coal in the ground under the ridgetops. This is inefficient and wasteful of coal resources. As equipment became larger and more powerful in the 1990's, mountaintop mining enabled the industry to become more productive and efficient by removing all the coal available. The inefficiency of "contour mining" kept open the possibility of re-entering the environment later, perhaps a second or third time, damaging any restoration that has been completed. "Mountaintop mining" would have precluded further environmental damage, thus allowing restoration to be greatly more sustainable and producing more energy that our country desperately needs.

"Area Mining" occurs in more rolling topography such as northern West Virginia, southern Ohio, or midwest and western states to reach coal seams close to the surface. This topography allows for easier extraction than difficult steep slope areas but the mining process requires the same equipment and methods as steep slope mountaintop mining. Post mining land use in these areas often include agricultural, recreational, and commercial/retail developments. The Mylan baseball and soccer parks, the FBI center, Pete Dye Golf Club, and Bridgeport shopping malls are examples in the Morgantown/Clarksburg corridors. These are beautifully reclaimed areas that offer high economic and quality of life values. Although the mining and environmental issues are the same in area mining, this mining is not demonized in the same manner as in southern West Virginia/eastern Kentucky.

Contour Mining shown in bright green band near top.

Reclaimed Area Mining near Morgantown, WV.

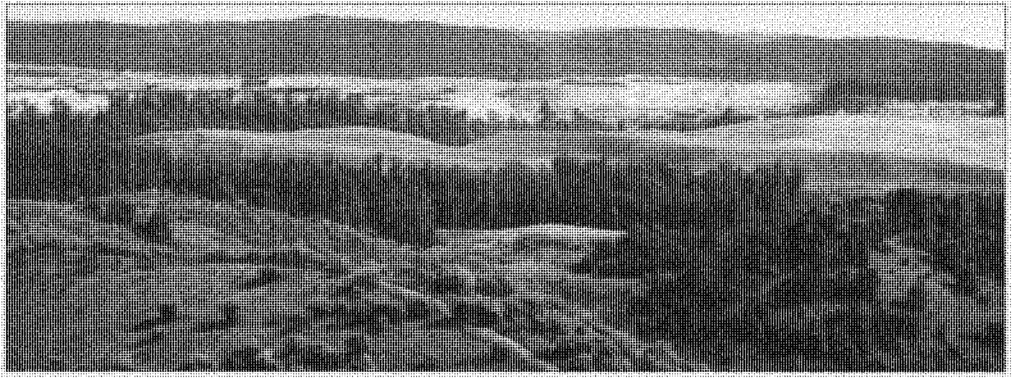


Mountaintop mining does not destroy or remove mountains. By law, mountains must be restored to "approximate original contour."

"Blowing off the tops" of mountains and filling streams with waste are simply provocative distortions of a highly regulated and engineered process.

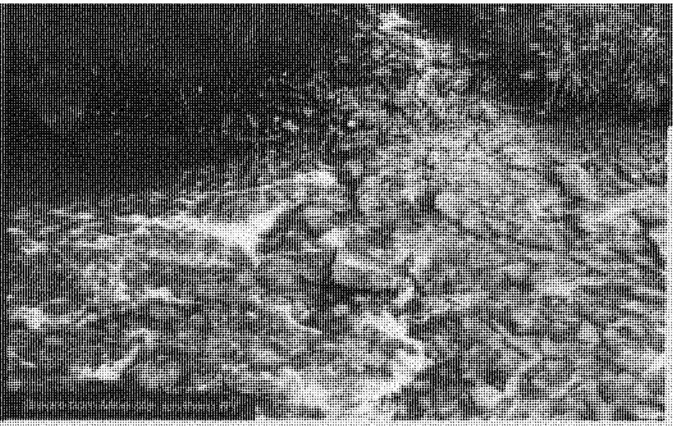
"Flattening mountains" is merely a provocative term. It's against the law and has no proof in fact. Leveling land for public or commercial use is merely accepted practice and common sense. Is mountaintop mining destroying all of our mountains? Absolutely not! The footprint is very small. That impression appears to be confirmed by information provided by the West Virginia Coal Association that says in 22 of the state's 55 counties the acreage permitted for such mining is less that 1 percent; in four other counties it is in the 1 to 3 percent range and three are there over that with Boone the largest of 6.8 percent. The 33 remaining counties have no permits for mountaintop mining. Furthermore, where reclamation is 30 years or older, evidence of mining is virtually gone except to the trained expert eye.

Coal was discovered in Boone county in 1742. It is amazing that it is today the highest coal producing county - producing over 33 million tons annually, 31 million tons by surface mining. Boone County is 503 square miles of a state that has 24,181 square miles. The 6.5 percentage of permitted acreage has relatively little mining in progress compared to acres and acres of restored land. It is today one of our most beautiful and rugged areas. In no way has mountaintop mining destroyed the land. It is useful, dynamic, and resourceful and will be for years to come. Economically it has 102 mines, underground and surface. It has a population of 25,535, estimated direct wages of $258,449,000, and severance tax receipts of $4,358,430. Take away mountaintop mining and it will simply revert to another Appalachian tragedy as would all of southern West Virginia and eastern Kentucky.



Mine Site, southern WV.

Mountaintop mining is a highly regulated project utilizing sophisticated hydrological and civil engineering techniques. Streams, technically defined by regulators as anywhere water might flow, allows for deception and half-truths by coal's opponents.



