

An aerial photograph of a mountainous region. A large, winding reservoir or dam is visible in the center, surrounded by dense green forests. The terrain is rugged with many ridges and valleys. The sky is clear and blue. The text 'APPALACHIAN COMMUNITIES HEALTH EMERGENCY ACT' is overlaid in a semi-transparent white box across the middle of the image.

APPALACHIAN COMMUNITIES HEALTH EMERGENCY ACT

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H.R.526: Appalachian Communities Health Emergency Act (2013-2014)

Final Report

H.R.526: Appalachian Communities Health Emergency Act

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Executive Summary

Mountaintop removal coal mining is an extractive practice common to the Appalachian Mountains in the states of Kentucky, Tennessee, Virginia, and West Virginia. The practice comprises of 3 major components: explosive blasting, valley filling, and the post-mining process. Each component can cause potential impacts on community health and the environment, necessitating government regulation. The US has regulated mountaintop mining through the Surface Mining Control and Reclamation Act (SMCRA) since 1977.

Despite having existing regulations, health outcomes in the regions with mountaintop mining have been observed to be lower than the statistical averages of the country. Moreover, correlative studies have demonstrated negative impacts of each of these processes on air, water, and soil. Changes in the three media may potentially result in negative effects on human health via inhalation, ingestion, and dermal contact. These provide impetus for the Appalachian Communities Health Emergency (ACHE) Act.

The ACHE Act proposes two primary solutions and two peripheral solutions. Primarily, it places an indefinite moratorium on the issuance of new mountaintop mining permits and requires the undertaking of comprehensive health impact studies during the moratorium period. Peripherally, it prescribes mandatory continuous impact monitoring to existing mountaintop-mining companies that wish to continue operations and puts in place a financial support mechanism to fund the health assessments.

The proposed solutions are underpinned by sound scientific principles. First, the Health Risk Assessment requires thorough identification of hazardous substances or situations that the communities are exposed to, quantification of the frequency of exposure, estimation of the magnitude of harm these hazardous substances or situations pose, and characterization of the probability of harm. Second, continuous impact monitoring requires selection of air, water, and soil contaminants for persistent tracking.

Beyond its scientific underpinnings, the ACHE Act's effectiveness hinges on whether existing economic, social, and political controversies can be neutralized. Critics and segments of the Appalachian community oppose the act because they contend that ACHE Act would negatively affect the economy of the Appalachian region. Moreover, some scientists have argued that existing research on the impacts of mountaintop mining is inconclusive without more independent review. Also, regulatory guidelines have been mired in controversy and susceptible to political maneuvering.

Finally, the proposed solutions have to be evaluated objectively through indicators of success. Specifically, a successful health risk assessment has to provide sufficient and

accurate data to make a determination on the health effects. Proper steps must, thus, be taken. This includes the collection of baseline quality data for comparison purposes, effective design of the assessment so the scientific community will agree with procedures and findings, good data collection in Appalachian neighborhoods, and effective communication to the public and the scientific community.

All in all, the ACHE Act has the right ingredients to be an effective legislation if enacted. The onus now falls on the Congress to act in good faith.



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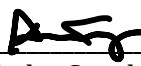
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I. Introduction

a. What is Mountaintop Removal Coal Mining

Mountaintop removal coal mining is an extractive practice common to the area of the Appalachian Mountains, in particular those of Kentucky, Tennessee, Virginia, and West Virginia (see Figure I-1). This is a form of surface mining in which the tops of mountains are removed using explosives in order to mine the coal beneath the surface. There are three major components of mountaintop removal coal mining processes namely: explosive blasting, valley filling, and the post-mining process. Often these processes are implemented in steep terrain where options for disposal of mine tailings are limited. As a result, the spoils of the mining are deposited into nearby valleys, coining the term “valley fills.” Valley fills can prove detrimental to ecosystems, especially their watersheds, and have the potential to bring contaminants in close proximity to local communities (USEPA, 2012a).

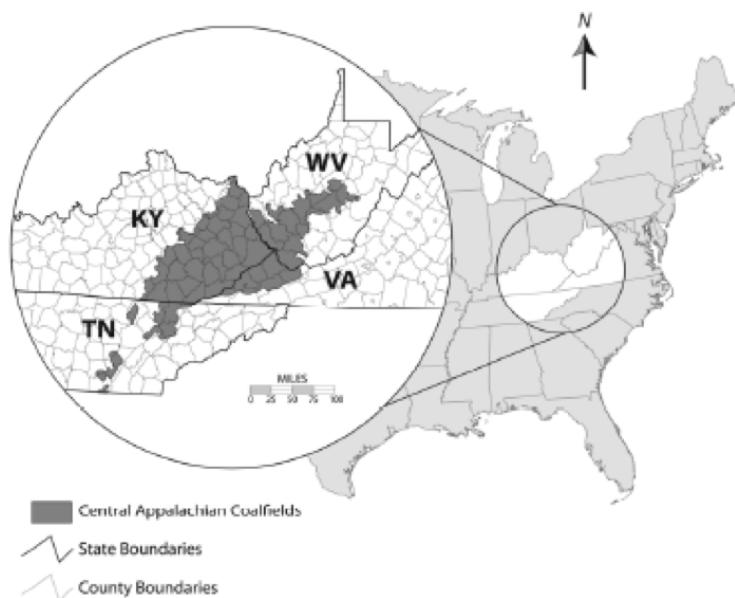


Figure I-1 - Locations of Surface Mining Coalfields (Source: USEPA)

Explosive Blasting

Mountaintop mining involves using explosives to expose coal seams beneath mountaintops. The explosives used contain large amounts of ammonium nitrate and diesel fuel. The explosions release coal dust and fly rock containing sulfur compounds, fine particulates including particulate matter, metals, silica and nitrogen dioxide into

the air. These air pollutants are highly mobile and can travel far beyond the mining site (Hendryx et al., 2008).

Valley Fills

The valley fill process is another key element of mountaintop mining that releases toxic substances into the environment. Valley filling involves depositing non-coal spoils, or excess rock, into nearby valleys (see Figure I.2). Valley fills permanently bury headwater streams under hundreds of meters of coal excavation waste. Once the coal seams that are previously buried under the mountaintop rock are exposed to oxygen and water, chemical reactions take place to break down the minerals into new substances that permanently alter the headstreams they bury. One example is the dissolution of the coal seam mineral, pyrite (FeS_2), when it comes into contact with water. The dissolution of pyrite forms sulfuric acid (H_2SO_4), which further dissociates to hydrogen and sulfate (SO_4^{2-}) ions. Sulfate in particular plays a major role in the water quality of the buried headstreams surrounding the mining sites (Lindberg, 2011).