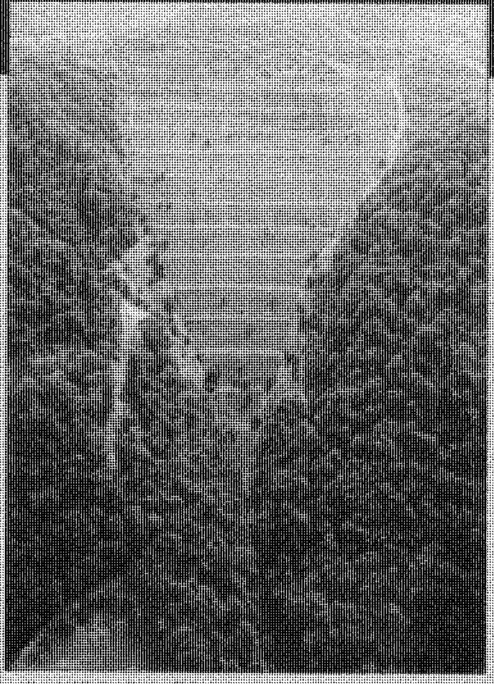
Mountaintop mining does not cover up miles and miles of streams. Tragically, the mountaintop mining process has been deceptively oversimplified and wrongfully characterized as blowing off the tops of mountains and covering up streams. It has been repeated over and over and over by reporters and coal opponents. This repetition will never replace the true facts. Its use is designed to instill fear and create negativity to a critical mining process, an industry and citizens. But we'll go on and on. Anyone not spending considerable time around the mining areas would think the "greedy coal operators" are lopping off all mountains and covering all fishing and navigable streams in the state. This is not reality. It is simply an inflammatory and distorted attack against the coal industry. Mountaintop mining is a primarily essential Appalachian technique in southern West Virginia, eastern Kentucky, and western Virginia. Mountaintop mining is legally characterized as surface mining that flows continuously from one side of a mountain ridge to the other. It does not "remove" the mountain; it does not "flatten" the mountains. These are simply outrageous characterizations by anti-mining groups for sensationalizing their attacks on the coal industry. In fact, unless a permit variance is granted by regulators for higher and better post mining land use, the mined area must, by law, be restored to "approximate original contour" and revegetated. Recent law changes and new technology allow the planting of millions of hardwood seedlings on reclaimed lands. Also, new permits allow mountaintop mines to correct old damage and mistakes of the past on mine lands. Mining coal utilizing surface methods is designed to maximize the economic extraction while minimizing the environmental effects to water resources, wildlife, insects and aquatic life, and overall scenic environment. The restoration develops beautifully over time. Unfortunately, most never get to view these areas as mining areas still under bond are off limits to public safety reasons. Only mining in progress is available to the public through pictures and other visual media by coal's opponents. Additionally, more counties are petitioning for mined land to be left in level condition more readily available for commercial post mine use. Large, prime building sites are very scarce in central Appalachian regions which make economic diversity all the more difficult.

The Permit

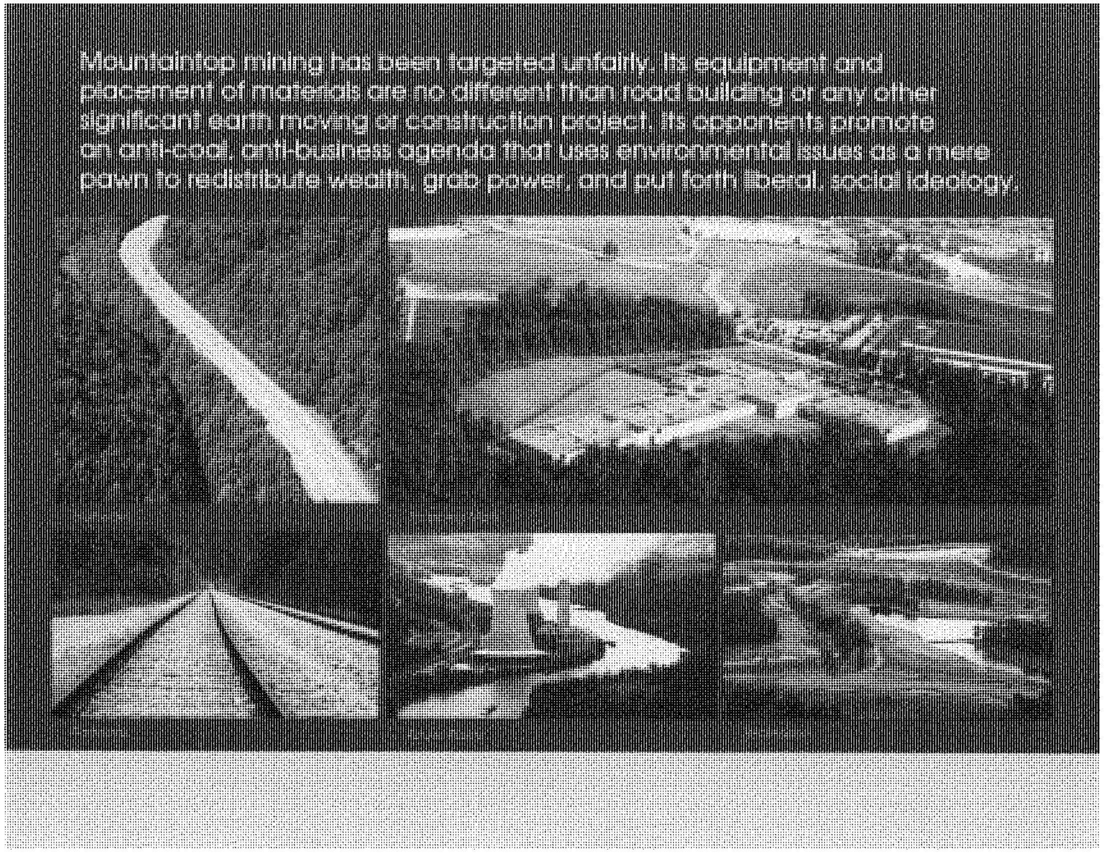
Mining can begin when the permit process is completed. The length of the permitting process varies from many months to years and permitting requires pages and pages of document and hours and hours of engineering for multiple governmental agencies.

Multiple government agencies can exercise their authority at any mine site on any given day to insure the environment and the miners are protected. Originally, the principal operations of surface mining became regulated under the Surface Mining Control and Reclamation Act of 1977. Principal permitting and enforcement falls to the West Virginia Department of Environmental Protection, with oversight by the Office of Surface Mining (OSM) and the EPA. The mission of the WV Division of Mining and Reclamation (DMR) is to regulate the mining industry in accordance with federal and state law. Activities include issuing and renewing permits for mineral extraction sites and related facilities, inspecting facilities for compliance, monitoring water quality, tracking [illegible] and control, and issuing and assessing violations.