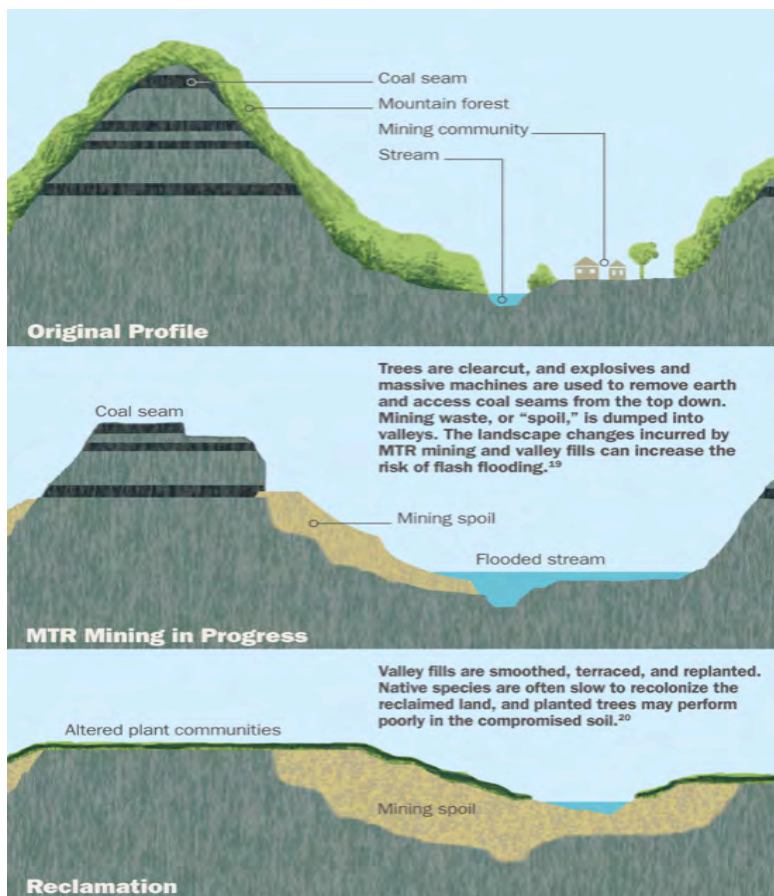


Figure I-2 - Valley Fill Process for Mountaintop Removal (Source: J. Tart, EHP)

Once in the watershed, sulfate increases aquatic pH levels, leading to higher amounts of dissolved selenium, manganese, iron and aluminum. Streams buried by sulfate laden mountain top spoil have dangerously high concentrations of elements such as selenium. Dissolved metal contaminants include manganese, iron, and aluminum, though selenium is by far of the most concern for human health. Selenium can significantly alter the biotic factors of the stream ecosystem, and has a high bioaccumulation rate, meaning that its toxicity increases as it moves up the food chain. In the case of the valley fill process, selenium tends to start off in sediment and the water column and move through the food chain via absorption through plants, microorganisms, and eventually fish native to Appalachian streams, such as the catfish and bluegill sunfish species (Savage, 2013). The EPA has a chronic standard for selenium in freshwater of 5 µg/L. Self reported figures of selenium discharge by current mining operations range in values from 14 µg/L to as high as 79 µg/L. In addition, studies have shown levels over the EPA standard of 5 µg/L are highly toxic to the fish and aquatic life of the streams buried by the valley fills (Lemly, 2009).

The Post Mining Process

After coal is mined, it is washed in a mixture of chemicals to reduce impurities that include clay, non-carbonaceous rock, and heavy metals to prepare for use in combustion. This processing activity contaminates billions of gallons of water, which is then held in unlined open storage pits held back by dams. This is "coal slurry" and it contains toxic sludge laced with various toxic chemicals such as lead, mercury, chromium and most importantly, arsenic. Since these pits are not lined, there is a high risk for these chemicals to leach into the groundwater and contaminate both private drinking water wells and the public drinking water supply (Epstein et al., 2011). Moreover, dam failures can expose communities to highly concentrated "coal slurry," with potentially disastrous consequences (see Figure I-3) (KnoxNews, 2008).



Figure I-3 - Tennessee Coal Dam Failure (Source: KnoxvilleNews, 2008)

II. Impact of Mountaintop Removal Coal Mining

These mining processes have led to the pollution of the air, soil and water of the surrounding areas. Residents of nearby towns have complained of the constant coal dust--particulate matter from pulverization of rock and coal--as well as the odorous aroma of hydrogen sulfide gas produced when bacteria encounter sulfate within the mining run-off (WHO 2003). Along with being unsightly, inhalation of particulate matter is a known cause of cardiovascular and respiratory stresses or disease (Hendryx et al 2008).

A 2010 EPA study revealed that the current valley fills have buried almost 2,000 miles of headwaters to the Mississippi River (USEPA, 2010). Water downstream from mountaintop removal mines and valley fills had salt concentrations up to 10 times that of water in un-mined watersheds. Changes in salt concentrations alter the life cycle of benthic macroinvertebrates and other aquatic organisms. These organisms are often used as a warning indicator for public health concerns (Holzman 2011).

Several peer-reviewed studies in the past decade focus on the relationship between mountaintop removal coal mining and its health impacts on local residents. Most of these studies conclude that mountaintop mining often correlates with negative health concerns in Appalachian communities, such as chronic cardiovascular disease, cancer, and respiratory disease. Zullig and Hendryx (2011) point out that after controlling for socioeconomic factors in a statistical regression model, mountaintop removal coal mining still plays a role in a local population's health problems. Other studies highlight similar conclusions. The Appalachian mining areas exhibit significantly higher chronic cardiovascular mortality rates than other non-mining areas (Esch and Hendryx, 2011). Both poverty and mountaintop removal coal mining factors are independently associated with such high mortality rates, which suggests that mining activities contribute to environmental and human health degradation in Appalachia (Hendryx, 2011).

A comprehensive report by Appalachian Voices (2012) supports these findings. Based on data collected by Centers for Disease Control and Prevention and National Center for Health Statistics, Appalachian states rank top among the states with the lowest health outcomes in the nation. Deaths from cancer, respiratory disease, and chronic cardiovascular disease during the period of 1999 to 2007 in counties with large number of mountaintop removal coalmines in the states of Kentucky, Tennessee, Virginia, and West Virginia, significantly outnumber counties in states without coalmines (see Figure II-1).

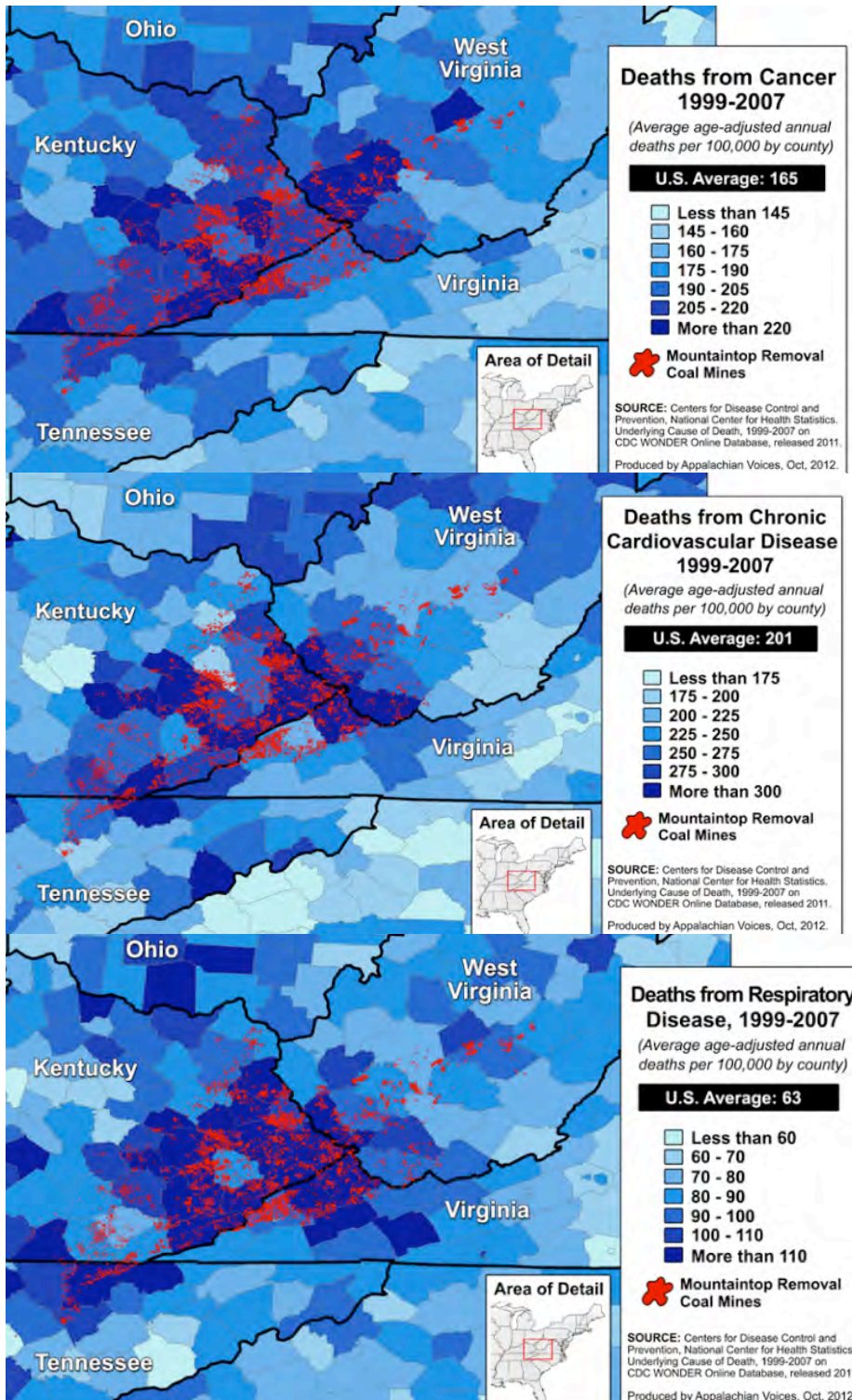


Figure II-1 - Cancer, Cardiovascular, and Respiratory Disease Death Rates in Appalachia (Source: CDC & Appalachia Voices)

a. Inhalation of Pollution and Particulate matter

Inhalation of air pollution and particulate matter has been linked to pulmonary and cardiac complications. Once inhaled, particulate matter, especially those below the size of 2.5 microns (PM_{2.5}), can easily become lodged in the lungs, causing lung irritation and breathing problems (see Figure II-2). Of the particulates released through explosions, silica is particularly toxic and can cause silicosis, or inflammation of the lungs (Lockwood et al., 2009).

Chronic exposure to particulate matter and dust released by mountaintop removal can also increase the risk of high blood pressure, atherosclerosis, and heart attacks. Heart disease is the leading cause of death in Appalachian coal mining communities, and areas with mountaintop removal coal mining have significantly higher mortality rates due to heart disease than other parts of Appalachia with similar socio-economic levels (Esch & Hendryx, 2011).

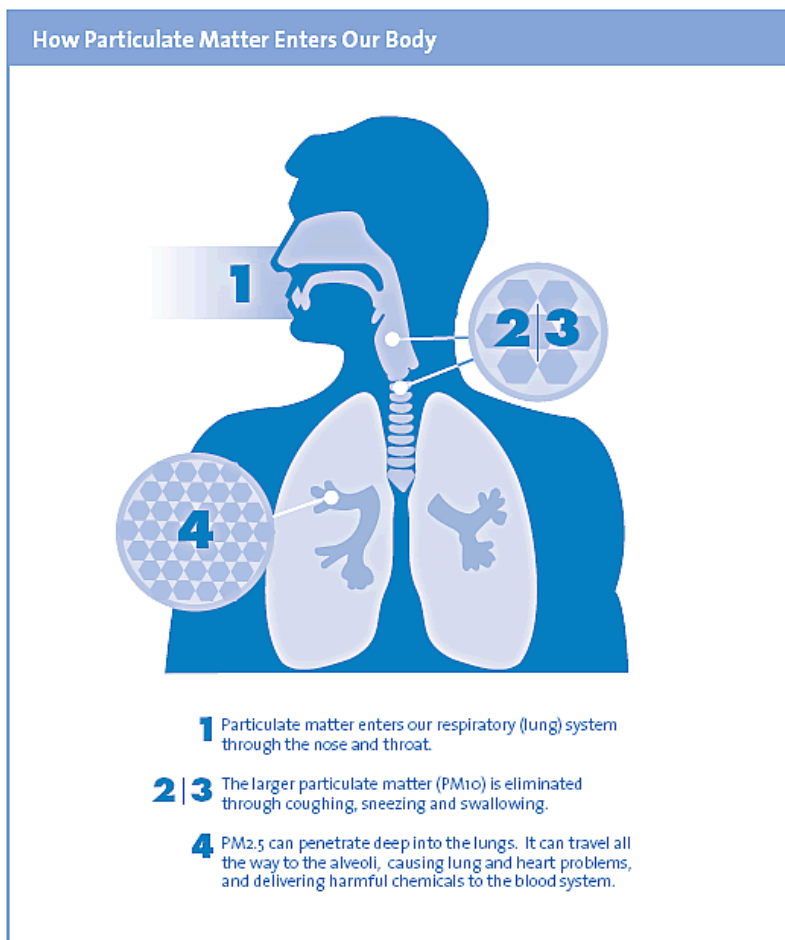


Figure II-2 - How Particulate Matter Enters Body (Source: British Columbia Air Quality)

b. Consumption of Selenium Contamination

Health impacts with regard to human contact with selenium contaminated fish or streams enriched with selenium can be high for those living in communities surrounding mountaintop removal coal mining sites. Humans can be exposed to selenium from these mining sites in various ways such as consuming drinking water that has been contaminated from selenium enriched stream water leaching into reservoirs. The most dangerous pathway of human contact with selenium is the consumption of contaminated fish, such as catfish and bluegill sunfish, in surrounding communities. These fish become contaminated by consuming plants and microorganisms that are contaminated with selenium, as well as through the transport of water through their gills. Due to bioaccumulation, by the time a fish is consumed by humans it has an exponentially higher level of selenium than the microorganisms that consumed the dissolved metal in the initial stages of the food chain.

The effects of selenium in toxic doses on marine life such as wild catfish and the bluegill sunfish have proven to be detrimental to the organisms' ability to reproduce effectively. Offspring of fish that exhibit highly toxic levels of selenium from bioaccumulation tend to be severely deformed (see Figure II-3) and neurologically flawed (Lindberg, 2011). When consuming fish with high levels of selenium, humans are susceptible to liver, kidney, and nervous system damage. Even small doses of selenium exposed to humans cause nervous system issues, deformed nails, and nausea (Kellogg, 2013). These health risks also arise with exposure to drinking water that has selenium levels that exceed the EPA standard. While residents of communities in Appalachia have reported higher than normal levels of birth defects, a link of causation between high selenium concentration in organisms and water supplies with the reported human complications cannot yet definitively be made.