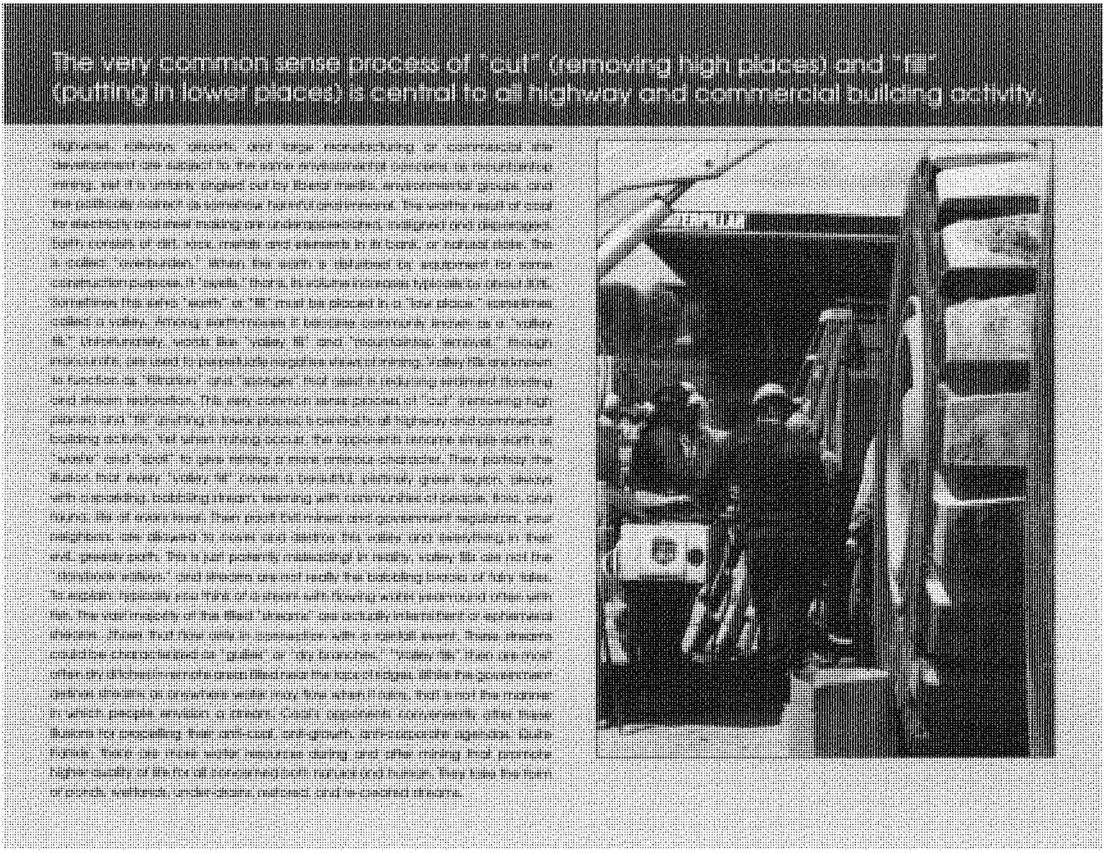
The U.S. Army Corp of Engineers is responsible for the interpretation and compliance of mining to the Clean Water Act. The Clean Water Act has three major sections: (1) 401 Water Quality Certification, (2) 402 Water Discharges, and (3) 404 Dredge and Fill Operations. Section 401 is state administered and requires placement of fill that material will not result in violation of applicable state water quality standards. Section 402 categorizes mining as "point source," meaning all discharges must comply with water quality effluent limitation on pollutants. Section 404 regulates the placement of fill material into any area that water may flow. The government calls this a stream. The most controversial section is the subject of "valley fills." Without valley fills, surface mining or underground mining is not possible. Obviously, the Surface Mining Act of 1977 was not designed to eliminate surface mining; hence, federal courts have not outlawed surface mining.



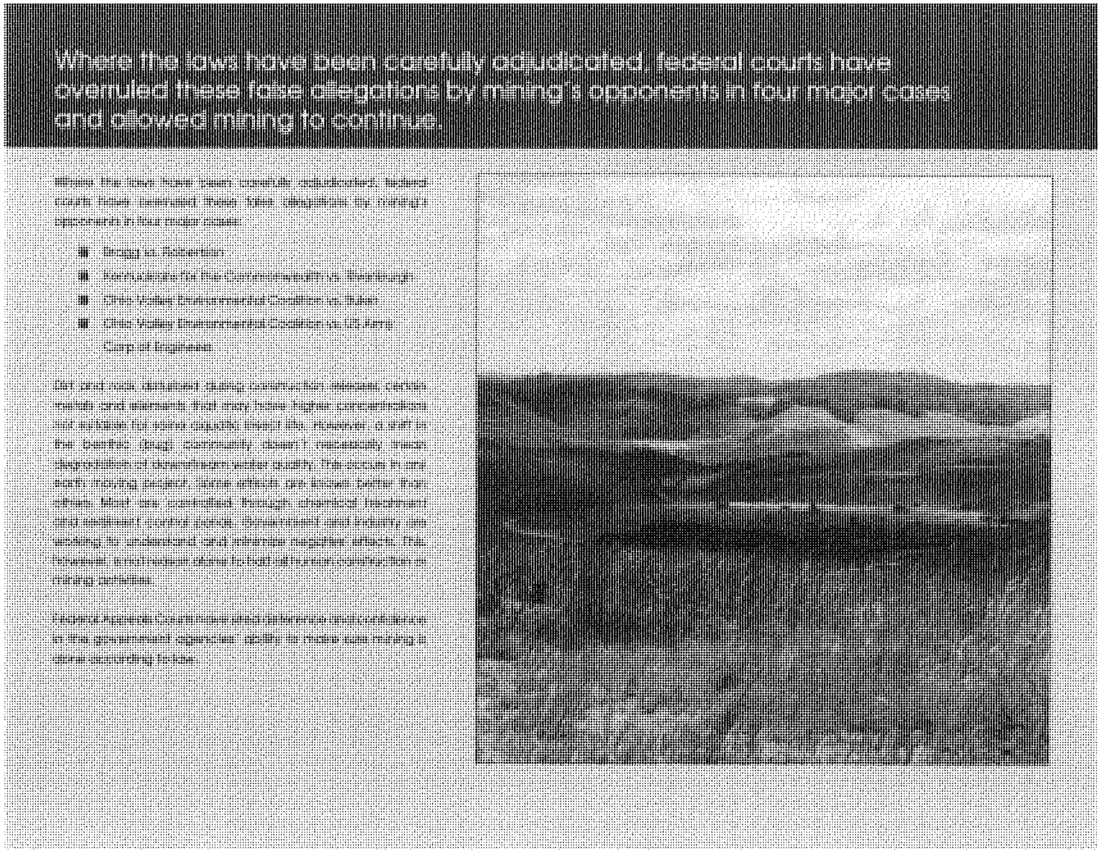
Head of Hollow "Valley Fill"



Mountaintop mining has been targeted unfairly. Its equipment and placement of materials are no different than road building or any other significant earth moving or construction project. Its opponents promote an anti-coal, anti-business agenda that uses environmental issues as a mere pawn to redistribute wealth, grab power, and put forth liberal, social ideology.



The very common sense process of "cut" (removing high places) and "fill" (putting in lower places) is central to all highway and commercial building activity.



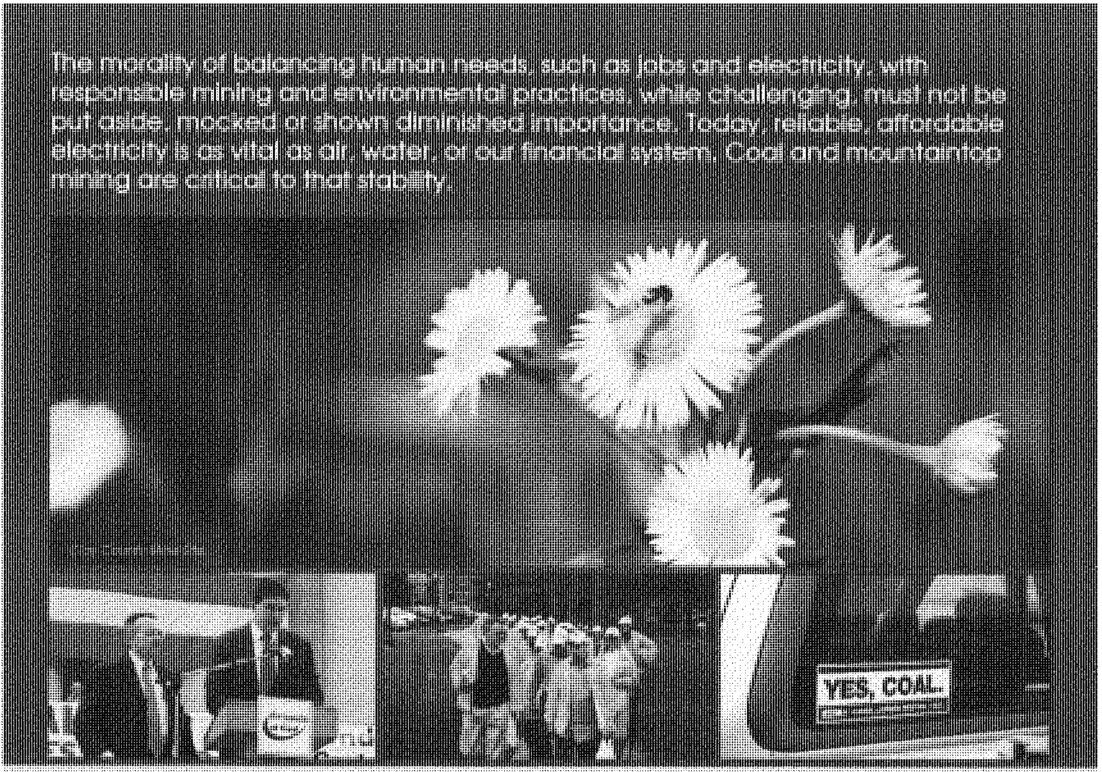
Where the laws have been carefully adjudicated, federal courts have overruled these false allegations by mining's opponents in four major cases and allowed mining to continue.

Where the laws have been carefully adjudicated, federal courts have overruled these false allegations by mining's opponents in four major cases:

- Bragg vs. Robertson
- Kentuckians for the Commonwealth vs. Rivenburgh
- Ohio Valley Environmental Coalition vs. Bulen
- Ohio Valley Environmental Coalition vs. US Army Corp of Engineers

Dirt and rock disturbed during construction releases certain metals and elements that may have higher concentrations not suitable for some aquatic insect life. However, a shift in the benthic (bug) community doesn't necessarily mean degradation of downstream water quality. This occurs in any earth moving project. Some effects are known better than others. Most are controlled through chemical treatment and sediment control ponds. Government and industry are working to understand and minimize negative effects. This, however, is not reason alone to halt all human construction or mining activities.

Federal Appeals Courts have shown deference and confidence in the government agencies' ability to make sure mining is done according to law.



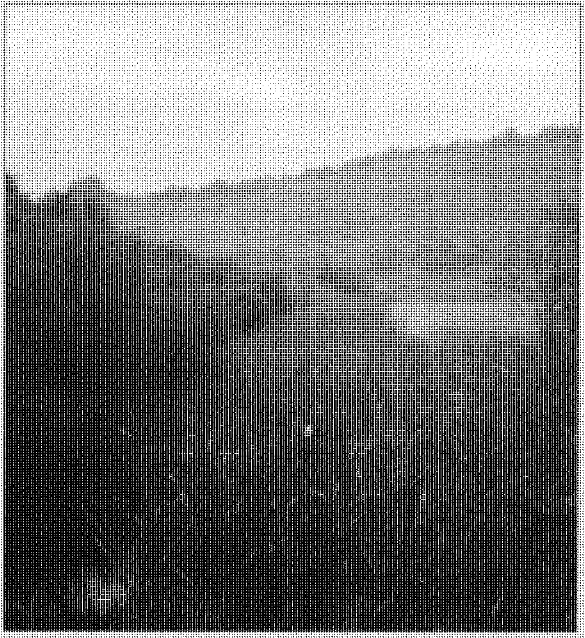
The morality of balancing human needs, such as jobs and electricity, with responsible mining and environmental practices, while challenging, must not be put aside, mocked or shown diminished importance. Today, reliable, affordable electricity is as vital as air, water, or our financial system. Coal and mountaintop mining are critical to that stability.

Unfortunately, life and the earth did not come with an instruction manual.