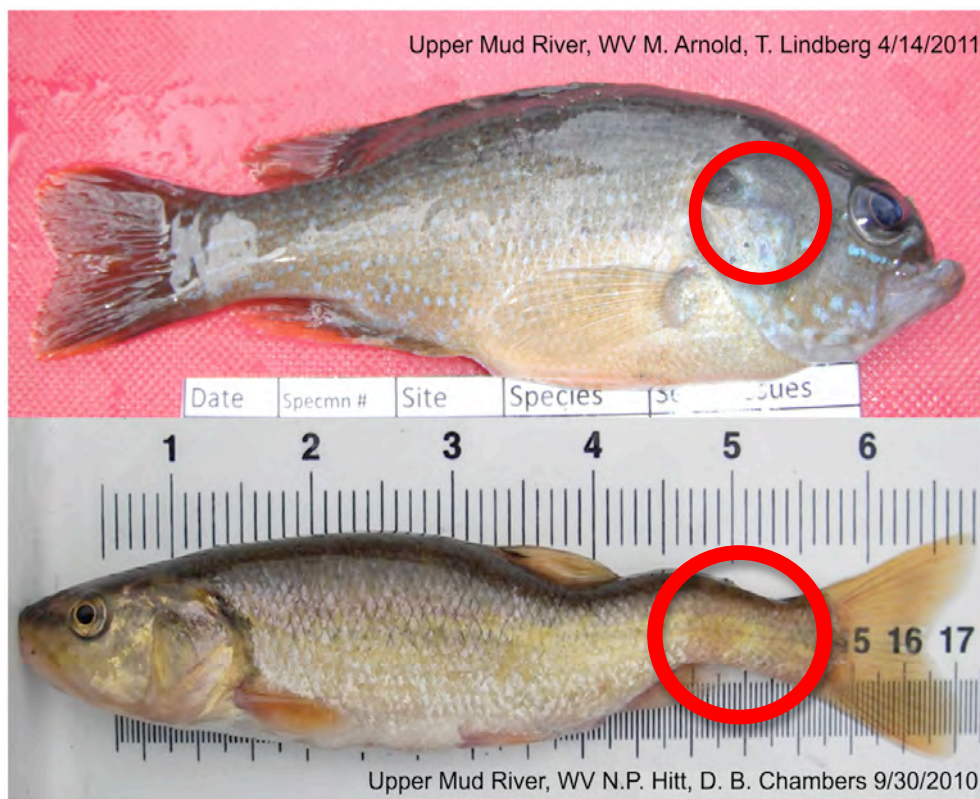


Figure II-3 - Fish Deformation (Source: Lindberg et. al, 2011)

c. Cancer-inducing Environment

In 2004, a pilot study was conducted by the Kentucky Community & Technical College System to analyze private wells for arsenic levels in counties with prevalent mountaintop mining, including eastern Kentucky and western West Virginia, southeastern Ohio, and northeastern Tennessee. A total of six percent of the 179 samples of private well water had arsenic concentrations that exceeded the EPA Arsenic concentration standard of 10 parts per billion (ppb). Based on the National Research Council's 2001 report to the USEPA, the lifetime risk of bladder and lung cancer from water arsenic exposure at 10 ppb is about one in 333 individuals, which is much higher than the standard of one in 10,000 individuals set for other carcinogens. Even at 5 ppb, the risk is 1 in 667, and at 3 ppb, the risk is 1 in 1000 (Shiber, 2005).

There have been several studies linking mountaintop mining to increased community cancer risks. Exposure to carcinogenic substances can occur through two pathways: groundwater contamination and air pollution. Surface water and groundwater around mountaintop mining are characterized by elevated sulfates, iron, manganese, arsenic, selenium, hydrogen sulfide, calcium, and aluminum. These are contaminants that can severely damage aquatic stream life and that can persist within the environment for

decades after mining has stopped. Elevated levels of airborne particulate matter around mining operations include silica, sulfur compounds, metals and nitrogen dioxide, ammonium nitrate among many other chemicals (Epstein et al., 2011).

In 2011, a peer-reviewed study by Hendryx et al. compared adult cancer rates in two different mountaintop mining communities in West Virginia, namely Boone and Raleigh County, against non-mining communities in Southern Pocahontas County. Volunteers went door to door in each community, gathering data on 773 people (409 surveys from Boone and Raleigh and 360 from Pocahontas county). Surveys included whether they had been diagnosed with cancer; length of time living in their community; whether they had worked as a coal miner; and tobacco use. Residents from Boone and Raleigh counties had higher rates of cancer (59 individuals compared to 34 in Pocahontas). Accounting for confounding variables like age, sex, family cancer history, and occupational exposure, the odds ratio was 2.03, meaning that self-reported cancer rates in counties where mountaintop removal occurs were nearly double the rates in nearby counties with no mountaintop removal. This study suggests that strong correlations exist between pollution from mountaintop removal coal mining and local cancer rates (Hendryx et al., 2011).

III. Overview of the ACHE Act

a. Purpose of the Bill

During the 1st session of the 113th congress on February 6th 2013, Democratic Congressman Mr. John Yarmuth from Kentucky proposed The Appalachian Communities Health Emergency Act, H.R. 526. His proposal was supported by 23 other congressmen and congresswomen, all from the Democratic Party. The present formulation of the ACHE Act is not the first of its kind. In the 112th congress, a similar bill, H.R. 5959, was defeated in Congress without making it to vote. The incidence of potential health risks in communities neighboring mountaintop mines suggests that the existing mining permit process may require improvements. Consequently, the Appalachian Communities Health Emergency Act primarily aims to place a moratorium on mountaintop removal coal mining until comprehensive health impact studies are conducted and published.

b. Proposed Solutions

In response to potential adverse health impacts of mountaintop removal coal mining on neighboring communities, the Appalachian Communities Health Emergency Act proposes two primary solutions (see Figure III-1): First, it proposes an indefinite moratorium on the issuance of permits for new or existing mountaintop mining projects. Second, it proposes the undertaking of comprehensive health impact studies during the moratorium period to ascertain the true health impact accruing from mining activities on the surrounding communities.

The other two sections of the act are peripheral solutions intended to support the two primary solutions (see Figure III-1). The third section of the Bill is a continuous impact monitoring, which serves as a compromise to companies currently conducting mountaintop mining, as well as the surrounding communities. It allows these companies to continue their existing operations as long as environmental pollutions are monitored and reported. Finally, the Act's financial support section provides a revenue stream to fund the pollution monitoring activities, as well as health impact studies.



Figure III-1 – Sections of the Appalachian Communities Health Emergency Act



Health Risk Assessment

The Act asks that the Director of the National Institute of Environmental Health Sciences study, support, and publicize the health impacts of mountaintop removal coal mining, and that the Secretary of Health and Human Services determine if such coal mining activities impose any health concerns to local communities.

Consequently, health risk assessment is the key solution offered by the Bill. It is important to realize that accurate and sound scientific research on health problems is necessary to ensure the safety of human health in the community. The health impact studies proposed are, thus, advantages in that it serves precisely this purpose.

However, since the Bill does not give any specific timeline on the comprehensive health studies, mining companies may offer strong resistance, as the Bill has the potential to decrease the profitability and predictability of their businesses for an indefinite period. Also, it may take a long time to complete the assessment, as it would be difficult to determine the overall impacts on the communities. In addition, the results go beyond just the mining industry; it jeopardizes the job security of locals employed in the mining sector.



Permit Moratorium

The Act implies that no permit for implementation or expansion of mountaintop mining can be issued if negative health consequences are formally recognized. As the true causal line between mountaintop mining and degradation of health is yet unknown, a moratorium on permits can prevent the further possible adverse impacts of mountaintop mining while scientific studies are undertaken. This is the fundamental

advantage of this section of the legislation. A broad restriction buys time for the science to be enhanced.

On the other hand, from a consumer's perspective, since the moratorium can be thought of as governmental intervention of the mining industry, it may thwart the energy market by increasing the coal price. Moreover, mountaintop mining is believed to currently supply energy to more than 25 million homes every year (National Mining Association, 2009). If the moratorium is implemented, it will be necessary to find alternative energy sources.

In addition, there were several lawsuits and controversies involving permits for mountaintop mining. The case of "Kentuckians for Commonwealth Inc. v. Rivenburgh" in 2003 is especially noteworthy. A nonprofit corporation, Kentuckians for Commonwealth Inc., representing Kentucky residents in their fight for social justice, requested a declaratory and injunctive relief to mountaintop mining permits that were given out by the Corps of Engineers. Kentuckians for Commonwealth felt that the interpretation of the Clean Water Act (CWA) by Corps of Engineers was illegal. Although the lower district court agreed with Kentuckians for Commonwealth Inc., and approved an injunctive relief, the Court of Appeals ruled that the injunction was far broader than necessary to provide Kentuckians complete relief because the plaintiffs were unable to show imminent probable irreparable injury from mountaintop mining (Kentuckians for Commonwealth Inc. v. Rivenburgh 2003). One conclusion we might draw from this legal action is that the permit moratorium may face legal challenges in future, even if passed by Congress.

However, to put things into perspective, the legal framework for environmental management has evolved over time. In a separate case in 2010, "West Virginia Highlands Conservancy v. Huffman," the Court of Appeals in the 4th district affirmed the trial court's decision to block permits for four mountaintop removal mine sites citing the "alarming cumulative stream loss" to valley fills, in clear violation of the CWA (Chhotray, 2008). Therefore, the legal framework has been changing its evaluation of the damage and injury to the people. Thus, it is still possible that the scope of the moratorium envisaged in this Act is acceptable.



Continuous Impact Monitoring

While scientific investigation proceeds, existing projects can advance as long as corporations continuously monitor and report associated air, water, and soil pollution. Otherwise, permits or authorization for existing projects may be suspended.

Continuous impact monitoring is advantageous in that the mandatory data collection creates a database that better quantifies the scale and magnitude of the environmental problem. Moreover, the mandatory reporting of pollution data improves transparency and allows the public to have access to unbiased mining pollution information (Bhogal & Dowlman, 2012).

More importantly, continuous impact monitoring serves its purpose by creating a politically palatable compromise between environmental groups that have called for a full moratorium on permits and industry lobbies who will never accept such a situation. In this case, this section is mutually beneficial to the diametrically opposing parties as long as the significant risk is not identified. Although environmental groups fail to get a full moratorium, they get pollution data of higher fidelity at the cost of the industry. On the other hand, although the coal industry has to incur expenses to monitor and report pollution levels, this is the lesser of two evils when compared to a full moratorium, which would have destroyed profit margins.

However, this section still has its disadvantages. First, it is clearly a costly process that will face some resistance from lobby groups representing industrial interest. Second, it is possible that lobbies may obfuscate the process by raising objections on the type of pollutants, spatial boundary, and frequency of monitoring and reporting (Smith, 1995).



Financial Support

A one-time fee will be administered to the entities currently employing mountaintop removal coal mining practices, the amount of which will be determined by the President. Fees collected may be used, if provided in appropriations acts, only to pay the costs of the studies and monitoring.

Primarily, this section creates a feasible funding path for continuous impact monitoring and a health risk assessment. Moreover, it avoids political tension by circumscribing the wide ideological differences between the two political parties with regards to government spending.

Unfortunately, there are also drawbacks. Once again, the imposition of a cost on mining operators may incentivize lobbying and resistance. Also, as the Act gives the President prerogative to decide the fee to be imposed, the administrative fee setting process might be affected by political considerations, as policy advisers may influence the President with their different interests (Vaughn & Villalobos, 2006). If the fee set were insufficient to fund comprehensive health studies, the Bill's solutions would not be effective.

IV. Science behind Proposed Solution

Among the four proposed solutions in the Bill, the community health risk assessment and continuous monitoring at mountaintop removal coal mining sites sections require further understanding of their associated scientific methodologies. During the moratorium, comprehensive health risk assessments will be conducted to determine whether mining activities impose health risk to local communities. Continuous monitoring will also keep track of emissions to the air, water, and soil, and will identify the ways in which residents of Appalachian communities may be exposed. Continuous monitoring will also keep records of emissions of the toxic substances released from certain mining activities and can contribute to future studies and regulations.

a. Health Risk Assessment

To evaluate the potential harm from the mountaintop removal coal mining activities, scientists need to go through the four steps of a health risk assessment in order to correlate the amount of exposure with the expected harm and to study the causal relationship between the health effects present in mountaintop removal coal mining communities (USEPA, 2012b).

Hazard Identification

Mountaintop removal coal mining activities release a variety of potentially toxic substances into the environment. For example, substances used during blasting contain high amounts of ammonium nitrate and explosive blasting increases particulate matter in the air, including tiny particles of silica, aluminum, and other metals (Hendryx et al., 2011). The valley fill process also increases the microbial production of hydrogen sulfide and increases the pH of downstream watersheds, leading to higher concentrations of dissolved selenium, manganese, aluminum, and iron in surface waters. The post-mining process can also release chemicals including arsenic, barium, lead, and chromium that can leach into groundwater. Previous research has documented increased lung cancer and other disease incidences and mortality in Appalachia. Peer reviewed independent studies also find that citizens of mountaintop mining regions are 50% more likely to have cancer (Hendryx et al., 2011). Current epidemiological studies have established a correlation between mountaintop removal coal mining and detrimental health effects. The following table (Table IV-1) shows some toxic substances that are released as a result of certain mining procedures and their corresponding health effects.

Substance	Mining Activity	Pollution Type	Health Effects	Cancer/ Non-cancer
Particulate Matter & Dust (PM _{2.5})	Explosive Blasting	Air	Silicosis, high blood pressure, atherosclerosis, heart attacks (Lockwood et al. 2009, Esch & Hendryx 2011)	Non-cancer
Selenium	Valley Fills	Water & Sediments	Liver, kidney, and nervous system damage, birth defect (Kellogg 2013)	Non-cancer
Arsenic	Post-Mining Process	Water	Bladder and lung cancer (National Research Council 2001)	Cancer

Table IV-1 – Toxic substances release during mining activities and their health effects

While there is a correlation between mining activities and adverse health effects, further research is needed to establish causation, which is essential for implementing future mining regulations. In general, there are four sources of evidence that contribute to hazard identification: epidemiology (human studies), animal studies, *in vitro* (bacterial and mammalian cell) testing, and *in silico* (computer models for structure-activity relationships).

Epidemiological Studies: Sometimes people develop chronic symptoms of a disease as much as 20 to 30 years after the initial exposure. As mountaintop removal mining began in the Appalachian states during early to mid 1970s (Montrie, 2003), the earliest populations exposed to such practices may only have started experiencing chronic impacts within the last 10 years. Given this knowledge, it may be necessary to conduct long-term studies on health outcomes related to mountaintop mining activities. This can be actuated through epidemiological studies involving scientists following populations in the communities surrounding mining sites to conduct observations on the frequency, distribution, and cause of diseases within Appalachian communities. Moreover, various interview and survey instruments that are culturally adjusted for potential confounding factors should be developed in the Appalachian area. It is also necessary to compare the health conditions of people in the Appalachian communities near mining sites to those of similar demographic and socioeconomic characteristics, but located farther from mining activities, in order to study the direct health impacts of mining activities.

Animal Studies: Some small mammals, like mice and rats, are commonly used to test and predict the effects of toxic substances. These effects can then be extrapolated to predict effects on humans. Because the lifetime of rodents is short, they generally provide information about the toxicity of substances relatively quickly. However, there are still uncertainties associated with extrapolating results from animal subjects to humans.

Besides epidemiological studies and animal studies, scientists can also utilize *in vitro* testing and *in silico* testing. *In vitro* testing is a human stem cell-based test, which could replicate the development of human central nervous system. *In vitro* testing could provide a more accurate and efficient testing method than animal studies. *In silico* means “performed on computer or via computer simulation.” *In silico* testing characterizes biological experiments carried out entirely through a computer. The various *in silico* techniques include bacterial sequencing techniques, molecular modeling, and whole cell simulations.