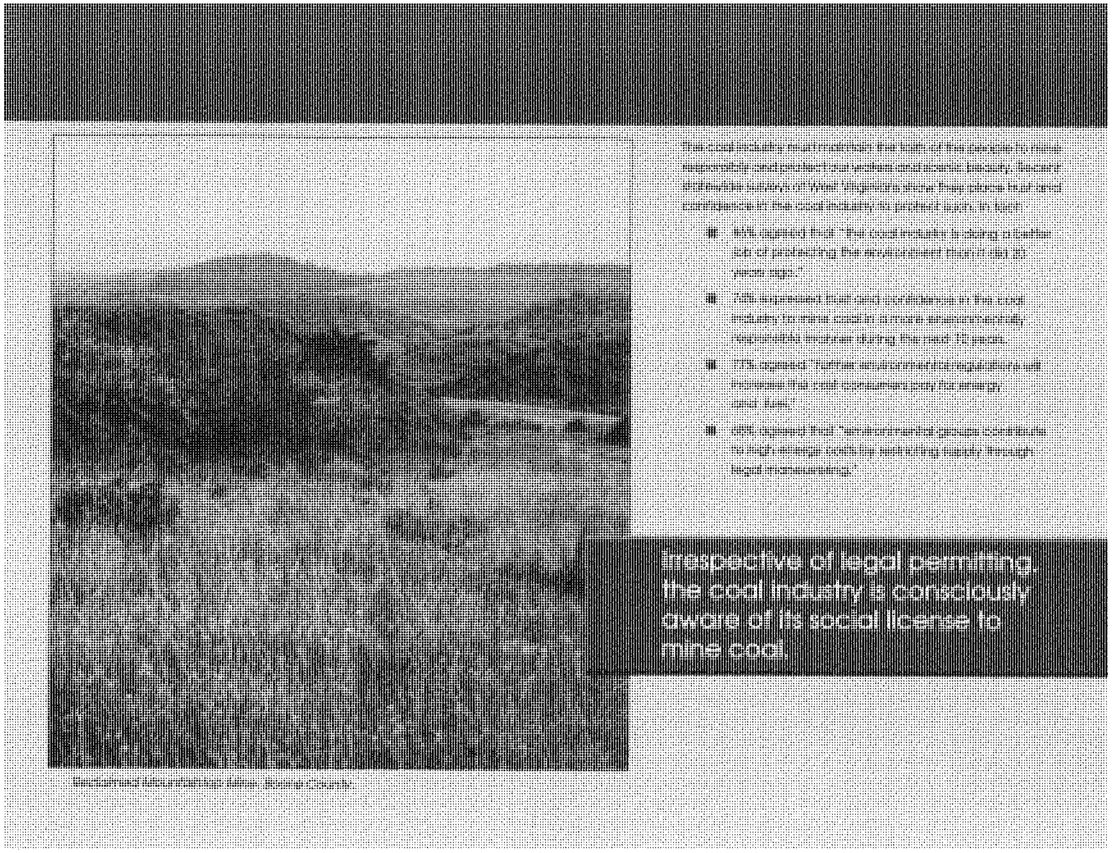
The earth and its inhabitants have been in dynamic change from its beginnings. The positive transformational role coal has played for mankind has not been truly appreciated. It has brought us through two world wars, the Korean and Vietnam experiences. The evolution of industrial and technical revolutions make us the safest and largest superpower in the world. It would be foolish and ungrateful to throw out the most abundant, affordable energy source on the planet without allowing new technology to correct coal's shortcomings. Through technology, coal is poised to be a better fuel than ever in its history and offer a "bridge to the future."

Stream Bordering Mountaintop Mines, Clay County

The intrinsic value of nature, its ecological interdependence, beauty and spirituality cannot be denied, minimalized, or ignored. The coal miners and coal communities acknowledge and live by these truths as human beings among neighbors.



Reclaimed Wetlands Mountaintop Mine, Boone County



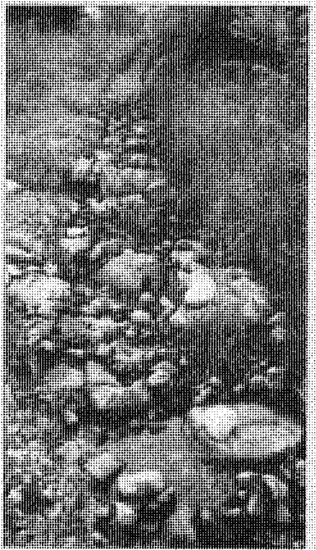
The coal industry must maintain the faith of the people to mine responsibly and protect our waters and scenic beauty. Recent statewide surveys of West Virginians show they place trust and confidence in the coal industry to protect such. In fact:

- 86% agreed that "the coal industry is doing a better job of protecting the environment than it did 20 years ago."
- 74% expressed trust and confidence in the coal industry to mine coal in a more environmentally responsible manner during the next 10 years.
- 77% agreed "further environmental regulations will increase the cost consumers pay for energy and fuel."
- 69% agreed that "environmental groups contribute to high energy costs by restricting supply through legal maneuvering."

Irrespective of legal permitting, the coal industry is consciously aware of its social license to mine coal.

Reclaimed Mountaintop Mine, Boone County.

It is troubling that coal's opponents, using our courts and sympathetic political influences, have placed bugs & insects (benthic macro-invertebrates) at a higher moral standing than the citizens who need lucrative, dependable JOBS.

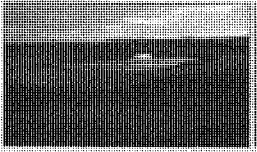


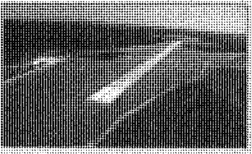
Reclaimed Stream, southern WV Mine Site

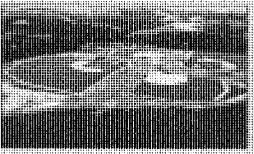
Coal's opponents have guilefully turned to the judiciary and political courts to utilize the complexities and ambiguities of the Clean Water Act and present a very convoluted representation of our ecosystem. Their argument is extremely debatable among experts and defies common sense. Are we expected to believe that as rock and dirt are moved to the dry ditches near the tops of mountains, that the benthic macro-invertebrates (bugs) will be forever destroyed, thus impacting the entire ecosystem and all life as we know it? The mining community is keenly aware of the ecological science involved in the benthic communities' importance in determining the health, structure, and function of streams, including freshwater. By law and regulation, they protect these relationships through mining design and mitigation. It is important to note that these creatures have lived and adapted themselves for millions and billions of years before man. They inhabit almost every square foot of the watersheds across the great globe, in and outside mined areas. This is hardly criteria for extinction or endangered species. Although metamorphosis times vary, (a) lifecycle of an egg, nymph, and adult most often lasts less than a year, perhaps more, depending on the insect order, they quickly breed and die naturally, sometimes within a day or two. They do not have house payments, car payments or student loans. In truth they quickly reestablish the disturbed and often mined lands to repeat their biological destiny and breed in large quantities difficult to imagine. If the bug theory by coal's opponents were extended by the courts, human beings could not build roads, homes, hospitals, schools, cities, or communities for fear of an ecological Armageddon. As if it mattered, more bugs are killed overwhelmingly by our windshields than on mine sites. Are we on such a destructive path that a human being's right to WORK and moral standing are subordinate to a bug or anything we wish to refer to as nature? Is man not part of nature and of higher moral standing than sentient creatures? As any truly informed person knows, an industry that is accused of covering streams that are not streams, with waste that is not waste, in valleys that are not valleys, with bugs having the moral equivalency of human beings in our court system, is distressing and disappointing. The coal industry seemingly gets no credit at all for the beautiful reclamation, and the truly small footprint of mining across West Virginia's 15 million acres. Reclaiming the land with bushes, grasses, and new hardwood seedlings that will gobble up more carbon dioxide is actually a step toward becoming carbon neutral.

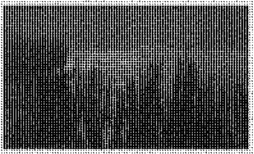
Moral and ethical choices strongly favor mining.