Exposure Assessment

An exposure assessment requires that scientists identify and quantify current levels of individual toxic substances, as well as which community or population of concern is exposed. Samples need to be taken from various locations near mining sites, especially locations that have the potential to contaminate the air, water, and soil of the surrounding communities.

The three main routes of exposure are inhalation, ingestion, and dermal contact. Residents in Appalachian communities can inhale particulate matter from the explosive blasting. Particulate matter, specifically PM_{2.5}, can cause pulmonary complications after long periods of exposure. Ingesting fish contaminated with selenium is also a concern for residents. Fish accumulate selenium by consuming plants and microorganisms that are contaminated with selenium from the water. Due to bioaccumulation, by the time a fish is consumed by a human, it has an exponentially higher level of selenium than at the initial stages of the food chain (Kellogg, 2013). Contaminated sediment, soil, and water can also come in contact with the skin and cause adverse health effects.

Generally, exposures can be separated based on duration into acute exposures and chronic exposures. Acute exposures are infrequent, high dose exposures following industrial accidents or other similar incidents. In this case, the exposures people in Appalachian communities are receiving would be considered mostly chronic, which is characterized by continuous, low level exposure to toxic substances in air, soil, and water; residents breathe air with particulate matter pollution, drink water that is potentially polluted with metals, and consume the fish that are potentially contaminated continuously, over the course of their entire lives.

Quantitative Toxicological Assessment

For non-cancer toxicity, a threshold dose level can be established. A threshold dose is a safe exposure level of the target chemical, below which no observable or appreciable damage occurs. The threshold dose of a contaminant is set at a level that incorporates all possible uncertainties. Scientists need to gather data on toxic effects and calculate the “safe” dose. Thus far in the science of evaluating cancer toxicity, there is no threshold because any dose of a carcinogen carries some risk. Cancer causing substances are regulated 10 to 1,000 times more strictly. Instead of establishing a threshold for these cancer-causing substances, scientists need to estimate the carcinogenic potency. Potency is a measure of the capacity of a given amount of a toxic substance to cause cancer. In some cases, exposure to small amounts of a carcinogen is sufficient to cause cancer, such as the solvent, benzene, which is a potent carcinogen that can increase the risk of leukemia by inhaling small amounts in the air (U.S. Department of Health and Human Services, 2003).

Risk Characterization

The last step of a health risk assessment, risk characterization, summarizes and incorporates information from the preceding steps. During this step, scientists determine whether mountaintop removal coal mining activities impose any health risks, both cancer and non-cancer, to local communities. For non-cancer chemicals, we divide the calculated exposure dose by the reference dose determined by the EPA to receive the hazard quotient. If the hazard quotient is lower than 1, then there is no risk imposed by this chemical. For carcinogenic chemicals, we multiply the dose by the slope factor to arrive at a risk level. The superfund upper limit risk for carcinogenic pollutants is $1E-04$, which means that a contamination situation is acceptable as long as its calculated risk level is lower than 1 in 10,000. Nonetheless, it should be noted that both central tendency and upper bound should be calculated so as to be conservative.

b. Continuous Impact Monitoring Requirement

While scientific investigations proceed, existing projects are required to continuously monitor and report associated air, water, and soil pollution. Explosive blasting releases particulate matter, specifically PM_{2.5}. Mining runoff, valley fills, and the post-mining process can also contaminate water and soil by releasing toxic substances such as lead, mercury, chromium, and most importantly, arsenic. It is important to monitor and keep track of the emissions released from ongoing projects in order to identify ways in which residents in nearby communities may be exposed and to avoid further negative health

impacts. Monitoring of the air, soil, and water can be conducted in an effort to comply with the continuous impact monitoring requirement of the Act.



Air Monitoring

Air samples can be taken using low, medium, or high volume air sampling equipment. A mass flow controlled volume sampler and a volumetric flow controlled sampler are two kinds of air sampling equipment (USEPA, 1999). Sampling equipment pulls air containing particulate matter and other airborne substances through a filter. For example, PM_{2.5}, which can deposit deep in the lungs and cause pulmonary complications, can be collected using a low volume sampler – a known volume of air is drawn through a preconditioned and pre-weighed filter for a period of 24 hours. Then by reweighing the filter at the end of the sampling period, the particulate matter concentration can be calculated in micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) (Mecklenburg County, 2014).



Water Monitoring

Water samples should be taken in the middle of a water body, if possible, as well as at various depths, in order to obtain an accurate representation of the water column in the water body. Samples should be filled to the top, with no room for air, to minimize volatile activity, and be transported to a laboratory for further analyses and testing. Some water quality measurements can be taken using instruments onsite, such as pH, turbidity, temperature, and dissolved oxygen. Laboratory testing through the use of ion chromatography can determine various contaminants, as well as heavy metal concentrations that are present in the water sample. Besides monitoring the water quality itself, it is also necessary to monitor the toxins in fish and gather fish consumption data in the area, because fish can concentrate high levels of chemicals, especially selenium, which can cause birth defects, due to bioaccumulation.



Soil Monitoring

Soil and sediment samples should be collected from the top 0 to 20 centimeters of the sediment profile at various locations, in order to identify any variations in pollution levels around the mining sites. The samples are then either air-dried or dried with the help of a thermal incubator. The dried samples are sieved and stored. However, measurements of pH and conductivity must be taken using a saturated sediment

sample. Heavy metal concentrations are obtained via digestion by acidic substances, as well as an inductively coupled plasma spectrometer or X-ray fluorescence, neutron activation analysis, and emission spectrographic techniques (USEPA, 2004).

V. Issues around Appalachian Mountaintop Removal Coal Mining and the Bill

a. Trend of Employment Rate

Economic benefits constitute a major portion in the debate on merits of mountaintop removal coal mining. Several stakeholders benefit from the status quo of the Appalachian coal mining industry currently. Since mountaintop removal mining is one of the most cost-effective methods to extract coal from underground, mining companies achieve greater profitability. Consumers also get to enjoy energy consumption at low costs. Most critically, part of the local community secures more employment opportunities if the number of mining jobs rebounds.

The number of mining jobs in Appalachia has been declining steadily since the late 1970s. This trend is observed for all four states in the Appalachian region. Over time, the number of mining jobs has declined but there has been a rebound since 2001 (Appalachian Voices, 2012). However, it is important to note the long-term trend of declining employment in the coal sector, losing 38,000 jobs since 1983 (Appalachian Voices, 2012). This is in part driven by mountaintop removal coal mining, which is more capital and less labor intensive than conventional mining or even other forms of surface mining. Moreover, the coal lobby has almost always exaggerated employment in the coal sector. While the coal lobby often cites significant contribution to employment and economy in the regions of their operations (Roanoke, 2014), employment in coal mining has a long term declining trend since the 1980s (Reis, 2013; Krugman, 2014). Also, out of 14 core industrial sectors in Appalachia, coalmining ranks second last (Appalachian Regional Commission, 2011).

b. Politicization of Science

Scientists and researchers who argue that mining does not pose a health risk often conduct research that is funded by the National Mining Association (NMA). These studies conclude that the adverse health outcomes prevalent in Appalachia cannot be solely attributed to mountaintop removal coal mining. For example, Borak et al. (2012) argue that some health disparities are not accounted for by the traditional risk factors used in current epidemiological research, because of the geographic isolation that characterizes rural Appalachia (Borak et al., 2012).

Geographic isolation creates logistical barriers to health care access and comprises a larger trend of limited employment opportunities, poverty, and a lack of health insurance. Borak et al. (2012) argue that cancer rates could be higher in rural areas of

Appalachia that also have mountaintop mining because there is less access to comprehensive diagnostic and treatment services (Borak et al., 2012). Cultural beliefs, like “fatalism,” are also described as reinforcing poor health behavior by discouraging early health intervention. Lastly, some researchers have described areas of rural Appalachia as “food deserts,” due to a lack of full service grocery stores, resulting in fewer options for nutritional diets (Borak et al., 2012). Borak et al. (2012) reassess the data used in several studies that relate coal mining to chronic disease in Appalachia. Given the myriad of “highly localized factors,” they conclude that mountaintop mining is not a significant variable to conclude impacting age-adjusted, all-causing mortality rates.

In another study funded by the NMA, Mecham et al. (2011) review publications ranging from 2007 to 2011 that specifically address coal mining as an environmental factor negatively impacting health. In their review, Mecham et al. (2011) conclude that Dr. Michael Hendryx, a researcher from the University of Indiana, has spearheaded the majority of research articles pertaining to mining and health in Appalachia. Although Dr. Hendryx has collaborated with 33 different authors, Mecham et al. (2011) assert that Hendryx and his co-authors are driven by an objective to provide proof to pressure policymakers to eliminate coal mining. Mecham et al. (2011) argue that independent researchers from various disciplines must be involved in researching the health disparities in Appalachia.

The diverging conclusions from different researchers point to the politicization of science in determining the relationship between mountaintop removal coal mining and negative health outcomes in Appalachia. Despite diverging conclusions, there seems to be consensus that more rigorous research is needed to create policy informed by scientific evidence.

c. Controversial Regulatory Guidelines

Standards set by regulatory bodies like the Environmental Protection Agency (EPA) are equally subject to controversy. Aquatic selenium concentration is a salient example of how the progression of scientific research can lead to the development of new regulatory standards. Selenium is a naturally occurring element that is released through a variety of activities, including agriculture, coal-fired power generation, and coal mining (Lemly, 2009). High levels of selenium have been linked to adverse effects on aquatic species. The most dangerous pathway of human contact with selenium is the consumption of contaminated fish, such as catfish and bluegill sunfish (Lemly, 2009).

Last year the EPA approved Kentucky's proposed criterion for chronic effects on selenium. The new standard is adopted and involves measuring selenium concentration in the tissue of fish, instead of the traditional limit, which is based on aquatic concentrations of selenium. Under the new guidelines, water bodies exceeding a concentration of 5 µg/L in the water will trigger a requirement to test selenium levels in fish tissue to compare against the 8.6 µg/g tissue standard (Payne, 2013).

The original selenium limits set by the EPA have not been updated in over a decade, and have been widely criticized, as it is only based on the findings from a single study. New scientific research has shown that chronic water quality concerns are more appropriately expressed as fish tissue criteria (Payne, 2013). The proposed changes are strongly supported by the mining industry, as well as representatives from the manufacturing and construction industries. Environmental groups like the Sierra Club, cite that the new standard is "scientifically indefensible" and that it fails to protect sensitive wildlife (Sierra Club, 2013). Another central criticism is that the new standard is difficult to implement and not legally binding. Eric Chance, a water quality specialist for Appalachian Voices, cites that testing fish tissue is limited in that it does not reveal how many fish the selenium pollution has already killed, and that citizen enforcement of the new standard will be challenging, if not impossible (Sierra Club, 2013).

The controversy behind aquatic selenium standards highlights the uncertainties and challenges that are inherent in assessing the human health risks associated with environmental toxins.

VI. Measuring the Bill's Success

The main goal of the Appalachian Communities Health Emergency Act is to determine whether or not communities surrounding mountaintop removal coal mining sites are in fact experiencing negative health impacts as a result of mining practices. Therefore, a successful health risk assessment will provide enough sufficient and accurate data for the Secretary of Health and Human Services to make a determination of whether or not mountaintop removal mining presents any excessive health risks to individuals living in the surrounding communities. Proper steps must be taken throughout the development and implementation of this site-specific assessment. These steps (see Figure VI-1) include the collection of sufficient baseline data, design of the assessment, community data collection and methodology, transparent communication, and adequate peer review by the scientific community. Further, based upon receipt of the health risk assessment, the Secretary of Health and Human Services will decide whether or not a determination on a definitive link between mountaintop mining and health risks to communities can be analyzed and published. If the assessment does not provide enough accurate information, or is perhaps invalidated by the scientific community during the peer review process, then the Secretary will most likely be unable to make a determination. Therefore, inconclusive results illustrate a failed program.

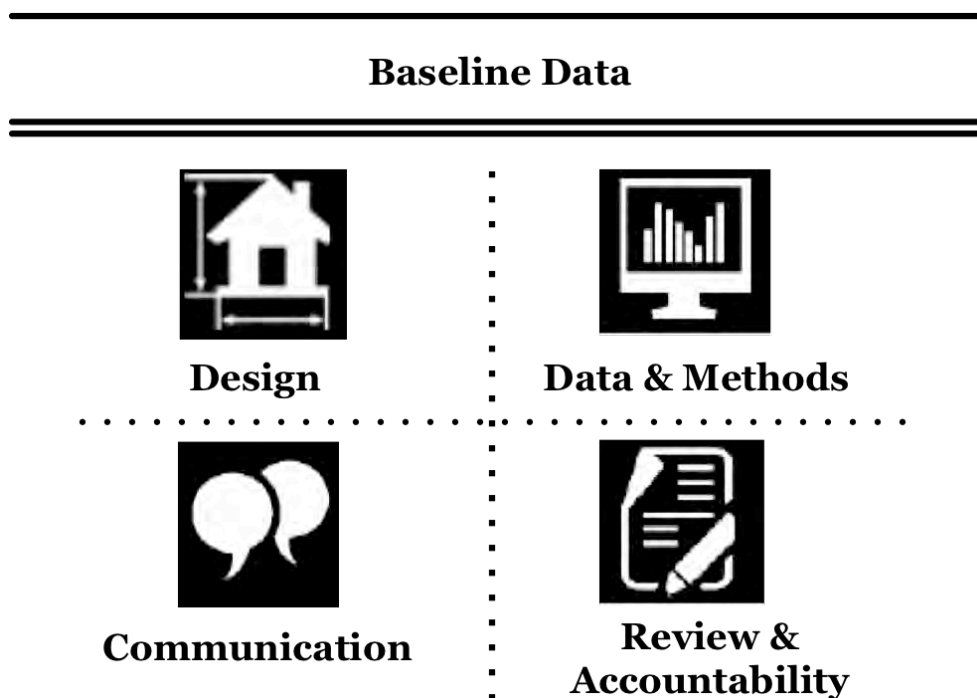


Figure VI-1 – Indicators of Success for the Appalachian Communities Health Emergency Act

a. Indicators of a Successful Comprehensive Health Risk Assessment

The Act asks that the National Institute of Environmental Health Sciences studies, supports, and publicizes the health impacts of mountaintop removal coal mining, and that the U.S. Department of Health and Human Services determine whether such mining activities impose any health risks to local communities. This is accomplished by conducting a comprehensive health risk assessment. Indicators of success will be measured based upon whether or not the following steps, commonly performed in routine assessments by organizations such as the Agency for Toxic Substances and Disease Registry (ATSDR), were followed accordingly and in good faith.

Collection of Baseline Data for Comparison

In order to complete a successful health risk assessment, a sufficient amount of relevant baseline data must be collected for comparative purposes against the data collected during the assessment. Community specific data with regards to hospital records, soil, air, and water records, and organism tissue records prior to mountaintop mining in an area should be found and included when available (Musso, 2014). Without this type of baseline data, there will not be anything to compare the data collected during the study to, thus making a determination of causation much more difficult and abstract. For example, community health records for time periods prior to the start of mining practices in an area can be used as a baseline for cancer rates or pulmonary disease rates to compare current records with. This can allow researchers to extrapolate trends and further equips them with better data to properly determine a linkage between mining and presently reported community health issues.