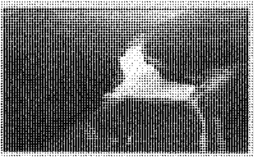
Examples of Post Mining Land Use

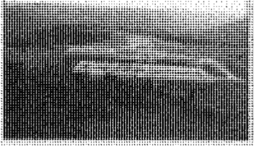

Twisted Gun Golf Course

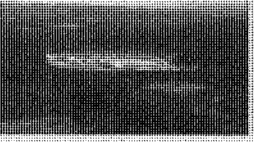

Logan County Airport

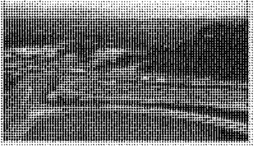

[illegible] Park Baseball Fields


Boone County Wetlands


Southern WV Recreation Area

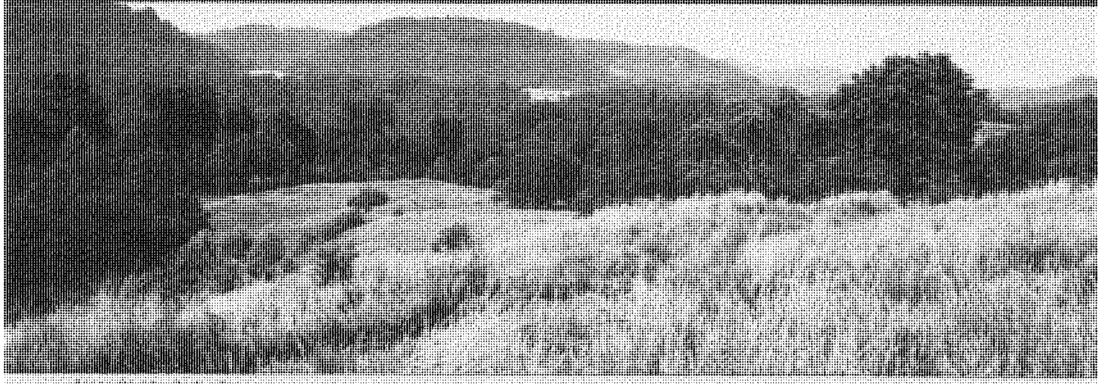

Southwestern Regional Jail


Mount Olive Prison

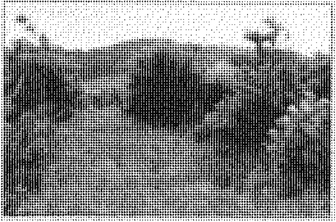

Mall in Bridgeport

We export most of our coal. Is it moral or ethical or to deny the millions of people in our country the value of the resource and put people out of work? Some suggest that an honest assessment of the positives and negatives associated with coal mining would lead us to the conclusion that mining is bad, unethical and immoral. Not true...it is just the opposite. How do coal's opponents resolve the moral and ethical hypocrisy of using electricity from coal, driving a car or perhaps using their computer, as these activities require "so-called" environmentally moral choices by their stated standards? Moral choices are not so clear. That makes it very unproductive to banter back and forth in such a self-righteous manner. Morals and ethics come down to personal beliefs, forged over our life experiences. Moral and ethical choices strongly favor coal mining. Consider that our health and longevity would be greatly reduced without coal fueling technology development. Mining coal has served the greater good of our state, nation and society as a whole. Coal has enabled the United States to defend itself and freedom around the world while helping to build the greatest economic power ever. Is that unethical? It appears unethical to mischaracterize the coal miners as lacking in respect and reverence for nature because of their profession. Society has demanded the coal. Without coal, we would have chopped down the forests and devastated our ecosystems long ago to provide basic human needs. Does this not show coal miners to have a greater reverence for nature as well as being [illegible], caring, and unselfish conservationists who are passionately committed to family and community? They live and work in these same mountains. It is their home, too.

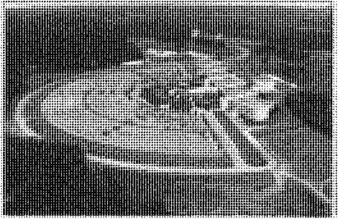
Mountaintop mining is absolutely critical to Central Appalachia's economic vitality, America's energy needs, and national security



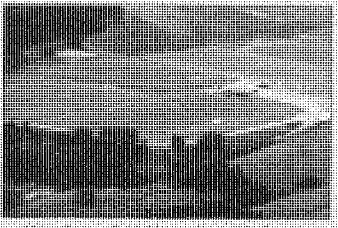
[illegible] County – [illegible]



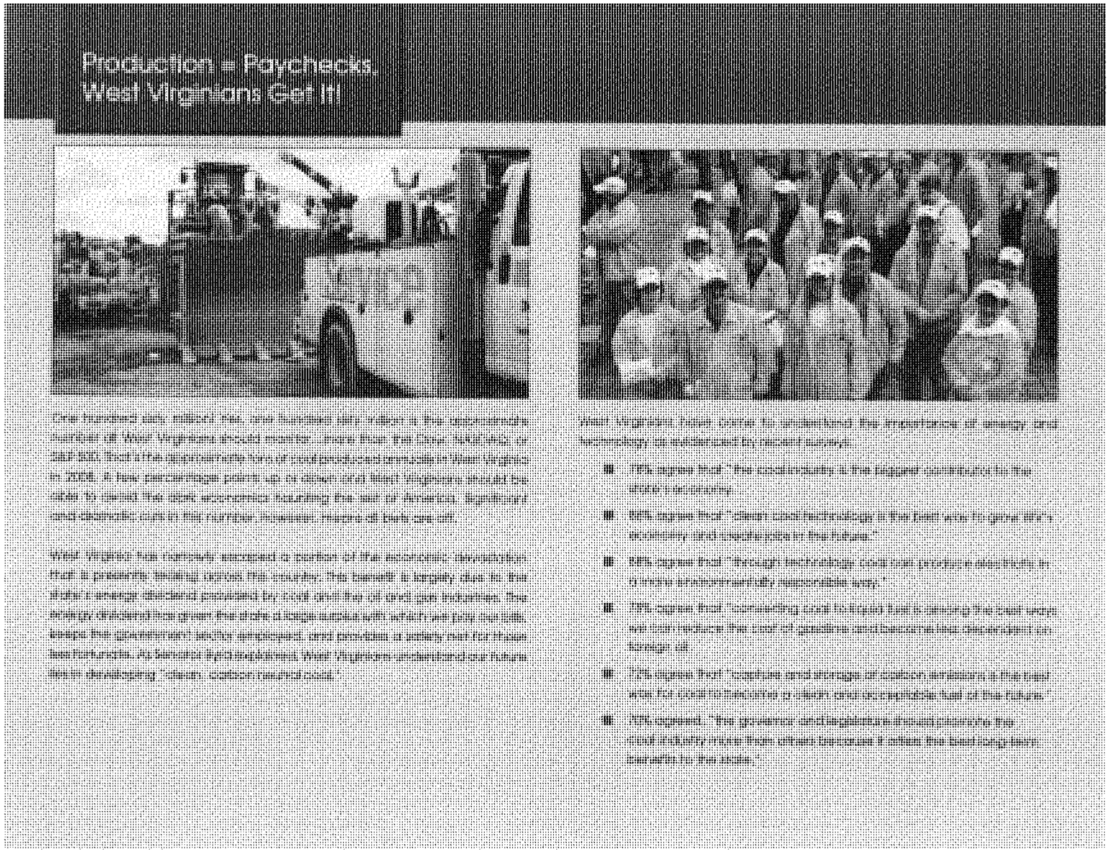
Hardwood Plantings-Clay County, Post Mine