Design of the Assessment

A recent media briefing by the American Chemistry Council (ACC) on April 25, 2014 noted some specific key areas that organizations, such as the ATSDR and Integrated Risk Information System (IRIS), should incorporate into risk assessments in order to make them successful. Drafting a successful design for the assessment sets the stage for a successful outcome. The ACC recommends delineating a tailored purpose, scope, and detailed technical approach to the assessment with a transparent process that allows for public comment and peer review (American Chemistry Council, 2014). By creating a transparent design from the get-go, it eliminates the potential problem of accusations claiming biased results down the road. In addition, transparency fosters an increased amount of legitimacy for the study. Further, although the legislation does not call for a

specific timetable, perhaps it would be advantageous to include one when designing the assessment to ensure a timely report.

Another aspect of the assessment design should be incorporating a mechanism to account for confounding factors such as access to healthcare or other potential community based stressors. The EPA published a framework for Cumulative Risk Assessment in 2003 that highlights some guidelines for ways to incorporate these other factors. This framework calls for a comprehensive integrated assessment of risk that involves multiple stressors, chemical and non-chemical, and how they act together with the focus on a population or place (National Environmental Justice Advisory Council, 2004). This can be one way to perhaps account for the suggested notion of environmental injustice in the Appalachia area with regards to access to healthcare and geologic isolation (Borak et al., 2012). As a recommendation, after the comprehensive health risk assessment has been completed, this aforementioned framework should be included in the subsequent community health assessment.



Data and Methods

A successful health risk assessment relies heavily on accurate and consistent data collection. In addition, the methodology for collecting the data should be explicitly stated in the design stage, so that all stakeholders are aware of the process. For our intent and purposes, data collection can be broken into four sub-categories:

- a. Data from Air: Particulate matter, such as silica and aluminum, should be measured using ambient air monitoring techniques, as outlined by the EPA such as the federal reference modeling method (USEPA, 1997). In addition, the EPA also suggests using a mass flow low volume sampler, which operates by pulling a known volume of air through a preconditioned and pre-weighed filter for a period of 24 hours (USEPA, 1999). The filter may be reweighed after the sampling period and the concentration of particulate matter 2.5 (PM_{2.5}) in micrograms per cubic meter (ug/m³) can be calculated (Mecklenburg County, 2014). There should be multiple monitors placed in specific predefined locations to ensure the accuracy of data.
- b. Data from Water and Soil: Both ground and surface water samples should be continuously taken and analyzed for contamination levels of the post mining slurry compounds (e.g. arsenic, barium, lead, mercury, lead, and chromium), sulfate ions, pH levels, selenium, and manganese. Water samples should be taken consistently and recorded from the middle of the water body, as well as at various depths, in order to obtain an accurate representation of the water column. Soil

samples should also be analyzed for the same suite of compounds.

- c. Data from Fish Organism Tissue: Levels of metal and non-metal elements, such as selenium and mercury, should be tested for in the cellular tissues of fish organism. Due to the bioaccumulation rate of selenium in particular, by the time fish are ingested by humans, there is an exponentially higher level of selenium present than in the earlier stages of the food chain (Kellogg, 2013). This ingestion pathway is of particular concern to human health.

All data collection should be consistent and recorded for transparency and to ensure accurate data history. After data collection, qualitative analysis should begin focusing on two main questions. First of all, is the chemical or compound in question detected? Next, is the chemical site-related, meaning is it naturally occurring or anthropogenic in nature?

A consistent methodology for calculating dose should be followed and compared with the EPA's regional screening level (RSL) table, to determine whether measured dosages are higher or lower than specified safe levels outlined in the table (USEPA, 2014) It is important to note that this methodology varies for cancer and non-cancer substances:

- a. Non-cancer: Specify contaminant and source region (soil, tap water, etc.) and identify threshold; the dose can be calculated through $Dose = C \times \frac{CR \times ED}{BW \times AT}$ (C = Concentration, CR = Contact Rate with medium, ED = Exposure Duration, BW = Body Weight, AT = Averaging Time). The formula varies for inhalation, ingestion, and dermal contact.
- b. Cancer: There is no threshold for carcinogenic toxicity; a single molecule can cause a cell to develop into a fatal tumor. The method asks for identification of the most sensitive tumor and estimation of carcinogenic potency (slope factor). Calculating cancer risk or rate in a health risk assessment will be particularly difficult given the nature of cancer development. In other words, a cancerous tumor may develop after decades after an individual coming in contact with a contaminant substance, which would be well outside the time frame of a health risk assessment.

A successful risk assessment will follow through with the data collection step in a transparent and consistent manner. If there is incomplete or inaccurate data, the results of the assessment will be considerably undermined. In addition, effects of the chemicals or compounds on children must be determined and presented as well, since children are far more sensitive to toxic contamination than adults due to lower body weight.



Communication

As has been mentioned, it is crucial for the success of the assessment that all data and findings are as transparent and accessible as possible. All data should be recorded and analyzed for anomalies prior to making available to the public. In addition, the report should be available online in an easy to navigate searchable database for all to view.



Review and Accountability

Once complete, the assessment must be subject to appropriate peer review and accountability by peer reviewers within the scientific community. Moreover, these peer reviewers must be independent of the study. A successful health risk assessment should, in theory, generate support among the scientific community. While it is beneficial to incorporate critical peer reviews in order to improve the legitimacy of the assessment, if all reviews are negative or locate errors or incorrect findings, the assessment will likely be deemed unacceptable. Additionally, there should be more opportunities for the general public to comment on the outcome of the risk assessment.

VII. Conclusion

Mountaintop removal coal mining is a cost-efficient extractive practice common to the area of the Appalachian states of Kentucky, Tennessee, Virginia, and West Virginia. The extraction process potentially poses negative impacts on the environment and human health in local communities. There have been correlative studies demonstrating negative impacts of mountaintop removal coal mining on air, water, and soil. Changes in air, water, and soil quality ultimately results in effects on human health through inhalation, ingestion, and dermal contact.

Despite having existing regulations controlling mountaintop mining, health outcomes have been observed to be lower in these regions. This provides impetus for the Appalachian Communities Health Emergency Act. The primary solutions are an indefinite moratorium on the issuance of permits for new and the undertaking of comprehensive health impact studies during the moratorium period. The peripheral solutions are mandatory continuous impact monitoring if existing mountaintop mines wish to continue operations and a financial support mechanism to fund health assessments.

The primary solution of a comprehensive health impact assessment is crucial for the Act, due to limitations in existing scientific studies that require additional research. First of all, an individual's county of residence may not correspond with coal mining exposure precisely (Zullig and Hendryx, 2011). Identification of mountaintop removal mining areas needs further refining. Additionally, due to lack of data at the individual level, researchers cannot determine with certainty if residents near mining areas coincide with individuals experiencing mortality from chronic diseases (Hendryx, 2011; Esch and Hendryx, 2011). Other confounding factors, such as diet, family history, psychological stress, and economic uncertainties among residents and workers, can create complexity in determining details around relationships between mountaintop removal coal mining and human health impact (Esch and Hendryx, 2011; Esch and Hendryx, 2011). Finally, lack of direct measures of environmental air or water quality information also complicates the issue, which can be resolved, as the Appalachian Communities Health Emergency Act demands that mining companies continuously monitor and report their environmental pollution.

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