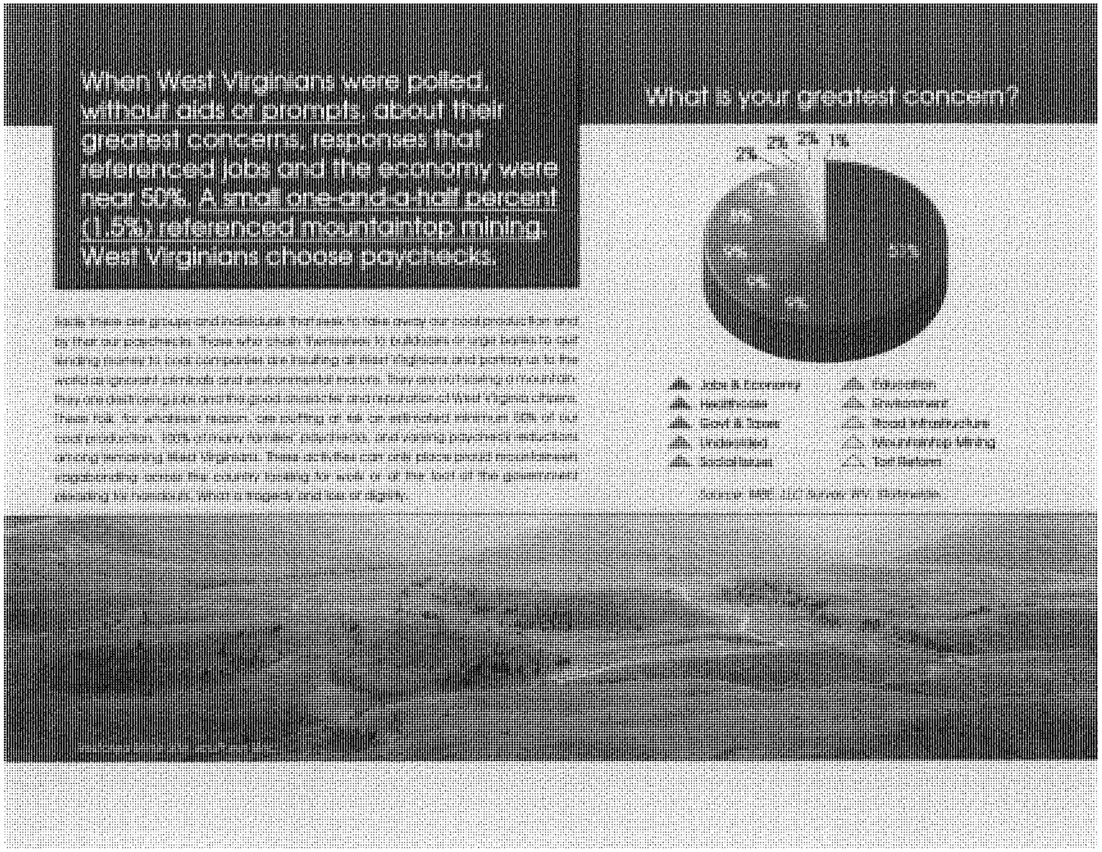
[illegible], Post Mine



[illegible] Soccer Fields-Morgantown, WV, Post Mine



Production = Paychecks. West Virginians Get It!



When West Virginians were polled, without aids or prompts, about their greatest concerns, responses that referenced jobs and the economy were near 50%. A small one-and-a-half percent (1.5%) referenced mountaintop mining. West Virginians choose paychecks.

What is your greatest concern?

The Multiplier Effect. It's not just coal jobs at stake. It's your job, your children, and your neighbor's job.

The attack on mountaintop mining, if successful would set off an economic death spiral among hospitals, pharmacies, banks, lawyers, retail, government, and industry all across West Virginia. The indirect employment (or employment multipliers) associated with jobs in the coal industry result from three effects: supplier effects, re-spending effects, and government employment effects.

Supplier effects are impacts that job destruction has on coal industry vendors. For example, Walker Machinery has nearly 550 employees with a $40 million dollar annual payroll. 75% of our revenues are directly from the coal industry, mostly mountaintop mining. These jobs offer important retirement and healthcare benefits. Thousands of such companies in West Virginia would simply be gone. What a slap in the face to the employees of suppliers like Walker who give time and resources to churches, schools, and communities. Walker Machinery and the Walker family, through whose philanthropy has given their time, effort, and millions of dollars to communities and organizations throughout our great state, would disappear. Thousands would suffer economic devastation because of false environmental accusations by a vocal, anti-coal minority.

Re-spending effects are the impacts that job destruction has on those sectors where workers spend their paychecks. For example, hospitals, doctors, drugs, pharmacies, grocery stores, and auto dealers are among the hundreds of places where coal miners and others would have spent money.

Government employment effects refer to the taxes that support jobs in federal, state, and local government, as well as government's societal expenditures. If workers in the coal industry and its suppliers lost their jobs, that would erode the tax base that supports government employment and severance (the tax on natural resources), property, and payroll taxes. These numbers would be astronomical for West Virginia.

Abolishing mountaintop mining would be the most serious attack on property rights since the founding fathers wrote the constitution.

Mature Valley Fill

Created Wetlands

Abolishing mountaintop mining would be the most serious attack on property rights since the founding fathers wrote the constitution. These lands, protected by the 5th Amendment, are owned by companies and individuals who will be denied their right to sell or use their natural resources. The doctrine of eminent domain and the government's power to take and control personal and private property, who is next?

This will also produce the largest "takings liability" law suit in history, thereby bogging down our judiciary. "Takings" items around the concept that someone must compensate the owners of coal and resources for their being denied the right to sell and/or produce these resources. In this case the government would most likely bear the cost. This simply means the taxpayer will pay.

Among lazy journalists, the politically-correct, Hollywood celebs, and liberal opportunists the placing, choosing, and editing of negative words and images regarding mountaintop mining is immoral and disgusting. For publication after publication to parrot and repeat the unbalanced, negative views of coal's opponents represents journalism, at the very least, as lazy and intellectually dishonest. If successful, their hurt and destruction will be immeasurable.

Although coal production, as with any manufacturing or commercial activity, can sometimes cause harm to individuals or their property. The coal industry strives to do no harm and is held responsible for such interruptions through bonding, the courts, the regulators, or its own good will. These challenges can be addressed without shutting down an entire state, region, or economy through conventional safeguards and communication.

Coal's Opponents wreak havoc and uncertainty on our jobs and economy.

In our viewpoint abolishing mountaintop mining would most likely:

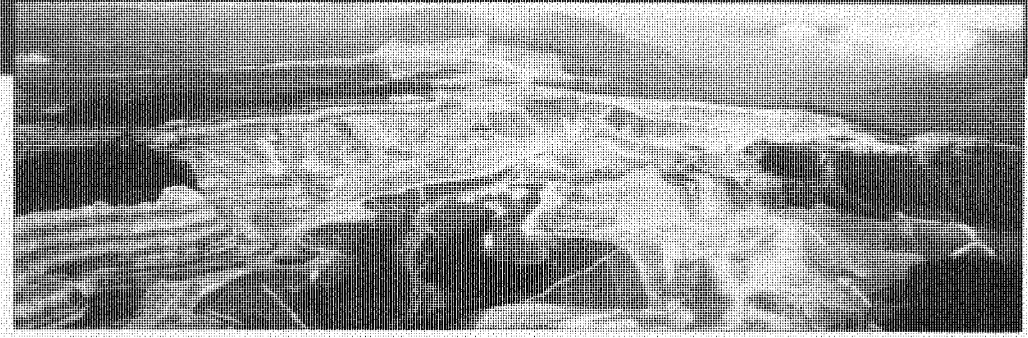
- Destroy the eastern coal industry and supporting companies
- Eliminate hundreds of small communities, churches, and schools
- Wipe out the self worth and dignity of families and breed despair
- Eradicate hopes of college and pathways from the cycles of poverty
- Place thousands and thousands on welfare rolls
- Place in default millions in loans and obligations
- Expand the credit crisis and destroy credit ratings
- Annihilate state and county revenues
- Increase tax burdens at all levels
- Create a healthcare catastrophe
- Make retirement an impossible dream
- Create more exodus to other states that are unable to handle the influx of the poor and jobless
- Impact coal-fired electricity generation and lead to rolling blackouts
- Skyrocket electricity costs
- Increase crime and intensify drug use
- Create widespread economic havoc and a national security crisis

Why and for what good purpose? Some within groups have a terribly misplaced value system with little confidence in our free, capitalist society. Even those with worthy intentions, or at best, unknown motivation, will fall victim to the law of unintended consequence that wreaks havoc far beyond the issues they seek to resolve.

Mountain Justice Gathering at the West Virginia State Capitol

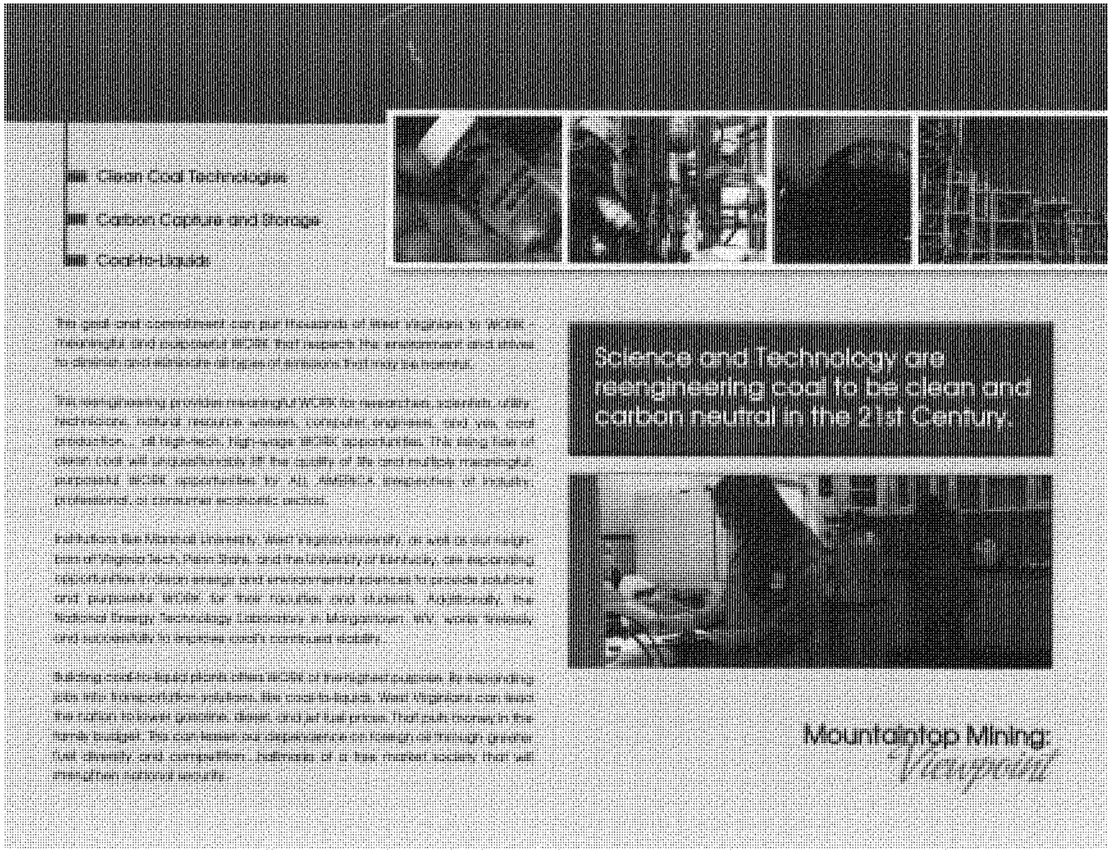
Man has shown himself compassionate and willing to sacrifice for the intrinsic value and beauty of the planet and all lower form of plant and animal life. Our coal miners protect our environment and make that great sacrifice for our quality of life every shift.

The people of Central Appalachia, and ultimately our great nation, are embroiled in a horrendous campaign of deceit and distortion, against the coal industry, and specifically the practice of mountaintop mining. The attack threatens entire economies and livelihoods on a catastrophic scale that jeopardizes our national security and the production of electricity.



Mining in Progress

Reclamation in Progress



- Clean Coal Technologies
- Carbon Capture and Storage
- Coal-to-Liquids

Science and Technology are reengineering coal to be clean and carbon neutral in the 21st Century.

Mountaintop Mining: *Viewpoint*